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Forecast for northern British Columbia coho salmon in 2000

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Abstract

This Research Paper documents forecasts of marine survival and abundance for the coho of northern British Columbia including the upper Skeena conservation area.

Marine survival:

In 2000, marine survival at the three northern indicators is expected to be above the mean of their respective periods of observation.

indicator	model	$\hat{s}_{2000}$	(50% CI)	observed mean and period of observation (year of sea-entry)	
Lachmach	sibling regression	0.14	(0.11–0.17)	0.091	(1987 – 1998)
Toboggan Creek hatchery	from Lachmach	0.05	(0.03–0.08)	0.029	(1987 – 1998)
Fort Babine hatchery	from Lachmach	0.03	(0.02–0.06)	0.024	(1993 – 1998)

The period of observation is short for all three indicators. The forecast for Fort Babine is poorly defined. The survival rate of wild Toboggan Creek coho should be comparable to Lachmach but cannot be reliably forecasted.

Abundance forecast:

The forecast total return of Lachmach coho is 2.3×10^3, which is below the mean of 2.8×10^3 observed over the period 1988 to 1999. Smolt production from Toboggan Creek in 1999 was estimated to have been 44×10^3, indicating high fresh water (FW) survival. Assuming that wild survival will be 1.2-times that of the forecast survival for hatchery coho (the same expansion observed for the 1999 return) the total return of wild Toboggan coho could be 2.7×10^3, or 56% of the mean total return of 4.8×10^3 observed between 1988 and 1999.

After the application of stock-recruitment and time-series models to reconstructions of abundance in 11 aggregate stocks in north coastal British Columbia, the following forecasts of abundance in 2000 were made.

aggregate	proportions of observed abundance and escapement less than forecasts[‡]		characterization of forecast abundance
	abundance	escapement	
Area 6	0.07	0.16	well below average
Babine	0.09	0.22	well below average
Area 4-U	0.10	0.23	well below average
Area 2E	0.16	0.31	below average
Area 7	0.22	0.43	below average
Area2W	0.23	0.39	below average
Area 4-L	0.23	0.63	below average
Area 5	0.31	0.65	below average
Area 3	0.33	0.77	below average
Area 8	0.33	0.76	below average
Area 1	0.51	0.81	average

[‡] Assuming a log-normal cumulative probability distribution with mean and standard deviation calculated over the observation period 1950 (1946 for Babine) to 1999 (return years).

Impacts of incremental Canadian fisheries

In the context of a simple approach to determining the status of coho within large geographic aggregates relative to two potential *Reference Points* (*RP*), the aggregates of Area 2W and Area 6 appear unable to support incremental Canadian fisheries. There are potentially some limited incidental fishing opportunities available on coho from the upper Skeena that would have limited risk of irreversible damage. However, forecasts for this area have not proven sufficiently reliable to proceed with incremental fishing, even if modest, without an early in-season indicator that would warn of unforeseen survival disasters such as the one that occurred in 1996 sea-entry. Such a system has been developed for the 2000 fishing season (Holtby 2000). We also note that the properties of the approach presented here for the estimation of *RP*s have not been explored in the context of aggregates represented by the average-stream index.

Résumé

Le présent document de recherche présente des prévisions de la survie en mer et de l'abondance du saumon coho du nord de la Colombie-Britannique, y compris la zone de conservation de la haute Skeena.

Survie en mer

On prévoit que les taux de survie en mer pour 2000, déterminés aux trois points repères du nord, seront supérieurs aux moyennes pour leurs périodes d'observation respectives.

Point repère	Modèle	$\hat{s}_{2000}$	(IC de 50 %)	Moyenne observée et période d'observation (année d'entrée en mer)	
Lachmach	Régression des espèces jumelles	0,14	(0,11–0,17)	0,091	(1987 – 1998)
Écloserie de Toboggan Creek	À partir de Lachmach	0,05	(0,03–0,08)	0,029	(1987 – 1998)
Écloserie de Fort Babine	À partir de Lachmach	0,03	(0,02–0,06)	0,024	(1993 – 1998)

La période d'observation est courte pour les trois points repères. La prévision pour Fort Babine est mal définie. Le taux de survie des cohos sauvages de Toboggan Creek devrait s'approcher de celui des saumons de Lachmach, mais on ne peut le prévoir de façon fiable.

Prévision de l'abondance

La remonte totale prévue des cohos de Lachmach est de $2{,}3\times10^3$, valeur inférieure à la moyenne de $2{,}8\times10^3$ observée de 1988 à 1999. On estime qu'en 1999, la production de saumouneaux de Toboggan Creek était de 44×10^3, ce qui indique un taux de survie élevé en eau douce (« FW »). En supposant que le taux de survie des saumons sauvages sera 1,2 fois celui des cohos provenant de l'écloserie (le facteur observé lors de la remonte de 1999), la remonte totale de cohos sauvages de Toboggan Creek pourrait atteindre $2{,}7\times10^3$, soit 56 % de la moyenne totale de 4.8 X 103 observée de 1988 à 1999.

L'application de modèles stock-recrutement et de séries chronologiques aux reconstructions des effectifs de 11 stocks combinés de la côte nord de la C.-B. a permis de faire les prévisions suivantes del'abondance pour l'année 2000.

Stock combiné	Proportions de l'abondance et de l'échappée observée moins leurs prévisions respectives‡: Abondance	Échappée	Caractérisation de l'abondance prévu

Stock combiné	Proportions de l'abondance et de l'échappée observée moins leurs prévisions respectives[‡]		Caractérisation de l'abondance prévu
	Abondance	Échappée	
Zone 6	0,07	0,16	Bien en deçà de la moyenne
Babine	0,09	0,22	Bien en deçà de la moyenne
Zone 4-U	0,10	0,23	Bien en deçà de la moyenne
Zone 2E	0,16	0,31	En deçà de la moyenne
Zone 7	0,22	0,43	En deçà de la moyenne
Zone 2W	0,23	0,39	En deçà de la moyenne
Zone 4-L	0,23	0,63	En deçà de la moyenne
Zone 5	0,31	0,65	En deçà de la moyenne
Zone 3	0,33	0,77	En deçà de la moyenne
Zone 8	0,33	0,76	En deçà de la moyenne
Zone 1	0,51	0,81	Moyen

[‡] En postulant une distribution log-normale des probabilités cumulatives dont la moyenne et l'écart-type sont calculées sur la période d'observation allant de 1950 (1946 pour le stock combiné de Babine) à 1999 (années de remonte).

Impacts des pêches canadiennes d'intensité croissante

Les résultats d'une méthode simple servant à déterminer l'état de stocks de saumon coho regroupés sur de grandes zones géographiques par rapport deux p*oints de référence* (*PR*) potentiels semblent indiquer que les stocks combinés des zones 2W et 6 ne peuvent soutenir des pêches canadiennes d'intensité croissante. Mais il y a peut-être des possibilités limitées de pêches opportunes du coho de la haute Skeena qui ne poseraient qu'un faible risque de dommages irréversibles. Toutefois, les prévisions pour cette région ne sont pas suffisamment fiables pour permettre une pêche d'intensité croissante, même restreinte, en l'absence d'un indicateur qui pourrait prévenir des désastres imprévus en début de saison pour la survie du saumon, comme celui qui est survenu lors de l'entrée en mer de 1996. Un tel système a été mis au point pour la saison de pêche 2000 (Holtby 2000). Nous remarquons aussi que les propriétés de la démarche d'estimation des *PR* présentée ici n'ont pas été étudiées dans le contexte des stocks combinés représentés par l'indice d'effectif moyen pour un cours d'eau.

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1. Introduction

In this Research Paper we detail:

1. Performance of the 1999 forecasts for coho aggregates in north coastal British Columbia (Holtby et al. 1999a)
2. A forecast of marine survival and total return for the wild indicator stock of the Lachmach River (Area 3; Work Channel);
3. Forecasts of marine survival for the Toboggan Creek and Fort Babine hatchery indicators (Area 4; upper Skeena conservation area);
4. Forecasts of the total return and escapement of the Babine Lake (Area 4; upper Skeena conservation area) coho aggregate;
5. Forecasts of indices of total return to the coho of the Nass (Area 3); the lower Skeena (Area 4 lower); the upper Skeena (Area 4 upper); the three Statistical Areas of QCI (1, 2W & 2E), Principe/Grenville (Area 5), Kitimat (Area 6); and Areas 7 and 8 on the Central Coast; and
6. Forecasts of the escapement indices to all coho aggregates under 1999 fishing rates relative to putative Limit Reference Points derived from stock-recruitment analysis.

2. Data Sources

Catches and escapement data for coded-wire tagged coho from the Lachmach River (wild indicator) and Toboggan Creek and Fort Babine hatchery indicators were obtained from an online database maintained by the Alaskan Dept. of Fish and Game[1]. Coded-wire tag (CWT) recovery data for 1999 are preliminary and may change as catch and escapement estimates are finalized. Escapement data for Lachmach River coho were obtained from program sources in the Stock Assessment Division. Visual escapement estimates for streams in Areas 1 to 6 were obtained from a database maintained by the Stock Assessment Division in the Prince Rupert Office. (BS, DFO, Prince Rupert). Escapement data for the Babine Lake coho aggregate were obtained from a database maintained by the Stock Assessment Division in the Prince Rupert Office. (pers. comm. L. Jantz, DFO, Prince Rupert). Escapement data for Toboggan hatchery and wild coho were obtained from the Toboggan Creek Enhancement Society (pers. comm. M. O'Neill, TCES, Smithers). Visual escapement estimates for the streams in Areas 7 to 10 were obtained from a database maintained by Fisheries Operations in Bella Coola (pers. comm. L. Enderud, DFO, Bella Coola). All data from 1999 should be considered preliminary and subject to revision as escapement estimates are finalized.

Coho could not be retained in Canadian waters in 1999 as part of the conservation measures undertaken to protect upper Skeena coho. There were some exceptions in terminal areas where surpluses were identified. Where there were fisheries, coho that were caught were released with minimal harm. Estimates of the exploitation rate in Canadian waters range between 1% and 5%.

Many of the analyses presented in this Working Paper use reconstructed time series of exploitation rate on Skeena coho. These reconstructions are derived from relationships between exploitation rate and effort stratified for gear, area and time for the period 1965 to 1987. Exploitation rate estimates of fishery-specific exploitation rate derived from coded-wire tags first became available in 1988 in northern BC. The reconstructions are part of a comprehensive assessment of coho in the northern boundary area and will be summarized elsewhere (unpubl. data, Northern Boundary Technical Committee of the Pacific Salmon Commission, Vancouver, BC.; Holtby et al. 1999b)

3. Forecasting Models and Retrospective Analysis of Predictive Power.

3.1 Forecasting models

We use three approaches to forecasting in the Research Paper. Where there are time-series longer than about 15 years we use four quasi time-series models. In each model the variable being forecast (v_t) is first transformed so that

$$Z_t = \Im(v_t) \quad (1)$$

The Log transformation was used for abundance. The Logit transformation[2] was applied to proportions such as survival (*s*). The four models can then be described as follows:

mnemonic	model	Equation
LLY ("Like Last Year")	$Z_{t+1} = Z_t + \varepsilon_t$	(2)
3YRA (3-year average)	$Z_{t+1} = \frac{\sum_{k=t-2,t} Z_k}{3} + \varepsilon_t$	(3)
RAT1 (1 year trend)	$Z_{t+1} = \frac{Z_t^2}{Z_{t-1}} + \varepsilon_t$	(4)
RAT3 (average 3-year trend)	$Z_{t+1} = \frac{\sum_{k=t-2,t} Z_k / Z_{k-1}}{3} Z_t + \varepsilon_t$	(5)

[1] Alaska Department of Fish and Game, Commercial Fisheries: http://tagotoweb.adfg.state.ak.us

[2] $Z_t = \log \frac{v_t}{1 - v_t}$

For each model we assume that the error term is normally distributed $\left(\varepsilon \sim N(0,\sigma^2)\right)$ and is independent of time. For the purpose of 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)
project trends?	NO	LLY	3YRA
	YES	RAT1	RAT3

For Lachmach River coho the marine survival rate was predicted using a "sibling-regression" model, where the total return of age-n.1[3] fish ($A_{n.1}$) is predicted from the observed age-n.0 escapement of males ($E_{n.0}$, 'jacks'):

$$\log_e A_{n.1} = b \log_e E_{n.0} + a \tag{6}$$

Survival (s_{smolt}) was then calculated by dividing the age-n.1 return in year t by the number of smolts counted out of the system in year t-1 (N_{smolt}).

All of the approximately 25 coho populations spawning above the Babine River counting fish have been combined into the Babine Lake aggregate. For these coho we have estimates of total escapement from 1946 to 1999. The fence was not operated in 1964. The 1964 escapement in that year was estimated from the Skeena test-fishery index using an iterative contingency-table algorithm (Brown 1974) implemented in Excel®[4] (pers. comm. J. Blick, ADFG, Juneau, AK). Estimates of age composition of returning adults exist for 15 years in the 1970's and 1980's. Age composition in the escapement is significantly related to spawner numbers in the brood year. We used that relationship to estimate age composition in years for which there were no data. Using the reconstructed exploitation rate time-series we then estimated total recruitment and did a standard Ricker stock-recruitment analysis (Hilborn and Walters 1992). Recruitment for the 1996 brood year is not yet complete because a significant proportion of the returning adults are age 2.1. To estimate recruitment of age 2.1 fish in the next year we used the number of age-1.1 fish ($N_{1.1}$) and the estimated age composition ($p_{1.1}$) for the current year.

Estimates of escapement to individual streams throughout BC have been made since at least 1950. These estimates are mostly based on visual inspections of the streams. The methods used to inspect the streams,

[3] The age designation follows the European convention, which is "number of FW winters**.**number of ocean winters". In most northern coho escapement and catch is made up of a mixture of age 1.1 and age 2.1 adults with some age 3.1 animals.
[4] Registered trade-mark of Microsoft Corp., Redmond, WA. Mention of this product does not constitute endorsement.

and convert the counts to estimates of escapement, the frequency of surveys, etc., are largely undocumented. These methods are known to differ between systems and to have changed over time. The records are also fragmentary. For example, of the 51 streams surveyed at some point between 1950 and 1999 in the upper Skeena (Area 4), there is only one system where there are counts in more than 80% of the years (Babine aggregate) and only seven with counts in at least half of the years. Nevertheless we think that the time series do contain 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. We then scaled the escapement (*E*) in each stream *i* to the maximum escapement recorded in that stream across all years *t*:

$$p_{i,t} = \frac{E_{i,t}}{\max(E_i)} \tag{7}$$

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 the streams of 11 Statistical Areas[5].

In Areas 1, 5 and 7 no streams were surveyed in 1995 and 1996. We used a contingency table fill-in to estimate values of $p_{\max}$ in both areas. In Area 1 and 5, time series of $p_{\max}$ from Areas 4L and 6 were used. In Area 7 time series of $p_{\max}$ in Areas 6 and 8 were used. No streams have been surveyed in Area 10 since 1990 and in Area 9 streams have been surveyed in only two years after 1990. We did not attempt to estimate those missing data.

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 and Central Coast areas have very similar ocean distributions (Anon. 1994). Most coded-wire tags have been recovered in troll fisheries both in Alaska and northern B.C. This lead 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 and Central Coast. We also know from patterns of CWT recoveries that fish from the lower and middle Skeena are more similar to coho from the more southerly areas, while fish from the Babine have similar distributions to Area 3 coho. We therefore assumed that the exploitation rate time series developed for Babine coho was applicable to Area 1 and Area 3 coho, while the time series developed for Toboggan Creek was applicable to all of the remaining areas. In using the exploitation rate time series for Skeena populations, the FW components of those exploitation time series were removed

[5] Areas 1, 2E, 2W, 3, and 5 to 10. The Skeena (Area 4) was divided into the upper and lower/middle areas. The upper Skeena encompasses the Bulkley/Morice and all streams upstream of its confluence with the Skeena, with the exception of the Kispiox, which was included with the middle Skeena. Areas 9 and 10 were combined.

before application to the other areas. We have no CWT data from Areas 9 and 10, and so don't know where coho from those areas are distributed. Consequently, no attempts to reconstruct abundance were made for coho from either of those two Statistical Areas.

Forecasts for these large aggregates were then 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 2000 using observed spawner indices in 1997.

The 'average-stream' indices may be effective descriptors of status of coho within a geographical area. The areas covered by each aggregate here are smaller than those recently proposed (Anon. 1999). Some regrouping 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:

$$Z = \frac{x - \bar{x}}{SD} \tag{8}$$

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 $Z \pm 3$ (Figure 1).

3.2 Retrospective analyses

To compare the performance of the forecast models and select the 'best' model, we computed both the Root Mean Square Error (*RMSE*):

$$RMSE = \sqrt{\overline{\left(v_{observed,t+1} - v_{predicted,t+1}\right)^2}} \tag{9}$$

and the Mean Absolute Deviation (*MAD*):

$$MAD = \overline{\left|\left(v_{observed,t+1} - v_{predicted,t+1}\right)^2\right|} \tag{10}$$

Note that this calculation is performed in the variable space and not in the transformed (equation 1) space. Retrospective analysis of the stock-recruitment (S-R) models was done by using the most inclusive model, starting with the third year in the series (1952 in all but the Babine aggregate) and predicting the total return in BY+1 until the 1999 return. From the S-R and the four time series models, the model with the smallest *RMSE* and *MAD* was selected.

4. Marine Survival Estimates

4.1 1999 Forecasts compared to marine survivals observed in 1999

Marine survival data for the three northern indicators are given in Table 1. Holtby et al (1999) forecast marine survival rates for the Lachmach wild indicator and for the Toboggan Creek and Fort Babine hatchery indicators. As the following Table shows, survivals were lower than predicted for Lachmach River coho and for wild Toboggan coho but higher than predicted for the two Skeena hatcheries. Survival at Lachmach was between the 10^{th} and 25^{th} percentile of the forecast. Survival at Toboggan hatchery was between the 75^{th} and 90^{th} percentile and at the Fort Babine hatchery between the 50^{th} and 75^{th} percentile. The survival of wild Toboggan Creek coho was over-forecast. This forecast is based on a small set of estimated wild smolt outputs and wild returns. Although the scalar had seemed to be quite constant, it is possible that when survival conditions are good the scalar is much less than the 3.6× to 4× previously estimated (Holtby et al. 1999a).

indicator	forecasting model	forecast survival ($\hat{s}_{1999}$)	50% CI	observed survival (s_{1999})
Lachmach River	sibling regression	0.175	0.143 – 0.215	0.125
Toboggan Creek	regression on Lachmach survival	0.046	0.028 – 0.075	0.104
Toboggan Creek (wild)	observed scalar from hatchery survival	0.176	none given	0.120
Fort Babine	regression on Lachmach survival	0.033	0.014 – 0.076	0.051

4.2 Marine Survival Rate Forecast

The forecast for the total return of Lachmach coho was made with the following sibling regression:

$$\log(A\ \text{n.1}) = 5.8643 + 0.3826\log(E\ \text{n.0})$$
$$(N = 11;\ \text{adj. } r^2 = 0.531;\ P < 0.01)$$

The estimated jack escapement ($E_{\text{n.0}}$) in 1999 to Lachmach was 130, which leads to a forecast total return of 2,268, which is slightly below the mean of 2,808 (Table 1; 1989 to 1999 returns, *Z*-score=–0.36). The 1999 smolt run at Lachmach was $16{\times}10^3$ leading to a marine survival forecast of 0.14, which is above the mean of 0.09 (Table 1; 1987 to 1998 sea-entry). The confidence intervals for the Lachmach survival and abundance forecasts are detailed in Table 2 and in Figure 2.

Very few or no jacks return to interior sites so no sibling regression is possible for either Babine or Toboggan Creek. However, the temporal patterns in marine survival are similar for the three northern indicators (Figure 3), allowing us to use the Lachmach forecast to forecast survivals in the Skeena indicators. The relationship between Lachmach and Toboggan survivals:

$$\operatorname{logit}\left(s_{Toboggan}\right) = 0.885\operatorname{logit}\left(s_{Lachmach}\right) - 1.408$$

(N = 12; adj. r^2 = 0.28; $P < 0.05$)

gives a forecast survival at Toboggan of 0.05 (50%CI: 0.03 – 0.08; Table 2; Figure 3). That survival is above average, although the data time series is quite short.

