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Forecast for southern and central British Columbia coho salmon in 2004

Prévisions pour le saumon coho du sud et du centre de la Colombie-Britannique pour 2004

Kent Simpson[1], Michael Chamberlain[2], Jennifer Fagan[3], Ron W. Tanasichuk[4] and Diana Dobson[4]

[1] Salmon Stock Assessment Section, Science Branch, South Coast
3225 Stephenson Point Rd., Nanaimo, B.C. V9T 1K3

[2] Stock Assessment Division, Science Branch, B.C. Interior
985 McGill Place., Kamloops, B.C. V2C 6X6

[3] Stock Assessment, Conservation Management, Science Branch, Central Coast
150 – 1260 Shoppers Row, Campbell River, B.C. V9W 2C8

[4] Stock Assessment Division, Science Branch
Pacific Biological Station, Nanaimo, B.C. V9T 6N7

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Abstract

This Working Paper presents 2004 forecasts of marine survival, abundance and distribution of coho in southern and central British Columbia (Areas 7 to 29: the Fraser River system and coastal waters south of approximately 53° N).

There are five hatchery and three wild coho indicator stocks in the Georgia Basin and west coast of Vancouver Island (wVI). Forecasts of survival for these stocks are:

Management Unit	Indicator	Recommended Model	Predicted Survival in 2004 (50% CI)[1]		Change (2004 forecast minus 2003 observed)
GB West	Big Qualicum	LLY	0.006	(0.004 - 0.010)	0%
	Quinsam	3YRA	0.013	(0.010 - 0.017)	35%
	Black (wild)	3YRA	0.047	(0.034 - 0.066)	60%
Lower Fraser	Chilliwack	RAT3	0.022	(0.015 - 0.031)	-13%
	Inch	LLY	0.010	(0.006 - 0.018)	0%
	Salmon (wild)	LLY	0.036	(0.026 - 0.049)	0%
SWVI, NWVI	Robertson	Sibling	0.029	(0.018 - 0.048)	-70%
	Carnation (wild)	Euphausiid	29	(17 - 50)	-94%

[1] The prediction for Carnation Cr. is for return, not survival.

Survival of coho on the east coast of Vancouver Island is expected to be poor, ranging from approximately 1% for hatcheries to 4.7% for higher productivity wild stocks. Although the wild forecast and the Quinsam hatchery forecast are larger than the survivals in 2003, there is an increased risk this year, based on sibling forecasts of hatchery survival, that survivals may be lower than last year. Survivals are forecast to remain about the same in the lower Fraser (LowFr) area. Although there is not a time series of survivals for the mainland shore of the Strait (the Georgia Basin East Management Unit), measured survivals suggest that coho survivals have been poorer in this Unit than elsewhere in the Georgia Basin. Overall for the Georgia Basin, we characterise survivals as poor, basing this qualitative assessment on previously higher survivals and on calculations of the survivals needed to sustain stocks of low to average productivity.

We forecast that an average proportion of coho that originated in the Georgia Basin will rear in the Strait of Georgia in the spring and summer before spawning. Although not a prediction of either an' inside' year or an 'outside' year, the proportion is expected to be more 'inside' than several of the last 10 years.

Survival of coho is forecast to be approximately 3% on wVI (SWVI and NWVI). This is about one third of the very good survival in 2003. Survival of Robertson Hatchery coho is forecast to be more than Georgia Basin hatcheries, as it has been for many years. The return of coho to the wild indicator, Carnation Creek, is forecast to decline from above average in 2003 to well below average. In summary the forecast is for a sharp reduction in survival and for returns to be below average or well below average.

The abundance of Thompson River coho in 2004 is expected to be ~34,271 animals. This is significantly more than the ~14,610 coho observed in 2003, but less then the brood year (2001) abundance of ~53,000. Returns in 2003 did not exceed their brood year return as well. While some individual Interior Fraser River populations are remaining stable or have increased slightly over the brood abundance, as a whole the abundance of this stock aggregate continues to remain low and is not recovering rapidly.

The abundance forecasts for central coastal British Columbia remain the only method of forecasting for this area. Forecasting methods conform to those of past forecasts in this area. The forecasts of total abundance

and escapement for the five Central Coast aggregates are given in the following table. Note that the abundance of coho in Area 13 (Johnstone Strait) is expected to be very poor:

		Total Return (Abundance)		Escapement		
Aggregate	Model	Forecast P †	Characterization	Forecast P †	Characterization	% of S_{max} ††
Area 7	3YRA	35%	average	61%	average	35%
Area 8	3YRA	20%	below average	44%	average	59%
Area 11	3YRA	56%	average	78%	well above average	109%
Area 12	3YRA	10%	well below average	57%	average	33%
Area 13	3YRA	4%	well below average	22%	below average	5%

† Proportions of past abundances or escapements that are less than the forecast value.

†† The forecast escapement as a percentage of the spawner number that on average produces maximum recruitment.

Résumé

Ce document de travail présente les prévisions de survie en mer, d'abondance et de répartition du saumon coho du sud et du centre de la Colombie-Britannique (zones 7 à 29 : le réseau fluvial du Fraser et les eaux côtières situées au sud d'environ 53° de latitude nord).

Voici les prévisions de la survie pour les huit stocks indicateurs (cinq stocks d'écloserie et trois stocks sauvages) du bassin de Georgia et de la côte Ouest de l'île de Vancouver (COIV).

Unité de gestion	Indicateur	Modèle recommandé	Taux de survie prévu en 2004 (I.C. de 50 %)[1]		Changement (prévue en 2004 moins l'observation de 2003)
BGO	Big Qualicum	LLY	0,006	(0,004 – 0,010)	0 %
	Quinsam	3YRA	0,013	(0,010 – 0,017)	35 %
	Black (sauvage)	3YRA	0,047	(0,034 – 0,066)	60 %
BasFr	Chilliwack	RAT3	0,022	(0,015 – 0,031)	-13 %
	Inch	LLY	0,010	(0,006 – 0,018)	0 %
	Salmon (sauvage)	LLY	0,036	(0,026 – 0,049)	0 %
SOIV, NOIV	Robertson	Germains	0,029	(0,018 – 0,048)	-70 %
	Carnation (sauvage)	Euphausiacés	29	(17 - 50)	-94 %

[1] La prévision pour Carnation Creek porte sur la remonte et non la survie.

Nous prévoyons que le taux de survie du coho sur la côte Est de l'île de Vancouver sera faible; il variera d'environ 1 % pour les stocks d'écloserie et à 4,7 % pour les stocks sauvages, plus productifs. Bien que les taux pour les stocks sauvages et le stock d'écloserie de la Quinsam soient plus élevés qu'en 2003, il existe un plus grand risque cette année, selon les prévisions du taux de survie des cohos d'écloserie, qu'ils soient plus faibles que l'an dernier. Les taux de survie devraient aussi rester à peu près semblables dans la région du Bas-Fraser (BasFr). Bien que nous ne disposions pas d'une série chronologique de taux de survie pour le littoral continental du détroit (unité de gestion de l'est du bassin de Georgia), les taux de survie observés donnent à penser qu'ils étaient plus faibles dans cette unité que cela n'était le cas ailleurs dans le bassin de Georgia. Dans l'ensemble du bassin, nous caractérisons les taux de survie comme faibles ; cette évaluation qualitative est basée sur les taux de survie antérieurs plus élevés et sur des calculs des taux nécessaires pour soutenir des stocks de productivité faible à moyenne.

Nous prévoyons qu'une proportion moyenne des cohos provenant du bassin de Georgia passeront le printemps et l'été dans le détroit de Georgia avant de frayer. Bien que cela ne soit pas une prévision du nombre en eaux « intérieures » ou en eaux « extérieures », la proportion devrait être plus « intérieure » que cela n'a été le cas les dix dernières années.

Sur la côte Ouest de l'île de Vancouver (SOIV et NOIV), nous prévoyons que le taux de survie du coho sauvage sera d'environ 3 %, soit le tiers de l'excellent taux observé en 2003. Le coho de l'écloserie Robertson devrait présenter un taux de survie plus élevé que ceux des écloseries du bassin de Georgia, comme c'est le cas depuis plusieurs années. Les effectifs de la remonte du coho sauvage indicateur dans le Carnation Creek devraient diminuer, pour passer d'un niveau au-dessus de la moyenne en 2003 à un niveau nettement au-dessous de la moyenne. En résumé, le taux de survie devrait présenter une baisse marquée et les effectifs des remontes devraient se situer au-dessous ou bien au-dessous de la moyenne.

Les effectifs du coho de la rivière Thompson devraient se chiffrer à 34 271 individus en 2004, soit significativement plus que les effectifs observés de 2003 (14 610 individus), mais moins que les effectifs de 53 000 observés lors de leur année d'éclosion (2001). En 2003, les remontes n'ont pas dépassé les remontes pour leur année d'éclosion. Bien que les effectifs de certaines populations intérieures du Fraser sont encore

stables ou ont légèrement augmenté par rapport aux effectifs observés à l'éclosion, dans l'ensemble, les effectifs de ce complexe de stocks, qui se rétablit lentement, continuent d'être faibles.

Les prévisions des effectifs pour la côte centrale de la Colombie-Britannique constituent toujours la seule méthode de prévision pour cette région. Les méthodes de prévision correspondent à celles utilisées pour les prévisions passées dans cette région. Le tableau suivant présente les prévisions du total des effectifs et de l'échappée pour les cinq complexes de stocks de la côte centrale. Nous prévoyons que les effectifs de coho dans la zone 13 (détroit de Johnstone) seront très faibles.

		Remonte totale (effectifs)		Échappée		
Zone	Modèle	Prévision [†]	Caractérisation	Prévision [†]	Caractérisation	% de S_{max} [††]
Zone 7	3YRA	35 %	moyenne	61 %	moyenne	35 %
Zone 8	3YRA	20 %	< moyenne	44 %	moyenne	59 %
Zone 11	3YRA	56 %	moyenne	78 %	bien > moyenne	109 %
Zone 12	3YRA	10 %	bien < moyenne	57 %	moyenne	33 %
Zone 13	3YRA	4 %	bien < moyenne	22 %	< moyenne	5 %

[†] Proportions des échappées ou des effectifs passés inférieures à la valeur prévue.
[††] Échappée prévue comme pourcentage du nombre de reproducteurs qui, en moyenne, donne un recrutement maximum.

1. Introduction

This Working Paper presents 2004 forecasts of the survival, ocean distribution and adult abundance of coho in southern British Columbia (sBC, Areas 14 to 29) and the Central Coast (CC, Areas 7 to 13). The methods we used in developing the forecasts of survival and ocean distribution are similar to those used in the previous forecast (Simpson et al. 2003)[1]. Forecasts before 2003 are: Simpson et al. (2002, 2001a), Holtby et al. (1999a, 2000), Kadowaki and Holtby (1998), Kadowaki (1997) and Kadowaki et al. (1996).

There are four changes from last year's forecast. First, we have not forecast marine survival for coho in Carnation Creek, the west coast of Vancouver Island (wVI) wild indicator stock. In the first two years of coded wire tag (CWT) escapements to the creek, large proportions of the escapements were not trapped at the fence as smolts. Until a longer time series of CWT-based survivals are collected, we will forecast the abundance of Carnation Cr. coho rather than their survival. Second, we experimented last year in forecasting returns per spawner of Thompson coho, comparing it with the usual forecast of returns. Our conclusion and that of the Salmon Subcommittee was that it was not helpful and we have not used returns per spawner this year. Third, there are no forecasts for Areas 9 and 10 (Rivers and Smith inlets) due to insufficient escapement data (all time series were shorter than our minimum requirement of 10 years). The forecast methodology for Areas 7, 8, 11, 12, and 13 was the same this year, although exploitation rates were adjusted to account for Mark Selective Fisheries in Areas 12 and 13 and there are new analyses of indicator stocks in Areas 7, 8 and 11). Finally, the catch per unit effort forecast of mean survival of coho from Georgia Basin hatcheries is not available this year because the trawl cruises were cancelled in 2003.

This forecast will refer to several Management Units south and east of the Central Coast:

Johnstone Strait/Mainland Inlets (JST): Johnstone Str., Queen Charlotte Str., and adjacent inlets (Areas 11, 12 and the northern portion of Area 13)

Georgia Basin – East (GBE): east side of the Str. of Georgia, excluding the Fraser R. system (Areas 15, 16, 28 and the coastal foreshore streams in Area 29)

Lower Fraser (LowFr): Lower Fraser R. system as far upstream as Hell's Gate (Area 29)

Interior Fraser (IntFr): upstream from Hell's Gate, including the Thompson R. system (Area 29)

Georgia Basin – West (GBW): west side of the Str. of Georgia (Areas 13 (southern portion), 14, 18 and the Str. of Georgia portion of Area 19

South-west Vancouver Island (SWVI): Victoria to Estevan Pt. (the remaining part of Area 19 and Areas 20-24)

North-west Vancouver Island (NWVI): Estevan Pt. to Cape Scott (Areas 25-27)

[1] Survival is defined here as adult returns (catch plus escapement) per smolt, sometimes referred to as 'marine' survival, although it includes parts of the freshwater migratory phases of smolts and adults.

2. Data Sources and Treatments

2.1 Estimates of Marine Fishing Mortality

Marine fisheries for coho in sBC have been limited since 1998 in order to conserve weak stocks of concern, primarily those originating from the Thompson River and Strait of Georgia. Only in Alberni Canal and in Nootka Sd. in wVI were there commercial fisheries that were allowed to retain coho in 2003. However, sport fisheries allowing retention of hatchery marked coho were common. Hatchery marked coho had their adipose fin removed at the hatchery ('Ad-clips' or simply 'clips'). In addition, retention of un-marked coho was allowed in total bag limits of two or four per day for parts of Areas 20, 23, 25 and 27 in wVI. Four coho per day, clipped or un-marked, were also allowed in Areas 7 to 10 and parts of Area 11 in the Central Coast. Prohibitions on retention of un-marked coho remained in effect in Johnstone Str., eastern Juan de Fuca Str. (Area 19) and in the Str. of Georgia. However, commencement of the mark selective fisheries in these areas was advanced to July 1 from August in 2002.

With the initiation of mass marking of hatchery coho in the 1995 brood year and widespread coho non-retention regulations in 1998, CWT recoveries decreased. Even though selective mark sport fisheries have expanded in recent years, recovery of tags in those fisheries can no longer rely on heads from marked coho being provided voluntarily by fishers. This is because a clip no longer signifies that the fish necessarily has a tag. Coho must now be scanned for the presence of a tag and budget restraints limit that coverage. In addition, much reduced harvest rates and selective mark fisheries mean that the mortality of coho that were caught and released becomes more important relative to the catch. The result is that CWT-based estimates of fishing mortality have become unreliable, especially for unmarked ('wild') coho (Pacific Salmon Commission 2002).

Instead, estimates of total mortality of Thompson coho from 1998 to 2000 were derived from estimating number of coho encounters by catch area and applying estimates of the proportion of Thompson coho in those encounters through genetic analysis of sampled coho (Irvine et al. 2001). We estimated 2001 to 2003 fishing mortalities for Thompson, Str. of Georgia and wVI indicator stocks using an approach that relies on historical estimates of CWT recoveries and effort. The method is described below. The same effort analysis will be done for Str of Georgia and wVI indicators for the 1998 to 2000 return years but it is not yet available. Both analyses require estimates of drop-off and release mortalities.

2.1.1 Marine fisheries, excluding Area 23 (Barkley Sound and Alberni Canal)

Historical exploitation rates were averaged for each indicator stock. The rates were estimated from CWT recoveries in various commercial and sport fisheries. The indicator stocks were Big Qualicum, Quinsam, Inch and Chilliwack hatcheries and Black and Salmon (Langley) creeks for the Georgia Basin; Robertson

Creek Hatchery for wVI; and Eagle and Salmon (Salmon Arm) rivers for the Thompson. Historical effort and exploitation rate data provided an average exploitation rate/unit effort for a given base period for each fishery-indicator combination. Observed effort in each recent year was then used to estimate annual fishery impacts assuming a proportional relationship between effort and exploitation rate and assuming standard release/drop-off mortality rates. In commercial fisheries, additional scalars were used to account for changes in fleet size, gear efficiency and selective fishing practices (e.g. coho avoidance and/or increased survival of bycatch). These scalars were subjectively determined by a fisheries manager (pers. comm., L. Hop Wo, Salmon Stock Assessment Section, South Coast Area, Nanaimo). For US fisheries, Alaskan exploitation rate was assumed to be the average observed during the 1987-1997 period and southern US fisheries were assumed to be half the average observed during the same period.

2.1.1.1 Commercial fisheries

The base period that was used depended on available effort data and CWT data. For commercial fisheries, the base period of historical exploitation rate and effort data was the return years 1987-1997. For net fisheries, the measure of effort was days open. The exploitation rate in a given month and year was divided by the effort (days open) observed in the fishery for that month. All the monthly observations were then averaged across the base period to estimate the average exploitation rate/day in each fishery for a given month. Mortality rates in net fisheries in year *t* were estimated by the following formula for each fishery-month combination:

$$Mortality_t = \left(\overline{ER/Effort}\right)_{87-97} \times Effort_t \times Fleet\,/\,Gear\,Scalar \times Release\ Mortality\ Scalar$$

Eqn. 1

where effort is measured in days open, and the Fleet/Gear scalar is based on a subjective assessment by a fisheries manager to account for fleet changes and selective fishing practices. The release mortality scalar was assumed to be 60% for gillnet fisheries and 25% for seine net fisheries. The estimated mortality rates in all fishery-month combinations were summed to estimate total exploitation rate for year t in net fisheries for each indicator stock.

For troll fisheries, where effort data are less reliable, the average exploitation rate/month was calculated for the fishery-indicator combination. Mortality rates in year t were estimated by the following formula:

$$Mortality_t = \left(\overline{ER/Effort}\right)_{87-97} \times Effort_t \times Fleet\,/\,Gear\,Scalar \times Target\,Scalar \times Release\,Mortality\,Scalar$$

Eqn. 2

where effort is measured by percentage of month open, and the Fleet/Gear scalar and Target scalars are determined by subjective assessment by a fisheries manager to account for the effects of downsizing the fleet size and avoiding coho, respectively. The release mortality scalar was assumed to be 15% for troll fisheries.

2.1.1.2 Recreational fisheries

The base period used for sport fisheries was from 1981 to 1997, except for Thompson stocks, for which data were limited to the 1987-1997 return years. Average exploitation rates for the base period were calculated for each indicator-fishery combination on an annual basis. Annual averages were calculated because historical recoveries in any month were relatively rare. It was assumed that before mandatory non-retention in 1998, catch was a reasonable indicator of encounters. Since 2001, encounters (catch and release) were estimated using creel surveys which also estimate effort (boat trips). The basic equation used to estimate exploitation rate in year *t* (some coho retention allowed) was:

$$ER_t = \overline{ER}_{87-97} \times Relative\ Effort_{t/87-97} \times Hatchery\ Stock\ Release\ Mortality\ Scalar$$

Eqn. 3

To scale historic average exploitation rates, the relative change in effort (boat trips) from the base period to year t was calculated for each catch region by the following ratio:

$$Relative\ Effort_{t/87-97} = \frac{Effort_t}{\overline{Effort}_{87-97}}$$

Eqn. 4

where effort is measured in boat-days. Sport fisheries allowed for coho retention during some times and areas, but there were still encounters of coho in non-directed fisheries. The only area that appeared to avoid coho during periods of non-retention was in northern Strait of Georgia (GSPTN). For that reason, relative effort was further scaled in GSPTN according to periods of coho non-retention and retention so that:

$$GSPTN\ Relative\ Effort_{t/87-97} = \frac{(Effort\ directed)_t + (Effort\ non-directed)_t}{\overline{Effort}_{87-97}}$$

Eqn. 5

where 'effort' in non-directed fisheries in GSPTN was estimated by correcting for the coho encounter rate so that:

$$GSPTN\ \ Effort, nd_t = \left(\frac{(Coho\ \ encounters\ /boat\ \ trips)_{nd,t}}{(Coho\ \ encounters\ /boat\ \ trips)_{d,t}} \right) \times Boat\ \ trips_{nd,t}$$

Eqn. 6

where nd and d refer to non-directed and directed fisheries, respectively. For wild indicator stocks the release mortality scalar was assumed to be 10%. For hatchery indicator stocks, the release mortality scalar was assumed to be 10% during non-retention periods, but was scaled higher to account for retention (selective mark fishery) periods. To account for retention periods, the scalar was adjusted according to the amount of total effort observed in non-directed and directed fisheries. In non-directed fisheries, release mortality was assumed to be 10% and in selective mark-only fisheries it was assumed that all encountered hatchery fish were retained:

$$Hatchery\ Stock\ Release\ Mortality\ Scalar = \left(\frac{Effort\ non-directed_t}{Total\ Effort_t}\right)\times 0.1 + \left(\frac{Effort\ directed_t}{Total\ Effort_t}\right)$$

Eqn. 7

Table 1 shows the resulting estimates of marine fishing mortality rates of Thompson coho and sBC indicator stocks from 2001 to 2003. Note that these are displayed as point estimates and therefore do not reflect the range of uncertainty in the data. The estimation of the 2003 exploitation of Thompson coho varied somewhat from the above procedure and is discussed further in Sect. 2.2, below.