The wild smolt output from Toboggan Creek in 1998 was 44×10^3 (95%CI: 36×10^3–54×10^3; SKR Consultants Ltd. 1999). The estimate is based on a mark-recapture estimate made using a trap near the confluence of Toboggan Creek and the Bulkley River. This is a much larger smolt run than would have appeared likely given the very poor return in 1997 (Holtby et al. 1999b), leading us to believe that FW survival might have been well above average for the 1997 brood year.

smolt year	estimated wild smolt number ($\times10^3$)	ratio of wild to hatchery marine survival	estimated wild survival
1995	38	3.895	0.097
1996	35	3.97	0.020
1997	42	3.61	0.067
1998	67	1.15	0.12
1999	44	est. 1.2	0.06

The variability of the ratio between observed hatchery and estimated wild survival (above Table) is too large to allow a useful forecast of wild survival or returns. If the scalar is the same as in 1999 (1998 sea-entry), wild survival estimated from the predicted survival of Toboggan hatchery coho would be 6% and the wild return would be 2.7×10^3. Assuming an exploitation rate of 22% (i.e., same as 1999), the wild escapement to Toboggan would be 2.1×10^3.

The same relationship for Fort Babine is much weaker largely because of the smaller time series and lower than expected survival for the 1995 brood year (Table 1). The predictive relationship is

$$\operatorname{logit}\left(s_{Babine}\right) = 1.449\operatorname{logit}\left(s_{Lachmach}\right) - 0.778$$

(N = 6; adj. r^2 = 0.30; P = 0.15)

The forecast survival for Babine coho is 0.03, which is unchanged from the 1999 forecast (Table 2; Figure 3). However, other than suggesting that survival will be above the mean of the very short time series, this prediction is not useful because its confidence interval is so broad.

5. Forecasts of abundance and escapement

5.1 Performance of the 1999 forecasts of abundance

Forecasts for abundance in 1999 were provided for Lachmach, Toboggan wild, the Babine aggregate, and the average-stream indices in Statistical Areas 3, 4-lower, 4-upper, 5, 6, 7 and 8. Performance of the 1999 forecasts is summarized in Table 15 and detailed for each area in Table 16 to Table 24. Realized abundance was between the 5th and 50th percentiles of the forecasts in all areas except the Babine and the upper Skeena (Area 4-upper). Of some concern are the poor returns to streams in Areas 6 and the generally poor returns to streams in Areas 5, 7 and 8.

5.2 Retrospective performance of forecasting models

For each of the aggregates, the performance as measured by the *RMSE* and *MAD* metrics is presented in Table 14. Only the results for the best two of the time-series models are presented, which in all cases were the LLY and 3YRA models. The S-R model was the best performer for the Area 1 (NQCI), Area 3 (the Nass), and Area 8 (the Bella Coola) aggregates and for all of Skeena (Babine Lake aggregate, Area 4U and 4L) aggregates.

5.3 2000 Abundance forecasts

Forecasts of abundance for the Lachmach wild indicator were presented in an earlier section (Table 2). Forecasts for the Babine Lake aggregate and for the average-stream index in the upper Skeena (Area 4-upper), the lower and middle Skeena (Area 4-lower), the Nass (Area 3), the Principe/Grenville Channel (Area 5), the Kitimat region (Area 6), the Bella Bella region (Area 7), the Bella Coola region (Area 8), and for the three areas on the Queen Charlotte Islands (Areas 1, 2W, 2E) were made following the same procedures, and are considered together in this section. The following Table summarizes the organization of data and forecast Tables and Figures. The Figures show the time series of total returns (Babine) or total return index (all other Areas) with S-R and 3YRA forecasts for 2000. The Figures also show the 1999 3YRA forecasts for each of the aggregates.

aggregate	data Table	forecast summary Table	relevant Figures
Babine Lake aggregate	Table 3	Table 31	Figure 5
upper Skeena	Table 4	Table 32	Figure 6
lower and middle Skeena	Table 5	Table 33	Figure 7
N QCI (Area 1)	Table 6	Table 27	Figure 8
W QCI (Area 2W)	Table 7	Table 28	Figure 9
E QCI (Area 2E)	Table 8	Table 29	Figure 10
Nass (Area 3)	Table 9	Table 30	Figure 11
Principe/Grenville (Area 5)	Table 10	Table 34	Figure 12
Kitimat (Area 6)	Table 11	Table 35	Figure 13
Bella Bella (Area 7)	Table 12	Table 36	Figure 14

aggregate	data Table	forecast summary Table	relevant Figures
Bella Coola (Area 8)	Table 13	Table 37	Figure 15
Central Coast (Areas 9 & 10)	not tabulated	no forecast given	Figure 16

Table 25 summarizes the results of the Ricker stock-recruitment model fits for the 11 coho aggregates. The time series for each aggregate are long with between 46 and 50 values and most 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. Consequently considerable caution must be used in interpreting forecasts generated with S-R models.

Table 26 summarizes the results of abundance forecasting for nBC coho aggregates. For all eight aggregates there are two abundance forecasts, one based on a stock-recruitment analysis and the other from the 3YRA time-series model. The forecasts for each aggregate are detailed in Table 27 to Table 37.

Abundance of all aggregates except NQCI is expected to be below the mean of the period 1950 to 1999 in 2000 (Table 26). Relative to mean abundance in each area over this period, the depression is most severe in Area 6 followed by the Babine Lake and upper Skeena aggregates. The QCIN, Area 3, Area 5 and Area 8 aggregates are the least depressed. The pattern of forecast abundance is in general agreement with the geographical pattern of the 1997 escapement disaster (Holtby et al. 1999b).

Forecasts of escapement are dependent not only on forecast abundance but also on exploitation rate. Alaskan exploitation rates ranged between 30% and 60% on Skeena CWT groups in 1999 and were largely unchanged from immediate past years. Alaskan exploitation rates are likely to remain the same in 2000. Therefore, at most 70% or as little as 40% of forecast abundance would be available for escapement in the absence of Canadian fisheries.

5.4 Forecast abundance, incremental exploitation and *Limit Reference Point*s

Fixed proportions of 'carrying-capacity' estimates derived from stock-recruitment relationships have been suggested as robust reference points or *RP*s, and ten to 15 percent of carrying capacity has been suggested as a suitable *Limit Reference Point*[6] (*LRP*) for salmonid populations (Johnston et al. 2000). The derivation of the 'average-stream' index of abundance suggests a simple approach to constructing a status index for a coho aggregate and for implementing a rudimentary (i.e., simplistic) basis for advising on fishery impacts on large coho aggregates. That advice to Canadian fisheries management must be formulated in terms of incremental Canadian exploitation because all of the coho populations in northern BC are currently exploited in Alaskan fisheries.

[6] The *Limit Reference Point* is generally interpreted as the level of abundance where fishing should stop. At abundance levels less than the *LRP,* the risk that the stock cannot rebuild to levels where there is harvestable surplus within a 'reasonable' period of time increases rapidly. The probability of escapement falling below the *LRP* should be held to a specified level to control the risk of such damage.

For the Babine aggregate and the 'average-streams' we have developed and presented expectations for abundance in 2000 with associated probability distributions. These probability distributions of abundance can be passed through fisheries to estimate probability distributions of escapement, which can then be compared to any *Reference Point* (*RP*). We have also fitted Ricker stock-recruitment relationship to each aggregate (Table 25). For these relationships, $S_{max,}$ which is the escapement producing the maximum recruitment (R_{max}), can be estimated as b/a. Two potential *RP*s were set at values of 10% and 20% of $1.2{\times}S_{max}$. The carrying capacity derived from the Ricker curves was expanded by a factor of 1.2 to inflate the value derived for the Babine aggregate to a value closer to the carrying capacity estimate derived from a simple habitat capacity measure (Holtby et al. 1999b). This modest inflation of the calculation should make the calculations more conservative but the extent of the protection afforded the lower productivity populations in the aggregate is not known. We also note that S_{max} is equivalent to *B*, the asymptotic recruitment at high spawner density in the Beverton-Holt stock-recruitment function and therefore that our proposed *RP*s are equivalent to those proposed for steelhead (Johnston et al. 2000).

We calculated distributions of forecast abundance in $\log_e$-transformed space for *Z*-scores from –10 to +10 at 0.05 intervals, transformed to normal space, and reduced abundance to account for Alaskan fishing using the average exploitation rate over the past three years. Potential incremental Canadian exploitation rates were set at 1% intervals from 0 to 10% and at 5% intervals from 15% to 50%. Abundance was again reduced to account for this set of potential Canadian fisheries and the resulting distributions compared against the two *RP*s. For each level of incremental fishing, the proportion of the distribution of escapement falling below the *RP*s was determined. These values are plotted for each aggregate (Figure 17 to Figure 26). The forecast abundance as proportions of S_{max} are also presented in the forecast tables (Table 27 to Table 37) and summarized for all aggregates in Table 38.

Escapement in Area 6 and in QCIW is not expected to reach either *RP* given Alaskan fishing (Figure 19; Figure 22, respectively). Escapement to Babine (Figure 17) and more generally to Area 4-Upper (Figure 18) would not reach the more conservative of the *RP*s with even low levels of incremental fishing but would reach the lower *RP* at all incremental fishing rates examined. The impacts of incremental fishing would be similar to those in Area 4-Upper in QCIE (Figure 23), Area 5 (Figure 24) and Area 7 (Figure 20). In the remaining Areas (QCIN, Area 3, Area 4-Lower), escapement would have a high probability of reaching both *RP*s at most of the incremental fishing rates examined.

From this simple analysis we might conclude that in the upper Skeena decisions about the incremental fisheries will involve the tradeoffs between economic benefits and desired rebuilding rates rather than risks of irreversible damage. That is not the case for Area 6 and Area 2W coho, where status appears to be very poor. The status of coho in Areas neighboring Area 6 (Area 2E and Area 5 and Area 7), while not as dire is clearly not as robust as in the northern Areas (1, 3, and 4-lower; Figure 26; Figure 25; Figure 27) or the southern most Area 8 (Figure 21).

6. Conclusions

6.1 Marine survival

In 2000, marine survival at the three northern indicators is expected to be above the mean of their respective periods of observation.

indicator	model	$\hat{s}_{2000}$	(50% CI)	observed mean and period of observation (year of sea-entry)
Lachmach	sibling regression	0.14	(0.11–0.17)	0.091 (1987 – 1998)
Toboggan Creek hatchery	from Lachmach	0.05	(0.03–0.08)	0.029 (1987 – 1998)
Fort Babine hatchery	from Lachmach	0.03	(0.02–0.06)	0.024 (1993 – 1998)

The period of observation is short for all three indicators. The forecast for Fort Babine is poorly defined. The survival rate of wild Toboggan Creek coho should be comparable to Lachmach but cannot be reliably forecast.

6.2 Abundance forecast

The forecast total return of Lachmach coho is 2.3×10^3, which is below the mean of 2.8×10^3 observed over the period 1988 to 1999. Smolt production from Toboggan Creek in 1999 was estimated to have been 44×10^3, indicating high FW survival. Assuming that wild survival will be 1.2-times that of the forecast survival for hatchery coho (the same expansion observed for the 1999 return) the total return of wild Toboggan coho could be 2.7×10^3, or 56% of the mean total return of 4.8×10^3 observed between 1988 and 1999.

After the application of stock-recruitment and time-series models to reconstructions of abundance in 11 aggregate stocks in north coastal British Columbia, we conclude the following about abundance in 2000:

aggregate	proportions of observed abundance and escapement less than forecasts‡		characterization of forecast abundance
	abundance	escapement	
Area 6	0.07	0.16	well below average
Babine	0.09	0.22	well below average
Area 4-U	0.10	0.23	well below average
Area 2E	0.16	0.31	below average
Area 7	0.22	0.43	below average
Area2W	0.23	0.39	below average
Area 4-L	0.23	0.63	below average
Area 5	0.31	0.65	below average
Area 3	0.33	0.77	below average
Area 8	0.33	0.76	below average
Area 1	0.51	0.81	average

‡ Assuming a log-normal cumulative probability distribution with mean and standard deviation calculated over the observation period 1950 (1946 for Babine) to 1999 (return years).

In the context of a simple approach to determining the status of coho within large geographic aggregates relative to two potential *Reference Points* (*RP*), the aggregates of Area 2W and Area 6 appear unable to support incremental Canadian fisheries. There are potentially some limited incidental fishing opportunities available on coho from the upper Skeena that would have limited risk of irreversible damage. However, forecasts for this area have not proven sufficiently reliable to proceed with incremental fishing, even if modest, without an early in-season indicator that would warn of unforeseen survival disasters such as the one that occurred in 1996 sea-entry. Such a system has been developed for the 2000 fishing season (Holtby 2000). We also note that the properties of the approach presented here for the estimation of *RP*s have not been explored in the context of aggregates represented by the average-stream index.

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Table 1. Marine survival rate estimates at three northern BC coho indicators. Toboggan and Fort Babine are hatchery indicators. Lachmach is a wild indicator. The stock size for Toboggan Creek is the wild component only.

	marine survival rates			total stock size	
return year	Lachmach	Toboggan	Fort Babine	Lachmach	Toboggan
1988	0.030	0.021		2,146	1,689
1989	0.044	0.027		1,590	5,498
1990	0.113	0.041		4,116	8,842
1991	0.121	0.060		4,194	8,125
1992	0.088	0.017		1,679	5,897
1993	0.061	0.028		2,065	3,638
1994	0.174	0.060	0.040	4,570	5,779
1995	0.082	0.018	0.010	3,223	2,736
1996	0.072	0.025	0.031	3,925	3,708
1997	0.055	0.005	0.006	1,728	691
1998	0.096	0.018	0.007	2,025	2,823
1999	0.125	0.104	0.051	2,437	7,872

Table 2. Forecasts of marine survival for three northern BC coho indicators and abundance for the Lachmach River, with associated confidence intervals. '*A*' is total abundance while '*s*' is marine survival.

	Lachmach		Toboggan	Fort Babine
probability of smaller return or survival	$\hat{A}_{2000}$	$\hat{s}_{2000}$		
99%	5242	0.323	0.281	0.55
95%	3906	0.241	0.16	0.21
90%	3417	0.211	0.12	0.13
75%	2792	0.172	0.08	0.06
50%	**2267**	**0.140**	**0.05**	**0.03**
25%	1842	0.114	0.03	0.02
10%	1505	0.093	0.02	0.008
5%	1316	0.081	0.012	0.004
1%	981	0.061	0.006	0.0009

Table 3. Stock-recruit data for the Babine coho aggregate.

brood year	total escapement	exploitation rate	proportion age 3	R/S
1946	13411	0.55	0.65	1.895
1947	10815	0.55	0.65	3.441
1948	13734	0.55	0.65	2.473
1949	12961	0.55	0.52	1.521
1950	11654	0.55	0.59	0.950
1951	2276	0.55	0.51	6.400
1952	10554	0.55	0.53	1.887
1953	7655	0.55	0.57	2.199
1954	3359	0.55	0.80	4.366
1955	9714	0.55	0.60	2.236
1956	9857	0.55	0.67	2.096
1957	4421	0.55	0.78	5.480
1958	8438	0.55	0.62	4.218
1959	12004	0.55	0.62	1.989
1960	7942	0.55	0.75	3.117
1961	14416	0.55	0.65	2.602
1962	15183	0.55	0.56	2.084
1963	7737	0.50	0.67	4.064
1964	10689	0.63	0.49	3.465
1965	22985	0.48	0.47	0.649
1966	13377	0.59	0.67	1.343
1967	12487	0.47	0.59	1.915
1968	13054	0.59	0.27	1.296
1969	6702	0.50	0.52	3.039
1970	10404	0.57	0.55	2.243
1971	9909	0.57	0.53	2.602
1972	5381	0.66	0.70	1.631
1973	11606	0.51	0.60	1.608
1974	13661	0.56	0.71	1.462
1975	4913	0.46	0.60	6.468
1976	4499	0.46	0.60	2.668
1977	10474	0.59	0.46	1.894
1978	11861	0.69	0.78	0.339
1979	2909	0.71	0.77	3.296
1980	5046	0.74	0.78	3.599
1981	2486	0.67	0.36	3.006
1982	2673	0.58	0.79	4.229
1983	3402	0.81	0.74	5.193
1984	3241	0.72	0.54	2.128
1985	2129	0.75	0.85	4.999
1986	3671	0.83	0.81	4.483
1987	2101	0.64	0.90	10.373
1988	3225	0.63	0.81	5.609
1989	5228	0.67	0.77	1.222
1990	5619	0.74	0.81	2.355
1991	4941	0.77	0.78	5.021
1992	1714	0.70	0.73	9.495
1993	2186	0.72	0.72	3.084
1994	4053	0.86	0.74	0.717
1995	2345	0.87	0.81	6.080
1996	2669	0.67	0.80	8.641
1997	453	0.55	0.76	
1998	4291	0.60	0.80	

brood year	total escapement	exploitation rate	proportion age 3	R/S
1999	14908	0.46	0.79	

Table 4. For the upper Skeena aggregate (Area 4U), indices of escapement and total return derived from visual stream counts. To translate the *Z-score* to proportions of the cumulative probability distribution use Figure 1.

				escapement		total return		
year	exploitation rate	records	pmax	N	Z-score	N	Z-score	R/S
1950	0.549	17	0.391	8.02E+02	0.71	1.78E+03	0.32	2.323
1951	0.549	17	0.284	5.83E+02	-0.02	1.29E+03	-0.29	3.445
1952	0.549	16	0.449	9.23E+02	1.11	2.04E+03	0.65	2.395
1953	0.549	22	0.402	8.26E+02	0.79	1.83E+03	0.39	2.217
1954	0.549	18	0.422	8.66E+02	0.92	1.92E+03	0.50	1.765
1955	0.549	22	0.474	9.74E+02	1.28	2.16E+03	0.80	2.222
1956	0.549	19	0.504	1.04E+03	1.49	2.29E+03	0.97	1.889
1957	0.549	15	0.242	4.97E+02	-0.31	1.10E+03	-0.53	3.510
1958	0.549	24	0.484	9.94E+02	1.35	2.20E+03	0.85	1.998
1959	0.549	23	0.463	9.50E+02	1.20	2.10E+03	0.73	2.292
1960	0.549	25	0.379	7.78E+02	0.62	1.72E+03	0.25	2.609
1961	0.549	19	0.392	8.05E+02	0.71	1.78E+03	0.33	2.295
1962	0.549	23	0.507	1.04E+03	1.50	2.31E+03	0.98	1.360
1963	0.500	24	0.481	9.89E+02	1.33	1.98E+03	0.57	1.261
1964	0.628	23	0.383	7.86E+02	0.65	2.11E+03	0.74	1.440
1965	0.483	23	0.359	7.37E+02	0.49	1.43E+03	-0.12	1.770
1966	0.591	22	0.279	5.72E+02	-0.06	1.40E+03	-0.15	2.479
1967	0.473	20	0.259	5.31E+02	-0.20	1.01E+03	-0.64	3.196
1968	0.587	19	0.268	5.50E+02	-0.13	1.33E+03	-0.24	3.975
1969	0.505	26	0.304	6.25E+02	0.12	1.26E+03	-0.32	3.874
1970	0.569	24	0.349	7.17E+02	0.42	1.66E+03	0.18	2.346
1971	0.571	14	0.365	7.50E+02	0.53	1.75E+03	0.29	1.533
1972	0.658	12	0.480	9.85E+02	1.32	2.88E+03	1.70	0.443
1973	0.512	11	0.404	8.30E+02	0.80	1.70E+03	0.23	1.332
1974	0.563	8	0.351	7.20E+02	0.43	1.65E+03	0.16	3.487
1975	0.461	9	0.096	1.97E+02	-1.31	3.65E+02	-1.45	11.186
1976	0.458	9	0.145	2.97E+02	-0.98	5.49E+02	-1.22	5.002
1977	0.588	9	0.398	8.17E+02	0.76	1.98E+03	0.58	3.123
1978	0.687	9	0.509	1.05E+03	1.52	3.34E+03	2.28	1.285
1979	0.712	4	0.055	1.14E+02	-1.59	3.95E+02	-1.41	2.020
1980	0.740	6	0.407	8.35E+02	0.82	3.21E+03	2.12	2.722
1981	0.667	7	0.245	5.04E+02	-0.29	1.51E+03	-0.01	3.226
1982	0.581	5	0.219	4.51E+02	-0.47	1.07E+03	-0.56	5.401
1983	0.807	6	0.267	5.49E+02	-0.14	2.84E+03	1.65	3.971
1984	0.719	8	0.189	3.88E+02	-0.68	1.38E+03	-0.18	1.525
1985	0.754	4	0.241	4.96E+02	-0.32	2.01E+03	0.62	1.025
1986	0.828	6	0.260	5.33E+02	-0.19	3.10E+03	1.98	1.552
1987	0.639	6	0.128	2.63E+02	-1.09	7.28E+02	-0.99	4.069
1988	0.630	5	0.068	1.39E+02	-1.50	3.76E+02	-1.43	6.628
1989	0.674	7	0.114	2.33E+02	-1.19	7.16E+02	-1.01	2.230
1990	0.738	8	0.128	2.63E+02	-1.09	1.00E+03	-0.65	3.428
1991	0.769	7	0.132	2.71E+02	-1.06	1.17E+03	-0.44	3.741

year	exploitation rate	records	pmax	escapement		total return		R/S
				N	Z-score	N	Z-score	
1992	0.703	8	0.077	1.58E+02	-1.44	5.34E+02	-1.24	1.774
1993	0.724	8	0.067	1.38E+02	-1.51	5.00E+02	-1.28	2.059
1994	0.690	6	0.232	4.76E+02	-0.38	1.53E+03	0.02	1.172
1995	0.577	4	0.040	8.21E+01	-1.69	1.94E+02	-1.66	14.730
1996	0.673	2	0.067	1.37E+02	-1.51	4.18E+02	-1.38	6.775
1997	0.443	3	0.019	3.99E+01	-1.84	7.17E+01	-1.82	
1998	0.574	7	0.275	5.64E+02	-0.09	1.32E+03	-0.25	
1999	0.360	9	0.321	6.59E+02	0.23	1.03E+03	-0.61	