Catches in 2002 of marked coho and catch releases of unmarked coho in the Strait of Georgia were 63% and 78% less, respectively, than in 2001 despite expansion of the selective mark fishery. In 2003, the catch of hatchery coho increased 2.5 times to 18,000 and catch releases of wild unmarked coho increased 1.7 times to 37,000. Applying 10% release mortality to the releases and adding the retained catch of unmarked coho, the unmarked mortality in the Str. of Georgia and Juan de Fuca Str. was ~7,000. Eighty-two percent of the unmarked mortality was recorded in Juan de Fuca Strait. Approximately 30,000 unmarked and 25,000 marked coho were retained in wVI. With an estimated 42,000 releases of unmarked coho, the total fishing mortality of unmarked fish is 35,000, which is a 2.9 times increase from 2002. Half the mortality occurred in Area 23 (pers. comm., D. Nagtegaal, Salmon Stock Assessment, South Coast Area, Nanaimo).

2.1.2 Area 23 (Barkley Sound and Alberni Canal)

The catch and release mortality of clipped coho in the directed Area 23 sport fishery in 2003 was calculated from creel data provided by K. Hein (Salmon Stock Assessment, South Coast Area, Nanaimo). Commercial catches of clipped (Ad-only) and Ad-CWT coho in Alberni Canal were provided by L. Kearey (Salmon Stock Assessment, South Coast Area, Nanaimo). This was done by assuming that all encounters of marked and tagged (CWT-ad) coho in the Area 23 sport fishery and Alberni Canal commercial fishery were Robertson-origin coho. Although obviously wrong, at least for the sport encounters, the over-estimate is probably very small based on historic recoveries from this fishery of CWT-ad coho. Some marked coho were released in the fishery. The ratio of CWT-ad coho to the total number of clipped coho in the Robertson escapement was used to estimate how many of these marked coho releases had tags and a release mortality of 10% was applied to that CWT-ad release estimate. Mortalities of Robertson Hatchery coho in other fisheries were calculated in the effort analysis explained above. The estimates of mortalities of CWT-ad coho in the Area 23 sport fishery equated to exploitations of 18.1%, 7% and 19.3% in 2003, 2002 and 2001, respectively.

An exploitation of 7.3% was assumed for Carnation coho in 2003 (cf. 3% in 2002). Being a wild stock, Carnation coho were tagged but not clipped. The creek is east of Bamfield, in Barkley Sd. Two unmarked coho per day could be retained in most of Barkley Sd. after July. However, no coho were allowed in daily catches after July off of Carnation Creek, in Numukamis Bay. Two clipped coho were allowed offshore of Barkley Sd. In Alberni Inlet and Alberni Canal (‘inside’ of Carnation Cr.), two unmarked coho were allowed in June and July and four were allowed after July. A large proportion of the effort was in Alberni Inlet and Canal. This effort was largely directed toward Robertson Hatchery coho. There were also two gillnet openings in Alberni Canal in late August – early September, which were targeting chinook but allowing coho retention. And there were three gillnet openings for coho in the Canal in September. The sport and commercial exploitation of unmarked Robertson Hatchery coho was about 9%, based on an analysis of that hatchery’s tagged but unmarked (CWT-only) release group (cf. 3% in 2002). This analysis included an allowance of 10% mortality of released fish in the sport fishery. Although much of the effort was ‘inside’ of Carnation, we chose not to vary such a low exploitation of unmarked Robertson coho to make an estimate for Carnation coho.

2.2 Interior Fraser, Including the Thompson River

The Interior Fraser River (IFR) is defined as the Fraser River watershed above Hells Gate and includes the Thompson River, the largest watershed in the Fraser River system. Coho originate from one of five geographically distinct sub-regions of the Interior Fraser River Management Unit (Irvine et al. 2001):

1. South Thompson: the South Thompson River and its tributaries;
2. North Thompson: the North Thompson River and its tributaries;
3. Lower Thompson: the mainstem Thompson River and tributaries downstream from the confluence of the North and South Thompson rivers, including the Nicola watershed;
4. Fraser Canyon: the Fraser River and tributaries upstream of Hells Gate, but downstream of the Thompson River confluence; and
5. Upper Fraser River: the Fraser River and tributaries upstream of the Thompson River confluence.

An ‘abundance’ time series was derived from an escapement time series (Irvine et al. 1999a, Irvine et al. 1999b; Irvine et al. 2000) that consists chiefly of spawner estimates made during visual surveys. We have been able to reliably reconstruct the escapement time series for the North and South Thompson systems as far back as 1975 and Lower Thompson streams back to 1984. Many Fraser/non-Thompson streams were not reliably assessed for coho escapement before 1998 and have been subjected to annual variations in assessment activities since 1998. The time series includes all of the streams within each sub-region where there were at least two annual estimates of escapement that we feel reflect changing patterns in fish abundance and includes wild and enhanced coho (Table 2). Catch and abundance (i.e. catch plus escapement including fish taken for brood stock) were estimated from the escapement time series for each censused stream using a time series of exploitation rates (Table 3).

The time series of exploitation rates for the Thompson were generated from the escapement estimates and the Mark Recovery Program (MRP) CWT recoveries for a variety of releases from 1986 to 1997. Escapement estimates prior to 1986 were the arithmetic average of measured values from 1986 to 1996.

Regulatory changes to salmon fisheries, beginning in 1998, saw most fisheries become non-retention for coho. Therefore, few coho were sampled for CWT's from which exploitation could be estimated. To account for the absence of CWT's recovered in recent fisheries, the exploitation rate of Thompson coho in Canadian marine fisheries was estimated by scaling the base period average exploitation rates by the fishing effort observed in 2003.

Another source of exploitation on IFR coho is from the fisheries conducted within the lower Fraser River. The 2003 fishery components in the lower Fraser River were:

- First Nations (directed net fishery for sockeye salmon in August, and chum and coho salmon in October, as well as a beach seine fishery for pink salmon in September)
- Recreational (directed fishery for sockeye and chinook salmon in August-beginning of September, and chinook, coho and chum salmon in October; directed pink salmon fishery in September)
- Commercial (chum gillnet)
- Test fishing (Albion, Whonnock, Cottonwood gillnets, and a new Area E gillnet test fishery)

To calculate the total in-river exploitation rates for the lower Fraser River in 2003 each fishery component was broken down into total coho mortality by day (the product of number of encounters and some associated gear specific mortality rate), then multiplied by the relative abundance of IFR coho for that day. The relative abundance model is based on DNA data from Irvine et al. (2000). The modelled proportion of IFR coho present in any given catch sample declines over time and the parameters of this decay are derived from an empirical fit of a Bayes model to the DNA data. This provides a measure of uncertainty in the relative abundance of IFR coho on any given day (Galbraith 2004, unpublished data).

United States (including Alaskan) exploitation rates on Interior Fraser coho were calculated using their Fisheries Resource Allocation Model (FRAM). As with Canadian exploitation rate calculations the US model derives ER's from CWT recoveries from US origin marine fisheries during an earlier base period and scaled to reflect 2003 fishing effort.

Adding the marine, in-river and US exploitations, the total exploitation on IFR coho in 2003 was ~12.6% (Table 1 and Table 3).

2.3 Strait of Georgia, Lower Fraser and West Vancouver Island Hatcheries

Five hatchery stocks are used in forecasting survival of south coast coho: Robertson (SWVI and NWVI), Quinsam and Big Qualicum (GBW), and Inch and Chilliwack (LowFr). Three wild stocks are used: Salmon (LowFr), Black (GBW) and Carnation (SWVI and NWVI).

Hatchery survival rate estimates are made only for CWT-ad coho. Hatchery releases of coded wire tagged smolts have also included unmarked (CWT-only) groups since 1997. Virtually all the rest of hatchery production was marked with a pelvic fin clip in 1997 (except at Quinsam and Robertson hatcheries) and with an adipose clip since then (Simpson et al. 2001b). This mass marking was to prepare for selective mark fisheries. Smolts captured at the Salmon, Black and Carnation creek fences are tagged (only starting in 2001 at Carnation). We stopped fin clipping the Salmon River and Black Creek runs in 1998 in preparation for selective mark fisheries. Carnation Creek coho are not marked either. In order to assess tag loss, we began clipping some of the Black Creek smolts again in 2003. About 10,000 CWT-ad and 33,000 CWT-only smolts were released.

We used the hatchery releases of CWT-ad smolts that are recorded in the MRP database maintained at the Pacific Biological Station in Nanaimo, BC. Hatchery escapements for last year were provided by the Habitat and Enhancement Branch (pers. comm. R. Cook, Vancouver; G. Bonnell, South Coast Area, Victoria). These are preliminary estimates: escapement data for years before last year are final/near-final estimates as entered in the MRP database. The differences between preliminary and final estimates are usually small. Smolt release and escapement data for Black Cr. are collected by us (KS) and Carnation Cr. data are provided by the BC Ministry of Forests (pers. comm. P. Tschaplinski, Victoria). Catch and release data for the freshwater sport fisheries in Somass R. (Robertson Hatchery) were provided by J. Patterson (DFO, S. Coast Area, Nanaimo). S. Stenhouse (DFO, S. Coast Area, Nanaimo) provided the same for Big Qualicum R. and S. Grant (DFO, Lower Fraser Area, Delta) provided creel data for Chilliwack/Vedder River. Creel surveys were not done in Nicomen Slough this year. There is a freshwater sport fishery in Nicomen Slough, which harvests Inch Cr. Hatchery coho. We assumed the exploitation rate in this fishery was 21%, the same as measured in 2002.

Data for each indicator are shown in Table 4. All years were queried in MRP using only those codes approved for survival analysis. Chilliwack returns are an exception. No Chilliwack releases prior to the 1996 brood year are approved for survival analysis because fishing mortality was insufficiently known for the large Chilliwack/Vedder sport fishery and HEB have some concerns regarding hatchery recovery procedures in some earlier years (pers. comm., R. Cook, HEB, Vancouver). We and earlier authors chose to use the releases of pre-1996 broods if they were production (not experimental) releases from the hatchery (not off-site). Jack and adult returns from each indicator are the sum of estimated recoveries in all catch regions, including Alaska and Washington. Some MRP recoveries show fish of ocean ages greater than one. These few recoveries were still accepted for the brood years assigned to them in MRP.

2.4 Central Coast

Escapement data for central coastal British Columbia were obtained from P. Zetterberg and M. Mortimer (Stock Assessment, Central Coast Area, Campbell River and Bella Coola). A review of reliability of system estimates for Areas 12 and 13 began in early 2004, resulting in a few streams being omitted from the original data series used for previous forecasts. All data from 2004 should be considered preliminary and subject to revisions until escapement estimates are finalized.

The exploitation of Toboggan Creek coho in the Skeena R. system is used for northern Central Coast Areas 7-11 and these data were obtained from J. Sawada, North Coast Area, Prince Rupert. For southern Central Coast Areas 12-13, we used time series of exploitations from northern Str. of Georgia indicators (3.1.2 below). The exploitation rate data series used for the 2004 forecasts differ from those used in the 2003 forecasts due to further analysis of historic data.

2.5 Salinity Data

The relative abundance of coho residing in the Strait of Georgia in their last ocean year is forecast using a relationship between catch distribution and salinities in the Strait. Salinity data for the Chrome Island and Sisters Islet lighthouses in the Strait of Georgia were obtained from R. Perkin, Institute of Ocean Sciences, Sidney, BC.

3. Methods - Forecasting Models and Retrospective Analysis of Predictive Power

3.1 Forecasting Models

3.1.1 Time Series

In this document, we forecast some of the following in different parts of the forecast area: catch distribution (p_{inside}), marine survival (s), and abundance (A). Survivals and abundances are forecast in more than one way. One method uses four quasi-time series models. In each model the variable being forecast (v_t) is first transformed:

$$Z_t = \Im(v_t) \qquad \text{Eqn. 8}$$

The Log transformation was used for abundance of Thompson and CC coho and abundance of Carnation Creek coho. The Logit transformation was applied to all survival data and it was also used to transform pinside values in its predictive regression with salinities.2 The four time series models are:

Mnemonic	Model	Equation
LLY ("Like Last Year")	$Z_{t+1} = Z_t + \varepsilon_t$	Eqn. 9
3YRA (3-year average)	$Z_{t+1} = \dfrac{\sum_{k=t-2,t} Z_k}{3} + \varepsilon_t$	Eqn. 10
RAT1 (1 year trend)	$Z_{t+1} = \dfrac{Z_t^2}{Z_{t-1}} + \varepsilon_t$	Eqn. 11
RAT3 (average 3-year trend)	$Z_{t+1} = \dfrac{\sum_{k=t-2,t} Z_k / Z_{k-1}}{3} Z_t + \varepsilon_t$	Eqn. 12

[2] The Logit transformation, $Z_t = \ln\left(\dfrac{v_t}{1-v_t}\right)$, stabilizes variances and puts survival and p_{inside} measures on the zero to infinity scale, which is necessary for regressing with the like-scaled salinity variable and for assuming normal errors in the time series analyses. It also straightens the salinity: p_{inside} relation.

For each model, we assume that the error term is normally distributed, $\varepsilon \approx N\left(0,\sigma^2\right)$, and is independent of time. For estimating uncertainty in the forecast value (Z_{t+1}), an estimate of σ^2 was obtained for the distribution of observed minus predicted for years $1\ldots t$.

The differences between the four models are summarized in the following table:

		Years used in prediction: 1	3 (≈ 1 cycle)
Allows projection of trends?	NO	LLY	3YRA
	YES	RAT1	RAT3

3.1.2 Abundance Forecasts for Central Coast

Comprehensive estimates of escapement to individual streams throughout BC began circa 1950. These estimates are mostly based on visual inspections of the streams. The methods used to inspect the streams, convert the counts to estimates of escapement, and the frequency of surveys, etc., are largely undocumented before the late 1990s. These earlier methods are known to differ between systems and to have changed over time. The records are also fragmentary, however we think that the time series act as indices of abundance and provide information about escapement trends in each area.

To extract that information we first coded the various designators for "no-data" to a common missing value indicator. For systems where a significant change in escapement methodology had occurred and was documented, such as initiation of a fence or mark-recapture program where a peak count was used before, a second series of data was started. The original data set was retained for comparison between systems in earlier years. We then took out streams that have had a significant hatchery contribution or had less than 10 years of data between the years 1950 to 2003. Finally, we have begun to look at the likely reliability of estimates for individual streams and are removing streams that probably have poor estimates. Examples of such streams include glaciated systems in the mainland inlets and systems that were not inspected at similar times over the years. We then scaled the escapement (E) in each stream i to the maximum escapement recorded in that stream across all years t:

$$p_{i,t} = \frac{E_{i,t}}{max\left(E_i\right)} \qquad \text{Eqn. 13}$$

Then the $p_{i,t}$ were averaged across all streams i within each year t to give a time series (p_{max}) for the Area as a whole. The "average-stream" or index escapement was constructed by multiplying p_{max} by the average across the *i* streams of max (E_i). This procedure was carried out for streams aggregated by Statistical Area.

To construct an index of total abundance we then made some assumptions about the time series of historical exploitation rates. We know from CWT recoveries in ocean fisheries between 1987 and 1994 that coho from the entire North Coast (Areas 1 to 6) and northern Central Coast (Areas 7-8) have similar ocean distributions (Anon. 1994). Most coded-wire tags have been recovered in troll fisheries both in Alaska and northern BC. This leads us to assume that the levels and the temporal patterns in ocean exploitation rates are likely similar between all of the sites in the North Coast and northern Central Coast. We have no CWT data from stocks in Area 11, so for the purposes of this forecast we assumed that the ocean distribution would be similar to Areas 7 and 8. The exploitation rates used for the Johnstone Strait management areas 12 and 13 were derived from three northern Strait of Georgia CWT indicator stocks: Quinsam (hatchery), Big Qualicum (hatchery) and Black Creek (wild) for years prior to mark selective fisheries, and Black Creek for 1998 to the present.

Forecasts for the average-stream indices were made in two ways. First, total returns to the "average stream" within each aggregate were forecast using the four time-series models. Second, the time series of escapement and returns were used as inputs to Ricker stock-recruitment analyses, which were then used to forecast recruitment and returns in 2004 using observed spawner indices in 2001.

The 'average-stream' indices may be effective descriptors of status of coho within a geographical area. Some re-grouping might be advisable to combine streams of similar physiography. However, the utility of the average-stream index in describing trends within an area have not been thoroughly explored and no diagnostics have been developed for recognizing situations where the index is unsuitable. To give the reader a feel for the approximate likelihood of forecast values, the forecasts have been expressed in terms of Z-scores:

$$Z = \frac{x - \overline{x}}{SD} \qquad \text{Eqn. 14}$$

Tabulated values of Z and their associated cumulative probability values can be found in most statistical texts but for convenience we have graphed the cumulative probability values for Z±3 (Figure 1).

3.1.3 Sibling Survival Forecasts for Strait of Georgia and wVI

Marine survival rates were also predicted using a sibling-regression model, where the total return of adult (age x.1) coho in year *t+1* was regressed on the estimated escapement of jacks (age x.0) the previous year:

$$\ln R_{t+1,x.1} = b \ln E_{t,x.0} + a \qquad \text{Eqn. 15}$$

Jack escapements were used rather than returns.[3] We do not estimate marine fishing mortality of age x.0 coho like we do age x.1 coho (Sect.2.1). There is little fishing mortality at this age and it is not normally considered in estimates of year class abundance and survival.

For all indicators except Carnation Creek, forecast returns were converted to forecast survivals by dividing by the number of smolts released in the brood. Confidence limits around the forecasts were determined using linear regression analysis.

3.1.4 Euphausiid - Based Return Forecast for wVI

This forecast is the product of several studies which collectively provide information that is being used to evaluate the effect of food and smolt output on early marine survival of salmon from wVI. The first study is a long-term euphausiid/zooplankton monitoring program which began in 1991 (Tanasichuk 1998). The second was a purse and beach seine survey that was done in Barkley Sound over the summers of 2000 and 2001 to examine the distribution, migration timing, diet, and daily ration of hatchery and wild salmon smolts. The third study was an extension of the second into near shore waters in wVI. Another objective of this third study was to describe the bias in samples of juvenile salmon collected by midwater trawl.

This forecast replaces an earlier methodology which forecast marine survival based on euphausiid abundance and smolt output (Simpson et al. 2002). A significant effect of smolt abundance existed only when the exceptionally low smolt abundance for the 1997 return year was included. We excluded the data for the 1997 return year because return appeared to be a consequence of the low smolt abundance in that brood, 892, which is by far the lowest in the 29 year time series. It is a consequence of the extremely low survival of the parental 1991 brood, which has been related to a strong El Nino event and the incursion of mackerel to wVI (e.g. Dobson et al. 2000). Returns for other years appeared to be independent of smolt number. Secondly, as explained in Sect. 1, it is now clear from the coded wire tagging of Carnation smolts, which began in 2001, that returns per smolt data for prior years cannot be considered good estimates of marine survival. Consequently, the euphausiid forecast of returns will not now be translated

[3] Some forecast documents before Simpson et al (2003) also stated that escapement was being used but returns were actually used sometimes. It was an insignificant error because virtually all age x.0 recoveries are in the escapement.

into a survival forecast, at least until a longer time series of cwt-based survivals are available. The variation of returns to Carnation Creek is now explained by the general regression:

$$\ln R_{t+1,x.1} = a \bullet \ln Eu_t + c \qquad \text{Eqn. 16}$$

where Eu is euphausiid abundance (no. • m^{-2}) and c is the intercept. The previous euphausiid abundance measure was for 9 – 12 mm *Thysanoessa spinifera*, the euphausiid that coho smolts consume on the Oregon coast (Petersen et al. 1982) and in Barkley Sound (Tanasichuk, in prep.) during their first summer (Simpson et al. 2003). Results of the 2000/2001 field work (Tanasichuk in prep.) showed that coho move quickly through the Sound in May (Figure 2). Catches of coho were disproportionately large in near shore waters suggesting that coho linger along the coast unlike sockeye and to a lesser extent chum which appear to move out very rapidly. Pearcy and Fisher (1990) reported similar results for the Oregon coast over 1981-85. Their diet analysis for near shore coho indicated that coho eat larger euphausiids (Figure 3) than coho do in Barkley Sound. The analytical approach that seemed to be the most biologically realistic was to test for a food effect using data for 9 – 12 mm *T. spinifera* in May and data for *T. spinifera* larger than 19 mm for the rest of the summer.