Table 5. For the lower Skeena aggregate (Area 4L), indices of escapement and total return derived from visual stream counts.

year	exploitation rate	records	pmax	escapement		total return		R/S
				N	Z-score	N	Z-score	
1950	0.549	29	0.191	7.84E+02	-0.56	1.74E+03	-0.67	2.306
1951	0.549	29	0.243	9.99E+02	-0.07	2.21E+03	-0.35	2.144
1952	0.549	21	0.256	1.05E+03	0.05	2.33E+03	-0.27	2.138
1953	0.549	24	0.179	7.34E+02	-0.68	1.63E+03	-0.74	3.363
1954	0.549	22	0.230	9.45E+02	-0.19	2.09E+03	-0.43	3.512
1955	0.549	24	0.243	1.00E+03	-0.07	2.22E+03	-0.35	3.537
1956	0.549	23	0.253	1.04E+03	0.02	2.30E+03	-0.29	2.248
1957	0.549	23	0.299	1.23E+03	0.46	2.72E+03	-0.02	1.753
1958	0.549	25	0.468	1.92E+03	2.04	4.26E+03	0.99	1.005
1959	0.549	6	0.264	1.09E+03	0.13	2.40E+03	-0.23	1.545
1960	0.549	11	0.246	1.01E+03	-0.04	2.24E+03	-0.34	2.589
1961	0.549	25	0.223	9.15E+02	-0.26	2.03E+03	-0.47	4.637
1962	0.549	23	0.196	8.06E+02	-0.51	1.78E+03	-0.63	5.160
1963	0.500	11	0.183	7.53E+02	-0.63	1.51E+03	-0.82	4.215
1964	0.628	32	0.395	1.63E+03	1.36	4.37E+03	1.06	2.016
1965	0.483	40	0.509	2.09E+03	2.43	4.05E+03	0.85	2.234
1966	0.591	54	0.430	1.77E+03	1.69	4.32E+03	1.03	1.376
1967	0.473	45	0.175	7.21E+02	-0.70	1.37E+03	-0.91	4.112
1968	0.587	52	0.632	2.60E+03	3.58	6.29E+03	2.32	1.255
1969	0.505	56	0.257	1.06E+03	0.06	2.14E+03	-0.40	2.697
1970	0.569	54	0.304	1.25E+03	0.50	2.90E+03	0.10	1.467
1971	0.571	55	0.320	1.32E+03	0.65	3.07E+03	0.21	1.319
1972	0.658	55	0.297	1.22E+03	0.44	3.57E+03	0.54	1.188
1973	0.512	52	0.205	8.44E+02	-0.42	1.73E+03	-0.67	2.032
1974	0.563	52	0.212	8.71E+02	-0.36	1.99E+03	-0.50	2.654
1975	0.461	50	0.174	7.16E+02	-0.72	1.33E+03	-0.93	3.722
1976	0.458	50	0.216	8.89E+02	-0.32	1.64E+03	-0.73	2.749
1977	0.588	50	0.184	7.55E+02	-0.63	1.83E+03	-0.60	3.479
1978	0.687	52	0.233	9.59E+02	-0.16	3.07E+03	0.21	1.937
1979	0.712	45	0.142	5.84E+02	-1.02	2.03E+03	-0.47	2.020
1980	0.740	53	0.196	8.07E+02	-0.51	3.11E+03	0.23	4.840
1981	0.667	52	0.151	6.22E+02	-0.93	1.87E+03	-0.58	5.526
1982	0.581	47	0.187	7.70E+02	-0.59	1.84E+03	-0.60	6.903
1983	0.807	52	0.179	7.37E+02	-0.67	3.81E+03	0.70	9.924

year	exploitation rate	records	pmax	escapement N	escapement Z-score	total return N	total return Z-score	R/S
1984	0.719	54	0.277	1.14E+03	0.25	4.05E+03	0.86	2.054
1985	0.754	36	0.148	6.07E+02	-0.96	2.47E+03	-0.19	2.521
1986	0.828	49	0.411	1.69E+03	1.50	9.82E+03	4.64	2.191
1987	0.639	35	0.296	1.21E+03	0.42	3.37E+03	0.40	4.007
1988	0.630	28	0.066	2.69E+02	-1.73	7.27E+02	-1.33	14.039
1989	0.674	39	0.222	9.12E+02	-0.27	2.80E+03	0.03	2.548
1990	0.738	48	0.326	1.34E+03	0.71	5.12E+03	1.56	1.771
1991	0.769	42	0.251	1.03E+03	0.01	4.46E+03	1.12	2.817
1992	0.703	46	0.196	8.05E+02	-0.51	2.71E+03	-0.03	2.511
1993	0.724	34	0.115	4.73E+02	-1.27	1.72E+03	-0.68	2.899
1994	0.690	25	0.258	1.06E+03	0.07	3.42E+03	0.44	1.258
1995	0.577	19	0.217	8.91E+02	-0.32	2.11E+03	-0.42	2.598
1996	0.673	15	0.150	6.16E+02	-0.94	1.88E+03	-0.57	3.237
1997	0.443	15	0.076	3.13E+02	-1.64	5.62E+02	-1.44	
1998	0.574	29	0.264	1.09E+03	0.13	2.55E+03	-0.13	
1999	0.200	12	0.378	1.55E+03	1.19	1.94E+03	-0.53	

Table 6. For the NQCI aggregate (Area 1), indices of escapement and total return derived from visual stream counts.

year	exploitation rate	records	pmax	escapement N	escapement Z-score	total return N	total return Z-score	R/S
1950	0.549	8	0.333	4.82E+03	0.68	1.07E+04	0.23	1.579
1951	0.549	9	0.303	4.38E+03	0.47	9.70E+03	0.04	2.074
1952	0.549	7	0.171	2.47E+03	-0.46	5.47E+03	-0.80	2.101
1953	0.549	4	0.170	2.47E+03	-0.46	5.46E+03	-0.80	2.100
1954	0.549	7	0.343	4.96E+03	0.75	1.10E+04	0.29	1.238
1955	0.549	5	0.190	2.75E+03	-0.32	6.10E+03	-0.67	2.317
1956	0.549	6	0.117	1.69E+03	-0.83	3.74E+03	-1.14	4.549
1957	0.549	8	0.232	3.36E+03	-0.03	7.44E+03	-0.41	1.897
1958	0.549	7	0.127	1.84E+03	-0.76	4.08E+03	-1.07	6.169
1959	0.549	10	0.313	4.52E+03	0.54	1.00E+04	0.10	2.075
1960	0.549	13	0.125	1.81E+03	-0.77	4.02E+03	-1.09	4.813
1961	0.549	12	0.315	4.56E+03	0.55	1.01E+04	0.11	3.722
1962	0.549	11	0.417	6.03E+03	1.26	1.34E+04	0.76	1.944
1963	0.500	10	0.107	1.55E+03	-0.90	3.10E+03	-1.27	3.198
1964	0.628	13	0.453	6.55E+03	1.52	1.76E+04	1.60	0.717
1965	0.483	13	0.568	8.22E+03	2.32	1.59E+04	1.26	0.446
1966	0.591	10	0.145	2.09E+03	-0.64	5.12E+03	-0.87	2.262
1967	0.473	13	0.172	2.49E+03	-0.44	4.73E+03	-0.94	2.544
1968	0.587	11	0.133	1.92E+03	-0.72	4.65E+03	-0.96	2.699
1969	0.505	8	0.072	1.04E+03	-1.14	2.11E+03	-1.46	8.313
1970	0.569	13	0.264	3.83E+03	0.20	8.88E+03	-0.13	2.817
1971	0.571	15	0.070	1.01E+03	-1.16	2.36E+03	-1.41	13.775
1972	0.658	15	0.229	3.31E+03	-0.05	9.66E+03	0.03	3.797
1973	0.512	15	0.241	3.48E+03	0.03	7.14E+03	-0.47	4.242
1974	0.563	15	0.499	7.22E+03	1.84	1.65E+04	1.38	1.996
1975	0.461	15	0.365	5.28E+03	0.90	9.81E+03	0.06	3.374
1976	0.458	15	0.633	9.16E+03	2.78	1.69E+04	1.46	1.343
1977	0.588	15	0.325	4.70E+03	0.62	1.14E+04	0.37	1.508

year	exploitation rate	records	pmax	escapement N	escapement Z-score	total return N	total return Z-score	R/S
1978	0.687	15	0.414	5.99E+03	1.25	1.92E+04	1.90	1.388
1979	0.712	15	0.313	4.53E+03	0.54	1.57E+04	1.23	2.020
1980	0.740	13	0.124	1.80E+03	-0.78	6.91E+03	-0.51	8.838
1981	0.667	15	0.169	2.44E+03	-0.47	7.35E+03	-0.43	5.402
1982	0.581	15	0.285	4.13E+03	0.34	9.84E+03	0.06	4.083
1983	0.807	14	0.232	3.36E+03	-0.03	1.74E+04	1.55	5.610
1984	0.719	15	0.263	3.80E+03	0.19	1.35E+04	0.79	2.570
1985	0.754	15	0.216	3.12E+03	-0.14	1.27E+04	0.63	2.108
1986	0.828	15	0.279	4.03E+03	0.30	2.34E+04	2.74	1.663
1987	0.639	15	0.290	4.19E+03	0.38	1.16E+04	0.41	1.996
1988	0.630	15	0.177	2.55E+03	-0.41	6.90E+03	-0.52	3.212
1989	0.674	11	0.137	1.98E+03	-0.69	6.09E+03	-0.68	6.140
1990	0.738	6	0.139	2.01E+03	-0.68	7.67E+03	-0.36	8.223
1991	0.769	7	0.151	2.19E+03	-0.59	9.45E+03	-0.01	3.425
1992	0.703	6	0.128	1.85E+03	-0.75	6.24E+03	-0.65	3.128
1993	0.724	2	0.411	5.94E+03	1.22	2.16E+04	2.38	0.882
1994	0.690	0	0.000	0.00E+00	-1.65	8.58E+03	-0.19	2.218
1995	0.577	0	0.000	0.00E+00	-1.65	5.78E+03	-0.74	3.740
1996	0.673	0	0.000	0.00E+00	-1.65	5.82E+03	-0.73	4.796
1997	0.443	0	0.000	0.00E+00	-1.65	4.33E+03	-1.02	
1998	0.574	12	0.247	3.57E+03	0.07	8.37E+03	-0.23	
1999	0.457	8	0.388	5.62E+03	1.06	1.03E+04	0.16	

Table 7. For the WQCI aggregate (Area 2W), indices of escapement and total return derived from visual stream counts.

year	exploitation rate	records	pmax	escapement N	escapement Z-score	total return N	total return Z-score	R/S
1950	0.527	13	0.443	6.55E+02	1.94	1.38E+03	1.75	1.144
1951	0.527	21	0.500	7.39E+02	2.35	1.56E+03	2.15	1.282
1952	0.527	16	0.344	5.09E+02	1.23	1.08E+03	1.06	0.621
1953	0.527	17	0.128	1.89E+02	-0.32	3.99E+02	-0.46	2.195
1954	0.527	14	0.417	6.16E+02	1.75	1.30E+03	1.57	1.268
1955	0.527	13	0.125	1.84E+02	-0.34	3.89E+02	-0.48	3.231
1956	0.527	6	0.064	9.44E+01	-0.78	2.00E+02	-0.91	6.473
1957	0.527	9	0.241	3.57E+02	0.49	7.54E+02	0.34	3.036
1958	0.527	7	0.264	3.90E+02	0.65	8.24E+02	0.49	2.434
1959	0.527	5	0.075	1.11E+02	-0.70	2.35E+02	-0.83	6.885
1960	0.527	9	0.386	5.70E+02	1.53	1.20E+03	1.35	1.544
1961	0.527	11	0.285	4.21E+02	0.81	8.90E+02	0.64	3.211
1962	0.527	3	0.333	4.93E+02	1.15	1.04E+03	0.98	2.419
1963	0.478	6	0.117	1.73E+02	-0.40	3.31E+02	-0.61	8.854
1964	0.606	14	0.465	6.88E+02	2.10	1.75E+03	2.56	1.301
1965	0.462	8	0.267	3.94E+02	0.68	7.32E+02	0.29	1.744
1966	0.569	15	0.559	8.26E+02	2.77	1.92E+03	2.95	0.636
1967	0.451	16	0.343	5.06E+02	1.22	9.22E+02	0.71	1.061
1968	0.565	14	0.251	3.71E+02	0.56	8.52E+02	0.56	1.000
1969	0.484	16	0.149	2.21E+02	-0.16	4.28E+02	-0.39	1.385
1970	0.547	14	0.208	3.08E+02	0.26	6.80E+02	0.17	0.183
1971	0.550	10	0.095	1.40E+02	-0.55	3.12E+02	-0.65	0.617

year	exploitation rate	records	pmax	escapement N	escapement Z-score	total return N	total return Z-score	R/S
1972	0.636	12	0.114	1.69E+02	-0.42	4.64E+02	-0.31	0.826
1973	0.490	6	0.019	2.86E+01	-1.10	5.60E+01	-1.23	5.990
1974	0.541	5	0.018	2.60E+01	-1.11	5.67E+01	-1.23	9.160
1975	0.440	10	0.051	7.50E+01	-0.87	1.34E+02	-1.05	5.590
1976	0.436	4	0.057	8.39E+01	-0.83	1.49E+02	-1.02	6.513
1977	0.566	7	0.060	8.94E+01	-0.80	2.06E+02	-0.89	6.750
1978	0.666	13	0.065	9.67E+01	-0.77	2.89E+02	-0.71	6.278
1979	0.690	11	0.131	1.93E+02	-0.30	6.24E+02	0.05	2.020
1980	0.718	15	0.081	1.19E+02	-0.66	4.24E+02	-0.40	5.399
1981	0.646	13	0.213	3.14E+02	0.29	8.87E+02	0.64	0.907
1982	0.559	13	0.049	7.26E+01	-0.88	1.65E+02	-0.98	6.392
1983	0.785	11	0.124	1.83E+02	-0.35	8.50E+02	0.55	3.586
1984	0.697	16	0.066	9.72E+01	-0.76	3.21E+02	-0.63	4.439
1985	0.732	18	0.041	6.13E+01	-0.94	2.29E+02	-0.84	6.907
1986	0.806	19	0.110	1.62E+02	-0.45	8.36E+02	0.52	1.730
1987	0.617	22	0.096	1.42E+02	-0.55	3.70E+02	-0.52	2.859
1988	0.608	23	0.140	2.07E+02	-0.23	5.28E+02	-0.17	2.235
1989	0.652	24	0.061	9.02E+01	-0.80	2.59E+02	-0.77	4.448
1990	0.716	21	0.060	8.87E+01	-0.80	3.13E+02	-0.65	5.165
1991	0.747	22	0.094	1.39E+02	-0.56	5.50E+02	-0.12	2.191
1992	0.681	21	0.070	1.03E+02	-0.73	3.25E+02	-0.63	3.248
1993	0.703	21	0.105	1.55E+02	-0.48	5.22E+02	-0.18	2.212
1994	0.665	19	0.081	1.20E+02	-0.65	3.58E+02	-0.55	3.480
1995	0.558	22	0.066	9.82E+01	-0.76	2.22E+02	-0.86	7.221
1996	0.636	23	0.127	1.87E+02	-0.33	5.15E+02	-0.20	1.860
1997	0.419	16	0.028	4.18E+01	-1.03	7.20E+01	-1.19	
1998	0.564	21	0.283	4.19E+02	0.80	9.61E+02	0.80	
1999	0.300	16	0.148	2.18E+02	-0.18	3.12E+02	-0.65	

Table 8. For the EQCI aggregate (Area 2E), indices of escapement and total return derived from visual stream counts.

year	exploitation rate	records	pmax	escapement N	escapement Z-score	total return N	total return Z-score	R/S
1950	0.549	32	0.112	3.70E+02	-0.99	8.19E+02	-1.27	4.086
1951	0.549	31	0.278	9.20E+02	0.35	2.04E+03	0.10	1.652
1952	0.549	43	0.405	1.34E+03	1.38	2.97E+03	1.15	0.935
1953	0.549	35	0.183	6.06E+02	-0.42	1.34E+03	-0.68	2.658
1954	0.549	32	0.242	8.03E+02	0.06	1.78E+03	-0.19	2.306
1955	0.549	21	0.152	5.03E+02	-0.67	1.11E+03	-0.94	4.127
1956	0.549	24	0.202	6.68E+02	-0.27	1.48E+03	-0.53	3.306
1957	0.549	27	0.247	8.19E+02	0.10	1.81E+03	-0.15	2.797
1958	0.549	26	0.261	8.64E+02	0.21	1.91E+03	-0.04	3.128
1959	0.549	27	0.317	1.05E+03	0.67	2.33E+03	0.43	2.430
1960	0.549	30	0.276	9.14E+02	0.33	2.02E+03	0.08	3.226
1961	0.549	25	0.369	1.22E+03	1.09	2.71E+03	0.86	2.465
1962	0.549	31	0.367	1.22E+03	1.07	2.69E+03	0.84	2.327
1963	0.500	26	0.353	1.17E+03	0.95	2.34E+03	0.44	3.241
1964	0.628	35	0.439	1.46E+03	1.65	3.91E+03	2.21	1.454
1965	0.483	25	0.250	8.28E+02	0.12	1.60E+03	-0.39	3.008

year	exploitation rate	records	pmax	escapement N	escapement Z-score	total return N	total return Z-score	R/S
1966	0.591	40	0.588	1.95E+03	2.86	4.77E+03	3.17	1.848
1967	0.473	44	0.357	1.18E+03	0.99	2.24E+03	0.33	2.534
1968	0.587	42	0.239	7.92E+02	0.04	1.92E+03	-0.04	2.736
1969	0.505	45	0.507	1.68E+03	2.20	3.40E+03	1.63	1.720
1970	0.569	27	0.511	1.69E+03	2.23	3.93E+03	2.23	1.083
1971	0.571	13	0.198	6.56E+02	-0.30	1.53E+03	-0.47	2.185
1972	0.658	16	0.328	1.09E+03	0.75	3.17E+03	1.38	1.998
1973	0.512	20	0.360	1.19E+03	1.01	2.45E+03	0.56	1.689
1974	0.563	16	0.115	3.80E+02	-0.97	8.69E+02	-1.22	6.328
1975	0.461	47	0.377	1.25E+03	1.15	2.32E+03	0.42	2.008
1976	0.458	42	0.316	1.05E+03	0.66	1.93E+03	-0.02	1.847
1977	0.588	45	0.267	8.85E+02	0.26	2.15E+03	0.23	1.838
1978	0.687	42	0.265	8.77E+02	0.24	2.81E+03	0.96	1.359
1979	0.712	39	0.178	5.89E+02	-0.46	2.04E+03	0.11	2.020
1980	0.740	36	0.138	4.57E+02	-0.78	1.76E+03	-0.22	4.227
1981	0.667	48	0.143	4.73E+02	-0.74	1.42E+03	-0.59	3.174
1982	0.581	51	0.105	3.49E+02	-1.04	8.31E+02	-1.26	6.496
1983	0.807	56	0.131	4.35E+02	-0.83	2.25E+03	0.34	5.938
1984	0.719	45	0.121	4.00E+02	-0.92	1.42E+03	-0.59	3.774
1985	0.754	36	0.121	4.00E+02	-0.92	1.62E+03	-0.37	3.765
1986	0.828	52	0.170	5.63E+02	-0.52	3.27E+03	1.49	2.618
1987	0.639	62	0.163	5.41E+02	-0.57	1.50E+03	-0.50	2.938
1988	0.630	57	0.170	5.65E+02	-0.52	1.52E+03	-0.48	2.875
1989	0.674	59	0.145	4.81E+02	-0.72	1.48E+03	-0.53	2.800
1990	0.738	55	0.116	3.86E+02	-0.95	1.47E+03	-0.53	2.719
1991	0.769	58	0.124	4.11E+02	-0.89	1.78E+03	-0.20	1.860
1992	0.703	53	0.124	4.11E+02	-0.89	1.38E+03	-0.64	2.262
1993	0.724	58	0.107	3.55E+02	-1.03	1.29E+03	-0.74	2.269
1994	0.690	34	0.063	2.09E+02	-1.38	6.72E+02	-1.44	4.549
1995	0.577	38	0.116	3.84E+02	-0.96	9.08E+02	-1.17	3.879
1996	0.673	38	0.095	3.15E+02	-1.12	9.64E+02	-1.11	3.872
1997	0.443	35	0.093	3.09E+02	-1.14	5.54E+02	-1.57	
1998	0.574	47	0.202	6.70E+02	-0.26	1.57E+03	-0.42	
1999	0.457	36	0.222	7.37E+02	-0.10	1.36E+03	-0.67	