All data analyses were done using JMP (2002). We began testing for significant regressions when the data series was five years long. Consequently analyses began with data up to and including the 1998 return year because we excluded data for 1997 return year. Log-transformed values of euphausiid biomass were used so that the residuals would be normally distributed and show no trend with respect to the predicted values.

3.1.5 CPUE Survival Forecast for Strait of Georgia

Consistent surveys for juvenile (age x.0) salmon in the Strait of Georgia were conducted in late June and July from 1996 to 2002, aboard the CCGS W.E. Ricker (Beamish et al. 2000; Simpson et al. 2003). We used a linear regression model to forecast the mean survival of coho from the Georgia Basin hatchery indicators, where the independent variable was catch per unit effort (CPUE) of clipped (hatchery) coho. This survey was not done in 2003 so a forecast is not available using this method. There is a proposal to resume the survey this year.

3.1.6 Salinity Regressions

Coho originating in systems around the Strait of Georgia are largely caught in the strait or on the west coast of Vancouver Island but the proportion caught in each area varies between years (Kadowaki 1997; Simpson et al. 2000). The measure of distribution we use is the proportion of the catch of hatchery indicator stocks that are taken in fisheries wholly within the Strait of Georgia (p_{inside}). We emphasize that forecasts of distribution are actually forecasts of catch distribution assuming average historic patterns of effort distribution. However, coho fisheries have been highly restricted in the inside waters of sBC since 1997. Consequently there has been no estimate of p_{inside} since 1997 and the time series models that were developed for the 1998 forecast (Kadowaki and Holtby 1998) cannot be applied. However, we note that the salinity model, which was developed by Kadowaki et al (1996), outperformed the time-series models by a large margin in 1998. The salinity model, which is described below, predicts the proportion of catch taken in the strait if pre-1997 fishing regimes were in place and this proportion is now used as an index of inside distribution. P_{inside} should not be interpreted as the proportion that are occupying the strait in their last year at sea.

Surface salinity's measured at Sisters and Chrome island lighthouses in the year of return are positively correlated with p_{inside}. These islands are in the central Strait of Georgia. Salinity in February of the year of return is the best predictor of p_{inside} up to the time of the forecast.[4] The regression model is:

$$\log it(\hat{p}_{inside}) = 1.002GSsal - 28.9 \qquad \text{Eqn. 17}$$

(N=23; adj. $r^2 = 0.69$; $P << 0.001$)

where *GSal* is the mean of the monthly mean salinities at Chrome and Sisters islands for February of the year of adult return. Confidence limits around the salinity forecast were determined using linear regression analysis.

3.2 Retrospective Analyses

To compare the performance of the forecast models we computed for a common period of years, $k = 1,n$ both the Root Mean Square Error (*RMSE*):

$$RMSE = \sqrt{\frac{\sum_{k=1}^{n}(v_{observed,k} - v_{predicted,k})^2}{n}} \qquad \text{Eqn. 18}$$

[4] The mean salinity from February to May is best of all (pers. comm., D. Blackbourn, 562 Bradley St., Nanaimo).

and the Mean Absolute Deviation (*MAD*):

$$MAD = \frac{\sum_{k=1}^{n} \left| \left(v_{observed,k} - v_{predicted,k} \right) \right|}{n} \qquad \text{Eqn. 19}$$

Note that this calculation is performed in the variable space and not in the transformed space (Eqn. 8). Unlike time series models, regression models evolve with the addition of new data. Since the purpose was to assess the likely accuracy of current regression equations, we applied these updated equations to their time series to obtain the $v_{predicted}$ values needed in the above equations.

4. Forecasts of Survival and Abundance - Strait of Georgia and wVI

4.1 Survivals and Abundances in 2003

Estimates of survival in 2002 and 2003 are compared in the following table for the five hatchery indicators and two Georgia Basin wild indicators. Returns are shown for Carnation Creek.

	Survival (or Return for Carnation Creek)		
	2002	2003	Relative Change
Quinsam	0.014	0.010	-32%
Black (wild)	0.049	0.030	-39%
Big Qualicum	0.010	0.006	-39%
Chilliwack	0.032	0.025	-22%
Inch	0.018	0.010	-44%
Salmon (wild)	0.071	0.036	-50%
Average StG-Fr	0.032	0.019	-40%
Robertson	0.043	0.093	115%
Carnation	368	493	34%

The return to Carnation Creek was the largest since the late 1980's (Table 4). The 9.3% survival of Robertson Hatchery coho in 2003 was the second highest survival measured in this 29 year time series, the 2000 return being the highest (10.3%).

In contrast, on the Strait of Georgia side of Vancouver Island (GBW), both hatchery indicator stocks continued to survive very poorly, with a combined average of less than 1%. Neither stock has survived better than 2% since 1995. Survival of Big Qualicum coho has declined each year since 2000. Their survival in 2003 was the second worst in the 29 year time series (1998 was the worst). Similarly, the only year with lower survival at Quinsam was 1999. Although not yet an indicator due to a still short time series, coho from the Goldstream River Hatchery, near Victoria, survived at about 2% in 2003, compared to 0.3% and ~7% in 2002 and 2001, respectively. Black Creek coho declined relatively the same as Quinsam and Big Qualicum. The survival of 3% last year was third lowest in the 18 year series and has been declining since 2001. The long term mean survival is 7.4%; the mean of the preceding three cycles (9 years) is 4.3%.

The only indicator stock in GBE is Myrtle Creek, near Powell River. It is too short a time series to be considered yet with the other indicators but the survival of the 2000 brood was only 0.5% last year.

Once again, Chilliwack and Inch hatchery indicator stocks in the LowFr Management Unit survived better than GBW hatcheries (Table 5). Survivals of GBW and LowFr wild and hatchery coho have posted successive declines since 2001. The survival of coho at Inch hatchery was the second lowest in the series. The survival at Chilliwack hatchery was still better than the low years in 1998 and 1999. Like at Black, coho at Salmon River survived better than coho from hatchery indicators in the same MU. Survivals at Salmon were better than at Black, like the hatchery comparison and also like previous years: only in 1992 and 1998 have survivals at Salmon been less than at Black. The 3.8% survival in 2003 compares with the long term average at Salmon of 9.1% and the 3 cycle average of 6.2%.

Survival of coho declined in all Georgia Basin indicators by 38% in 2003, which is about the same decline rate seen in 2002. Compared to historic averages and estimates of marine survivals needed by wild populations of average productivity to sustain themselves (2% - 3%), Georgia Basin survivals were poor last year, particularly in GBE and GBW. They have been at these levels for about eight years now and have been decreasing for two or three years. The very low survival at Myrtle Creek is a concern because it is consistent with other sparse assessment data suggesting that the status of coho in the GBE Management Unit is particularly poor.

4.2 Forecast Performance in 2003

The performance of the 2003 forecasts (Simpson et al. 2003) is summarized in the following table and in Table 5 and Figure 4.

	Quinsam	Big Qualicum	Chilliwack	Inch	GB Hatcheries (mean)	Black	Salmon	Robertson	Carnation Return
Observed in 2003	0.010	0.006	0.025	0.010	0.013	0.030	0.042	0.097	493
Sibling forecast	0.006	0.010	0.034	0.031	0.020			0.047	264
% obs of forecast	163%	64%	73%	32%	63%			206%	187%
Quasi TS model	3YRA	LLY	RAT3	LLY		3YRA	LLY	LLY	3YRA
Forecast	0.014	0.016	0.040	0.021	0.023	0.043	0.063	0.047	246
% obs of forecast	70%	40%	62%	48%	56%	69%	67%	206%	200%
Euphausiid forecast									420
% obs of forecast									117%
CPUE forecast					0.014				
% obs of forecast					91%				

The models with the best retrospective performances are shaded in the above table. These are the models with the least RMSE and MAD scores up to 2003. All Georgia Basin indicator stocks survived more poorly than forecast, although the CPUE forecast of hatchery survival was essentially correct. Robertson Hatchery coho survived twice as well as forecast and the return to Carnation Creek was 17% better than would have been forecast if the present model was used. The one that was used forecast a return of 254 but there was a major error in the data. Observed survivals were all within the 90% confidence intervals of the forecasts. The time series forecasts of Inch and Black survival were within the 50% interval, as was the CPUE forecast of the survival of coho from the Georgia Basin hatcheries. Overall, the 2003 forecasts was less accurate than last year but better than average (cf. Simpson et al. 2001a, 2002).

4.3 Forecast of Survival and Abundance in 2004

The retrospective performances of all models are shown in Table 6. The euphausiid forecast of the return of Carnation Cr. coho is based on only five years. MAD and RMSE scores for the time series and sibling models were calculated for the same period and the euphausiid forecast performance was superior to them.

4.3.1 Euphausiid Model (Carnation Creek)

Table 7 summarises the data used in the analysis. We found that variations in Carnation Creek coho returns were best explained by the biomass of *T. spinifera* longer than 19 mm in August (Figure 5). Table 8 presents the results of the retrospective analysis. Parameter estimates appeared to have stabilised as of the forecasts for the 2000 return year. The MAD and RMSE are 64.5 and 69.0 fish respectively.

The regression used to forecast 2004 returns is:

$$\ln R_{2004,x.1} = 0.85 \bullet \ln Eu_{2003} + 1.19 \qquad \text{Eqn. 20}$$

Adj. R^2=0.63, $p<0.01$, n=10

The parameter estimate for the slope was significantly different than zero ($p<0.05$). The biomass of T. spinifera longer than 19 mm in August 2003 (Eu) was 13 mg dry mass • m-2; this is the lowest biomass in the time series. The forecasted return is 29 coho (50% CI: 17 – 50).

4.3.2 Time Series and Sibling Models

Survival forecasts and associated confidence intervals are shown for the sibling regressions in Table 9 and for the time series models in Table 10. The survival forecasts and the Carnation Cr. return forecast made by the best performing models are:

	Best Models			Alternate Models		
		$\hat{S}_{2004}$	(50% CI)		$\hat{S}_{2004}$	(50% CI)
Georgia Basin West						
Big Qualicum	LLY	0.006	(0.004 - 0.010)	Sibling	0.003	(0.002 - 0.005)
Quinsam	3YRA	0.013	(0.010 - 0.017)	Sibling	0.0015	(0.0006 - 0.0013)
Black (wild)	3YRA	0.047	(0.034 - 0.066)	-		
Lower Fraser						
Chilliwack	RAT3	0.022	(0.015 - 0.031)	Sibling	0.005	(0.003 - 0.009)
Inch	LLY	0.010	(0.006 - 0.018)	Sibling	0.028	(0.016 - 0.049)
Salmon (wild)	LLY	0.036	(0.026 - 0.049)	-		
West coast of Vancouver Island						
Robertson	Sibling	0.029	(0.018 - 0.048)	3YRA	0.067	(0.031 - 0.141)
Carnation (wild)[1]	Euphausiid	29	(17 - 50)	Sibling	433	(278 - 674)
				3YRA	372	(208 - 664)

[1] For comparison, historic mean returns are:

Last 6 years:	272
Last 12 years:	258
All years:	335

All indicators in the Georgia Basin were best forecast with time series models (Figure 6 and Figure 7). Sibling and euphausiid regression models were selected in wVI for Robertson and Carnation respectively (Figures 4 and 8). The probability plots are shown in Figures 9 and 10. Wild survivals in LowFr, as indicated by Salmon River, are forecast to remain the same as last year, i.e. 3.6%. Black Creek coho are forecast to survive better (4.7%). The outlook for the Georgia Basin hatchery indicators is for poor survivals, similar to or less than 2003 except for Quinsam, which, like neighboring Black, is predicted to survive a little better (Table 11). Although the retrospective performances of the sibling models were considerably poorer (Table 6), we must note that low jack escapements in 2003 resulted in extremely poor survival forecasts in the sibling regressions for Quinsam (0.1%), Big Qualicum (0.3%) and Chilliwack (0.5%) (Table 9).

The retrospective performance of the 3YRA time series model for Robertson Hatchery is virtually the same as the selected sibling model (Table 6). The former predicts a survival of 6.7% and the recommended forecast is 2.9%. The sibling forecast is recommended because of its slightly lower combined MAD-RMSE score and because it is the more conservative of the two. Both forecast a decline in wVI coho survival in 2004, back to a roughly average survival for this indicator (the long term mean survival is 4.7%). When retrospective analyses of the time series and sibling models are run for the Carnation Creek indicator using the same recent five year period that is available for the euphausiid model, the best model is the euphausiid model. However, the very low densities of *T. spinifera* in 2003 are out of the bounds of the regression, meaning the prediction of only 29 coho has additional uncertainty associated with it. A return of 29 would be similar to the record low return of the 1991 brood year, which was impacted by an El Nino event in 1993 (Table 4).

Overall, coho in the Strait of Georgia and wVI are not expected to survive better in 2004. There may be a significant reduction in wVI survivals to below the long term average level. Coho survivals from hatcheries in the Georgia Basin are expected to continue at very low levels and low abundances of jacks at Quinsam, Big Qualicum and Chilliwack hatcheries increase the probability that they will survive more poorly than forecast. Wild survivals are forecast to be in the 3% to 5% range in GBW and LowFr. GBE remains a concern with respect to wild survivals and stock status.

5. Forecast of Abundance – Interior Fraser

5.1 Abundances in 2003

The abundance (catch plus escapement) of Thompson coho in 2003 was ~ 14,600, which was less then the brood year (2000) abundance of ~16,000 (sum of South, North and lower Thompson in Table 3). The Thompson escapement in 2003 (~13,200) was the lowest to the Thompson River watershed in the 20-year time series (1984-2003). The estimated brood escapement in 2000 was 15,300. The lower abundance is believed to be at least partly due to decreased marine survival. Lower escapements are also due to an increase in fishing mortality: ~7.1% in 2002 to ~12.6% in 2003 (Table 1).

5.2 Forecast Performance in 2003

Forecasts of total abundance for 2003 provided in last year's forecast document (Simpson et al. 2003) were evaluated by comparing these forecasts with the estimated coho abundances observed in 2003 (Table 12). Forecasts using the 3YRA model were 2.7, 2.4 and 2.2 times the observed abundances for the lower Thompson, South and North Thompson watersheds, respectively. Figure 11 shows the forecast and observed abundances for the total Thompson watershed. The severe over-forecast is likely the result of a reduction in marine survival of 2000 brood year smolts.

5.3 Forecast of Abundance in 2004

The averaging models (LLY and 3YRA) once again outperformed the ratio models in forecasting total returns to the Thompson system (Table 13). The 3YRA model continues to be the model of choice for the Thompson watershed. The forecast total abundance of Thompson River watershed coho in 2004 is 34,271 animals (Table 14 and Figure 11). This forecast is over twice the observed abundance in 2003 but represents an expected decrease from the 2001 brood abundance of ~53,000 coho. The forecast is 44% of the geometric mean abundance from 1989 to 2003.

The time series of reliable escapement data for non-Thompson systems in the interior Fraser is too short to evaluate model performance.

6. Forecast of Abundance – Central Coast

6.1 Forecast Performance in 2003

Performance of the forecasts can be determined only for the average -stream indices in Statistical Area 7 (Table 15 and Table 16), Area 8 (Table 17 and Table 18), Area 12 (Table 19 and Table 20) and Area 13 (Table 21 and Table 22). Because the exploitation rates for all forecast aggregates were revised in 2004 and there was a preliminary audit performed based on reliability of stream estimates for Areas 12 and 13, we have provided performance information for both forecasts based on the information used for last years forecast (2003) and based on the updated information in 2004. Forecasts were not provided for Area 11 in 2003 (Areas 9 to 11 were forecast as a group).

Total stock size was over-forecast for Areas 7 and 12 and under-forecast for Areas 8 and 13 (for both the exploitation rates and stream selections used in last year's document and for the updated series used for the 2004 forecasts). Our ability to estimate wild coho returns in the Central Coast remains poor, with the exception of a few reliable indicators: Martin River (Area 8), Docee River (Area 10), Keogh & Klinaklini Rivers (Area 12), and Heydon River (Area 13).

The reason why the Area 7 forecast was high is unknown, but may be due to the poor brood year (2000) or due to survey timing and difficulties in enumerating key index systems Over-estimation in the Area 12 forecast was likely due to an unforeseen reduction in marine survival, encountered at the Keogh River (Area 12 indicator) (pers. comm., P. van Will, Stock Assessment, Port Hardy), which was not indicative of the trend within the years that comprised the 3 YRA forecast model (a slight improving trend in marine survival was evident between the modelled years).

The reason why the Area 8 forecast was low cannot be determined reliably. There was no apparent trend in the 2003 estimated escapements in Area 8, some index systems showed an increase in escapement over 2001/2002, however the indicator system, Martin River, showed a decline. The Area 13 forecast was probably low due to difficulties in enumeration and changes in estimation requirements in 2002. Historically, field personnel were required to submit documents with final run estimation by species for the rivers they surveyed. The methodology used to derive these estimates is usually not well documented. In 2002, final run estimates were not submitted. Instead, peak live + dead or AUC estimates were calculated by DFO staff in Central Coast (pers. comm., P. Zetterberg, Stock Assessment, Campbell River) and used as run estimates. Because the forecast was based on a 3YRA model, even a difference in one year of data will affect the final forecast.

6.2 Forecast of Abundance in 2004

The following table summarises the organisation of the forecast tables and figures. The tables show the forecasts for total return (stock size) produced by the Ricker stock-recruitment (S-R) analysis and the best of the time series models, which in all cases was 3YRA. Assuming that the exploitation rate in 2004 will be the same as last year, the forecast escapement is also shown for both models. The tables also show the forecast escapements as percentages of S_{max}, the spawner number that on average produces maximum recruitment.

Aggregate	preferred model	forecast summary Table	relevant Figure
Area 7 (Bella Bella)	3YRA	Table 23	Figure 12
Area 8 (Bella Coola)	3YRA	Table 24	Figure 13
Area 11 (Seymour)	3YRA	Table 25	Figure 14
Area 12 (Johnstone Strait)	3YRA	Table 26	Figure 15
Area 13 (Johnstone/Georgia Straits)	3YRA	Table 27	Figure 16

Table 28 summarises the results of the S-R model fits for the various coho aggregates.

The time series for each aggregate are long and have at least an eight-fold range in S. However, the properties of these indices of aggregate abundance and their use in stock and recruitment analyses have not been explored. Although the forecast is believed to be conservative, considerable caution must be used in interpreting forecasts based on the stream indices.

The following table summarises the forecasts of abundance and escapement for the aggregates:

			Total Return (Abundance)		Escapement		
Aggregate	Group	Model	Forecast *P*	Characterization	Forecast *P*	Characterization	% of S_{max}
Area 7	4	3YRA	35%	average	61%	average	35%
Area 8	5	3YRA	20%	below average	44%	average	59%
Area 11	5	3YRA	56%	average	78%	well above average	109%
Area 12	5	3YRA	10%	well below average	57%	average	33%
Area 13	6	3YRA	4%	well below average	22%	below average	5%

The “Forecast P” values are the proportions of observed abundances or escapements in the time series that were less than the forecast value. This calculation was made assuming a log-normal cumulative probability distribution with mean and standard deviation calculated over the observation period from 1950 (1953 for Areas 11, 12, and 13) to 2003. Probability values between 35% and 65% were characterized as average; probabilities of less than 15% or greater than 85% were characterized as well below or well above average, respectively. “Groups” indicate groups made by Holtby et al. (1999b) for north coast and central coast coho, based on geography, distributions of CWT’s in fisheries and on productivity. The group numbers are consistent with the 2002 and 2003 forecast documents for these aggregates (Holtby et al. 2002; Simpson et al. 2003). This is a convenient way to summarise the forecasts because forecasts of abundance and escapement for average stream indices are useful only in the context of how far they deviate from the long-term means of their respective time series.

Area 7, 8, and 11 coho abundances in 2004 are forecast to be below average to average and escapement levels will be average to above average if exploitation rates do not significantly increase. Additional information from systems such as Docee River (Area 10), Bella Coola River (Area 8), and Martin River (Area 8) suggest strong brood years for the 2004 return, and abundances may be better than forecast in these areas. As in 2003, the forecasts for the JST aggregates are for poorer abundances than the aggregates to the north. The forecast of abundance in these JST aggregates is no better than well below average. With continued restrictions to fisheries, i.e., no increases over 2003 levels of exploitation, escapement is forecast to be average in Area 12 and below average in Area 13.

7. Forecast of Distribution – Strait of Georgia / wVI

As noted in Sect. 3.1.6, the predictive regression uses pre-1998 data only, when catch data were still available. The salinity at Sisters and Chrome islands averaged 28.37‰ in February, 2004, yielding a predicted value of 0.40. Figure 17 shows the fitted relationship and a probability plot of the confidence interval for p_{inside}. Confidence levels are tabulated in Table 30. An index of 0.40 is comparable to the long term mean (Simpson et al. 2001b). Although this is a forecast for a slightly more outside distribution than in 2003 (p_{inside} was 0.46 in 2003), it is still a stronger inside forecast than the mean of the previous 10 years (0.29). These years have been marked by frequent strong outside distributions. The 2004 forecast is best characterized as an intermediate inside/outside distribution. There is a more than 95% probability that it will not be as strong an inside year as 2001 for example.

8. Conclusions

8.1 Survival and Abundance

Recommendationed forecasts for the marine survival of hatchery and wild indicator populations are given in the following table (the Carnation forecast is actually for return, not survival):

Management Unit	Indicator	Recommended Model	Predicted Survival in 2004 (50% CI)[1]		Change (2004 forecast minus 2003 observed)
GB West	Big Qualicum	LLY	0.006	(0.004 - 0.010)	0%
	Quinsam	3YRA	0.013	(0.010 - 0.017)	35%
	Black (wild)	3YRA	0.047	(0.034 - 0.066)	60%
Lower Fraser	Chilliwack	RAT3	0.022	(0.015 - 0.031)	-13%
	Inch	LLY	0.010	(0.006 - 0.018)	0%
	Salmon (wild)	LLY	0.036	(0.026 - 0.049)	0%
SWVI, NWVI	Robertson	Sibling	0.029	(0.018 - 0.048)	-70%
	Carnation (wild)	Euphausiid	29	(17 - 50)	-94%

[1] The prediction for Carnation Cr. is for return, not survival.

Predictions by PSC Management Unit follow:

8.1.1 Georgia Basin West

Based on both time series and sibling forecasts, survival of coho on the east coast of Vancouver Island is expected to be poor, ranging from approximately 1% for hatcheries to 4.7% for higher productivity wild stocks like Black Creek. The expected hatchery survivals represent no change to a slight increase in 2004. Sibling forecasts have not performed well in predicting hatchery survivals. However, the probability of even lower survivals is increased in light of the low jack abundances in 2003. The sibling forecasts predict record low survivals of 0.1% and 0.3% for Quinsam and Big Qualicum coho. Survival of Black Creek coho declined in 2003 but the wild forecast is for increased survivals, back to that seen in 2002.

8.1.2 Georgia Basin East

The survival of 2000 brood coho at Myrtle Creek was only 0.5%. Spawners per smolt (over-estimates of marine survival) were 2.8% and 2.6% in 2001 and 2002. If Myrtle Creek coho are indicative of other GBE coho populations, marine survivals are less in GBE than in LowFr or GBW. Assuming that replacement survivals are in the order of 2%, many GBE populations may be declining even with the present low exploitation.

8.1.3 Lower Fraser

Coho are forecast to survive either the same or about the same, in the 1% to 2% range for hatcheries and about 4% for wild coho. All are well below long term averages.

8.1.4 Georgia Basin (GBW, GBE, LowFr *in toto*)

All wild and hatchery indicators in the Georgia Basin have followed the same trend: minimum survivals in about 1998 after a relatively steady decadal decline followed by a slight improvement until 2001 and a decrease since. With the exception of Black Creek, survivals are approaching the minimum survivals of five years ago. Our data are not complete, e.g. the GBE unit, and the forecasts have not been precise. Sibling forecasts are for extremely low survivals in three of four indicators. Uncertainty in the forecasts coupled with below average survivals equate to high risk.

8.1.5 Southwest Vancouver Island and Northwest Vancouver Island

A very poor return of coho to Carnation Creek is forecast by the euphausiid regression model, based on record low euphausiid densities in Barkley Sound in 2003. However, the observed density is far below the bounds of the regression, so the forecast is less reliable. Survival of wVI coho, as indicated by Robertson Creek Hatchery coho, is forecast to be lower in the 2001 brood year. The 3YRA and sibling models, predict survivals to decrease by 28 to 70 percent, respectively. Given the poor return expected at Carnation Creek and the slightly better performance of the sibling regression and using the risk averse principle, we recommend the sibling forecast of 2.9% survival for wVI coho. Because the previous brood survived well, the forecast survival can still be characterized as average for the time series if an 'average' survival is defined as exceeding 35%-65% of the survivals in the time series. The mean survival of Robertson coho over the entire time series is 4.7%.

8.1.6 Interior Fraser (Thompson)

The forecast abundance of coho from the Thompson River watershed in 2004 is 34,271 animals. This forecast is more then twice the observed abundance in 2003, which was the lowest escapement recorded since 1984, the first year where accurate escapement data was available for the entire Thompson River drainage. The forecast represents a potential decrease from the 2001 brood abundance of ~53,000.

While the exploitation rate on Interior Fraser River coho in 2003 (~12.6%) was higher than the last two years (~7.1% for 2001 and 2002) and the highest since 1997, it is still below the 15% ER cap assigned to Interior Fraser River (Thompson) coho stocks in 1998. The apparent reduction in survival encountered by the progeny of the 2000 brood year has resulted in fewer coho surviving to maturity. Thus, even with low fishing pressure, if marine survivals remain low or continue to drop (cf. forecasts of survivals in the Georgia Basin), the outlook for Thompson and other interior Fraser coho is for a continued decline.

8.1.7 Central Coast

The time series forecasts of abundance and escapement for the average-stream indices of the five Central Coast aggregates show some indication of geographic patterning. Abundance of coho in the northern part of the forecast region (Areas 7,8, and 11) is forecast to be below average to average in 2004. However, provided fisheries do not expand much over levels in 2003 (approximately 23% exploitation on these stocks), escapements are expected to be average (Areas 7 and 8) to well above average (Area 11).

Abundances for Johnstone Strait streams (Areas 12 and 13) are expected to be well below average in 2004. Provided fisheries do not expand much over the 2003 levels (approximately 4% exploitation on these stocks), escapements are expected to be average and below average respectively. Area 13 continues to be an area of concern.

Escapement and exploitation data in the Central Coast is generally poor and caution should be taken when interpreting these forecasts. Further review of the reliability of escapement information must take place. This is illustrated in the example of the two performance tables for the Area 12 aggregate. Although both over-forecast, the performance improved substantially when the forecast omitted the lower reliability systems. Further retrospective analyses should be completed to assess the performance of the adjusted stream composition to past forecasts. Also, escapement monitoring of reliable indicator systems in all Central Coast areas (systems with fences and mark-recapture programs) must continue as most do not yet fit the 10 year minimum data criteria to be included in the abundance forecasts (Table 29). Furthermore, the methods used to derive final escapement estimates must be reviewed and remain as consistent as possible if forecasts are to be calculated using the abundance forecast methodology.

Review of the exploitation rates used for these systems is also necessary. The indicators used to determine abundance for all aggregates (Areas 7-13) are the best available, but there has been limited ability to verify the assumption that exploitation rates are similar. The success of the Martin River (Area 8) program as an exploitation rate indicator is unknown. Difficulties in the ability to collect CWT information in coho escapement without a fence have created a significant amount of error around exploitation rate calculations. If the program does not continue, programs such as the Drake Inlet indicator in Area 6 will hopefully provide better exploitation rate information for Areas 7 and 8. Continued monitoring of wild indicator systems with coded-wire tag application and reliable adult enumeration programs in the Johnstone Straits aggregates (Area 12 – Keogh River and Area 13- Heydon River) should provide better exploitation rate information specific to this area.

8.2 Distribution

Salinity data suggest that the proportion of 2002 brood coho residing in the Strait of Georgia in 2004 will be comparable to the long term mean. It can be characterized as an intermediate distribution, not an 'inside' distribution but more inside than in several of the last 10 years.

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TABLES

Table 1. Estimates of fishing mortality on indicator stocks from 2001 to 2003. Estimates do not include test fishing mortalities and only for Robertson (RCH) are mortalities from aboriginal and freshwater sport fisheries included.

Brood Year	Thompson	Strait of Georgia Indicators						wVI Indicators
		Quinsam	Big Qualicum	Black (wild)	Chilliwack	Inch	Salmon (wild)	Robertson
2001	0.071	0.065	0.071	0.046	0.073	0.096	0.078	0.211
2002	0.071	0.093	0.100	0.059	0.090	0.126	0.105	0.127
2003	0.126	0.065	0.071	0.043	0.073	0.098	0.080	0.205

Table 2. Streams in the interior Fraser data sets. The 'W' and 'E' indicate wild and enhanced streams respectively although it is realized that many of the wild streams are to a certain degree, enhanced.

Non-Thompson/Fraser		Lower Thompson		South Thompson		North Thompson	
Beaver Creek	W	Bonaparte River	W	Adams River (lwr)	W	Albreda River	W
Bridge River	W	Guichon Creek	W	Adams River (up)	W	Avola Creek	W
Chilko River	W	Nicola River (lower)	W	Anstey River	W	Barrierre River	W
Gates Creek	W	Nicola River (upper)	W	Bessette Creek	W	Blue River	W
Horsefly River	W	Tranquille Creek	W	Blurton Creek	W	Brookfield. Creek	W
McKinley Creek	W	Coldwater River	E	Bolean Creek	W	Cedar Creek	W
Mitchell River	W	Deadman River	E	Canoe Creek	W	Clearwater. River	W
Nahatlatch River	W	Spius Creek	E	Cayenne Creek	W	Cook Creek	W
Portage Creek	W			Creighton Creek	W	Crossing Creek	W
Cayoosh Creek	W			Danforth Creek	W	E. Barrierre River	W
Seton River	W			Duteau Creek	E	Fennel Creek	W
Summit Creek	W			Harbour Creek	W	Finn Creek	W
				Harris Creek	E	Goose Creek	W
				Huihill Creek	W	Haggard Creek	W
				Hunakwa Creek	W	Lion Creek	W
				Ireland Creek	W	Mahood River	W
				Johnson Creek	W	Mann Creek	W
				Kingfisher Creek	W	McTaggart Creek	W
				McNomee Creek	W	N. Thompson River	W
				Momich Creek	W	Raft River	W
				Noisey Creek	W	Reg Christie Creek	W
				Onyx Creek	W	Shannon Creek	W
				Owlhead Creek	W	Tumtum Creek	W
				Scotch Creek	W	Wireca. Creek	W
				Seymour River	W	Dunn Creek	E
				Shuswap River (lwr)	W	Lemieux Creek	E
				Shuswap River (mid)	W	Louis Creek	E
				Sinmax Creek	W		
				South Pass Creek	W		
				Tappen Creek	W		
				Trinity Creek	W		
				Wap Creek	W		
				Eagle River	W		
				Salmon River	E		

Table 3. Estimated fishery exploitation rates (ER), escapements (E), marine fishery catches, and total abundances (R) for interior Fraser coho salmon.

Return		South Thompson			North Thompson			Lower Thompson			Non-Thompson Fraser		
Year	ER	E	catch	R	E	catch	R	E	catch	R	E	catch	R
1975	0.681	5,864	12,490	18,354	22,286	47,468	69,754						
1976	0.681	3,920	8,349	12,268	20,675	44,037	64,713						
1977	0.681	8,490	18,082	26,572	42,804	91,171	133,975						
1978	0.681	7,996	17,032	25,028	39,095	83,269	122,364						
1979	0.681	10,198	21,720	31,918	47,819	101,851	149,670						
1980	0.681	7,025	14,964	21,989	10,542	22,454	32,996						
1981	0.681	4,120	8,775	12,895	20,615	43,909	64,524						
1982	0.681	5,849	12,459	18,308	42,295	90,087	132,382						
1983	0.681	6,196	13,196	19,392	35,086	74,731	109,816						
1984	0.681	15,394	32,789	48,183	69,552	148,141	217,692	5,155	12,050	17,205			
1985	0.681	16,998	36,205	53,204	45,160	96,188	141,349	1,913	4,060	5,973			
1986	0.657	16,521	31,665	48,186	104,267	199,846	304,113	2,211	4,300	6,511			
1987	0.537	21,087	24,478	45,564	54,884	63,710	118,594	4,208	4,945	9,153			
1988	0.712	24,426	60,376	84,802	70,612	174,539	245,150	4,013	9,830	13,843			
1989	0.645	17,208	31,288	48,496	30,677	55,779	86,455	3,423	6,340	9,763			
1990	0.737	8,609	24,069	32,677	25,697	71,844	97,542	4,421	12,600	17,021			
1991	0.677	4,160	8,737	12,896	14,585	30,633	45,217	3,794	8,825	12,619			
1992	0.815	11,886	52,239	64,125	22,042	96,875	118,917	4,905	21,000	25,905			
1993	0.876	1,873	13,172	15,045	9,669	67,999	77,667	8,416	61,500	69,916			
1994	0.433	4,485	3,430	7,915	10,031	7,671	17,702	5,252	3,965	9,217			
1995	0.562	3,622	4,639	8,261	22,477	28,794	51,272	1,984	2,525	4,509			
1996	0.835	1,760	8,906	10,667	12,319	62,325	74,645	1,209	5,900	7,109			
1997	0.405	2,034	1,384	3,418	6,722	4,573	11,295	4,217	2,820	7,037			
1998	0.070	4,946	375	5,321	9,125	685	9,810	2,628	200	2,828	8,147	610	8,757
1999	0.090	3,074	305	3,379	8,916	885	9,801	5,007	495	5,502	5,389	535	5,924
2000	0.034	3,785	134	3,919	7,032	250	7,282	4,459	157	4,616	4,723	144	4,867
2001	0.071	13,093	1,001	14,094	25,743	1,967	27,710	10,450	799	11,249	12,317	941	13,258
2002	0.071	10,565	807	11,372	20,884	1,596	22,480	16,795	1,284	18,079	8,011	612	8,623
2003	0.126	3,097	434	3,531	6,799	682	7,481	3,297	300	3,597	7,675	695	8,370

Table 4. Release and recovery summaries for the eight wild and hatchery indicator stocks used to generate survival forecasts.

Brood Year	Smolt Release[3]	Jack (Age x.0) Escapement [2]	Adult (Age x.1)					
			Marine Catch [1]	Freshwater Catch	Total Catch[1]	Escapement [2]	Return	Survival
Chilliwack R. Hatchery (LowFr)								
1980	54,665	467	4,659	412	5,071	1,508	6,579	0.120
1981	28,502	307	2,367	132	2,499	1,600	4,098	0.144
1982	100,841	550	13,168	456	13,624	5,319	18,943	0.188
1983	27,851	143	2,552	160	2,712	948	3,661	0.131
1984	129,770	495	16,529	677	17,207	5,332	22,538	0.174
1985	59,935	743	8,735	256	8,991	1,862	10,853	0.181
1986	68,658	289	6,260	452	6,712	1,951	8,663	0.126
1987	39,250	244	3,059	145	3,205	956	4,161	0.106
1988	39,801	206	2,510	100	2,611	986	3,597	0.090
1989	39,500	149	1,560	43	1,603	640	2,243	0.057
1990	39,797	152	1,827	111	1,938	419	2,357	0.059
1991	39,673	82	1,823	102	1,925	608	2,533	0.064
1992	39,654	154	895	36	931	548	1,480	0.037
1993	39,808	191	895	81	976	607	1,583	0.040
1994	36,256	67	193	95	288	601	889	0.025
1995	74,456	131	46	41	87	880	967	0.013
1996	37,282	43	21	52	73	405	478	0.013
1997	82,059	42	85	1,109	1,194	1,619	2,813	0.034
1998	36,976	98	85	567	652	1,085	1,737	0.047
1999	42,795	87	103	217	320	1,042	1,362	0.032
2000	38,726	40	52	247	299	659	959	0.025
2001	35,162	10						
Inch Cr. Hatchery (LowFr)								
1983	38,711	8	2,065	10	2,075	516	2,591	0.067
1984	38,774	150	2,878	19	2,897	552	3,449	0.089
1985	19,723	76	3,531	31	3,561	452	4,014	0.203
1986	19,504	12	1,420	19	1,440	677	2,116	0.109
1987	27,458	67	1,894	5	1,899	307	2,206	0.080
1988	38,019	36	2,163	21	2,184	516	2,700	0.071
1989	29,367	33	2,152	5	2,158	692	2,850	0.097
1990	31,629	91	2,057	11	2,068	543	2,611	0.083
1991	21,172	106	1,011	10	1,021	259	1,280	0.060
1992	20,303	4	853	10	863	253	1,116	0.055
1993	21,540	90	657	30	687	150	837	0.039
1994	21,174	5	70	7	77	146	223	0.011
1995	38,707	7	9	16	26	177	202	0.005
1996	41,918	7	35	104	139	665	804	0.019
1997	40,206	25	21	25	46	404	450	0.011
1998	40,201	131	174	392	566	1,749	2,315	0.058
1999	39,911	21	74	135	209	512	721	0.018
2000	39,998	25	32	77	108	294	402	0.010
2001	39,189	21						

Table 4. (cont'd)

Brood Year	Smolt Release[3]	Jack (Age x.0) Escapement [2]	Adult (Age x.1)					
			Marine Catch [1]	Freshwater Catch	Total Catch[1]	Escapement [2]	Return	Survival
Salmon R. (LowFr Wild Indicator)								
1984	10,059		839		839	406	1,245	0.124
1985	20,022		3,277		2,421	1,316	4,593	0.229
1986	24,634		2,421		2,686	921	3,342	0.136
1987	26,911		2,686		1,203	970	3,656	0.136
1988	20,390		1,203		2,112	448	1,651	0.081
1989	29,435		2,112		1,292	769	2,881	0.098
1990	28,141		1,292		999	1,184	2,476	0.088
1991	15,611		999		1,199	563	1,562	0.100
1992	35,256		1,199		1,402	1,318	2,517	0.071
1993	30,052		1,402		129	1,065	2,467	0.082
1994	24,719		129		11	972	1,101	0.045
1995	5,872		11		96	152	163	0.028
1996	38,369		96		61	973	1,069	0.028
1997	28,883	46	61		143	1,727	1,788	0.062
1998	25,163	237	143		203	1,701	1,844	0.073
1999	27,269	275	203		62	1,738	1,941	0.071
2000	21,602	26	62		62	709	771	0.036
2001	10,712	42						
Quinsam R. Hatchery (GBW)								
1974	57,502	954	3,122		3,122	617	3,739	0.065
1975	73,442	1,923	5,678		5,678	1,456	7,134	0.097
1976	72,104	1,611	3,777		3,777	1,535	5,312	0.074
1977	117,667	1,419	9,800		9,800	2,134	11,934	0.101
1978	57,158	664	3,117		3,117	918	4,035	0.071
1979	88,610	1,382	3,057		3,057	1,198	4,255	0.048
1980	57,385	398	3,117	3	3,121	918	4,038	0.070
1981	102,021	639	3,823	18	3,841	1,691	5,532	0.054
1982	147,404	1,112	8,891	25	8,916	2,272	11,188	0.076
1983	100,360	861	6,728	37	6,765	2,501	9,266	0.092
1984	57,573	725	3,691	12	3,703	811	4,514	0.078
1985	42,176	910	2,607	8	2,615	736	3,351	0.079
1986	44,457	834	3,261		3,261	1,468	4,729	0.106
1987	39,362	776	2,546	10	2,557	512	3,068	0.078
1988	39,466	299	1,104		1,104	546	1,650	0.042
1989	39,400	243	1,830		1,830	487	2,317	0.059
1990	39,411	233	1,034		1,034	331	1,365	0.035
1991	42,470	314	709		709	256	965	0.023
1992	36,277	271	564		564	348	912	0.025
1993	38,947	129	220		220	316	536	0.014
1994	59,418	159	273		273	425	697	0.012
1995	62,702	486	30		30	573	603	0.010
1996	39,813	91	15		15	282	297	0.007
1997	39,322	201	23		23	441	464	0.012
1998	42,352	186	44		44	638	683	0.016
1999	42,996	201	53	48	101	516	617	0.014
2000	42,665	69	27		27	389	416	0.010
2001	42,980	22						

Table 4. (cont'd)