Table 9. For the Nass aggregate (Area 3), indices of escapement and total return derived from visual stream counts.

year	exploitation rate	records	pmax	escapement N	escapement Z-score	total return N	total return Z-score	R/S
1950	0.525	7	0.094	4.46E+02	-1.41	9.40E+02	-1.03	2.329
1951	0.525	7	0.172	8.14E+02	-0.84	1.71E+03	-0.75	2.247
1952	0.525	8	0.104	4.92E+02	-1.34	1.04E+03	-0.99	4.412
1953	0.525	8	0.089	4.20E+02	-1.45	8.85E+02	-1.05	3.161
1954	0.525	7	0.129	6.10E+02	-1.16	1.28E+03	-0.90	2.905
1955	0.525	7	0.270	1.28E+03	-0.12	2.69E+03	-0.40	1.767
1956	0.525	7	0.136	6.45E+02	-1.10	1.36E+03	-0.88	2.915
1957	0.525	7	0.129	6.09E+02	-1.16	1.28E+03	-0.90	4.475
1958	0.525	6	0.255	1.21E+03	-0.23	2.54E+03	-0.45	2.713
1959	0.525	5	0.181	8.58E+02	-0.77	1.81E+03	-0.71	3.657

year	exploitation rate	records	pmax	escapement N	escapement Z-score	total return N	total return Z-score	R/S
1960	0.525	1	0.200	9.47E+02	-0.64	1.99E+03	-0.65	5.003
1961	0.525	3	0.389	1.84E+03	0.75	3.88E+03	0.03	2.939
1962	0.525	3	0.233	1.10E+03	-0.39	2.33E+03	-0.53	5.400
1963	0.477	6	0.489	2.31E+03	1.48	4.42E+03	0.23	2.266
1964	0.604	8	0.438	2.07E+03	1.11	5.23E+03	0.52	2.113
1965	0.460	13	0.649	3.07E+03	2.65	5.69E+03	0.68	1.473
1966	0.567	13	0.585	2.77E+03	2.18	6.40E+03	0.94	1.090
1967	0.450	9	0.398	1.88E+03	0.81	3.42E+03	-0.13	2.299
1968	0.563	13	0.544	2.57E+03	1.88	5.89E+03	0.75	1.639
1969	0.482	11	0.259	1.23E+03	-0.20	2.37E+03	-0.51	2.311
1970	0.546	14	0.388	1.83E+03	0.74	4.04E+03	0.09	1.109
1971	0.548	15	0.457	2.16E+03	1.25	4.78E+03	0.36	0.893
1972	0.634	10	0.257	1.22E+03	-0.22	3.33E+03	-0.17	1.546
1973	0.489	7	0.223	1.05E+03	-0.47	2.06E+03	-0.62	2.126
1974	0.540	7	0.193	9.15E+02	-0.68	1.99E+03	-0.65	3.389
1975	0.439	9	0.218	1.03E+03	-0.50	1.84E+03	-0.70	2.960
1976	0.435	17	0.233	1.10E+03	-0.39	1.95E+03	-0.66	1.967
1977	0.565	17	0.247	1.17E+03	-0.29	2.69E+03	-0.40	2.372
1978	0.665	19	0.265	1.26E+03	-0.16	3.74E+03	-0.02	2.266
1979	0.689	19	0.130	6.13E+02	-1.15	1.97E+03	-0.66	2.020
1980	0.717	19	0.148	7.02E+02	-1.01	2.48E+03	-0.47	8.659
1981	0.644	19	0.244	1.16E+03	-0.31	3.25E+03	-0.20	6.013
1982	0.558	20	0.207	9.77E+02	-0.59	2.21E+03	-0.57	8.439
1983	0.783	19	0.280	1.32E+03	-0.05	6.10E+03	0.83	4.923
1984	0.695	20	0.390	1.84E+03	0.75	6.05E+03	0.81	1.822
1985	0.730	17	0.478	2.26E+03	1.40	8.38E+03	1.65	1.250
1986	0.804	17	0.333	1.57E+03	0.34	8.03E+03	1.53	3.197
1987	0.615	14	0.335	1.58E+03	0.35	4.12E+03	0.12	3.730
1988	0.606	12	0.180	8.50E+02	-0.78	2.16E+03	-0.59	5.531
1989	0.651	17	0.286	1.35E+03	0.00	3.88E+03	0.03	3.429
1990	0.715	18	0.413	1.95E+03	0.92	6.85E+03	1.10	4.585
1991	0.745	13	0.239	1.13E+03	-0.35	4.43E+03	0.23	12.375
1992	0.679	9	0.347	1.64E+03	0.44	5.12E+03	0.48	4.419
1993	0.703	7	0.244	1.16E+03	-0.31	3.89E+03	0.03	2.516
1994	0.835	3	0.592	2.80E+03	2.24	1.70E+04	4.73	0.665
1995	0.851	5	0.294	1.39E+03	0.05	9.35E+03	2.00	2.027
1996	0.634	5	0.306	1.45E+03	0.14	3.96E+03	0.06	2.834
1997	0.524	4	0.126	5.94E+02	-1.18	1.25E+03	-0.92	
1998	0.597	3	0.241	1.14E+03	-0.34	2.83E+03	-0.35	
1999	0.487	4	0.303	1.43E+03	0.12	2.79E+03	-0.36	

Table 10. For the Principe/Grenville aggregate (Area 5), indices of escapement and total return derived from visual stream counts.

year	exploitation rate	records	pmax	escapement N	escapement Z-score	total return N	total return Z-score	R/S
1950	0.549	26	0.254	8.21E+02	0.01	1.82E+03	-0.16	2.978
1951	0.549	26	0.303	9.78E+02	0.32	2.17E+03	0.15	2.864
1952	0.549	32	0.346	1.12E+03	0.59	2.47E+03	0.42	2.909
1953	0.549	31	0.331	1.07E+03	0.49	2.37E+03	0.33	3.104

year	exploitation rate	records	pmax	escapement		total return		R/S
				N	Z-score	N	Z-score	
1954	0.549	33	0.359	1.16E+03	0.67	2.57E+03	0.51	2.434
1955	0.549	33	0.443	1.43E+03	1.20	3.17E+03	1.04	1.758
1956	0.549	33	0.472	1.53E+03	1.38	3.38E+03	1.22	1.819
1957	0.549	27	0.450	1.45E+03	1.24	3.22E+03	1.08	2.050
1958	0.549	37	0.307	9.93E+02	0.35	2.20E+03	0.18	3.304
1959	0.549	28	0.421	1.36E+03	1.06	3.01E+03	0.90	1.880
1960	0.549	32	0.335	1.08E+03	0.52	2.40E+03	0.36	3.422
1961	0.549	38	0.544	1.76E+03	1.83	3.89E+03	1.68	2.642
1962	0.549	27	0.324	1.05E+03	0.45	2.32E+03	0.29	4.122
1963	0.500	32	0.454	1.47E+03	1.27	2.93E+03	0.83	2.385
1964	0.628	35	0.568	1.84E+03	1.98	4.93E+03	2.60	1.423
1965	0.483	33	0.669	2.16E+03	2.61	4.18E+03	1.93	1.259
1966	0.591	41	0.574	1.86E+03	2.02	4.53E+03	2.25	0.458
1967	0.473	38	0.304	9.82E+02	0.33	1.86E+03	-0.12	0.645
1968	0.587	38	0.486	1.57E+03	1.47	3.79E+03	1.59	0.614
1969	0.505	37	0.157	5.07E+02	-0.60	1.03E+03	-0.86	2.428
1970	0.569	33	0.076	2.46E+02	-1.10	5.71E+02	-1.26	5.219
1971	0.571	31	0.097	3.14E+02	-0.97	7.31E+02	-1.12	5.405
1972	0.658	35	0.141	4.55E+02	-0.70	1.33E+03	-0.59	3.423
1973	0.512	31	0.163	5.27E+02	-0.56	1.08E+03	-0.81	2.699
1974	0.563	24	0.217	7.00E+02	-0.22	1.60E+03	-0.35	3.001
1975	0.461	24	0.307	9.91E+02	0.34	1.84E+03	-0.14	2.086
1976	0.458	15	0.186	6.02E+02	-0.41	1.11E+03	-0.79	2.491
1977	0.588	17	0.244	7.90E+02	-0.05	1.92E+03	-0.07	2.077
1978	0.687	21	0.232	7.48E+02	-0.13	2.39E+03	0.35	1.811
1979	0.712	31	0.139	4.49E+02	-0.71	1.56E+03	-0.39	2.020
1980	0.740	30	0.113	3.65E+02	-0.87	1.40E+03	-0.53	3.602
1981	0.667	27	0.207	6.69E+02	-0.28	2.01E+03	0.01	1.898
1982	0.581	9	0.041	1.34E+02	-1.32	3.19E+02	-1.49	19.416
1983	0.807	23	0.088	2.83E+02	-1.03	1.46E+03	-0.47	11.002
1984	0.719	35	0.094	3.04E+02	-0.99	1.08E+03	-0.81	5.061
1985	0.754	15	0.120	3.87E+02	-0.83	1.57E+03	-0.38	3.506
1986	0.828	42	0.224	7.25E+02	-0.17	4.21E+03	1.96	1.040
1987	0.639	14	0.154	4.96E+02	-0.62	1.38E+03	-0.55	1.620
1988	0.630	16	0.206	6.65E+02	-0.29	1.80E+03	-0.18	0.997
1989	0.674	1	0.067	2.15E+02	-1.16	6.61E+02	-1.18	3.167
1990	0.738	26	0.073	2.36E+02	-1.12	9.02E+02	-0.97	4.945
1991	0.769	24	0.047	1.50E+02	-1.29	6.49E+02	-1.19	10.637
1992	0.703	26	0.063	2.04E+02	-1.19	6.87E+02	-1.16	5.532
1993	0.724	11	0.058	1.86E+02	-1.22	6.75E+02	-1.17	8.129
1994	0.690	2	0.187	6.03E+02	-0.41	1.94E+03	-0.05	2.961
1995	0.577	0	0.138	4.45E+02	-0.72	1.05E+03	-0.84	2.971
1996	0.673	0	0.126	4.08E+02	-0.79	1.25E+03	-0.66	2.806
1997	0.443	1	0.333	1.08E+03	0.51	1.93E+03	-0.06	
1998	0.574	4	0.205	6.62E+02	-0.30	1.55E+03	-0.39	
1999	0.457	2	0.160	5.17E+02	-0.58	9.52E+02	-0.93	

Table 11. For the Kitimat aggregate (Area 6), indices of escapement and total return derived from visual stream counts.

year	exploitation rate	records	pmax	escapement N	escapement Z-score	total return N	total return Z-score	R/S
1950	0.527	80	0.223	1.01E+03	0.27	2.14E+03	0.08	3.030
1951	0.527	84	0.458	2.08E+03	2.30	4.40E+03	2.22	1.475
1952	0.527	9	0.362	1.64E+03	1.47	3.48E+03	1.35	1.989
1953	0.527	83	0.298	1.35E+03	0.92	2.86E+03	0.76	3.168
1954	0.527	82	0.353	1.60E+03	1.39	3.39E+03	1.27	2.082
1955	0.527	84	0.267	1.21E+03	0.65	2.56E+03	0.48	1.647
1956	0.527	84	0.458	2.08E+03	2.30	4.40E+03	2.22	0.907
1957	0.527	61	0.428	1.94E+03	2.04	4.11E+03	1.95	1.064
1958	0.527	65	0.222	1.01E+03	0.27	2.13E+03	0.08	2.438
1959	0.527	74	0.185	8.42E+02	-0.05	1.78E+03	-0.26	3.776
1960	0.527	66	0.214	9.74E+02	0.20	2.06E+03	0.01	3.356
1961	0.527	71	0.217	9.85E+02	0.22	2.08E+03	0.03	3.411
1962	0.527	74	0.319	1.45E+03	1.10	3.06E+03	0.95	2.278
1963	0.478	73	0.387	1.76E+03	1.69	3.37E+03	1.25	1.252
1964	0.606	70	0.270	1.22E+03	0.68	3.11E+03	1.00	2.006
1965	0.462	55	0.445	2.02E+03	2.19	3.76E+03	1.61	1.371
1966	0.569	34	0.244	1.11E+03	0.45	2.57E+03	0.49	1.205
1967	0.451	57	0.196	8.91E+02	0.04	1.62E+03	-0.41	1.919
1968	0.565	58	0.362	1.64E+03	1.47	3.77E+03	1.63	1.412
1969	0.484	42	0.136	6.18E+02	-0.47	1.20E+03	-0.81	3.588
1970	0.547	50	0.155	7.03E+02	-0.31	1.55E+03	-0.47	1.813
1971	0.550	49	0.194	8.81E+02	0.02	1.96E+03	-0.09	1.717
1972	0.636	55	0.232	1.05E+03	0.35	2.89E+03	0.80	1.415
1973	0.490	46	0.129	5.88E+02	-0.53	1.15E+03	-0.85	2.273
1974	0.541	49	0.148	6.72E+02	-0.37	1.47E+03	-0.55	2.215
1975	0.440	41	0.196	8.88E+02	0.04	1.59E+03	-0.44	2.217
1976	0.436	50	0.166	7.56E+02	-0.21	1.34E+03	-0.67	2.889
1977	0.566	55	0.127	5.77E+02	-0.55	1.33E+03	-0.68	3.043
1978	0.666	53	0.128	5.82E+02	-0.54	1.74E+03	-0.30	2.424
1979	0.690	58	0.159	7.23E+02	-0.28	2.33E+03	0.27	2.020
1980	0.718	53	0.121	5.48E+02	-0.61	1.95E+03	-0.10	3.324
1981	0.646	59	0.114	5.16E+02	-0.67	1.46E+03	-0.56	3.824
1982	0.559	68	0.130	5.90E+02	-0.53	1.34E+03	-0.67	4.651
1983	0.785	56	0.086	3.91E+02	-0.90	1.82E+03	-0.22	6.818
1984	0.697	66	0.122	5.53E+02	-0.60	1.83E+03	-0.21	1.890
1985	0.732	82	0.130	5.90E+02	-0.53	2.20E+03	0.14	1.558
1986	0.806	79	0.154	6.98E+02	-0.32	3.60E+03	1.47	2.034
1987	0.617	76	0.101	4.57E+02	-0.78	1.19E+03	-0.81	3.839
1988	0.608	48	0.070	3.18E+02	-1.04	8.11E+02	-1.17	4.410
1989	0.652	45	0.083	3.79E+02	-0.93	1.09E+03	-0.91	3.265
1990	0.716	30	0.121	5.49E+02	-0.60	1.94E+03	-0.11	1.983
1991	0.747	47	0.082	3.72E+02	-0.94	1.47E+03	-0.55	2.012
1992	0.681	44	0.091	4.14E+02	-0.86	1.30E+03	-0.71	1.529
1993	0.703	36	0.075	3.40E+02	-1.00	1.14E+03	-0.86	2.199
1994	0.665	37	0.074	3.36E+02	-1.01	1.00E+03	-0.99	1.863
1995	0.558	33	0.034	1.54E+02	-1.35	3.48E+02	-1.61	5.864
1996	0.636	30	0.087	3.93E+02	-0.90	1.08E+03	-0.92	1.221
1997	0.419	37	0.028	1.29E+02	-1.40	2.23E+02	-1.73	

year	exploitation rate	records	pmax	escapement N	escapement Z-score	total return N	total return Z-score	R/S
1998	0.564	55	0.121	5.49E+02	-0.60	1.26E+03	-0.75	
1999	0.194	29	0.060	2.71E+02	-1.13	3.36E+02	-1.62	

Table 12. For the Bella Bella aggregate (Area 7), indices of escapement and total return derived from visual stream counts.

year	exploitation rate	records	pmax	escapement N	escapement Z-score	total return N	total return Z-score	R/S
1950	0.527	20	0.251	4.12E+02	0.11	8.70E+02	0.00	3.679
1951	0.527	21	0.373	6.13E+02	0.95	1.29E+03	0.88	2.663
1952	0.527	29	0.491	8.06E+02	1.75	1.70E+03	1.73	2.132
1953	0.527	32	0.429	7.06E+02	1.33	1.49E+03	1.29	2.077
1954	0.527	30	0.447	7.35E+02	1.45	1.55E+03	1.41	1.464
1955	0.527	32	0.506	8.32E+02	1.85	1.76E+03	1.84	1.324
1956	0.527	33	0.477	7.83E+02	1.65	1.66E+03	1.63	1.380
1957	0.527	22	0.336	5.52E+02	0.69	1.17E+03	0.61	1.706
1958	0.527	21	0.269	4.42E+02	0.24	9.34E+02	0.13	3.237
1959	0.527	25	0.393	6.47E+02	1.09	1.37E+03	1.03	1.884
1960	0.527	23	0.182	2.99E+02	-0.35	6.32E+02	-0.50	4.172
1961	0.527	30	0.411	6.76E+02	1.21	1.43E+03	1.16	2.600
1962	0.527	28	0.413	6.79E+02	1.22	1.43E+03	1.17	2.374
1963	0.478	28	0.279	4.58E+02	0.31	8.77E+02	0.01	2.745
1964	0.606	27	0.439	7.22E+02	1.40	1.83E+03	2.00	1.442
1965	0.462	26	0.537	8.82E+02	2.06	1.64E+03	1.59	1.338
1966	0.569	28	0.411	6.76E+02	1.21	1.57E+03	1.45	1.096
1967	0.451	27	0.256	4.21E+02	0.15	7.67E+02	-0.22	2.216
1968	0.565	27	0.390	6.41E+02	1.06	1.47E+03	1.25	1.725
1969	0.484	30	0.226	3.71E+02	-0.06	7.18E+02	-0.32	2.130
1970	0.547	24	0.214	3.51E+02	-0.14	7.76E+02	-0.20	1.869
1971	0.550	26	0.324	5.32E+02	0.61	1.18E+03	0.64	1.492
1972	0.636	26	0.219	3.59E+02	-0.10	9.87E+02	0.24	1.748
1973	0.490	21	0.149	2.44E+02	-0.58	4.79E+02	-0.82	2.678
1974	0.541	23	0.261	4.29E+02	0.19	9.36E+02	0.13	1.556
1975	0.440	12	0.195	3.20E+02	-0.27	5.70E+02	-0.63	2.425
1976	0.436	20	0.247	4.06E+02	0.09	7.19E+02	-0.32	1.219
1977	0.566	20	0.146	2.39E+02	-0.60	5.52E+02	-0.67	2.078
1978	0.666	16	0.173	2.85E+02	-0.41	8.52E+02	-0.04	2.454
1979	0.690	19	0.123	2.02E+02	-0.75	6.53E+02	-0.45	2.020
1980	0.718	10	0.042	6.87E+01	-1.31	2.44E+02	-1.30	7.528
1981	0.646	9	0.193	3.18E+02	-0.28	8.96E+02	0.05	1.178
1982	0.559	15	0.105	1.72E+02	-0.88	3.89E+02	-1.00	2.458
1983	0.785	10	0.078	1.28E+02	-1.06	5.97E+02	-0.57	3.536
1984	0.697	17	0.072	1.18E+02	-1.10	3.90E+02	-1.00	2.278
1985	0.732	21	0.057	9.33E+01	-1.21	3.48E+02	-1.09	2.020
1986	0.806	20	0.064	1.04E+02	-1.16	5.39E+02	-0.69	3.118
1987	0.617	17	0.075	1.23E+02	-1.08	3.21E+02	-1.14	3.866
1988	0.608	18	0.045	7.39E+01	-1.29	1.88E+02	-1.42	5.198
1989	0.652	23	0.040	6.55E+01	-1.32	1.88E+02	-1.42	6.171
1990	0.716	18	0.094	1.54E+02	-0.96	5.42E+02	-0.68	3.890
1991	0.747	17	0.057	9.29E+01	-1.21	3.67E+02	-1.05	7.621

year	exploitation rate	records	pmax	escapement N	escapement Z-score	total return N	total return Z-score	R/S
1992	0.681	16	0.080	1.31E+02	-1.05	4.11E+02	-0.96	4.015
1993	0.703	17	0.071	1.17E+02	-1.11	3.94E+02	-0.99	4.889
1994	0.665	1	0.188	3.08E+02	-0.32	9.20E+02	0.10	2.006
1995	0.558	0	0.000	1.66E+02	-0.91	3.75E+02	-1.03	5.227
1996	0.636	0	0.000	2.77E+02	-0.44	7.63E+02	-0.23	1.800
1997	0.419	3	0.097	1.59E+02	-0.93	2.74E+02	-1.24	
1998	0.564	13	0.308	5.06E+02	0.50	1.16E+03	0.60	
1999	0.194	8	0.198	3.26E+02	-0.24	4.04E+02	-0.97	

Table 13. For the Bella Coola aggregate (Area 8), indices of escapement and total return derived from visual stream counts.

year	exploitation rate	records	pmax	escapement N	escapement Z-score	total return N	total return Z-score	R/S
1950	0.527	19	0.451	3.13E+03	0.64	6.62E+03	0.39	2.041
1951	0.527	20	0.586	4.07E+03	1.44	8.60E+03	1.15	1.865
1952	0.527	22	0.348	2.42E+03	0.04	5.11E+03	-0.19	3.224
1953	0.527	20	0.374	2.59E+03	0.19	5.48E+03	-0.05	3.056
1954	0.527	22	0.533	3.70E+03	1.13	7.83E+03	0.85	1.800
1955	0.527	22	0.492	3.42E+03	0.88	7.22E+03	0.62	2.420
1956	0.527	21	0.593	4.12E+03	1.48	8.70E+03	1.19	2.119
1957	0.527	23	0.458	3.18E+03	0.68	6.71E+03	0.43	2.231
1958	0.527	21	0.449	3.12E+03	0.63	6.59E+03	0.38	2.612
1959	0.527	12	0.743	5.16E+03	2.37	1.09E+04	2.03	1.091
1960	0.527	11	0.360	2.50E+03	0.10	5.27E+03	-0.13	2.682
1961	0.527	15	0.678	4.71E+03	1.98	9.95E+03	1.67	1.653
1962	0.527	8	0.362	2.51E+03	0.12	5.31E+03	-0.11	3.149
1963	0.478	11	0.462	3.20E+03	0.71	6.14E+03	0.21	1.674
1964	0.606	9	0.430	2.98E+03	0.52	7.57E+03	0.76	1.630
1965	0.462	8	0.628	4.36E+03	1.69	8.10E+03	0.96	1.629
1966	0.569	12	0.472	3.27E+03	0.76	7.60E+03	0.77	1.623
1967	0.451	5	0.145	1.01E+03	-1.16	1.84E+03	-1.44	7.478
1968	0.565	14	0.604	4.19E+03	1.55	9.64E+03	1.55	1.390
1969	0.484	6	0.232	1.61E+03	-0.65	3.12E+03	-0.95	3.483
1970	0.547	10	0.573	3.97E+03	1.36	8.78E+03	1.22	1.175
1971	0.550	14	0.363	2.52E+03	0.12	5.59E+03	-0.01	1.689
1972	0.636	11	0.326	2.26E+03	-0.10	6.21E+03	0.23	1.812
1973	0.490	16	0.342	2.37E+03	0.00	4.65E+03	-0.37	1.859
1974	0.541	15	0.311	2.16E+03	-0.18	4.70E+03	-0.35	1.751
1975	0.440	17	0.286	1.99E+03	-0.33	3.54E+03	-0.79	2.845
1976	0.436	21	0.404	2.80E+03	0.36	4.97E+03	-0.24	2.178
1977	0.566	18	0.220	1.53E+03	-0.72	3.52E+03	-0.80	1.992
1978	0.666	15	0.201	1.40E+03	-0.83	4.18E+03	-0.55	1.766
1979	0.690	15	0.356	2.47E+03	0.08	7.97E+03	0.91	2.020
1980	0.718	12	0.128	8.90E+02	-1.26	3.16E+03	-0.94	6.372
1981	0.646	13	0.146	1.01E+03	-1.16	2.85E+03	-1.06	4.824
1982	0.559	15	0.119	8.24E+02	-1.32	1.87E+03	-1.43	3.507
1983	0.785	17	0.163	1.13E+03	-1.05	5.28E+03	-0.13	2.460
1984	0.697	15	0.275	1.91E+03	-0.40	6.29E+03	0.26	1.443
1985	0.732	12	0.102	7.08E+02	-1.42	2.64E+03	-1.14	5.012

year	exploitation rate	records	pmax	escapement N	escapement Z-score	total return N	total return Z-score	R/S
1986	0.806	8	0.092	6.36E+02	-1.48	3.28E+03	-0.89	11.269
1987	0.617	5	0.111	7.72E+02	-1.36	2.02E+03	-1.38	14.686
1988	0.608	3	0.221	1.53E+03	-0.71	3.91E+03	-0.65	3.699
1989	0.652	4	0.149	1.03E+03	-1.14	2.97E+03	-1.01	2.567
1990	0.716	3	0.563	3.90E+03	1.30	1.38E+04	3.13	1.160
1991	0.747	10	0.274	1.90E+03	-0.40	7.51E+03	0.73	3.423
1992	0.681	6	0.127	8.83E+02	-1.27	2.77E+03	-1.09	5.167
1993	0.703	6	0.106	7.36E+02	-1.39	2.48E+03	-1.20	5.501
1994	0.665	2	0.375	2.60E+03	0.19	7.77E+03	0.83	1.362
1995	0.558	2	0.288	2.00E+03	-0.32	4.52E+03	-0.42	1.812
1996	0.636	3	0.243	1.68E+03	-0.59	4.63E+03	-0.37	2.019
1997	0.419	2	0.263	1.82E+03	-0.47	3.14E+03	-0.95	
1998	0.564	9	0.263	1.83E+03	-0.46	4.19E+03	-0.54	
1999	0.194	5	0.314	2.18E+03	-0.16	2.71E+03	-1.11	

Table 14. Retrospective performance measures for nBC coho aggregates. Results for the best two time series models are tabulated.

	S-R model		3YRA model		LLY model	
aggregate	*RMSE*	*MAD*	*RMSE*	*MAD*	*RMSE*	*MAD*
Area 1	5170	4144	5686	4546	6626	5342
Area 2W	354	282	273	206	384	308
Area 2E	820	625	706	558	934	695
Nass	2811	1867	3315	2087	3370	2109
lower Skeena	1684	1150	1812	1263	2192	1484
upper Skeena	806	619	972	778	1238	954
Babine Lake	9665	8129	10671	8780	11824	9774
Area 5	1009	740	829	599	968	705
Area 6	809	637	686	548	780	581
Area 7	322	258	270	220	387	318
Area 8	2690	1977	3025	2161	3436	2476

Table 15. Summary of forecast performance in 1999 for total returns or abundance. Nominal probability levels were 1%, 5%, 10%, 25%, 50%, 75%, 90%, 95% and 99%. Model performance is summarized relative to the total return at each of these probability levels. The performance of the preferred model is shaded.

	observed total return relative to return at stated nominal percentile	
aggregate	S-R model	3YRA time series model
Area 3	<50th	<75th
Lachmach[7]	<10th	
Babine Lake	<99th	>99th
upper Skeena	<75th	<90th
lower Skeena	<25th	<90th
Area 5	<5th	<25th
Area 6	<1st	<10th
Area 7	<1st	<25th
Area 8	<5th	<25th

[7] Lachmach forecast is based on a sibling regression and not a stock-recruitment relationship.

Table 16. Performance of the 1999 forecast total return for the Area 3 aggregate. Stock-recruitment and time series models were used to forecast in 1999. The preferred model is underlined.

probability of a lower value	total return		
	observed	1999 forecast	
		S-R	3YRA
99%		8923	9641
95%		6548	6316
90%		5601	5079
75%		4396	3556
50%	**2793**	**3442**	**2410**
25%		2764	1633
10%		2318	1143
5%		2106	919
1%		1800	602

Table 17. Performance of the 1999 forecast total return for the Babine Lake coho aggregate. Stock-recruitment and time series models were used to forecast in 1999. The preferred model is underlined.

probability of a lower value	total return		
	observed	1999 forecast	
		S-R	3YRA
99%		31163	23372
95%		22303	14080
90%		18779	10842
75%		14306	7072
50%	**27455**	**10774**	**4436**
25%		8273	2783
10%		6634	1815
5%		5856	1398
1%		4737	842

Table 18. Performance of the 1999 forecast total return and marine survival for the Lachmach River wild indicator. The forecasts are based on a sibling regression model.

probability of a lower value	total return		marine survival	
	observed	1999 forecast	observed	1999 forecast
99%		8871		0.401
95%		6593		0.298
90%		5782		0.262
75%		4748		0.075
50%	**2437**	**3877**	**0.144**	**0.175**
25%		3166		0.143
10%		2600		0.118
5%		2280		0.103
1%		1694		0.077

Table 19. Performance of the 1999 forecast total return for the upper Skeena coho aggregate. Stock-recruitment and time series models were used to forecast in 1999. The preferred model is underlined.

probability of a lower value	total return		
	observed	1999 forecast	
		S-R	3YRA
99%		1958	2793
95%		1540	1675
90%		1367	1287
75%		1138	836
50%	**1030**	**948**	**522**
25%		806	326
10%		708	212
5%		660	163
1%		588	98

Table 20. Performance of the 1999 forecast total return for the lower and middle Skeena coho aggregate. Stock-recruitment and time series models were used to forecast in 1999. The preferred model is underlined.

	total return		
	observed	1999 forecast	
probability of a lower value		S-R	3YRA
99%		4953	5330
95%		3873	3424
90%		3427	2726
75%		2844	1877
50%	**1941**	**2364**	**1249**
25%		2010	832
10%		1767	573
5%		1649	456
1%		1472	293

Table 21. Performance of the 1999 forecast total return for the Area 5 aggregate. Stock-recruitment and time series models were used to forecast in 1999. The preferred model is underlined.

	total return		
	observed	1999 forecast	
probability of a lower value		S-R	3YRA
99%		4365	6016
95%		3107	3981
90%		2623	3218
75%		2026	2272
50%	**952**	1572	1554
25%		1262	1063
10%		1068	750
5%		978	606
1%		852	401

Table 22. Performance of the 1999 forecast total return for the Area 6 aggregate. Stock-recruitment and time series models were used to forecast in 1999. The preferred model is underlined.

	total return		
	observed	1999 forecast	
probability of a lower value		S-R	<u>3YRA</u>
99%		2357	2050
95%		1911	1467
90%		1721	1235
75%		1464	932
50%	**336**	**1244**	**685**
25%		1075	503
10%		955	380
5%		894	320
1%		801	229

Table 23. Performance of the 1999 forecast total return for the Area 7 aggregate. Stock-recruitment and time series models were used to forecast in 1999. The preferred model is underlined.

	total return		
	observed	1999 forecast	
probability of a lower value		S-R	<u>3YRA</u>
99%		1676	1799
95%		1382	1304
90%		1256	1105
75%		1087	842
50%	**404**	**942**	**627**
25%		830	466
10%		751	355
5%		711	301
1%		649	218

Table 24. Performance of the 1999 forecast total return for the Area 8 aggregate. Stock-recruitment and time series models were used to forecast in 1999. The preferred model is underlined.

	total return		
	observed	1999 forecast	
probability of a lower value		S-R	3YRA
99%		10462	16643
95%		8189	11098
90%		7227	9006
75%		5935	6400
50%	**2706**	**4840**	**4408**
25%		4002	3036
10%		3412	2158
5%		3115	1751
1%		2662	1168

Table 25. Summary of the Ricker stock-recruitment analyses on reconstructed time series for 10 northern BC coho aggregates and the Babine Lake aggregate.

	Ricker stock-recruitment analysis						
aggregate	*N*	adj. r^2	*a*'	*b*'	S_{MSY}	S_{MAX}[§]	u_{MSY}
NQCI (Area 1)	47	0.55	2.069	7795	2769	3768	0.74
WQCI (Area 2W)	47	0.38	1.812	703	262	388	0.68
EQCI (Area 2E)	47	0.45	1.552	2275	890	1466	0.61
Nass (Area 3)	47	0.30	1.832	3612	1343	1971	0.68
Babine Lake	51	0.42	1.863	19708	7285	10581	0.69
upper Skeena (Area 4-Upper)	47	0.30	1.764	1510	569	857	0.66
lower Skeena (Area 4-Lower)	47	0.37	1.872	2425	895	1295	0.69
Principe (Area 5)	47	0.40	1.849	2130	789	1152	0.69
Kitimat (Area 6)	47	0.29	1.316	2772	1131	2107	0.54
Bella Bella (Area 7)	47	0.43	1.468	1115	443	760	0.58
Bella Coola (Area 8)	47	0.52	1.829	5316	1978	2907	0.68

[§] The carrying capacity, or the spawner number producing on average the maximum recruitment..

Table 26. Summary of abundance forecasts for ten nBC coho aggregates and the Babine Lake aggregate. Details of these forecasts are contained in Table 27 to Table 37. The forecast from the preferred model for each aggregate are underlined. Abundance forecasts are in units of average-stream escapement and are not total coho returns to the aggregate.

aggregate	reconstructed abundance			$\hat{A}_{2000}$ forecast abundance			
	average	standard deviation	A_{1999}	stock-recruitment	*Z*-score†	3YRA time series model	*Z*-score†
QCIN	9.52E+03	5.07E+03	1.03E+04	<u>9.59E+03</u>	0.02	7.21E+03	-0.45
QCIW	6.04E+02	4.46E+02	3.12E+02	2.33E+02	-0.83	<u>2.78E+02</u>	-0.73
QCIE	1.95E+03	8.88E+02	1.36E+03	1.22E+03	-0.83	<u>1.06E+03</u>	-1.00
Nass	3.79E+03	2.78E+03	2.79E+03	<u>2.57E+03</u>	-0.44	2.15E+03	-0.59
lower Skeena	2.75E+03	1.52E+03	1.94E+03	<u>1.65E+03</u>	-0.72	1.41E+03	-0.88
upper Skeena	1.52E+03	7.98E+02	1.03E+03	<u>5.19E+02</u>	-1.26	4.61E+02	-1.33
Babine	1.93E+04	8.84E+03	1.49E+04	<u>7.39E+03</u>	-1.35	6.67E+03	-1.43
Principe	2.00E+03	1.13E+03	9.52E+02	1.78E+03	-0.19	<u>1.42E+03</u>	-0.51
Kitimat	2.05E+03	1.06E+03	3.36E+02	3.89E+02	-1.57	<u>4.55E+02</u>	-1.51
Bella Bella	8.72E+02	4.81E+02	4.04E+02	4.77E+02	-0.82	<u>5.05E+02</u>	-0.76
Bella Coola	5.60E+03	2.61E+03	2.71E+03	<u>4.48E+03</u>	-0.43	3.93E+03	-0.76

†*Z*-score = (observation – mean)/standard deviation). For time series with *N* between 45 and 49 about 50% of observations lie within a *Z*-score of ±0.68 while about 90% of observations lie within a *Z*-score of ±1.67.

Table 27. For the QCI N aggregate (Area 1), forecasts and associated confidence intervals for total return, escapement and proportion of S_{max} 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 0.46 was assumed.

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%	2.2E+04	2.54	3.0E+04	4.10	1.2E+04	4.64	1.6E+04	6.97	111%	150%
95%	1.6E+04	1.36	2.0E+04	1.98	8.9E+03	2.87	1.1E+04	3.81	81%	97%
90%	1.4E+04	0.94	1.6E+04	1.20	7.8E+03	2.26	8.5E+03	2.64	71%	77%
75%	1.2E+04	0.42	1.1E+04	0.25	6.3E+03	1.47	5.9E+03	1.22	58%	53%
50%	**9.6E+03**	**0.02**	**7.2E+03**	**-0.45**	**5.2E+03**	**0.87**	**3.9E+03**	**0.17**	**47%**	**36%**
25%	8.1E+03	-0.28	4.8E+03	-0.93	4.4E+03	0.43	2.6E+03	-0.53	40%	24%
10%	7.0E+03	-0.49	3.3E+03	-1.22	3.8E+03	0.12	1.8E+03	-0.97	35%	16%
5%	6.5E+03	-0.59	2.7E+03	-1.35	3.5E+03	-0.03	1.4E+03	-1.17	32%	13%
1%	5.7E+03	-0.75	1.7E+03	-1.54	3.1E+03	-0.27	9.3E+02	-1.45	28%	8%

§probability of a lower value

Table 28. For the QCI W aggregate (Area 2W), forecasts and associated confidence intervals for total return, escapement and proportion of S_{max} 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 0.30 was assumed.

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%	8.1E+02	0.47	1.9E+03	2.95	5.7E+02	1.53	1.3E+03	5.28	65%	154%
95%	5.0E+02	-0.23	1.1E+03	1.04	3.5E+02	0.46	7.5E+02	2.38	40%	85%
90%	4.1E+02	-0.44	7.9E+02	0.41	2.8E+02	0.14	5.5E+02	1.43	33%	63%
75%	3.0E+02	-0.68	4.8E+02	-0.28	2.1E+02	-0.21	3.3E+02	0.39	24%	38%
50%	**2.3E+02**	**-0.83**	**2.8E+02**	**-0.73**	**1.6E+02**	**-0.45**	**1.9E+02**	**-0.29**	**19%**	**22%**
25%	1.9E+02	-0.93	1.6E+02	-0.99	1.3E+02	-0.59	1.1E+02	-0.69	15%	13%
10%	1.6E+02	-0.98	9.8E+01	-1.13	1.2E+02	-0.68	6.9E+01	-0.90	13%	8%
5%	1.5E+02	-1.01	7.3E+01	-1.19	1.1E+02	-0.71	5.1E+01	-0.99	12%	6%
1%	1.4E+02	-1.04	4.0E+01	-1.26	9.7E+01	-0.76	2.8E+01	-1.10	11%	3%

[§]probability of a lower value

Table 29. For the QCI E aggregate (Area 2E), forecasts and associated confidence intervals for total return, escapement and proportion of S_{max} 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 0.22 was assumed.

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%	2.1E+03	0.19	2.7E+03	0.87	1149	0.90	1477	1.70	45%	58%
95%	1.7E+03	-0.24	2.0E+03	0.10	940	0.40	1107	0.80	37%	43%
90%	1.6E+03	-0.41	1.8E+03	-0.21	860	0.20	954	0.43	34%	37%
75%	1.4E+03	-0.64	1.4E+03	-0.64	752	-0.06	749	-0.07	30%	29%
50%	**1.2E+03**	**-0.83**	**1.1E+03**	**-1.00**	**660**	**-0.29**	**574**	**-0.49**	**26%**	**23%**
25%	1.1E+03	-0.98	8.1E+02	-1.28	586	-0.46	440	-0.82	23%	17%
10%	9.8E+02	-1.10	6.4E+02	-1.48	530	-0.60	345	-1.05	21%	14%
5%	9.2E+02	-1.16	5.5E+02	-1.58	500	-0.68	298	-1.17	20%	12%
1%	8.3E+02	-1.26	4.1E+02	-1.73	448	-0.80	223	-1.35	18%	9%

[§]probability of a lower value

Table 30. For the Area 3 aggregate (Nass), forecasts and associated confidence intervals for total return, escapement and proportion of S_{max} 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 0.30 was assumed.