Brood Year	Smolt Release[3]	Jack (Age x.0) Escapement [2]	Adult (Age x.1) Marine Catch [1]	Freshwater Catch	Total Catch[1]	Escapement [2]	Return	Survival
Big Qualicum R. Hatchery (GBW)								
1971	100,896	1,527						
1972	100,933	1,176	23,485		23,485	13,466	36,951	0.366
1973	57,425	83	15,253		15,253	1,392	16,645	0.290
1974	75,512	1,085	8,966		8,966	3,450	12,416	0.164
1975	90,520	4,186	9,963		9,963	3,832	13,795	0.152
1976	38,748	974	5,433		5,433	2,052	7,485	0.193
1977	50,224	474	11,303		11,303	3,120	14,423	0.287
1978	45,328	439	3,991		3,991	1,763	5,754	0.127
1979	55,435	702	4,530		4,530	1,198	5,728	0.103
1980	51,984	265	4,696	3	4,699	1,102	5,802	0.112
1981	49,274	591	2,650	12	2,662	1,233	3,894	0.079
1982	42,453	177	1,771	17	1,788	342	2,130	0.050
1983	21,868	33	126		126	63	189	0.009
1984	87,365	71	387	11	398	144	542	0.006
1985	74,194	423	883		883	230	1,113	0.015
1986	27,462	96	217		217	138	355	0.013
1987	42,412	372	1,233	8	1,241	576	1,818	0.043
1988	44,813	246	1,901	10	1,911	847	2,757	0.062
1989	36,474	180	1,618	5	1,624	511	2,135	0.059
1990	37,362	353	1,834	11	1,845	647	2,492	0.067
1991	38,235	188	1,709	77	1,786	834	2,620	0.069
1992	37,957	48	609	10	619	496	1,115	0.029
1993	38,917	236	352	15	367	255	622	0.016
1994	37,616	79	180	7	187	349	536	0.014
1995	38,827	40	8	16	24	143	167	0.004
1996	40,331	135	23	73	96	431	527	0.013
1997	37,806	64	19	25	43	352	395	0.010
1998	40,836	133	34	17	51	450	502	0.012
1999	40,596	181	42	6	48	378	426	0.010
2000	41,543	39	19	3	21	245	266	0.006
2001	42,566	20						
Black Cr. (GBE and GBW Wild Indicator)								
1983	24,134	95	6,531		6,531	824	7,355	0.125
1984	31,648	46	2,198		2,198	559	2,757	0.114
1985	35,640	455	3,087		3,087	1,542	4,629	0.127
1986	74,997	305	3,233		3,233	2,603	5,836	0.114
1987	29,203	559	6,014		6,014	1,080	7,094	0.124
1988	118,382	824	2,680		2,680	3,069	5,749	0.076
1989	52,351	1,837	6,419		6,419	1,522	7,941	0.122
1990	49,873	1,710	5,010		5,010	700	5,710	0.063

Table 4. (cont'd)

Brood Year	Smolt Release[3]	Jack (Age x.0) Escapement [2]	Adult (Age x.1) Marine Catch [1]	Freshwater Catch	Total Catch[1]	Escapement [2]	Return	Survival
Black Cr. (cont'd)								
1991	54,898	757	1,980		1,980	685	2,665	0.058
1992	76,003	1,214	2,580		2,580	1,484	4,064	0.046
1993	18,152	1,079	1,959		1,959	182	2,141	0.034
1994	13,736	280	430		430	292	722	0.043
1995	69,996	242	364		364	3,085	3,449	0.046
1996	24,582	523	13		13	406	419	0.017
1997	26,247	575	17		17	555	572	0.022
1998	151,129	1,950	512		512	10,611	11,123	0.073
1999	42,419	2,700	124		124	1,973	2,097	0.049
2000	88,421	72	112		112	2,499	2,611	0.030
2001	32,791	176						
Robertson Cr. Hatchery (wVI)								
1972	44,536	1,625	1,909	4	1,913	1,050	2,963	0.067
1973	44,071	1,177	2,402	-	2,402	1,013	3,415	0.077
1974	55,672	1,040	2,655	-	2,655	1,361	4,016	0.072
1975	51,460	1,547	1,617	-	1,617	902	2,519	0.049
1976	43,047	464	2,361	-	2,361	1,415	3,776	0.088
1977	51,019	425	1,287	-	1,287	1,088	2,375	0.047
1978	51,916	307	730	4	733	434	1,167	0.022
1979	48,776	110	724	-	724	249	974	0.020
1980	144,742	1,035	5,392	14	5,405	2,798	8,203	0.057
1981	125,895	1,051	6,332	20	6,353	2,315	8,668	0.069
1982	94,740	44	1,204	-	1,204	744	1,948	0.021
1983	52,092	85	1,275	12	1,288	750	2,037	0.039
1984	46,061	41	737	18	756	577	1,333	0.029
1985	41,474	86	551	-	551	213	764	0.018
1986	50,967	396	1,751	21	1,772	741	2,513	0.049
1987	61,191	608	3,733	32	3,765	1,755	5,520	0.090
1988	43,524	139	1,654	-	1,654	910	2,564	0.059
1989	41,773	57	1,391	6	1,397	529	1,926	0.046
1990	40,221	140	730	14	744	219	964	0.024
1991	38,419	-	11	-	11	7	18	0.000
1992	36,873	2	275	-	275	188	463	0.013
1993	42,248	23	417	-	417	337	753	0.018
1994	43,005	228	463	-	463	848	1,311	0.030
1995	39,566	54	42	5	47	1,345	1,392	0.035
1996	39,578	57	31	-	31	749	781	0.020
1997	40,499	66	936	16	952	3,209	4,161	0.103
1998	40,207	83	641	15	656	2,380	3,036	0.076
1999	40,068	70	220	62	282	1,451	1,733	0.043
2000	40,317	159	929	44	973	2,931	3,904	0.097
2001	40,246	62						

Table 4. (cont'd)

Brood Year	Smolt Release[3]	Jack (Age x.0) Escapement [2]	Adult (Age x.1) Marine Catch [1]	Freshwater Catch	Total Catch[1]	Escapement [2]	Return	Returns/ smolt[4]
Carnation Cr. (wVI Wild Indicator) - Coded Wire Tag Releases and Recoveries								
1999	2,005	25	3	-	3	93	96	0.048
2000	4,613	81	12	-	12	232	244	0.053
2001	4,308	80						
Carnation Cr. (wVI Wild Indicator) - Total (tagged and untagged) releases and recoveries								
1972	2,658	75	286	-	286	158	444	*0.167*
1973	2,121	54	292	-	292	123	415	*0.196*
1974	3,062	35	248	-	248	127	375	*0.122*
1975	2,560	53	181	-	181	102	283	*0.111*
1976	4,646	233	521	-	521	312	833	*0.179*
1977	3,530	114	207	-	207	175	382	*0.108*
1978	4,567	101	194	-	194	119	313	*0.068*
1979	4,164	61	500	-	500	174	674	*0.162*
1980	3,470	61	196	-	196	103	299	*0.086*
1981	3,745	83	131	-	131	49	180	*0.048*
1982	3,113	25	110	-	110	69	179	*0.057*
1983	1,978	59	184	-	184	119	303	*0.153*
1984	2,833	27	78	-	78	64	142	*0.050*
1985	2,648	58	137	-	137	57	194	*0.073*
1986	2,712	98	353	-	353	156	509	*0.188*
1987	3,862	160	403	-	403	195	598	*0.155*
1988	3,222	128	278	-	278	211	489	*0.152*
1989	3,103	51	278	-	278	107	385	*0.124*
1990	5,253	43	297	-	297	95	392	*0.075*
1991	3,989	6	15	-	15	9	24	*0.006*
1992	4,759	104	256	-	256	175	431	*0.091*
1993	3,480	90	90	-	90	74	164	*0.047*
1994	892	85	24	-	24	49	73	*0.082*
1995	4,942	123	9	-	9	285	294	*0.059*
1996	4,865	69	2	-	2	47	49	*0.010*
1997	2,842	79	7	-	7	136	143	*0.050*
1998	4,828	79	14	-	14	269	283	*0.059*
1999	2,101	114	11	-	11	357	368	*0.175*
2000	4,712	218	25	-	25	468	493	*0.105*
2001	4,510	141						

[1] Includes recoveries identified in MRP as coming from coho that are older than ocean age 1. Numbers are small.

[2] All hatchery escapements in the last year of returns are from hatchery records. Wild stock escapements are from Stock Assessment records of adipose-clipped coho up to and including the 1995 BY and CWT coho thereafter.

[3] Some smolts are age 2. in wild indicators, especially Carnation Creek. Smolt abundances in this column are for two years after the brood year shown, even though age 2. smolts are from the preceding brood year. Smolt numbers are the number of live coded wire tagged smolts, except for 'Carnation - total', where the total (tagged and untagged) smolts are shown.

[4] Only the coded wire tagged data are true marine survivals. Returns per smolt are calculated from the long time series of total smolt and total return abundances at Carnation Creek because smolts were not tagged until the 1999 brood year. Returns per smolt are over-estimates of marine survival, cf. CWT data and total smolt and return data for the 1999 and 2000 brood years.

Table 5. Performance of survival forecasts for 2003, showing the model, the observed survival and the forecast with confidence limits.

	Strait of Georgia Indicators							wVI Indicators	
	Quinsam	Big Qualicum River	Chilliwack	Inch	GB Hatcheries (Mean)	Black (wild)	Salmon (wild)	Robertson	Carnation (wild)[2]
Survival 2003 (observed)	0.010	0.006	0.025	0.010	0.013	0.030	0.036	0.093	493
Model	3YRA	LLY	RAT3	LLY	CPUE	3YRA	LLY	Sibling	Euphausiid
CI:75%[1]	0.018	0.027	0.055	0.047	0.017	0.042	0.083	0.077	456
Forecast	**0.014**	**0.016**	**0.040**	**0.021**	**0.014**	**0.043**	**0.063**	**0.047**	**420**
CI:25%	0.011	0.010	0.029	0.009	0.011	0.021	0.048	0.029	384
CI:10%	0.008	0.006	0.021	0.004	0.009	0.015	0.037	0.018	349
CI:5%	0.007	0.004	0.018	0.002	0.008	0.012	0.032	0.014	325
CI:1%	0.005	0.002	0.012	0.001	0.005	0.008	0.023	0.008	270

[1] In this case, 75% of observed values are expected to be less than the stated value.
[2] The 2003 forecast was a 'survival' forecast. This table shows what the return forecast was.

Table 6. Retrospective analysis of performance of time series, sibling and euphausiid forecast models. The recommended models are shown in bold.

		Time Series Models				Sibling	Euphausiid
		LLY	3YRA	RAT1	RAT3	Model	Model
Georgia Basin West							
Big Qualicum	MAD	**0.0235**	0.0302	0.0308	0.0309	0.0257	
	RMSE	**0.0418**	0.0429	0.0552	0.0565	0.0488	
	n	**25**	25	25	25	25	
Quinsam	MAD	0.0141	**0.0133**	0.0205	0.0141	0.0171	
	RMSE	0.0177	**0.0173**	0.0280	0.0190	0.0219	
	n	23	**23**	23	23	23	
Black (wild)	MAD	0.0239	**0.0223**	0.0389	0.0275		
	RMSE	0.0303	**0.0265**	0.0527	0.0342		
	n	14	**14**	14	14		
Lower Fraser							
Chilliwack	MAD	0.0157	0.0236	0.0210	**0.0153**	0.0240	
	RMSE	0.0207	0.0277	0.0260	**0.0193**	0.0349	
	n	17	17	17	**17**	17	
Inch	MAD	**0.0194**	0.0227	0.0309	0.0206	0.0233	
	RMSE	**0.0230**	0.0284	0.0442	0.0299	0.0285	
	n	**14**	14	14	14	14	
Salmon (wild)	MAD	**0.0208**	0.0282	0.0328	0.0278		
	RMSE	**0.0259**	0.0338	0.0362	0.0330		
	n	**13**	13	13	13		
West coast of Vancouver Island							
Robertson	MAD	0.0260	0.0251	0.0396	0.0308	**0.0196**	
	RMSE	0.0317	0.0300	0.0541	0.0370	**0.0251**	
	n	25	25	25	25	**25**	
Carnation (wild)							
- Long time series	MAD	197	168	4,872	269	114	
	RMSE	246	206	22,188	353	149	
	n	25	25	25	25	25	
- Recent euphausiid time series	MAD	111	172	166	150	61	**64**
	RMSE	113	191	197	217	85	**69**
	n	4	4	4	4	4	**4**

Table 7. Coho smolt output, returns and euphausiid time series. Euphausiid biomass is dry August biomass (mg dry mass • m^{-2}) of *T. spinifera* longer than 19 mm.

	Year		Coho		Euphausiid
Brood	Smolt	Return	Smolts	Returns	biomass
1989	1991	1992	3103	385	.
1990	1992	1993	5253	392	145
1991	1993	1994	3989	24	55
1992	1994	1995	4759	431	398
1993	1995	1996	3480	164	125
1994	1996	1997	892	73	402
1995	1997	1998	4942	294	119
1996	1998	1999	4865	49	18
1997	1999	2000	2842	143	49
1998	2000	2001	4828	283	225
1999	2001	2002	2101	368	185
2000	2002	2003	4712	493	402

Table 8. Retrospective analysis of Carnation Creek coho return forecasts made using the euphausiid-return simple regression. Year-specific forecasts are made using all data up to the forecasting year. Data for the 1997 return year were excluded. Lower – 25% confidence limit. Upper – 75% confidence limit for forecast.

Return	Adj.	Ln Euphausiid Biomass			Intercept			Forecast	Observed
Year	R^2	Est.	SE	p	Est.	SE	p	(50% CI)	
1999	0.56	1.38	0.563	0.09	-1.59	2.791	0.61		49
2000	0.55	0.91	0.344	0.05	0.81	1.609	0.64	77 (57 - 105)	143
2001	0.51	0.85	0.313	0.04	1.17	1.433	0.45	320 (239 - 429)	283
2002	0.55	0.83	0.270	0.02	1.23	1.264	0.37	265 (214 - 329)	368
2003	0.58	0.86	0.247	0.01	1.14	1.174	0.36	545 (412 - 719)	493
					MAD: 64.5				
					RMSE: 69.0				

Table 9. Forecasts, using sibling regressions, of adult returns and survivals in 2004 for the four Strait of Georgia hatchery indicators and two wVI indicators.

	Quinsam	Big Qualicum	Chilliwack	Inch	Robertson	Carnation
a (intercept)	1.064	1.658	2.937	5.696	4.964	2.694
b (slope)	1.079	1.068	0.993	0.426	0.509	0.682
N	27	28	21	18	29	29
r^2 adjusted	0.78	0.74	0.69	0.25	0.61	0.36
Tagged Smolt Release (2003)	42,980	42,566	35,162	39,189	40,246	-
Jack Escapement (2003)	22	20	10	21	62	141
Predicted Adult Return (2004)	62	128	185	1,088	1,169	**433**
Predicted Survival (2004)	**0.001**	**0.003**	**0.005**	**0.028**	**0.029**	-
Confidence Intervals:						
1%	0.0003	0.000	0.001	0.003	0.005	88
5%	0.0005	0.001	0.002	0.006	0.009	144
10%	0.0006	0.001	0.002	0.009	0.011	185
25%	0.0009	0.002	0.003	0.016	0.018	278
75%	0.0022	0.005	0.009	0.049	0.048	674

Table 10. Time series forecasts of survival or abundance of adult coho returning to southern BC indicators in 2004.

	Strait of Georgia Indicators						wVI Indicators	
	Quinsam	Big Qualicum	Black (wild)	Chilliwack	Inch	Salmon (wild)	Robertson	Carnation (wild)
Model	3YRA	LLY	3YRA	RAT3	LLY	LLY	3YRA	3YRA
CI:75%[1]	0.017	0.010	0.066	0.031	0.018	0.049	0.141	664
2004 forecast	**0.013**	**0.006**	**0.047**	**0.022**	**0.010**	**0.036**	**0.067**	**372**
CI:25%	0.010	0.004	0.034	0.015	0.006	0.026	0.031	208
CI:10%	0.008	0.003	0.024	0.011	0.003	0.019	0.015	122
CI:5%	0.007	0.002	0.020	0.009	0.002	0.016	0.009	87
CI:1%	0.005	0.001	0.013	0.006	0.001	0.011	0.004	45

[1] In this case, 75% of observed values are expected to be less than the stated value.

Table 11. Best forecast models for 2004 and the relation of 2004 forecasts to survivals in 2003.

Management Unit	Indicator	Recommended Model	Predicted Survival in 2004 (50% CI)[1]		Change (2004 forecast minus 2003 observed)
GB West	Big Qualicum	LLY	0.006	(0.004 - 0.010)	0%
	Quinsam	3YRA	0.013	(0.010 - 0.017)	35%
	Black (wild)	3YRA	0.047	(0.034 - 0.066)	60%
Lower Fraser	Chilliwack	RAT3	0.022	(0.015 - 0.031)	-13%
	Inch	LLY	0.010	(0.006 - 0.018)	0%
	Salmon (wild)	LLY	0.036	(0.026 - 0.049)	0%
SWVI, NWVI	Robertson	Sibling	0.029	(0.018 - 0.048)	-70%
	Carnation (wild)	Euphausiid	29	(17 - 50)	-94%

[1] The prediction for Carnation Cr. is for return, not survival.

Table 12. Performance of 2003 forecasts of total abundance for the Thompson River watershed. All forecasts were based on the 3YRA 'abundance' based model.

	Lower Thompson		South Thompson		North Thompson		Total Thompson	
CI	Forecast	Observed	Forecast	Observed	Forecast	Observed	Forecast	Observed
99%	82,859		47,399		116,433		233,308	
95%	41,049		27,656		63,222		126,453	
90%	29,187		21,090		46,536		93,923	
75%	17,060		13,631		28,432		58,804	
50%	**9,633**	**3,597**	**8,500**	**3,531**	**16,695**	**7,481**	**35,724**	**14,610**
25%	5,439		5,300		9,803		21,702	
10%	3,179		3,426		5,989		13,588	
5%	2,261		2,612		4,409		10,092	
1%	1,120		1,524		2,394		5,470	

Table 13. Retrospective analysis of performance of four 'abundance' based models in predicting the abundance of coho in the interior Fraser. The recommended models are shaded.

		LLY	3YRA	RAT1	RAT3
South Thompson	*RMSE*	2.00E+04	1.77E+04	8.76E+04	2.51E+04
	MAD	1.31E+04	1.31E+04	3.59E+04	1.81E+04
	n	25	25	25	25
North Thompson	*RMSE*	8.00E+04	6.40E+04	1.89E+05	1.10E+05
	MAD	5.95E+04	4.85E+04	1.27E+05	7.60E+04
	n	25	25	25	25
Lower Thompson	*RMSE*	1.98E+04	1.60E+04	5.09E+04	2.99E+04
	MAD	1.13E+04	9.72E+03	2.12E+04	1.48E+04
	n	16	16	16	16
Total Thompson	*RMSE*	8.72E+04	6.88E+04	2.17E+05	1.08E+05
	MAD	6.07E+04	5.54E+04	1.39E+05	7.76E+04
	n	16	16	16	16

Table 14. Forecasts of total abundance for Thompson River watershed coho in 2004 and associated confidence intervals. All forecasts are based on the '3YRA' model. 'n' refers to the number of recent years used to calculate the return probabilities and to calculate the geometric means.

Probability of	Lower Thompson		South Thompson		North Thompson		Total Thompson	
a lower value	Return n=16	% of GM[1] n=20	Return n=25	% of GM[1] n=29	Return n=25	% of GM[1] n=29	Return n=16	% of GM[1] n=20
99%	8.7E+04	914%	4.8E+04	285%	1.2E+05	204%	2.3E+05	300%
95%	4.1E+04	436%	2.8E+04	164%	6.3E+04	111%	1.2E+05	161%
90%	2.9E+04	304%	2.1E+04	124%	4.7E+04	82%	9.2E+04	119%
75%	1.6E+04	173%	1.3E+04	79%	2.8E+04	50%	5.7E+04	74%
50%	**9.0E+03**	**95%**	**8.3E+03**	**49%**	**1.7E+04**	**29%**	**3.4E+04**	**44%**
25%	4.9E+03	52%	5.1E+03	30%	9.8E+03	17%	2.1E+04	27%
10%	2.8E+03	29%	3.3E+03	19%	6.0E+03	10%	1.3E+04	17%
5%	2.0E+03	21%	2.5E+03	15%	4.4E+03	8%	9.4E+03	12%
1%	9.3E+02	10%	1.4E+03	8%	2.4E+03	4%	5.1E+03	7%

[1] Geometric mean escapement for the last n years.