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%	6.7E+03	1.04	8.4E+03	1.64	4.8E+03	5.29	6.0E+03	7.13	202%	252%
95%	4.7E+03	0.33	5.5E+03	0.62	3.4E+03	3.09	3.9E+03	4.00	142%	167%
90%	4.0E+03	0.08	4.5E+03	0.24	2.9E+03	2.35	3.2E+03	2.82	122%	135%
75%	3.2E+03	-0.22	3.1E+03	-0.23	2.3E+03	1.43	2.2E+03	1.37	96%	95%
50%	**2.6E+03**	**-0.44**	**2.1E+03**	**-0.59**	**1.8E+03**	**0.74**	**1.5E+03**	**0.27**	**78%**	**65%**
25%	2.1E+03	-0.60	1.5E+03	-0.84	1.5E+03	0.26	1.0E+03	-0.48	64%	44%
10%	1.8E+03	-0.70	1.0E+03	-0.99	1.3E+03	-0.07	7.4E+02	-0.96	55%	31%
5%	1.7E+03	-0.75	8.3E+02	-1.06	1.2E+03	-0.22	6.0E+02	-1.18	51%	25%
1%	1.5E+03	-0.83	5.5E+02	-1.17	1.1E+03	-0.47	3.9E+02	-1.49	45%	17%

[§]probability of a lower value

Table 31. For the Babine Lake aggregate, forecasts and associated confidence intervals for total return, escapement and proportion of S_{max} 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 0.46 was assumed.

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%	1.4E+04	-0.63	4.2E+04	2.54	7.5E+03	-0.06	2.3E+04	3.06	59%	178%
95%	1.1E+04	-0.99	2.4E+04	0.51	5.7E+03	-0.41	1.3E+04	1.06	45%	101%
90%	9.5E+03	-1.11	1.8E+04	-0.16	5.2E+03	-0.53	9.7E+03	0.40	41%	76%
75%	8.3E+03	-1.25	1.1E+04	-0.92	4.5E+03	-0.67	6.0E+03	-0.35	35%	47%
50%	**7.4E+03**	**-1.35**	**6.7E+03**	**-1.43**	**4.0E+03**	**-0.77**	**3.6E+03**	**-0.85**	**31%**	**28%**
25%	6.8E+03	-1.42	4.0E+03	-1.74	3.7E+03	-0.84	2.2E+03	-1.15	29%	17%
10%	6.4E+03	-1.47	2.5E+03	-1.91	3.4E+03	-0.89	1.3E+03	-1.32	27%	11%
5%	6.2E+03	-1.49	1.9E+03	-1.98	3.3E+03	-0.91	1.0E+03	-1.39	26%	8%
1%	5.9E+03	-1.52	1.1E+03	-2.07	3.2E+03	-0.94	5.7E+02	-1.48	25%	5%

[§]probability of a lower value

Table 32. For the upper Skeena aggregate (Area 4-Upper), forecasts and associated confidence intervals for total return, escapement and proportion of S_{max} 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 0.32 was assumed.

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%	9.0E+02	-0.78	3.0E+03	1.86	6.4E+02	0.17	2.1E+03	5.18	62%	209%
95%	7.1E+02	-1.02	1.7E+03	0.22	5.1E+02	-0.28	1.2E+03	2.07	49%	118%
90%	6.5E+02	-1.09	1.3E+03	-0.32	4.6E+02	-0.43	9.0E+02	1.04	45%	88%
75%	5.7E+02	-1.19	7.8E+02	-0.93	4.1E+02	-0.60	5.6E+02	-0.11	40%	54%
50%	**5.2E+02**	**-1.26**	**4.6E+02**	**-1.33**	**3.7E+02**	**-0.73**	**3.3E+02**	**-0.87**	**36%**	**32%**
25%	4.8E+02	-1.30	2.7E+02	-1.56	3.4E+02	-0.82	1.9E+02	-1.32	33%	19%
10%	4.6E+02	-1.33	1.7E+02	-1.69	3.3E+02	-0.88	1.2E+02	-1.57	32%	12%
5%	4.5E+02	-1.35	1.3E+02	-1.75	3.2E+02	-0.91	8.9E+01	-1.67	31%	9%
1%	4.3E+02	-1.37	7.1E+01	-1.82	3.1E+02	-0.95	5.0E+01	-1.80	30%	5%

[§]probability of a lower value

Table 33. For the lower Skeena aggregate (Area 4-Lower), forecasts and associated confidence intervals for total return, escapement and proportion of S_{max} 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 0.38 was assumed.

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%	3.6E+03	0.57	5.9E+03	2.05	2.6E+03	3.55	4.2E+03	7.22	166%	270%
95%	2.7E+03	-0.03	3.8E+03	0.69	1.9E+03	2.05	2.7E+03	3.84	124%	174%
90%	2.4E+03	-0.24	3.0E+03	0.19	1.7E+03	1.52	2.2E+03	2.59	109%	139%
75%	2.0E+03	-0.51	2.1E+03	-0.43	1.4E+03	0.85	1.5E+03	1.07	90%	96%
50%	**1.6E+03**	**-0.72**	**1.4E+03**	**-0.88**	**1.2E+03**	**0.33**	**1.0E+03**	**-0.06**	**76%**	**65%**
25%	1.4E+03	-0.88	9.4E+02	-1.19	1.0E+03	-0.05	6.7E+02	-0.82	65%	43%
10%	1.2E+03	-0.99	6.5E+02	-1.38	8.9E+02	-0.32	4.7E+02	-1.29	57%	30%
5%	1.2E+03	-1.04	5.2E+02	-1.46	8.3E+02	-0.46	3.7E+02	-1.50	53%	24%
1%	1.0E+03	-1.13	3.4E+02	-1.58	7.4E+02	-0.67	2.4E+02	-1.80	47%	15%

[§]probability of a lower value

Table 34. For the Area 5 aggregate (Principe/Grenville), forecasts and associated confidence intervals for total return, escapement and proportion of S_{max} 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 0.46 was assumed.

$P^{\S}$	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%	6.5E+03	4.01	5.4E+03	3.01	4.7E+03	7.46	3.9E+03	5.91	337%	279%
95%	4.1E+03	1.91	3.6E+03	1.41	3.0E+03	4.17	2.6E+03	3.40	214%	186%
90%	3.4E+03	1.22	2.9E+03	0.81	2.4E+03	3.10	2.1E+03	2.46	174%	150%
75%	2.4E+03	0.40	2.1E+03	0.06	1.7E+03	1.81	1.5E+03	1.28	126%	107%
50%	**1.8E+03**	**-0.19**	**1.4E+03**	**-0.51**	**1.3E+03**	**0.89**	**1.0E+03**	**0.39**	**92%**	**73%**
25%	1.3E+03	-0.59	9.8E+02	-0.91	9.5E+02	0.26	7.0E+02	-0.23	69%	50%
10%	1.0E+03	-0.86	6.9E+02	-1.16	7.4E+02	-0.15	4.9E+02	-0.62	53%	36%
5%	9.0E+02	-0.98	5.6E+02	-1.27	6.4E+02	-0.34	4.0E+02	-0.80	46%	29%
1%	6.9E+02	-1.16	3.7E+02	-1.44	5.0E+02	-0.62	2.7E+02	-1.06	36%	19%

§probability of a lower value

Table 35. For the Area 6 aggregate (Kitimat), forecasts and associated confidence intervals for total return, escapement and proportion of S_{max} 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 0.19 was assumed.

$P^{\S}$	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%	8.5E+02	-1.14	1.5E+03	-0.55	6.1E+02	-0.50	1.1E+03	0.35	24%	42%
95%	6.4E+02	-1.33	1.0E+03	-0.97	4.6E+02	-0.78	7.4E+02	-0.25	18%	29%
90%	5.7E+02	-1.40	8.6E+02	-1.13	4.1E+02	-0.88	6.1E+02	-0.49	16%	24%
75%	4.7E+02	-1.50	6.3E+02	-1.34	3.3E+02	-1.01	4.5E+02	-0.79	13%	18%
50%	**3.9E+02**	**-1.57**	**4.6E+02**	**-1.51**	**2.8E+02**	**-1.12**	**3.2E+02**	**-1.03**	**11%**	**13%**
25%	3.3E+02	-1.63	3.3E+02	-1.63	2.3E+02	-1.20	2.3E+02	-1.20	9%	9%
10%	2.8E+02	-1.67	2.4E+02	-1.71	2.0E+02	-1.26	1.7E+02	-1.32	8%	7%
5%	2.6E+02	-1.69	2.0E+02	-1.75	1.9E+02	-1.29	1.4E+02	-1.37	7%	6%
1%	2.2E+02	-1.73	1.4E+02	-1.81	1.6E+02	-1.34	1.0E+02	-1.46	6%	4%

§probability of a lower value

Table 36. For the Area 7 aggregate (Bella Bella), forecasts and associated confidence intervals for total return, escapement and proportion of S_{max} 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 0.19 was assumed.

$P^{§}$	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%	1.0E+03	0.31	1.5E+03	1.36	7.3E+02	1.43	1.1E+03	2.92	80%	119%
95%	7.8E+02	-0.19	1.1E+03	0.45	5.6E+02	0.72	7.8E+02	1.63	61%	85%
90%	6.9E+02	-0.38	9.1E+02	0.09	4.9E+02	0.45	6.5E+02	1.11	54%	72%
75%	5.7E+02	-0.62	6.9E+02	-0.38	4.1E+02	0.10	4.9E+02	0.44	45%	54%
50%	**4.8E+02**	**-0.82**	**5.0E+02**	**-0.76**	**3.4E+02**	**-0.18**	**3.6E+02**	**-0.10**	**37%**	**40%**
25%	4.0E+02	-0.97	3.7E+02	-1.04	2.9E+02	-0.40	2.6E+02	-0.50	32%	29%
10%	3.5E+02	-1.09	2.8E+02	-1.23	2.5E+02	-0.56	2.0E+02	-0.77	27%	22%
5%	3.2E+02	-1.14	2.3E+02	-1.32	2.3E+02	-0.64	1.7E+02	-0.90	25%	18%
1%	2.8E+02	-1.24	1.7E+02	-1.46	2.0E+02	-0.78	1.2E+02	-1.10	22%	13%

§probability of a lower value

Table 37. For the Area 8 aggregate (Bella Coola), forecasts and associated confidence intervals for total return, escapement and proportion of S_{max} 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 0.19 was assumed.

$P^{§}$	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%	1.1E+04	2.05	1.5E+04	1.36	7.8E+03	4.62	1.1E+04	7.07	224%	307%
95%	8.0E+03	0.93	1.0E+04	0.45	5.7E+03	2.84	7.1E+03	4.02	164%	204%
90%	7.0E+03	0.52	8.1E+03	0.09	5.0E+03	2.20	5.8E+03	2.88	142%	165%
75%	5.6E+03	-0.01	5.7E+03	-0.38	4.0E+03	1.36	4.1E+03	1.46	114%	117%
50%	**4.5E+03**	**-0.43**	**3.9E+03**	**-0.76**	**3.2E+03**	**0.70**	**2.8E+03**	**0.37**	**92%**	**81%**
25%	3.6E+03	-0.75	2.7E+03	-1.04	2.6E+03	0.19	1.9E+03	-0.38	75%	55%
10%	3.0E+03	-0.98	1.9E+03	-1.23	2.2E+03	-0.17	1.4E+03	-0.85	62%	39%
5%	2.7E+03	-1.10	1.6E+03	-1.32	2.0E+03	-0.36	1.1E+03	-1.07	56%	32%
1%	2.2E+03	-1.29	1.0E+03	-1.46	1.6E+03	-0.66	7.4E+02	-1.39	46%	21%

§probability of a lower value

Table 38 . For each aggregate, the approximate probabilities of escapement in 2000 falling below three reference points. The reference points are 100% S_{MAX}, the nominal carrying capacity, 25% and 10% of S_{MAX}. The indicated forecasting model was the best performer among the four time series model and the stock-recruitment model.

		approximate probability that escapement in 2000 will fall below the indicated reference point			
aggregate	forecast model	reference point	100% S_{MAX}	25% S_{MAX}	10% S_{MAX}
Area 1 (NQCI)	S-R		<99%	<1%	<1%
Area 2W (WQCI)	3YRA		<99%	<90%	<25%
Area 2E (EQCI)	3YRA		>99%	<75%	<5%
Area 3 (Nass)	S-R		<90%	<1%	<1%
Area 4L (lower Skeena)	S-R		<90%	<1%	<1%
Area 4U (upper Skeena	S-R		>99%	<1%	<1%
Babine Lake	S-R		>99%	<1%	<1%
Area 5 (Grenville/Principe)	3YRA		<75%	<1%	<1%
Area 6 (Kitimat)	3YRA		>99%	>99%	<50%
Area 7 (Bella Bella)	3YRA		>99%	<5%	<1%
Area 8 (Bella Coola)	S-R		<75%	<1%	<1%

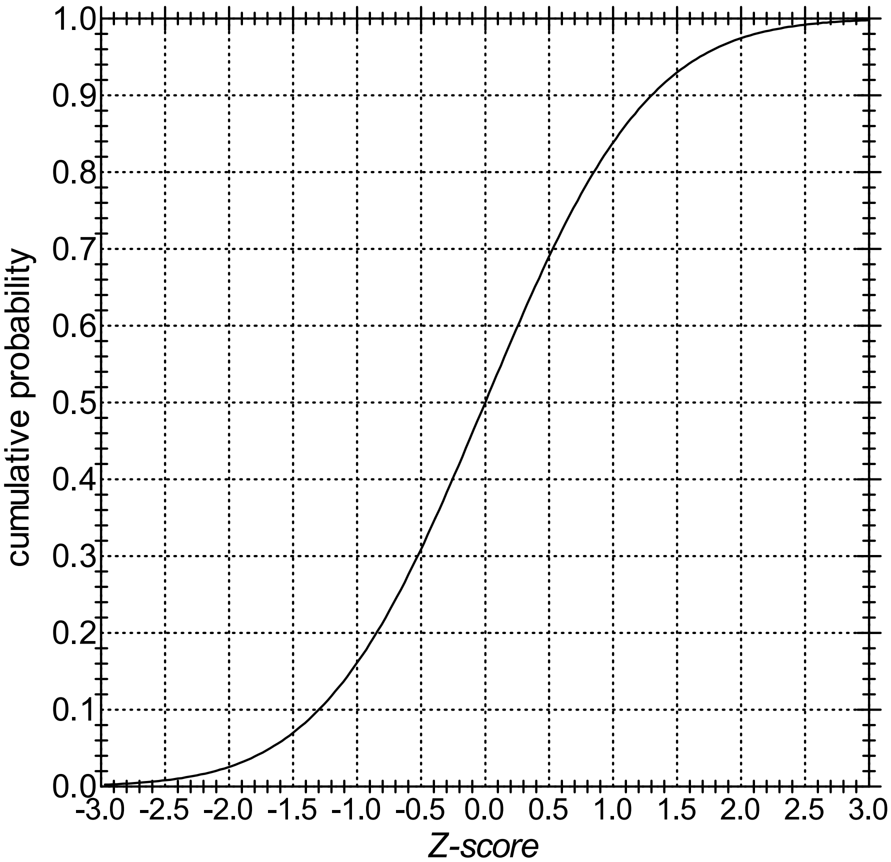

Figure 1. Cumulative probabilities for *Z*-scores applicable to the time series of Babine Lake coho and the average-stream indices from the Statistical Areas. This plot can be used to convert *Z-scores* to probabilities.

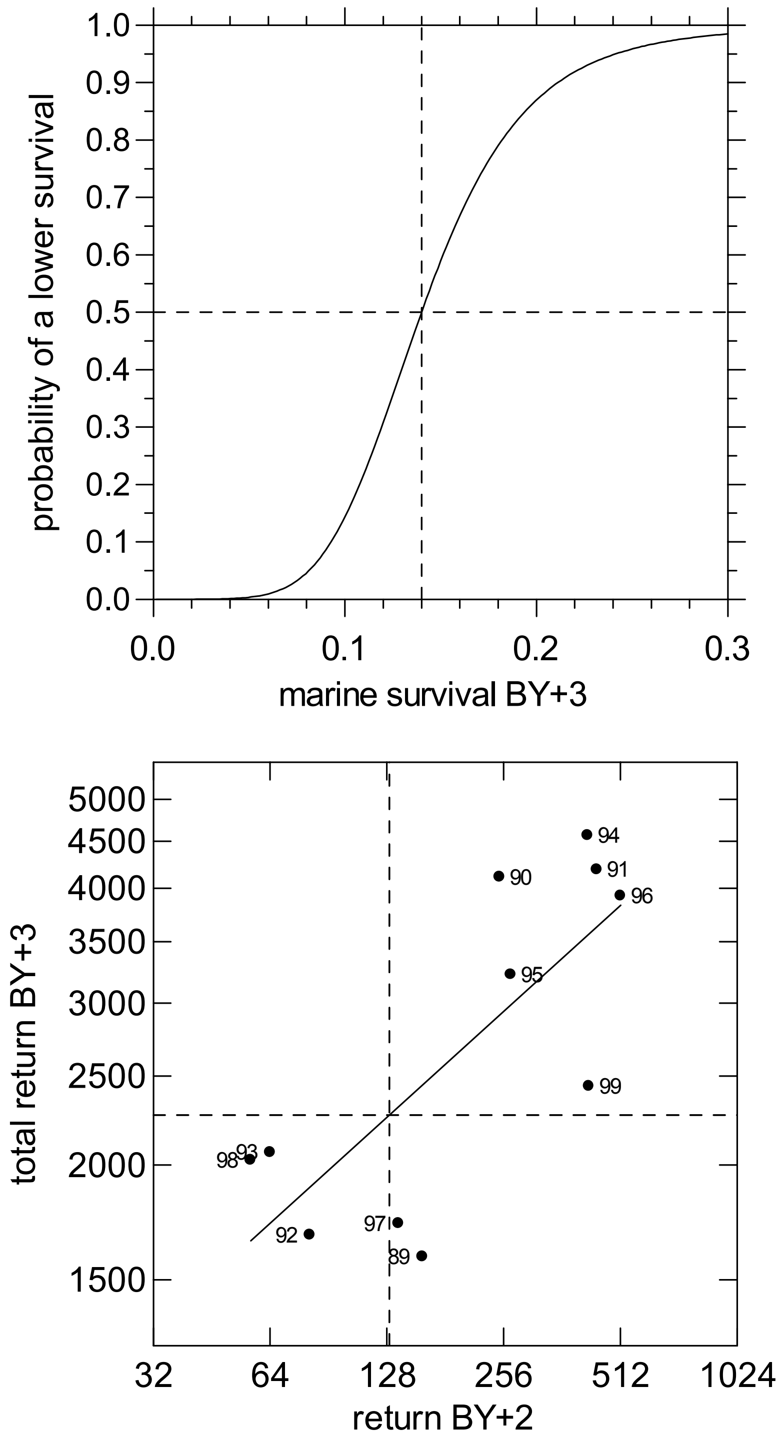

Figure 2. Return and survival forecast for Lachmach River coho in 1999 using the sibling regression model. The lower panel is the sibling relationship. The upper panel is the probability distribution for the predicted age 3+4 return.

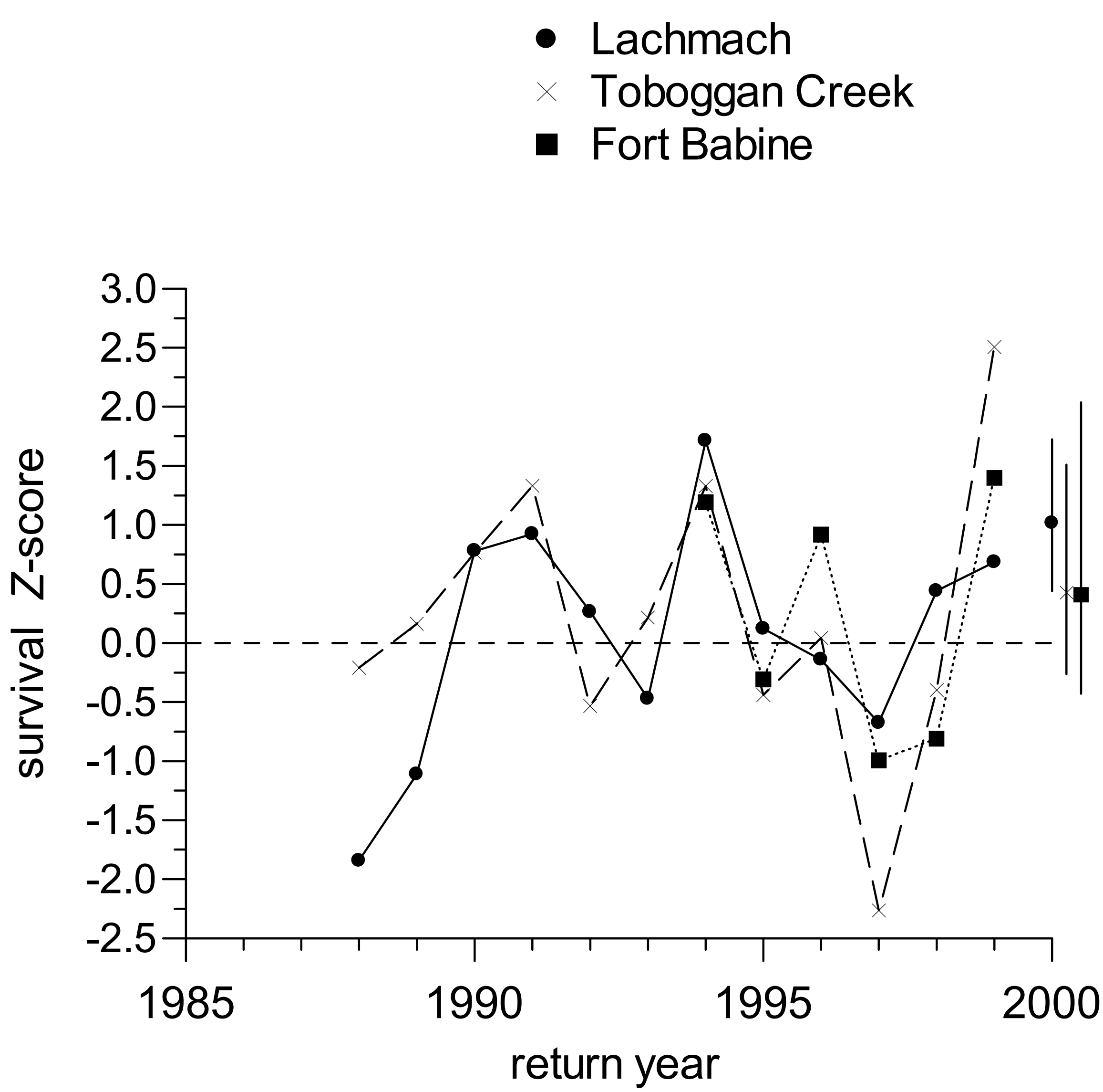

Figure 3. Time series of standardized survivals for three northern BC coho indicators. Forecast survivals for 2000 are shown with 50% confidence intervals.