Table 15. Performance of the 2003 forecast total return for the Area 7 aggregate as defined in the 2003 PSARC forecast document. Stock-recruitment and time series models were used to forecast in 2003. The preferred model is underlined.

	total return		
	observed	2003 forecast	
probability of a lower value		S-R	<u>3YRA</u>
99%		1562	1487
95%		1232	1085
90%		1094	923
75%		906	708
50%	**420**	**744**	**530**
25%		620	397
10%		531	304
5%		486	259
1%		416	189

Table 16. Performance of the 2003 forecast total return for the Area 7 aggregate based on new exploitation rate not shown in the 2003 PSARC forecast document. Stock-recruitment and time series models were used to forecast in 2003. The preferred model is underlined.

	total return		
	observed	2003 forecast	
probability of a lower value		S-R	<u>3YRA</u>
99%		1489	1577
95%		1183	1150
90%		1054	977
75%		878	748
50%	**423**	**726**	**559**
25%		608	418
10%		523	320
5%		480	272
1%		413	198

Table 17. Performance of the 2003 forecast total return for the Area 8 aggregate based on data used in the 2003 PSARC forecast document. Stock-recruitment and time series models were used to forecast in 2003. The preferred model is underlined.

	total return		
	observed	2003 forecast	
probability of a lower value		S-R	<u>3YRA</u>
99%		8010	5031
95%		5283	3251
90%		4275	2596
75%		3044	1797
50%	**1545**	**2125**	**1202**
25%		1512	805
10%		1134	557
5%		963	445
1%		725	287

Table 18. Performance of the 2003 forecast total return for the Area 8 aggregate based on new exploitation rate not used in the 2003 PSARC forecast document. Stock-recruitment and time series models were used to forecast in 2003. The preferred model is underlined.

	total return		
	observed	2003 forecast	
probability of a lower value		S-R	<u>3YRA</u>
99%		8006	5313
95%		5280	3433
90%		4271	2741
75%		3040	1897
50%	**1556**	**2121**	**1269**
25%		1509	849
10%		1131	588
5%		960	469
1%		721	303

Table 19. Performance of the 2003 forecast total return for the Area 12 aggregate as defined in the 2003 PSARC forecast document. Observed total return includes data from streams omitted in the 2004 forecast due to poor reliability of estimates. Stock-recruitment and time series models were used to forecast in 2003. The preferred model is underlined.

	total return		
	observed	2003 forecast	
probability of a lower value		S-R	<u>3YRA</u>
99%		13842	5436
95%		8864	3465
90%		7048	2747
75%		4875	1879
50%	**696**	**3288**	**1241**
25%		2253	820
10%		1627	561
5%		1348	445
1%		967	284

Table 20. Performance of the 2003 forecast total return for the Area 12 aggregate using adjusted exploitation rates and selected streams. Stock-recruitment and time series models were used to forecast in 2003. The preferred model is underlined.

	total return		
	observed	2003 forecast	
probability of a lower value		S-R	<u>3YRA</u>
99%		12434	5500
95%		8350	3655
90%		6809	2961
75%		4913	2098
50%	**1016**	**3476**	**1441**
25%		2501	989
10%		1888	701
5%		1606	568
1%		1210	377

Table 21. Performance of the 2003 forecast total return for the Area 13 aggregate as defined in the 2003 PSARC forecast document. Observed total return includes data from streams omitted in the 2004 forecast due to poor reliability of estimates. Stock-recruitment and time series models were used to forecast in 2003. The preferred model is underlined.

	total return		
	observed	2003 forecast	
probability of a lower value		S-R	<u>3YRA</u>
99%		2189	798
95%		1396	505
90%		1106	399
75%		759	271
50%	**294**	**505**	**178**
25%		339	117
10%		238	80
5%		194	63
1%		132	40

Table 22. Performance of the 2003 forecast total return for the Area 13 aggregate using adjusted exploitation rates and selected streams. Stock-recruitment and time series models were used to forecast in 2003. The preferred model is underlined.

	total return		
	observed	2003 forecast	
probability of a lower value		S-R	<u>3YRA</u>
99%		2212	733
95%		1418	471
90%		1126	375
75%		775	259
50%	**288**	**516**	**172**
25%		346	115
10%		243	79
5%		196	63
1%		133	40

Table 23. For the Area 7 aggregate, 2004 forecasts and associated confidence intervals for total return, escapement and proportion of Smax from the Stock-Recruitment (S-R) and time series (3YRA) models. Z-scores for the forecasts of total return and escapement are also given. An exploitation rate of 0.229 was assumed for 2004. The 3YRA is the preferred model.

P[§]	forecast total return				forecast escapement				proportion of Smax	
	S-R	z-score	3YRA	z-score	S-R	z-score	3YRA	z-score	S-R	3YRA
99%	1653	1.64	1600	1.53	1275	3.65	1233	3.47	101%	98%
95%	1287	0.89	1169	0.65	992	2.47	901	2.09	79%	72%
90%	1132	0.58	994	0.29	873	1.97	766	1.53	69%	61%
75%	922	0.15	763	-0.18	711	1.30	588	0.79	56%	47%
50%	**740**	**-0.22**	**571**	**-0.57**	**570**	**0.71**	**441**	**0.17**	**45%**	**35%**
25%	598	-0.51	428	-0.86	461	0.26	330	-0.29	37%	26%
10%	497	-0.72	328	-1.06	383	-0.07	253	-0.61	30%	20%
5%	446	-0.82	279	-1.16	344	-0.23	215	-0.77	27%	17%
1%	365	-0.99	204	-1.32	282	-0.49	157	-1.01	22%	13%

[§] probability of a lower value

Table 24. For the Area 8 aggregate, 2004 forecasts and associated confidence intervals for total return, escapement and proportion of Smax from the Stock-Recruitment (S-R) and time series (3YRA) models. Z-scores for the forecasts of total return and escapement are also given. An exploitation rate of 0.229 was assumed for 2004. The 3YRA is the preferred model.

P[§]	forecast total return				forecast escapement				proportion of Smax	
	S-R	z-score	3YRA	z-score	S-R	z-score	3YRA	z-score	S-R	3YRA
99%	7635	3.29	6002	2.18	5886	7.11	4627	5.18	311%	245%
95%	5042	1.54	3893	0.76	3887	4.04	3001	2.69	205%	159%
90%	4082	0.89	3114	0.24	3147	2.91	2401	1.77	166%	127%
75%	2911	0.10	2162	-0.41	2244	1.53	1667	0.64	119%	88%
50%	**2036**	**-0.49**	**1451**	**-0.88**	**1569**	**0.49**	**1119**	**-0.20**	**83%**	**59%**
25%	1452	-0.88	974	-1.21	1119	-0.20	751	-0.76	59%	40%
10%	1092	-1.13	676	-1.41	842	-0.62	522	-1.12	44%	28%
5%	929	-1.24	541	-1.50	716	-0.82	417	-1.28	38%	22%
1%	702	-1.39	351	-1.63	541	-1.09	271	-1.50	29%	14%

[§] probability of a lower value

Table 25. For the Area 11 aggregate, 2004 forecasts and associated confidence intervals for total return, escapement and proportion of Smax from the Stock-Recruitment (S-R) and time series (3YRA) models. Z-scores for the forecasts of total return and escapement are also given. An exploitation rate of 0.225 was assumed for 2004. The 3YRA is the preferred model.

P §	forecast total return				forecast escapement				proportion of Smax	
	S-R	z-score	3YRA	z-score	S-R	z-score	3YRA	z-score	S-R	3YRA
99%	4270	3.22	7912	7.24	3292	6.18	6100	12.63	365%	676%
95%	2686	1.47	4554	3.53	2071	3.38	3511	6.68	230%	389%
90%	2125	0.85	3421	2.28	1639	2.39	2638	4.68	182%	293%
75%	1471	0.13	2140	0.87	1134	1.23	1650	2.41	126%	183%
50%	**1010**	**-0.38**	**1279**	**-0.09**	**779**	**0.41**	**986**	**0.89**	**86%**	**109%**
25%	720	-0.70	765	-0.65	555	-0.10	590	-0.02	62%	65%
10%	551	-0.89	478	-0.97	424	-0.40	369	-0.53	47%	41%
5%	477	-0.97	359	-1.10	368	-0.53	277	-0.74	41%	31%
1%	379	-1.08	207	-1.27	293	-0.70	160	-1.01	32%	18%

§ probability of a lower value

Table 26. For the Area 12 aggregate, 2004 forecasts and associated confidence intervals for total return, escapement and proportion of Smax from the Stock-Recruitment (S-R) and time series (3YRA) models. Z-scores for the forecasts of total return and escapement are also given. An exploitation rate of 0.04 was assumed for 2004. The 3YRA is the preferred model.

P §	forecast total return				forecast escapement				proportion of Smax	
	S-R	z-score	3YRA	z-score	S-R	z-score	3YRA	z-score	S-R	3YRA
99%	13200	2.61	4859	0.08	12632	9.59	4650	2.69	327%	120%
95%	8483	1.18	3286	-0.39	8118	5.68	3145	1.39	210%	81%
90%	6754	0.66	2684	-0.58	6463	4.25	2568	0.89	167%	67%
75%	4677	0.03	1925	-0.81	4476	2.54	1842	0.26	116%	48%
50%	**3154**	**-0.43**	**1337**	**-0.98**	**3019**	**1.28**	**1280**	**-0.23**	**78%**	**33%**
25%	2156	-0.74	929	-1.11	2063	0.45	889	-0.56	53%	23%
10%	1548	-0.92	666	-1.19	1482	-0.05	638	-0.78	38%	17%
5%	1276	-1.00	544	-1.22	1221	-0.28	521	-0.88	32%	13%
1%	904	-1.12	368	-1.28	865	-0.59	352	-1.03	22%	9%

§ Probability of a lower value.

Table 27. For the Area 13 aggregate, 2004 forecasts and associated confidence intervals for total return, escapement and proportion of Smax from the Stock-Recruitment (S-R) and time series (3YRA) models. Z-scores for the forecasts of total return and escapement are also given. An exploitation rate of 0.04 was assumed for 2004. The 3YRA is the preferred model.

P §	forecast total return				forecast escapement				proportion of Smax	
	S-R	z-score	3YRA	z-score	S-R	z-score	3YRA	z-score	S-R	3YRA
99%	3330	1.53	808	-0.64	3186	7.39	773	0.79	83%	20%
95%	2137	0.50	526	-0.88	2046	4.27	504	0.05	53%	13%
90%	1701	0.13	421	-0.97	1628	3.13	403	-0.22	42%	10%
75%	1178	-0.32	293	-1.08	1128	1.76	280	-0.56	29%	7%
50%	**796**	**-0.65**	**196**	**-1.16**	**762**	**0.76**	**188**	**-0.81**	**20%**	**5%**
25%	545	-0.86	132	-1.22	522	0.10	126	-0.98	14%	3%
10%	394	-0.99	92	-1.25	377	-0.30	88	-1.09	10%	2%
5%	326	-1.05	73	-1.27	312	-0.48	70	-1.14	8%	2%
1%	233	-1.13	48	-1.29	223	-0.72	46	-1.20	6%	1%

§ Probability of a lower value.

Table 28. Summary of the Ricker stock-recruitment analyses on reconstructed time series for the Statistical Area aggregates.

aggregate	Ricker stock-recruitment analysis						
	N	adj. r^2	a'	b'	S_{MSY}	S_{MAX} §	u_{MSY}
Area 7	50	0.28	1.25	1310	540	1048	0.52
Area 8	50	0.33	1.79	2825	1058	1577	0.67
Area 11	47	0.41	1.85	1391	515	752	0.69
Area 12	47	0.25	1.69	5442	2077	3218	0.65
Area 13	47	0.01	1.42	4569	1830	3213	0.57

§ The spawner number producing on average the maximum recruitment.

Table 29. Indicator projects in Areas 8 to 13.

Area	River	Methods	Year Started	Number of Years
Area 8	Martin River	Mark Recapture, Reliable Peak Count Index	2001	3
Area 8	Bella Coola River System	Tower Count + index systems	1998	6
Area 10	Docee River	Fence Count	1998	6
Area 12	Keogh River	Fence Count	1998	6
Area 12	Klinaklini River	Fishwheel + Fence Count	1997	7
Area 13	Heydon River	Fence Count	1998	6
Area 13	Simms Creek	Fence Count	1999	5
Area 13	Village Bay Creek	Fence Count	1999	5

Table 30. Forecast of p_{inside} in 2004 for Strait of Georgia hatchery indicators, where p_{inside} is an index of the proportion of coho residing in the Strait in their second year of ocean life.

Parameter	*pinside*
a	-28.9
b	1.002
N	23
Confidence Intervals:	
1% lower	0.131
5% lower	0.193
10% lower	0.233
25% lower	0.305
Forecast	**0.396**
75% lower	0.495
90% lower	0.587
95% lower	0.642
99% lower	0.741

FIGURES

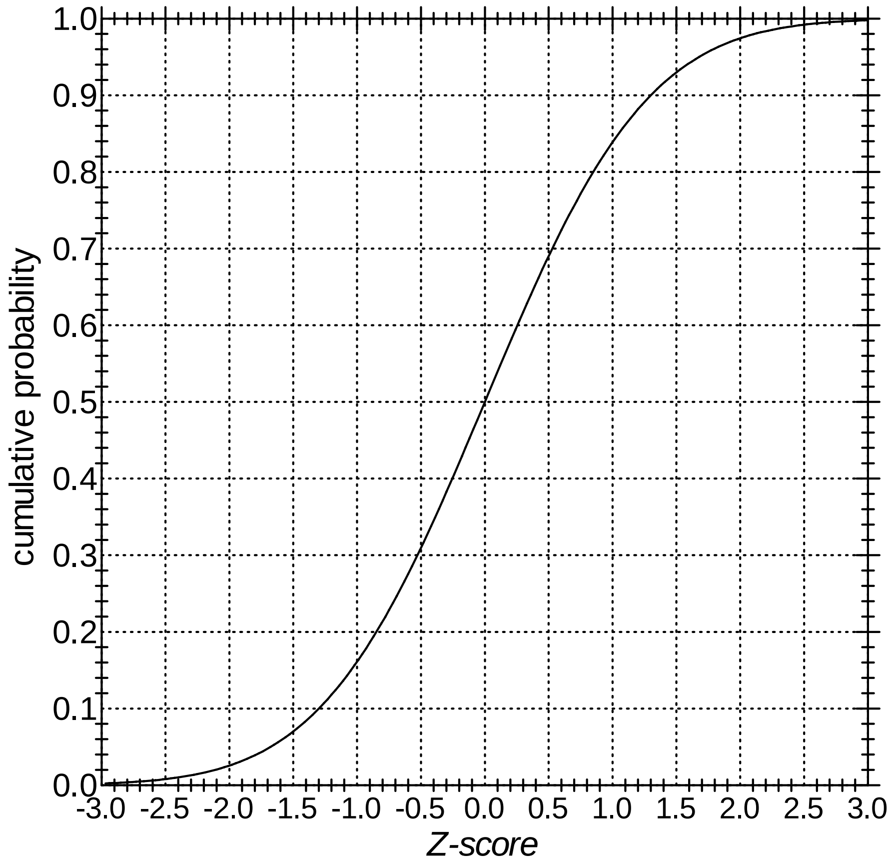

Figure 1. Cumulative probabilities for *Z*-scores applicable to the time series of average-stream indices from the Statistical Areas. This plot can be used to convert *Z-scores* to probabilities.

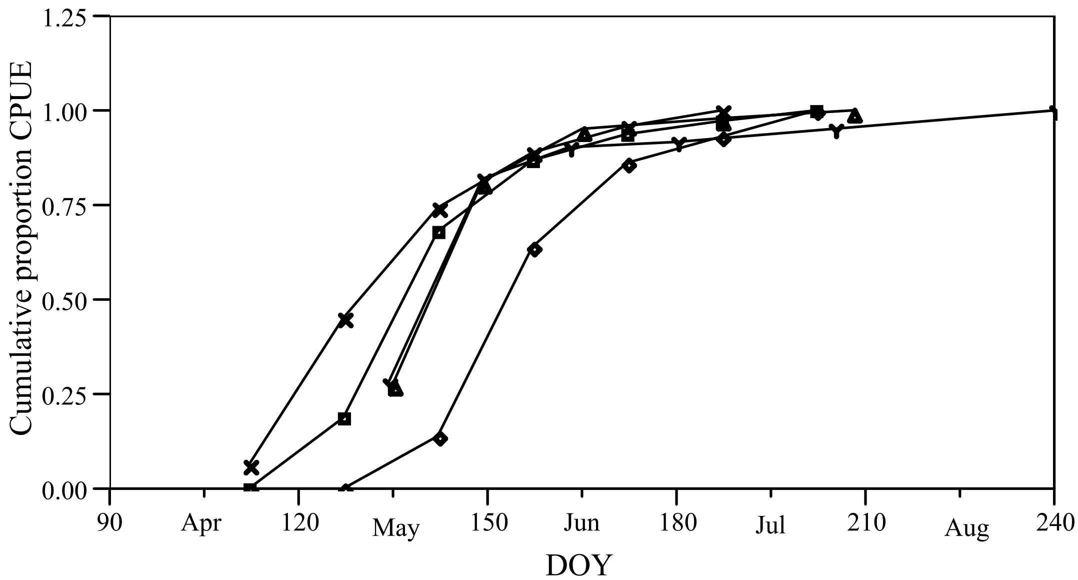

Figure 2. Cumulative proportion of annual CPUE for coho smolts in Barkley Sound. Crosses – 1987. Squares – 1988. Diamonds – 1989. Triangles – 2000. Y's – 2001. 1987-89 data (B. Hargreaves, DFO, unpubl. res.)

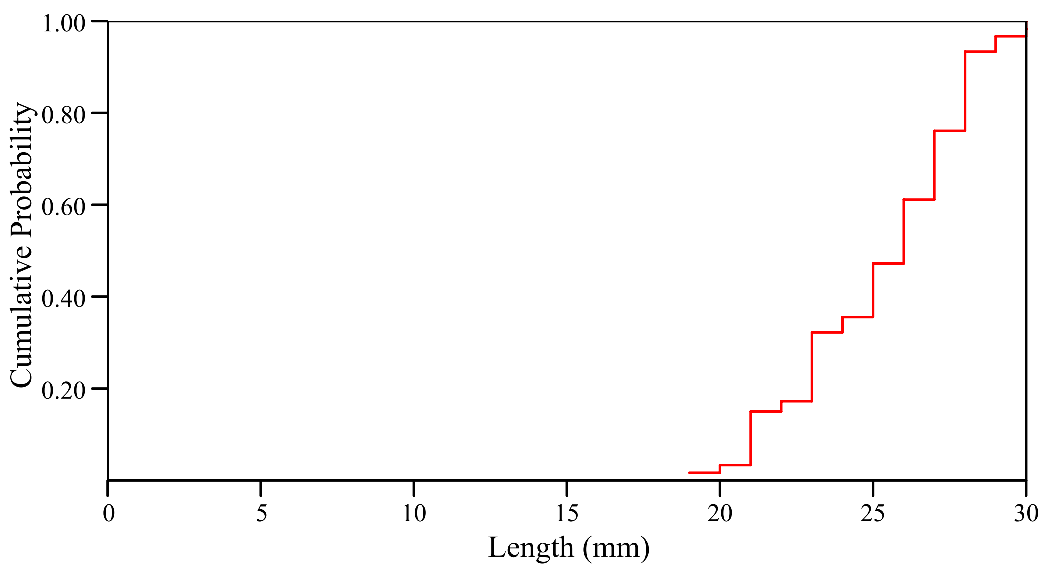

Figure 3. Cumulative density function for *T. spinifera* in stomachs of coho collected outside of Barkley Sound. Range of x-axis describes size range of euphausiids available.

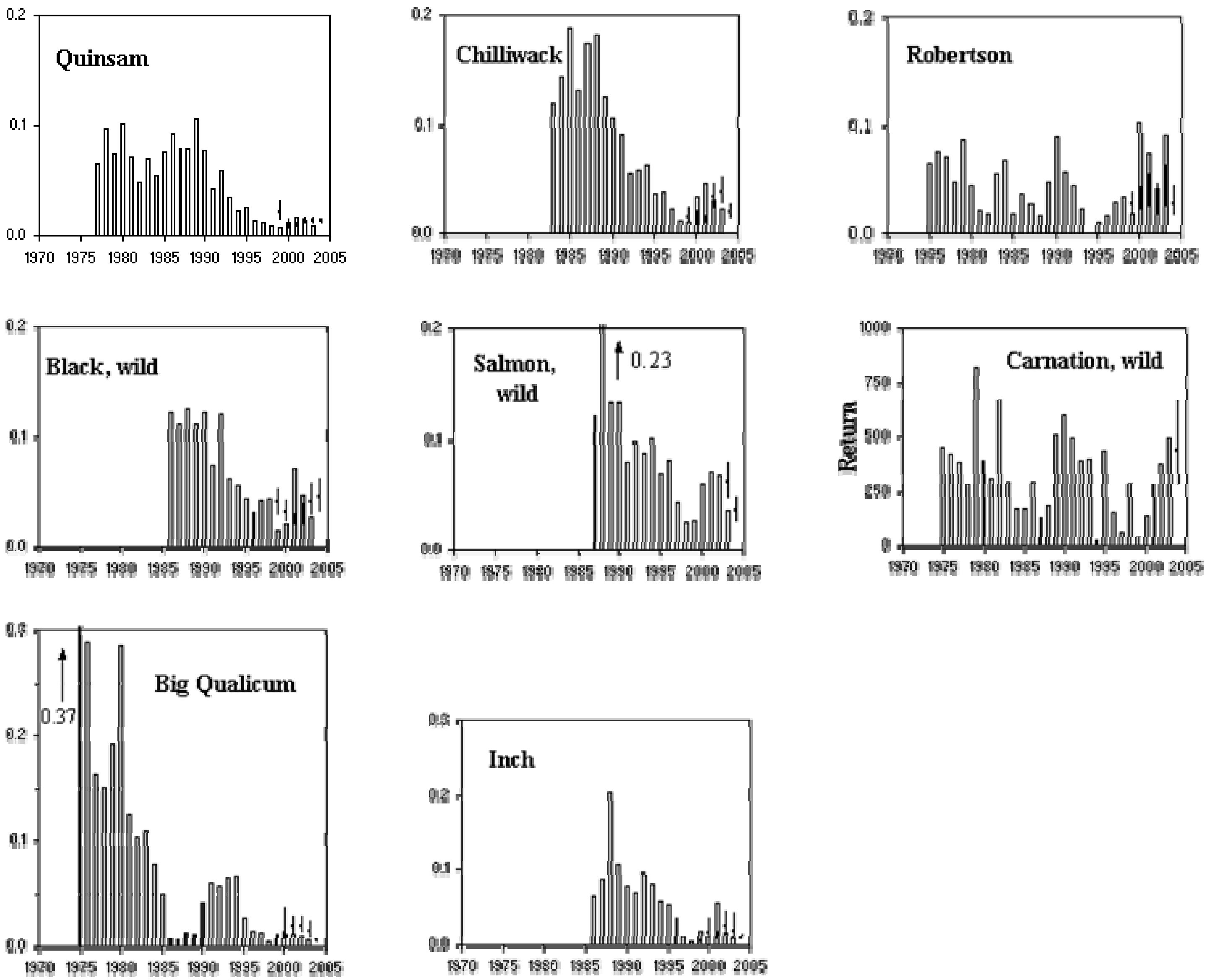

Figure 4. Marine survivals of southern BC coho since 1974. Indicator stocks are arranged in left to right columns for GBW, LowFr and WCVI, respectively. Forecasts since 1999 are shown as point symbols and bars, the latter indicating the 50% CL's. Solid bars in the Big Qualicum graph indicate years when fish culture problems reduced smolt quality.

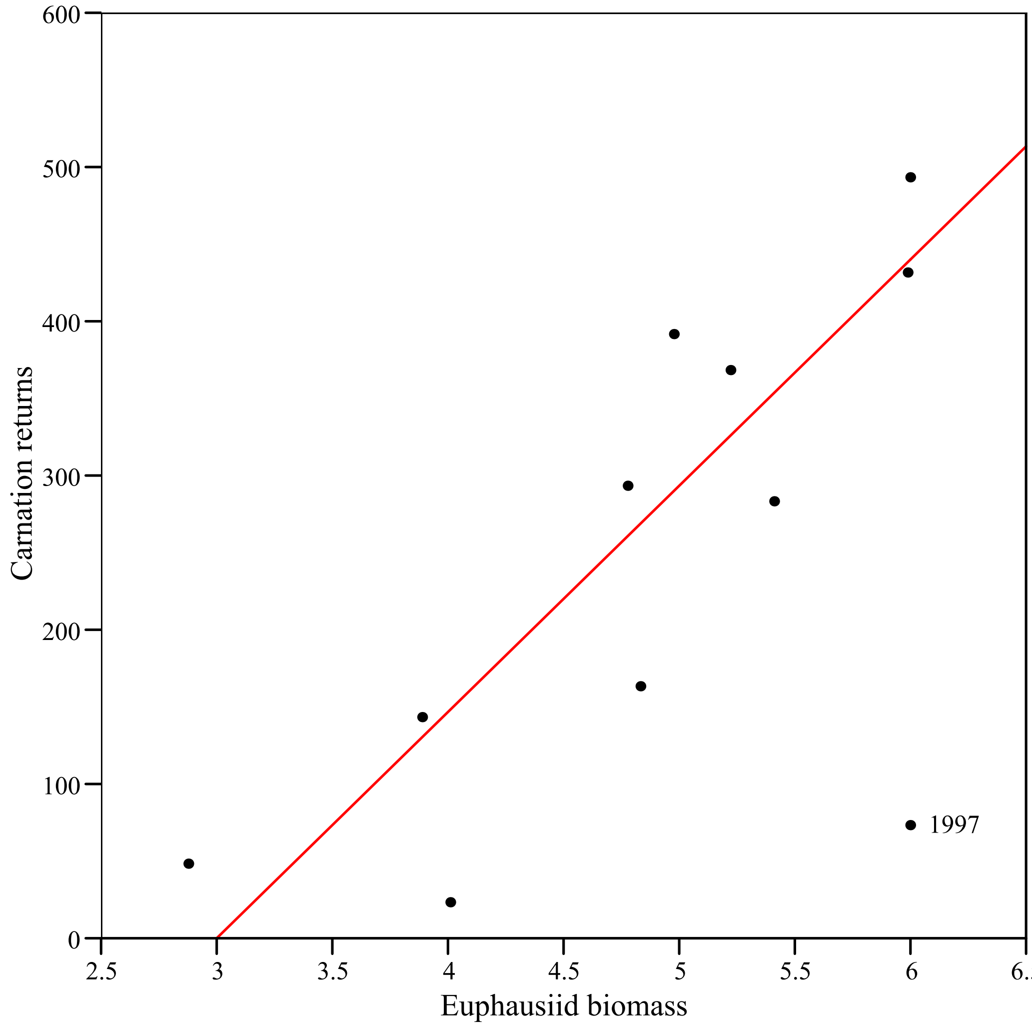

Figure 5. Scatter plot of Carnation Creek coho returns against the ln dry biomass (mg dry mass • m-2) of *T. spinifera* longer than 19 mm in August. Line is least squares regression fit. Value is return year.

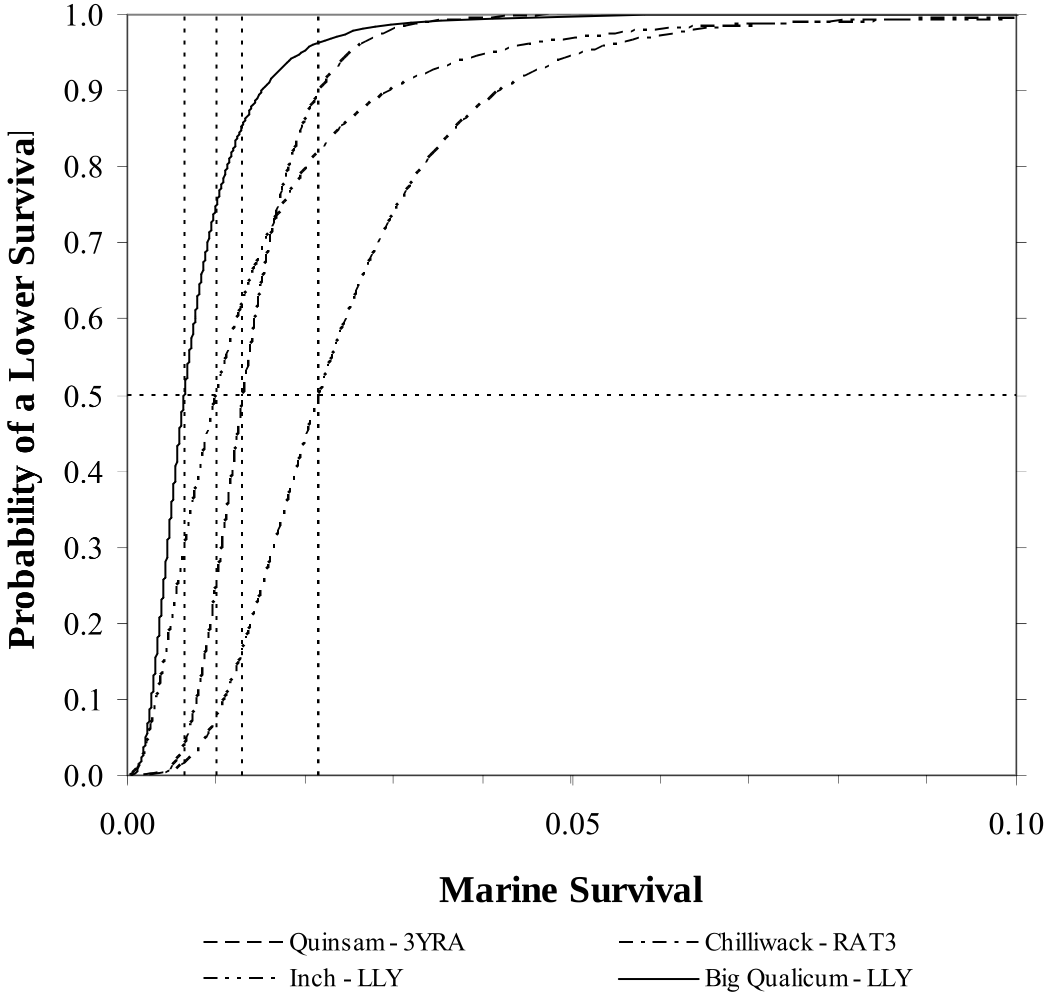

Figure 6. Cumulative probability distributions around the time-series forecasts of marine survivals in 2004 for four hatchery indicators in the Georgia Basin. All are the best forecast models for individual indicators.

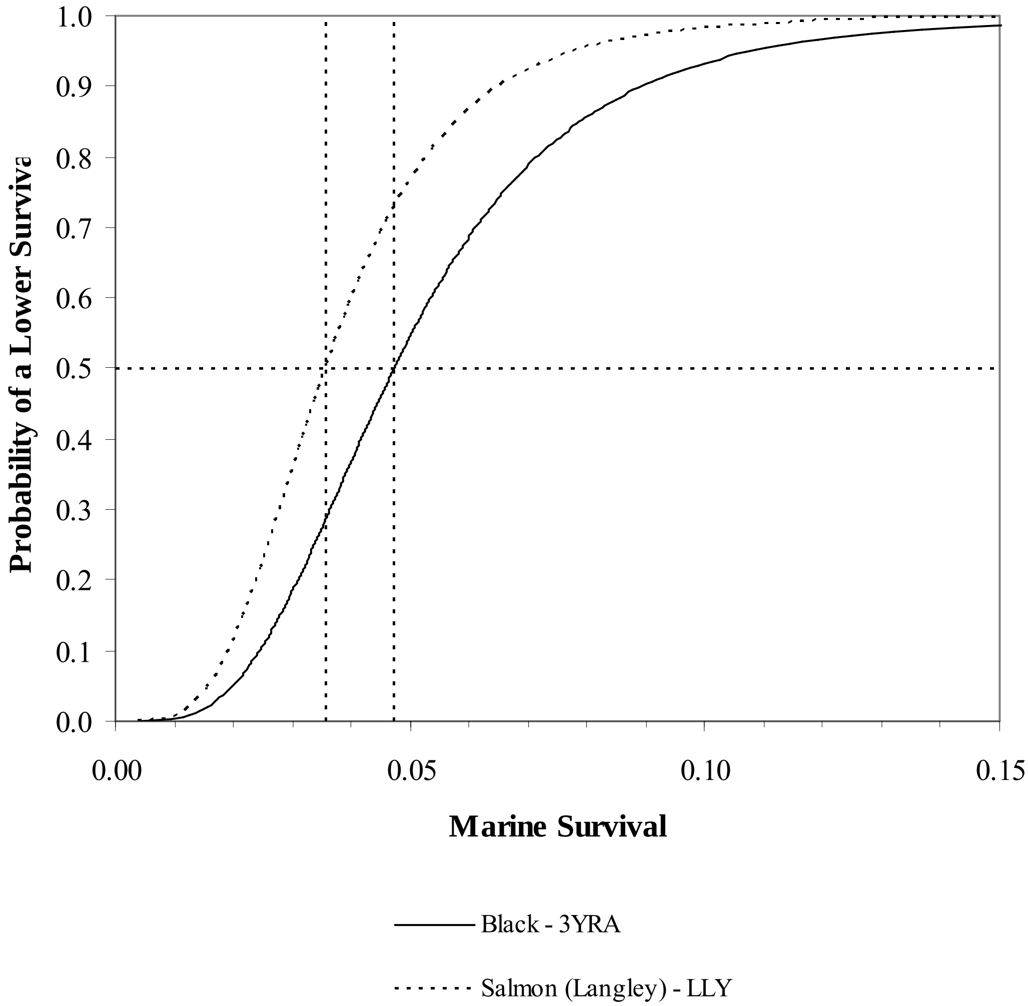

Figure 7. Cumulative probability distributions around the best available forecasts of marine survival in 2004 for two wild indicators in the Georgia Basin: Black Creek and Salmon River (Langley). Both are time-series forecasts.

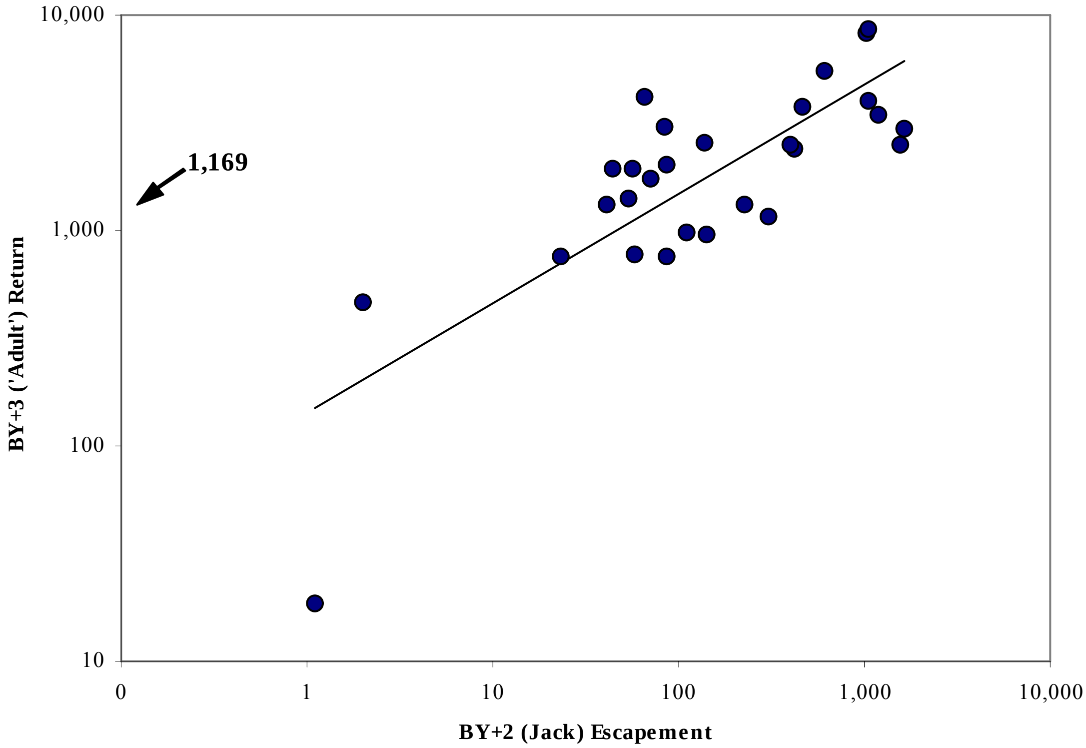

Figure 8. Sibling relationship for Robertson Creek Hatchery coho, showing the forecast adult return in 2004 of Ad-CWT coho, based on a 2003 escapement of 62 Ad/CWT jack coho. The 1,169 forecast return equates to a survival of 2.9%.

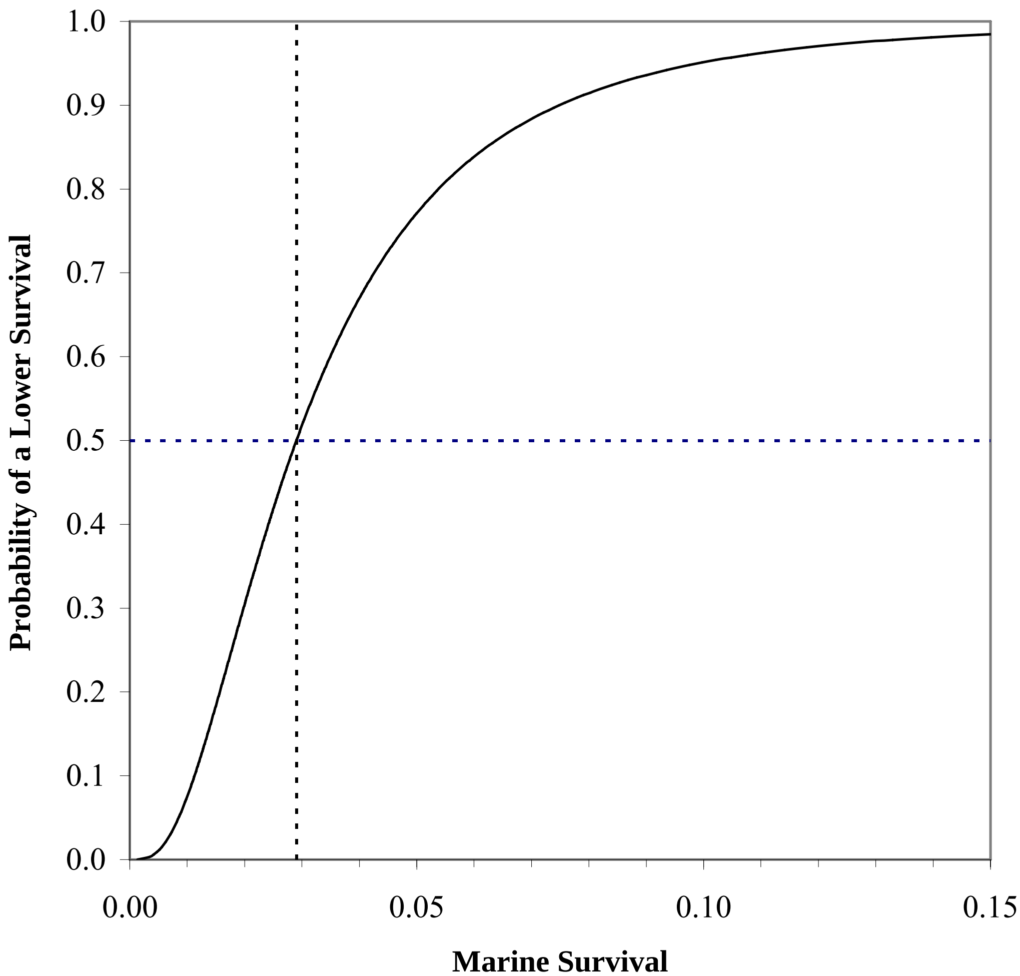

Figure 9. Cumulative probability distribution around the sibling forecast of survival of Robertson Hatchery coho in 2004. This is the recommended forecast model.

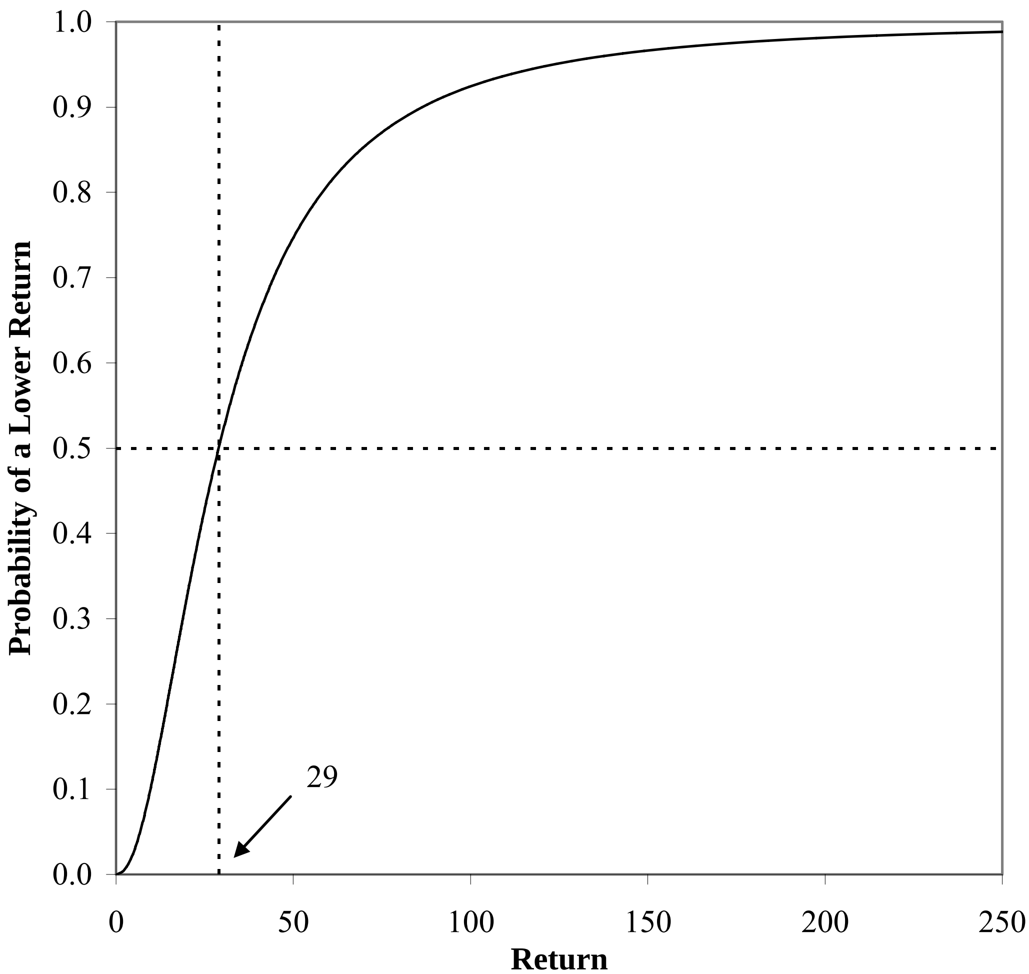

Figure 10. Cumulative probability distribution around the forecast of return in 2004 to Carnation Creek, the wVI wild indicator population. The euphausiid model was used based on its superior retrospective performance.