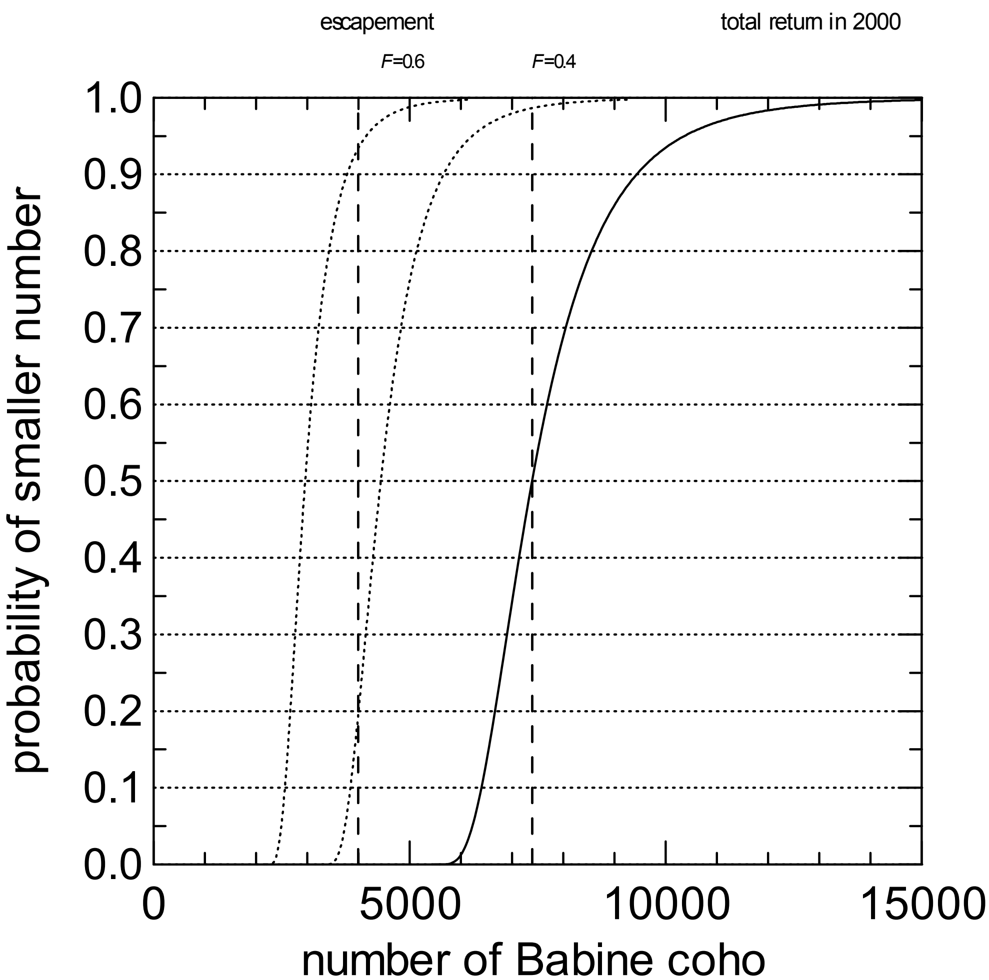

Figure 4. Stock-recruitment forecast for Babine coho aggregate in 2000. Escapement (dotted lines) is forecast for two exploitation rates (0.4 and 0.6). The solid line is the forecast for the total return in 2000. The two vertical dashed lines indicate the point forecasts for total return on the right and after fishing at the rate observed in 1999 of 46%.

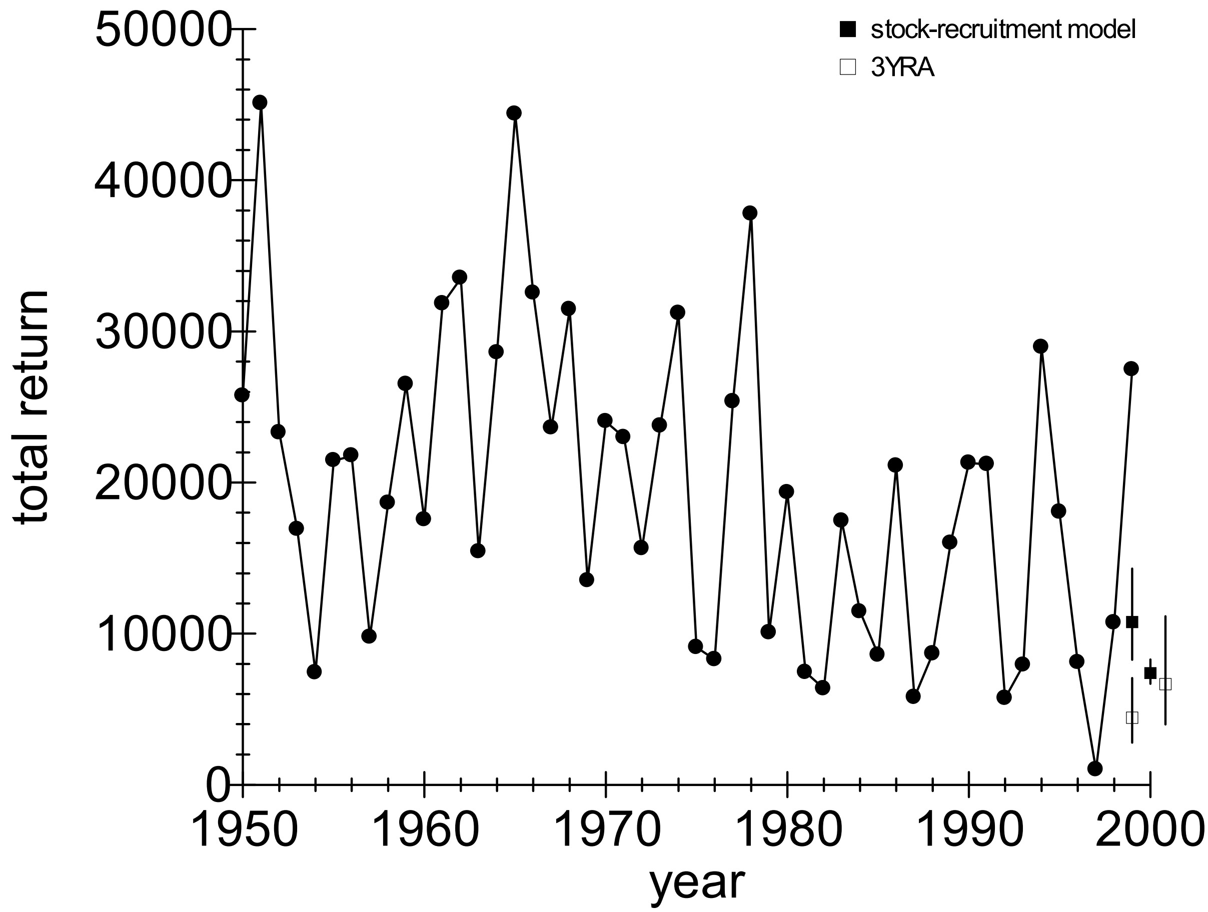

Figure 5. Estimated total return of the Babine Lake coho aggregate. The S-R and 3YRA forecasts with 50% CI are shown for both 1999 and 2000.

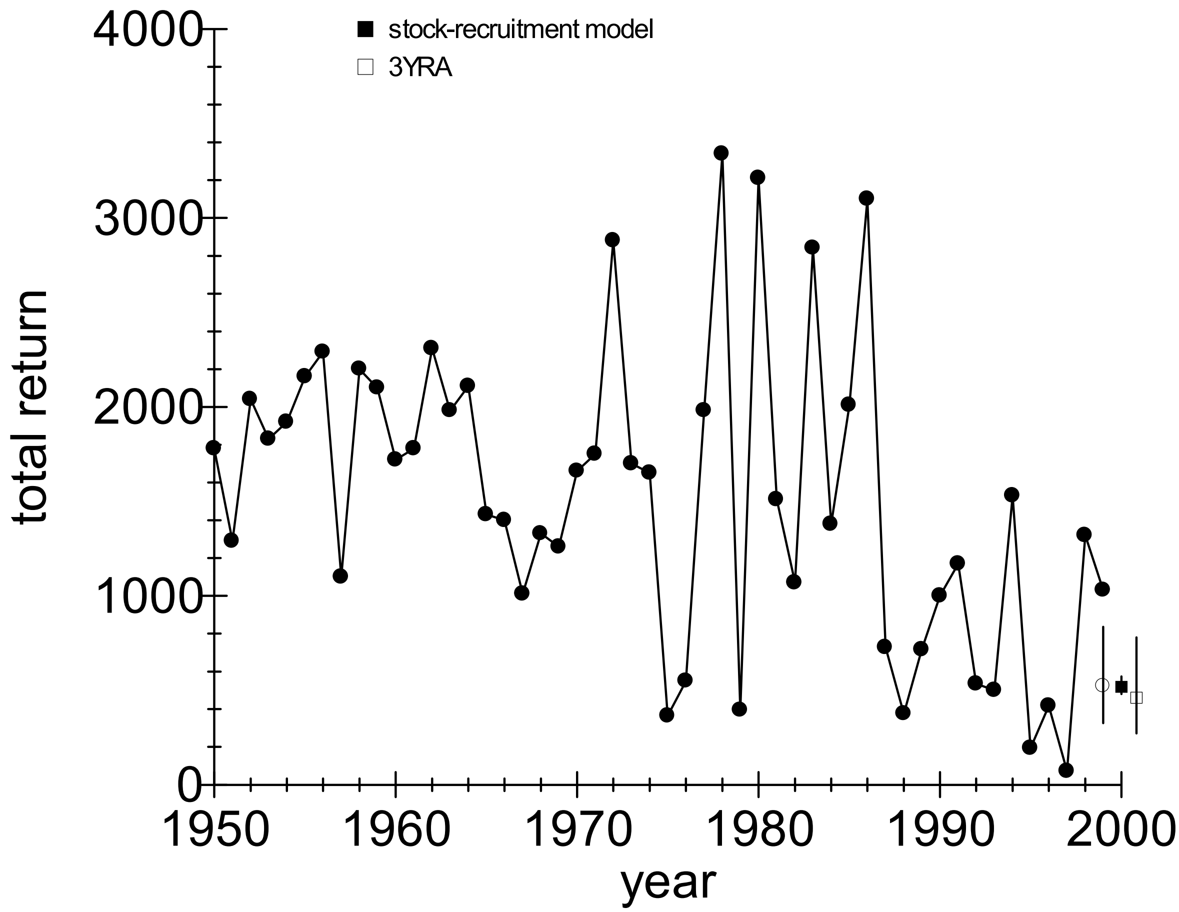

Figure 6. Total return for the average stream in the upper Skeena (Area 4). The 3YRA forecast for 1999 and the S-R and 3YRA forecasts for 2000 with associated 50% CI are shown.

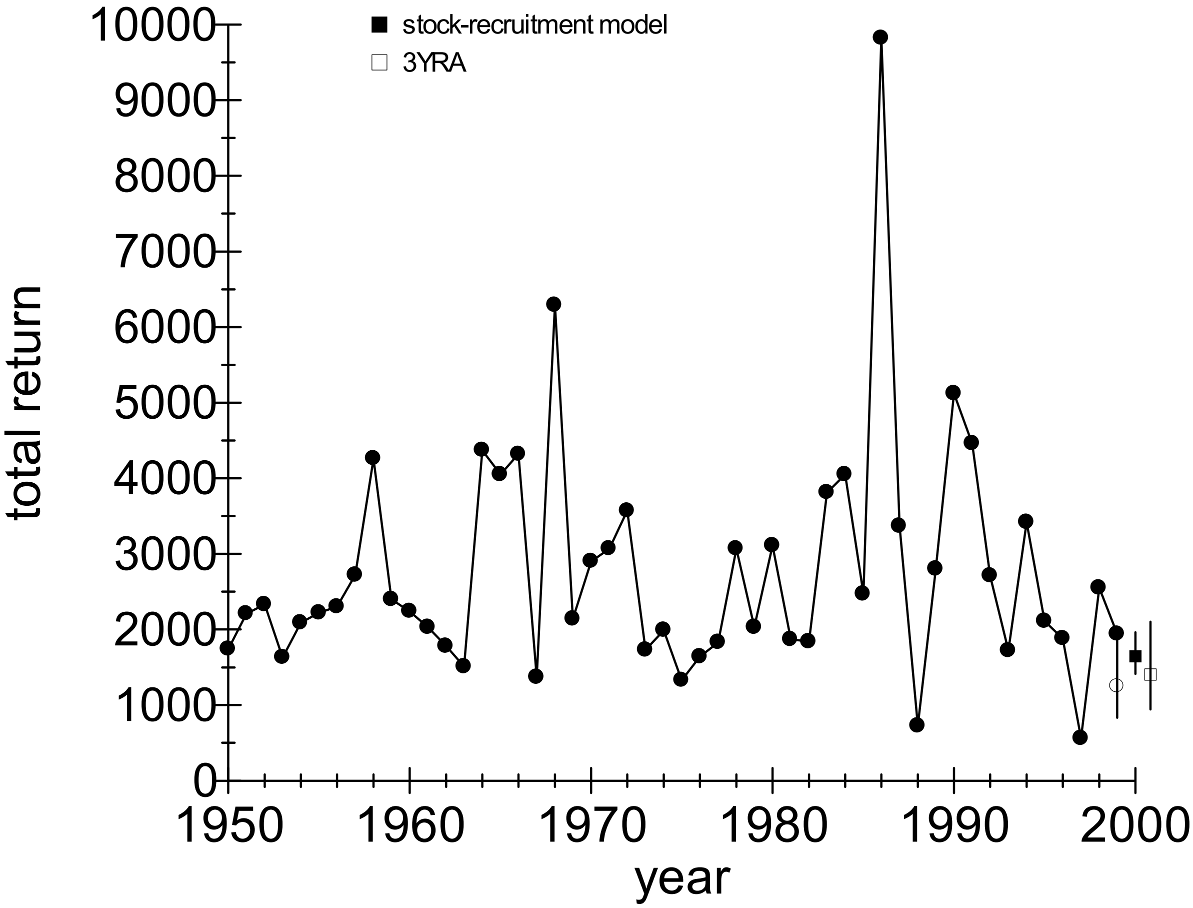

Figure 7. Total return for the average stream in the lower and middle Skeena (Area 4). The 3YRA forecast for 1999 and the S-R and 3YRA forecasts for 2000 with associated 50% CI are shown

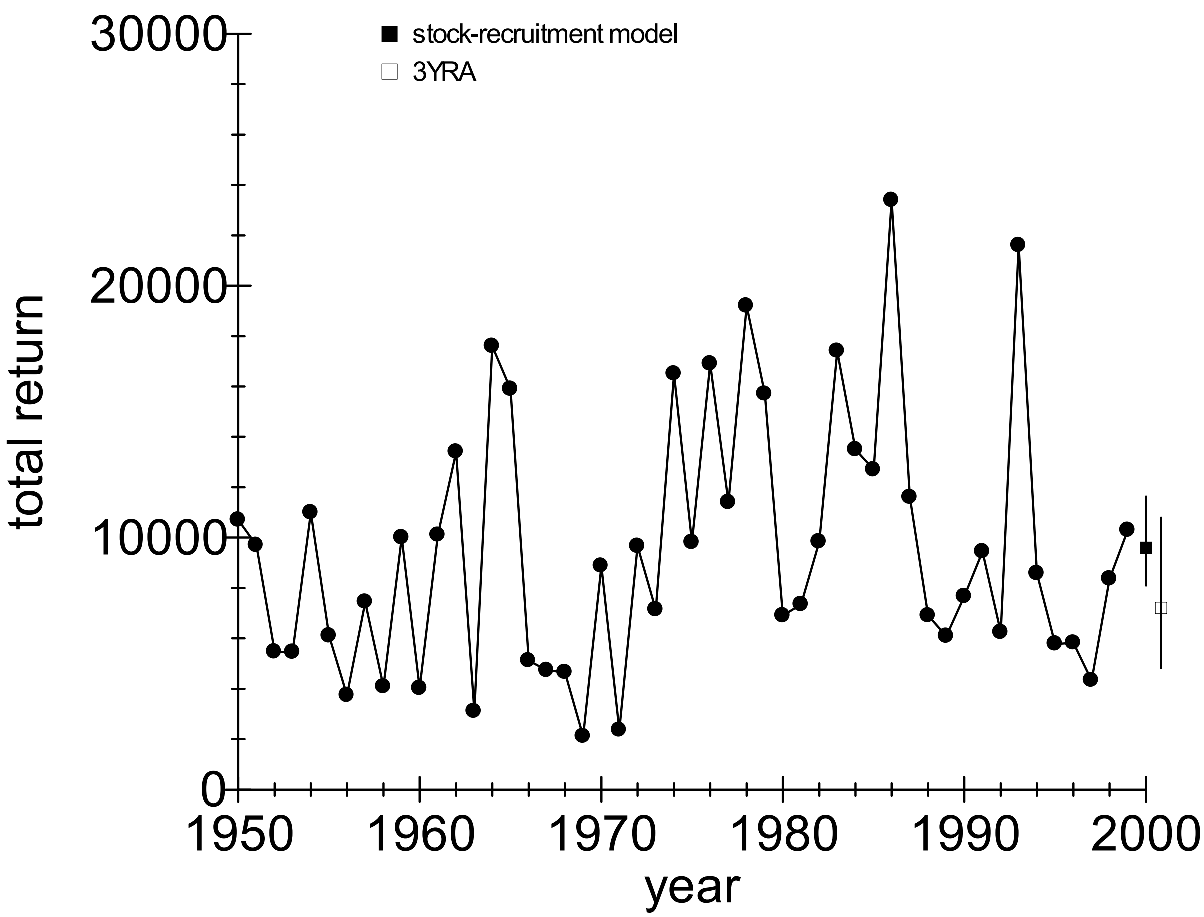

Figure 8. Total return for the average stream on the north coast of the Queen Charlotte Islands (Area 1). The S-R and 3YRA forecasts with associated 50% CI are shown.