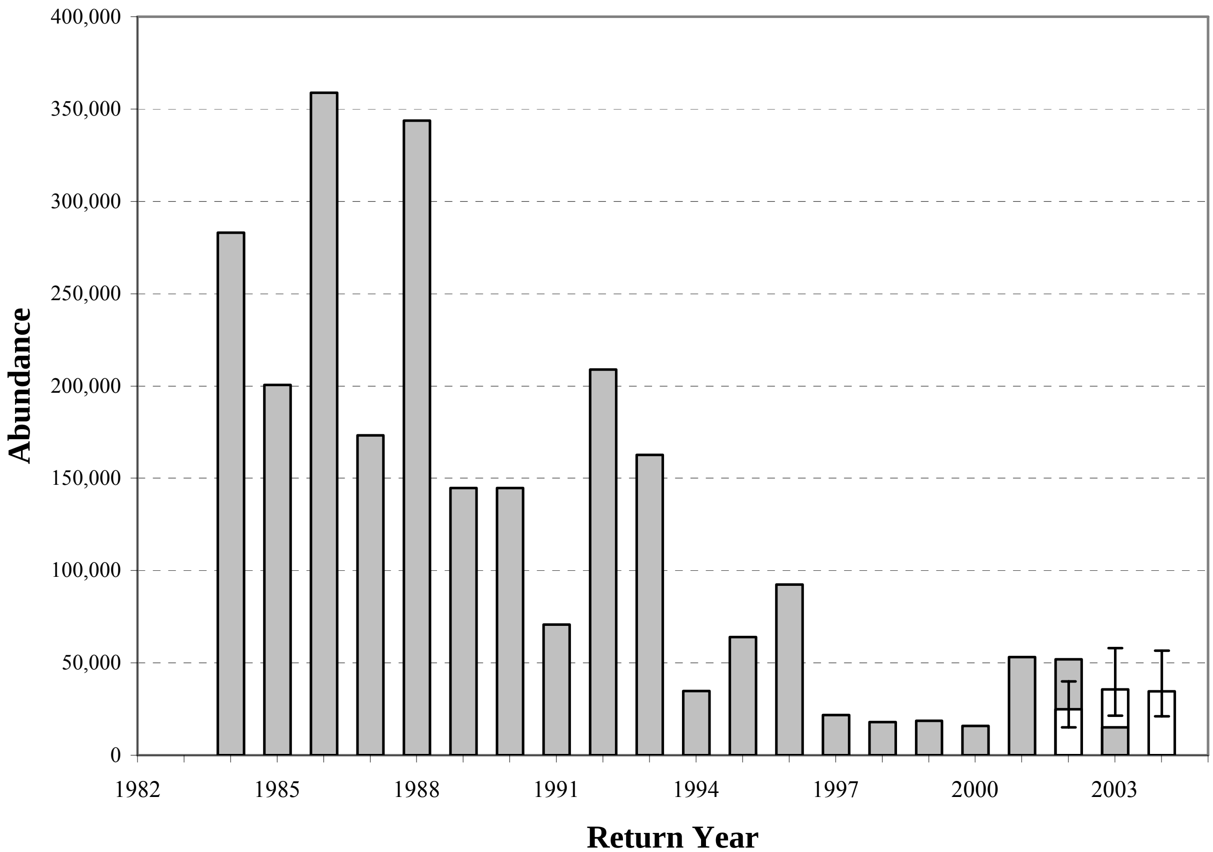

Figure 11. Estimated abundance of Thompson River watershed coho from 1984 to 2003. The forecasts for 2002 to 2004 are shown as clear bars with associated 50% CI's.

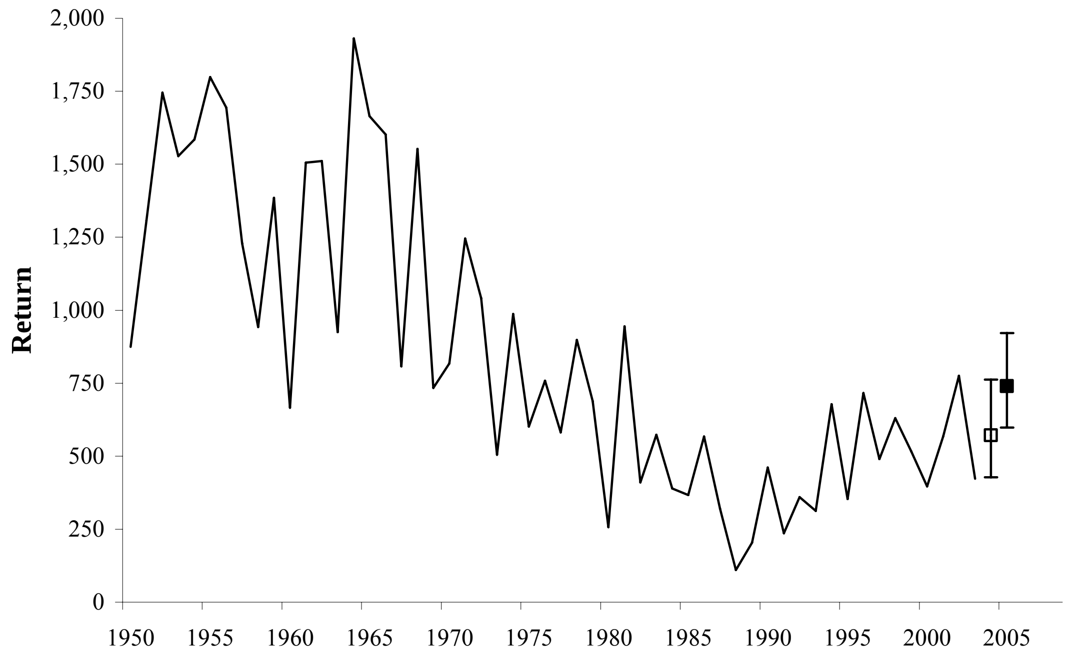

Figure 12. Area 7: annual returns to the average stream and the S-R (■) and 3YRA (□) forecasts for 2004 with associated 50% CI. The 3YRA model is the preferred model.

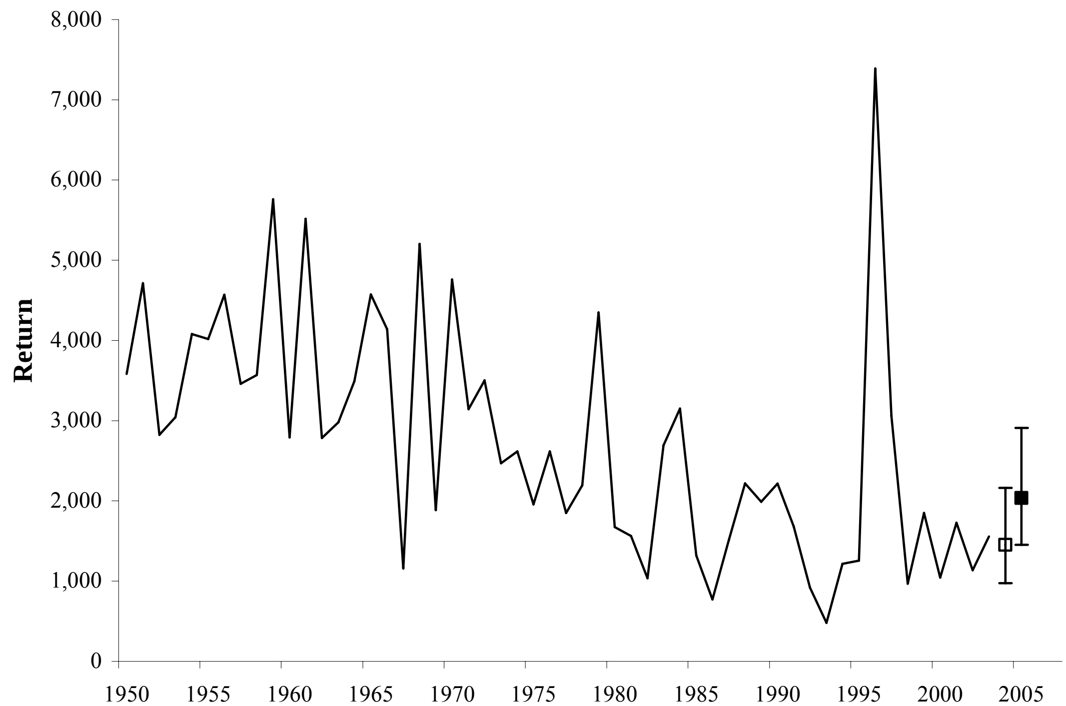

Figure 13. Area 8: annual returns to the average stream and the S-R (■) and 3YRA (□) forecasts for 2004 with associated 50% CI. The 3YRA model is the preferred model.

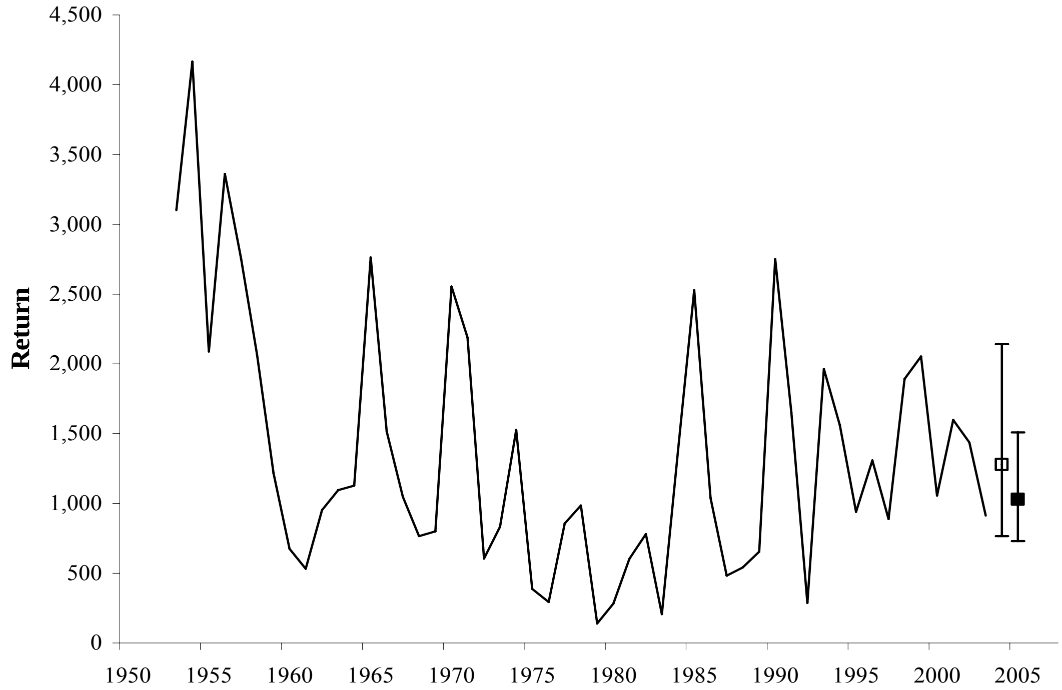

Figure 14. Area 11: annual returns to the average stream and the S-R (■) and 3YRA (□) forecasts for 2004 with associated 50% CI. The 3YRA model is the preferred model.

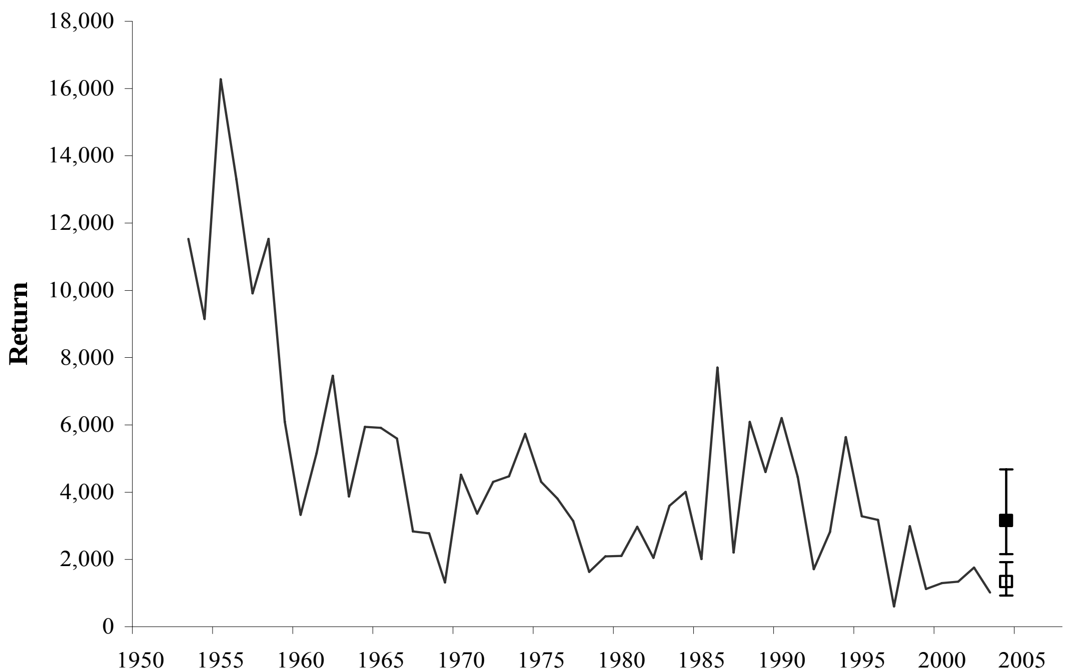

Figure 15. Area 12: annual returns to the average stream and the S-R (■) and 3YRA (□) forecasts for 2004 with associated 50% CI. The 3YRA model is the preferred model.

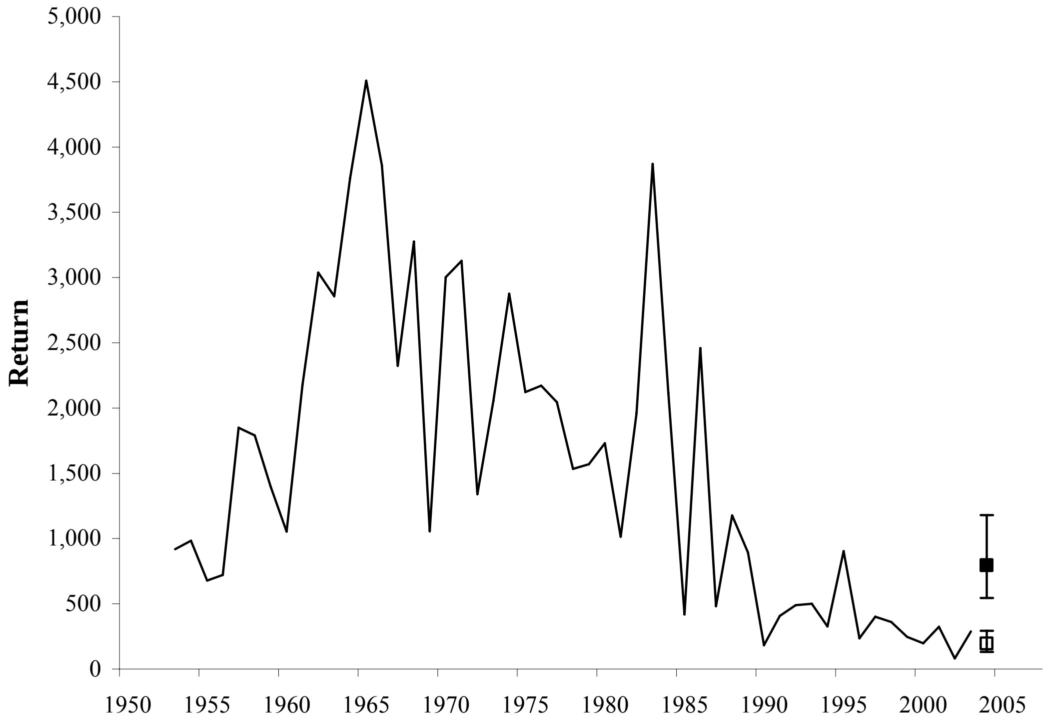

Figure 16. Area 13: annual returns to the average stream and the S-R (■) and 3YRA (□) forecasts for 2004 with associated 50% CI. The 3YRA model is the preferred model.

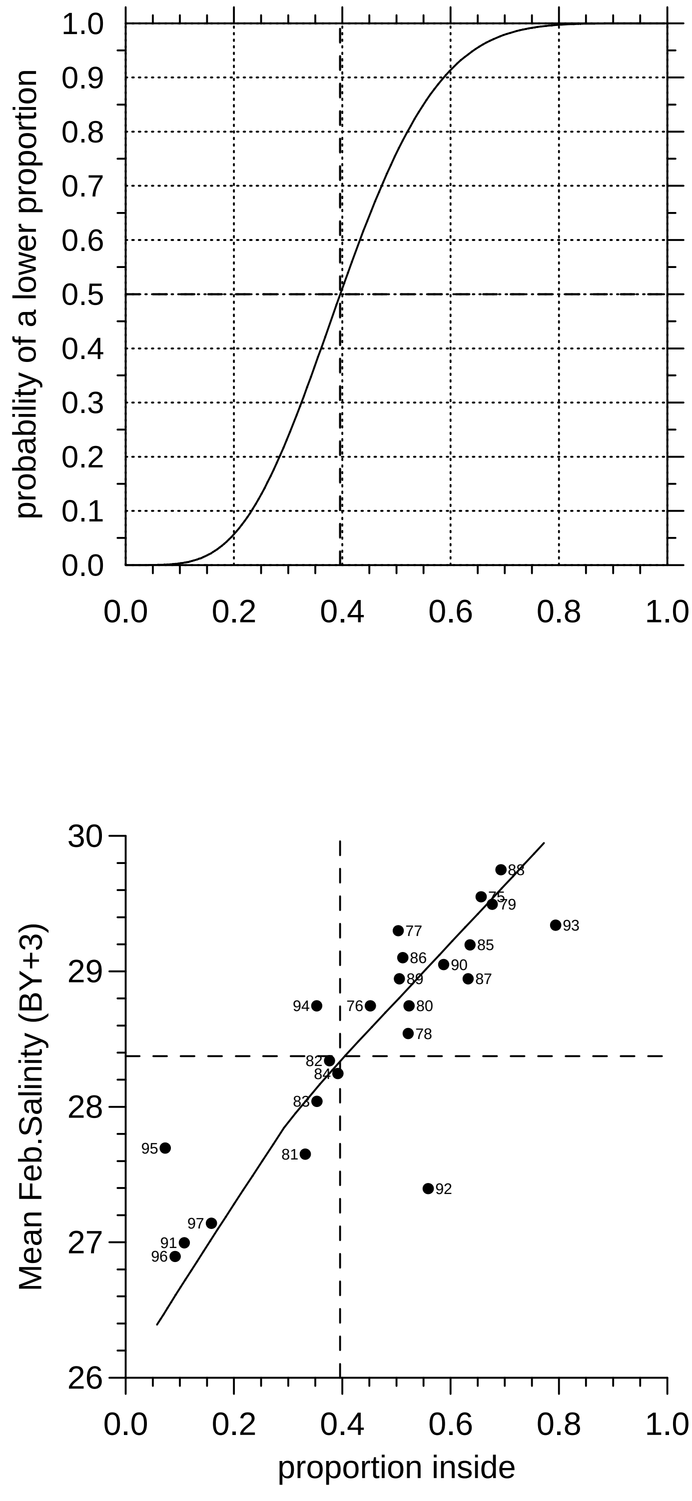

Figure 17 Predicting p_{inside} for 2004 using mean February salinities at Chrome and Sisters islands. The lower panel is the predictive relationship. The upper panel is the probability distribution for the point prediction.