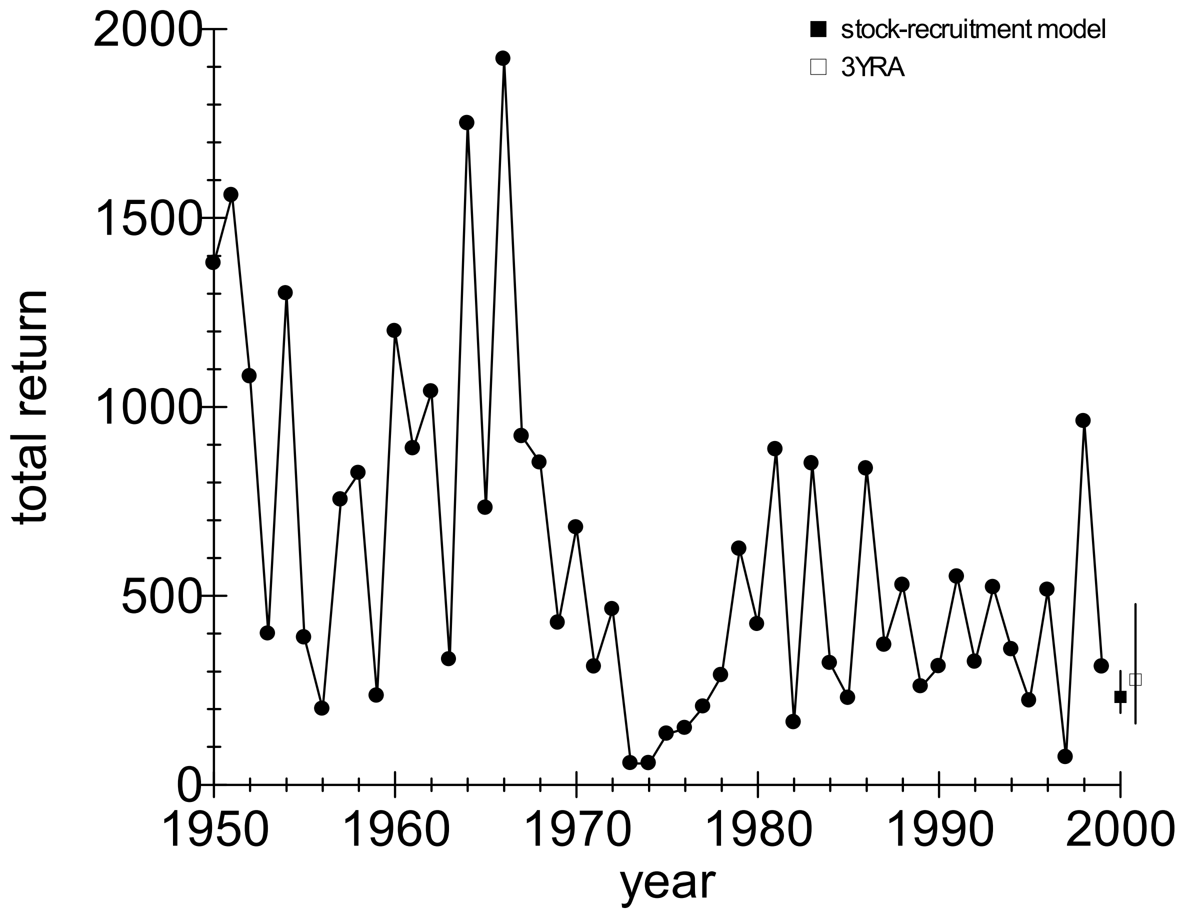

Figure 9. Total return for the average stream on the west coast of the Queen Charlotte Islands (Area 2W). The S-R and 3YRA forecasts with associated 50% CI are shown.

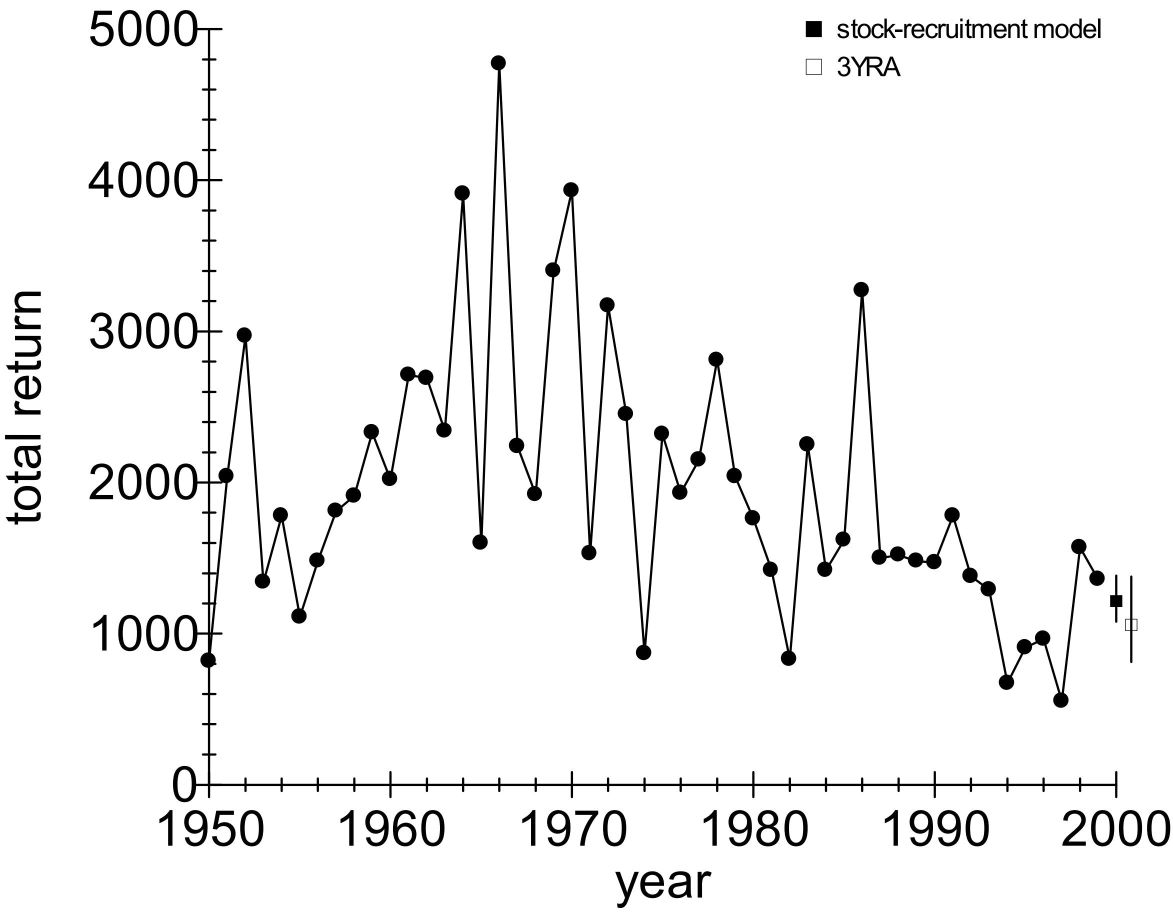

Figure 10. Total return for the average stream on the east coast of the Queen Charlotte Islands (Area 2E). The S-R and 3YRA forecasts with associated 50% CI are shown.

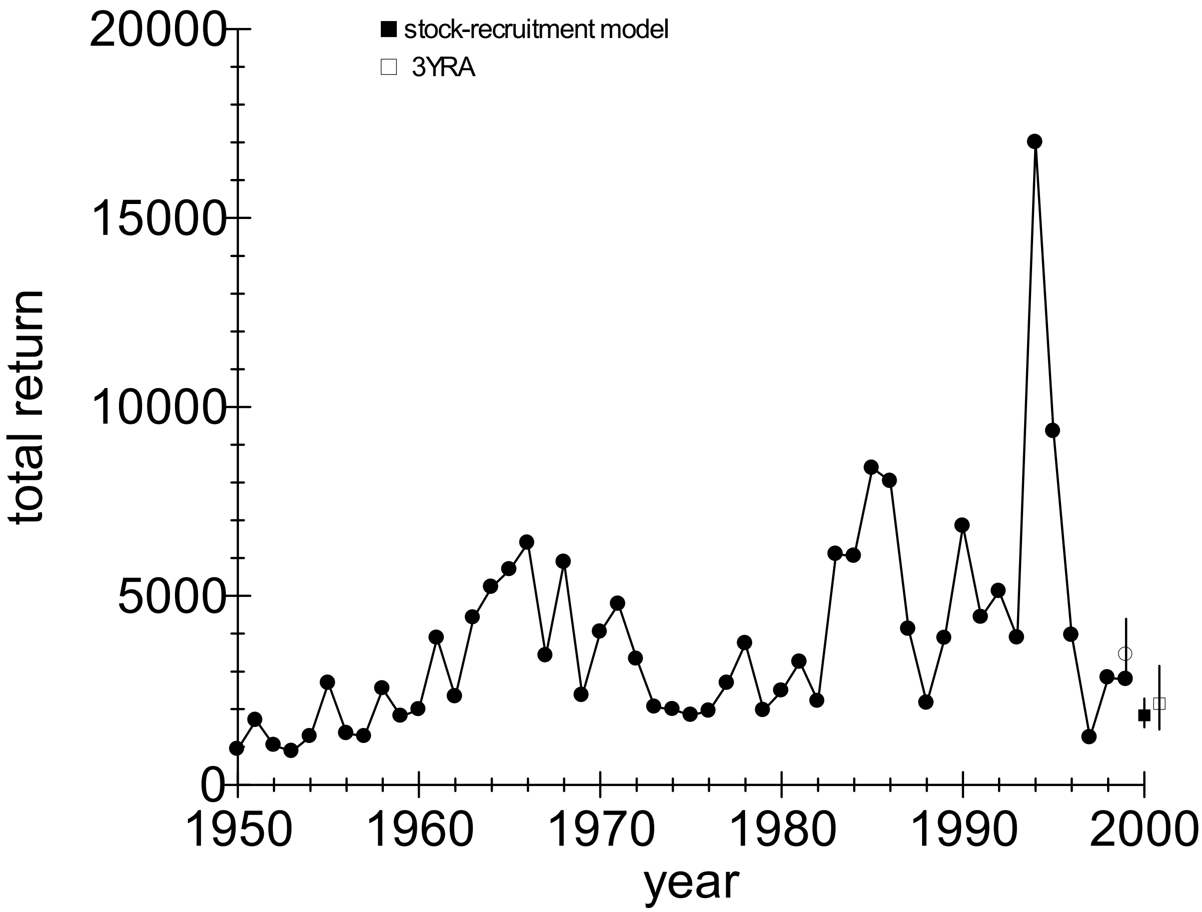

Figure 11. Total return to the average stream in Area 3. The 3YRA forecast for 1999 and the S-R and 3YRA forecasts for 2000 with associated 50% CI are shown.

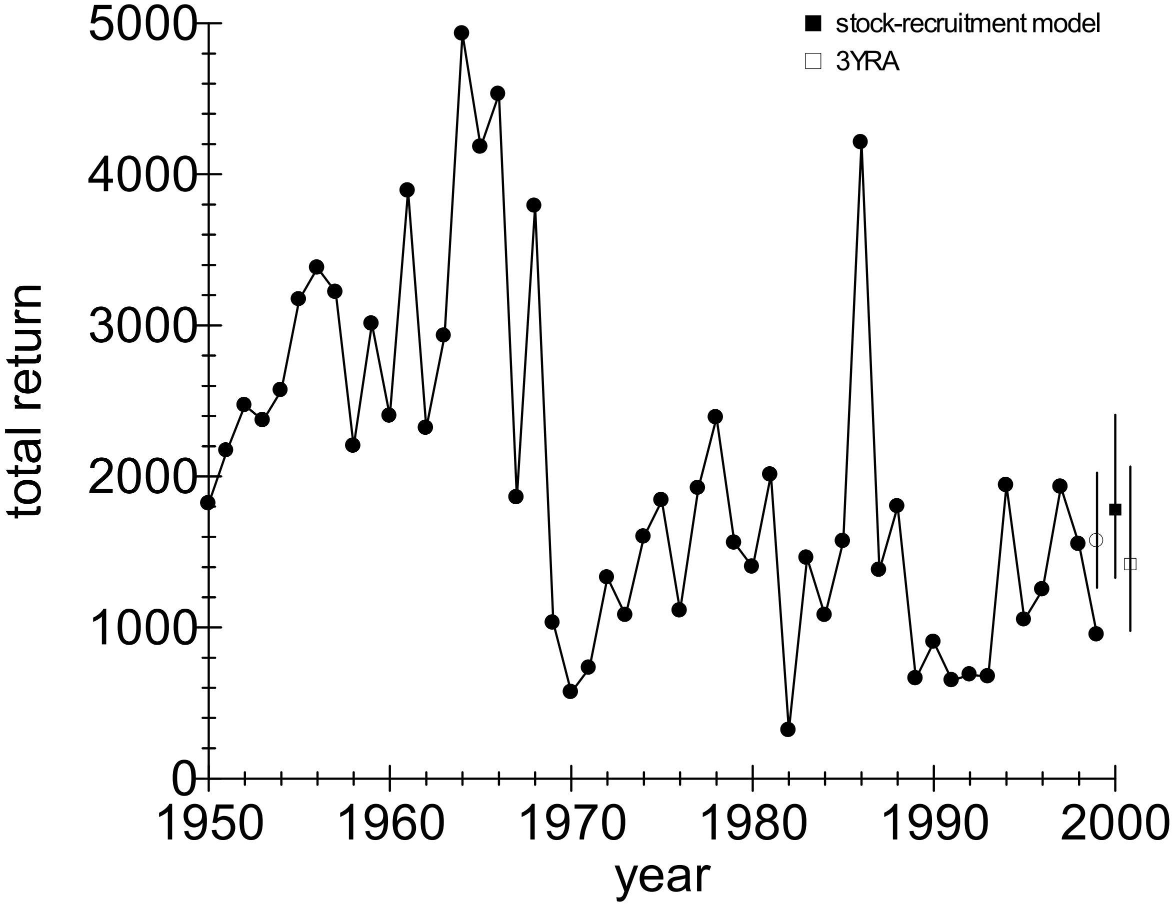

Figure 12. Total return to the average stream of the Principe/Grenville (Area 5) aggregate. The 3YRA forecast for 1999 and the S-R and 3YRA forecasts for 2000 with associated 50% CI are shown.

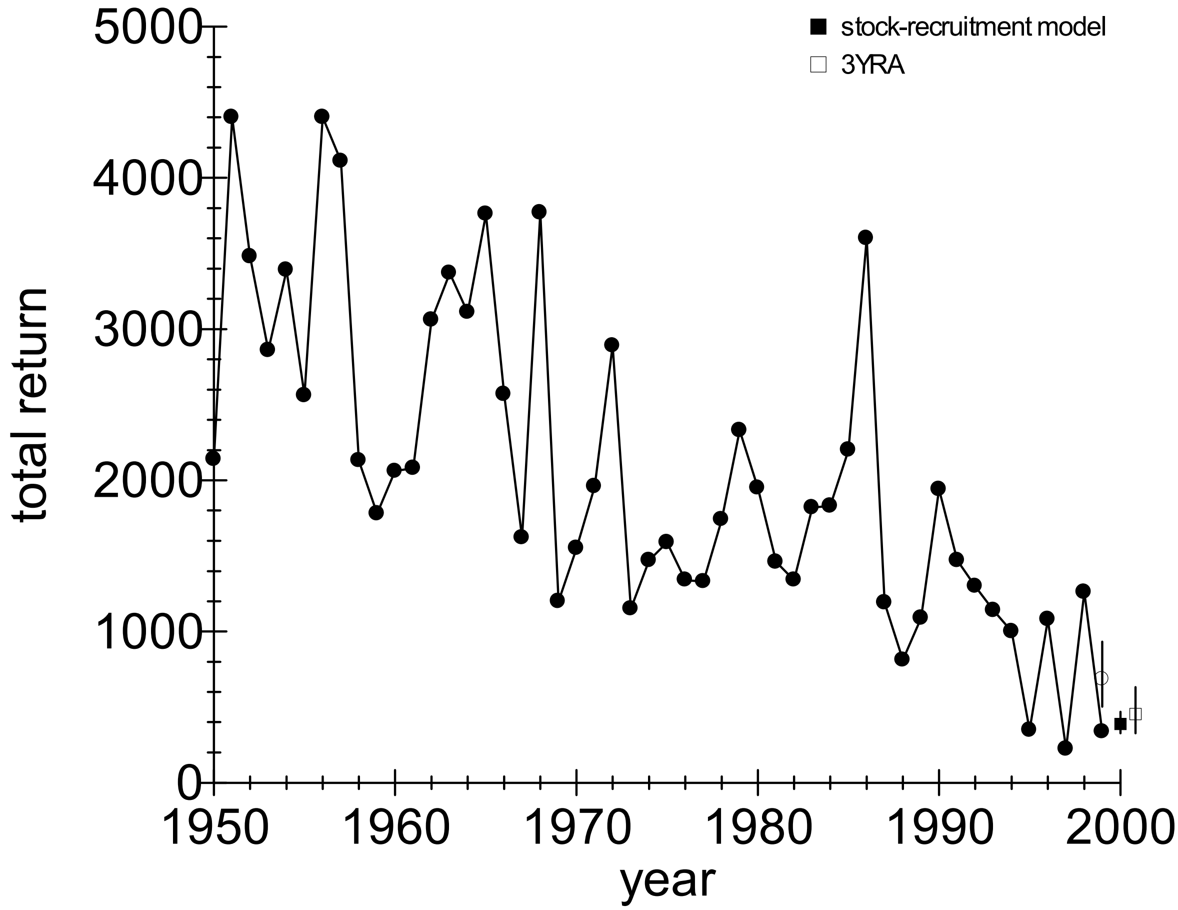

Figure 13. Total return to the average stream in Area 6. The 3YRA forecast for 1999 and the S-R and 3YRA forecasts for 2000 with associated 50% CI are shown.

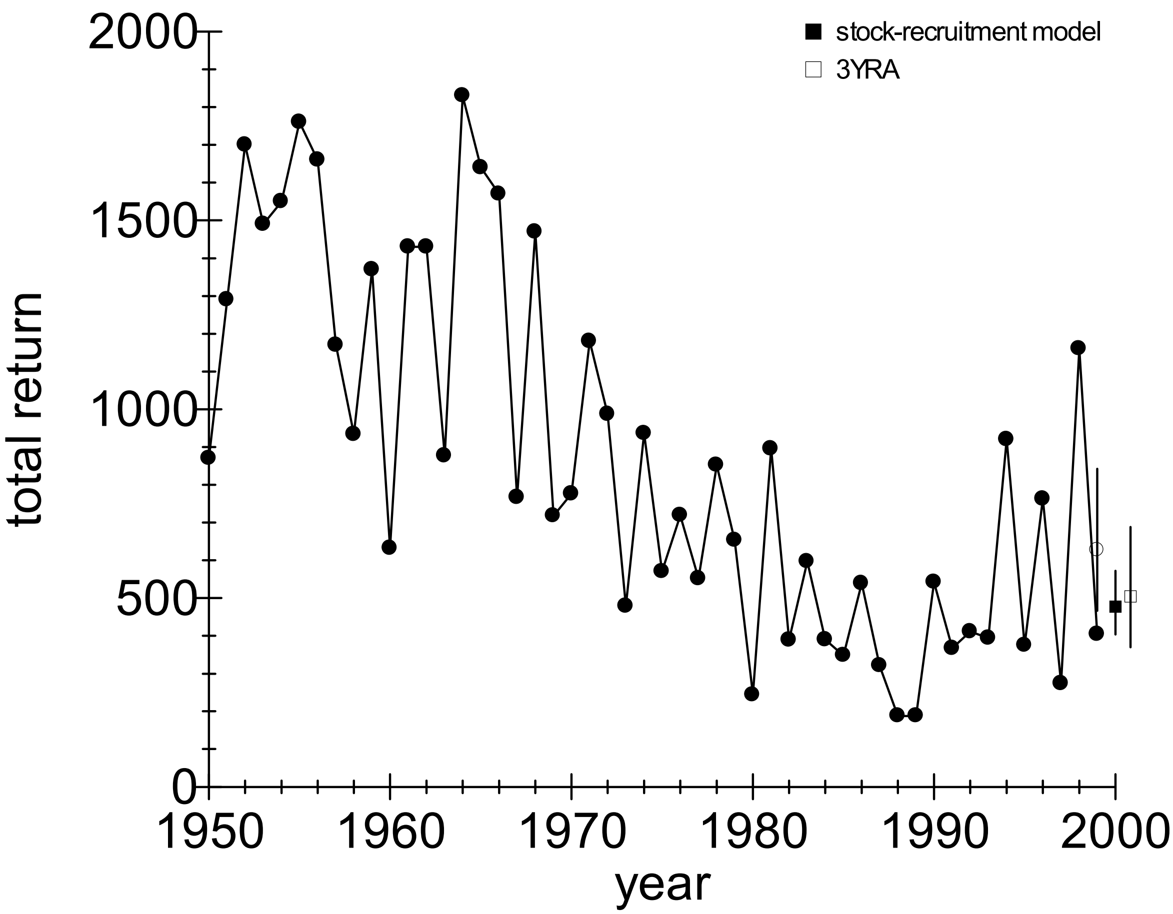

Figure 14. Total return to the average stream of the Area 7 (Bella Bella) aggregate. The 3YRA forecast for 1999 and the S-R and 3YRA forecasts for 2000 with associated 50% CI are shown.

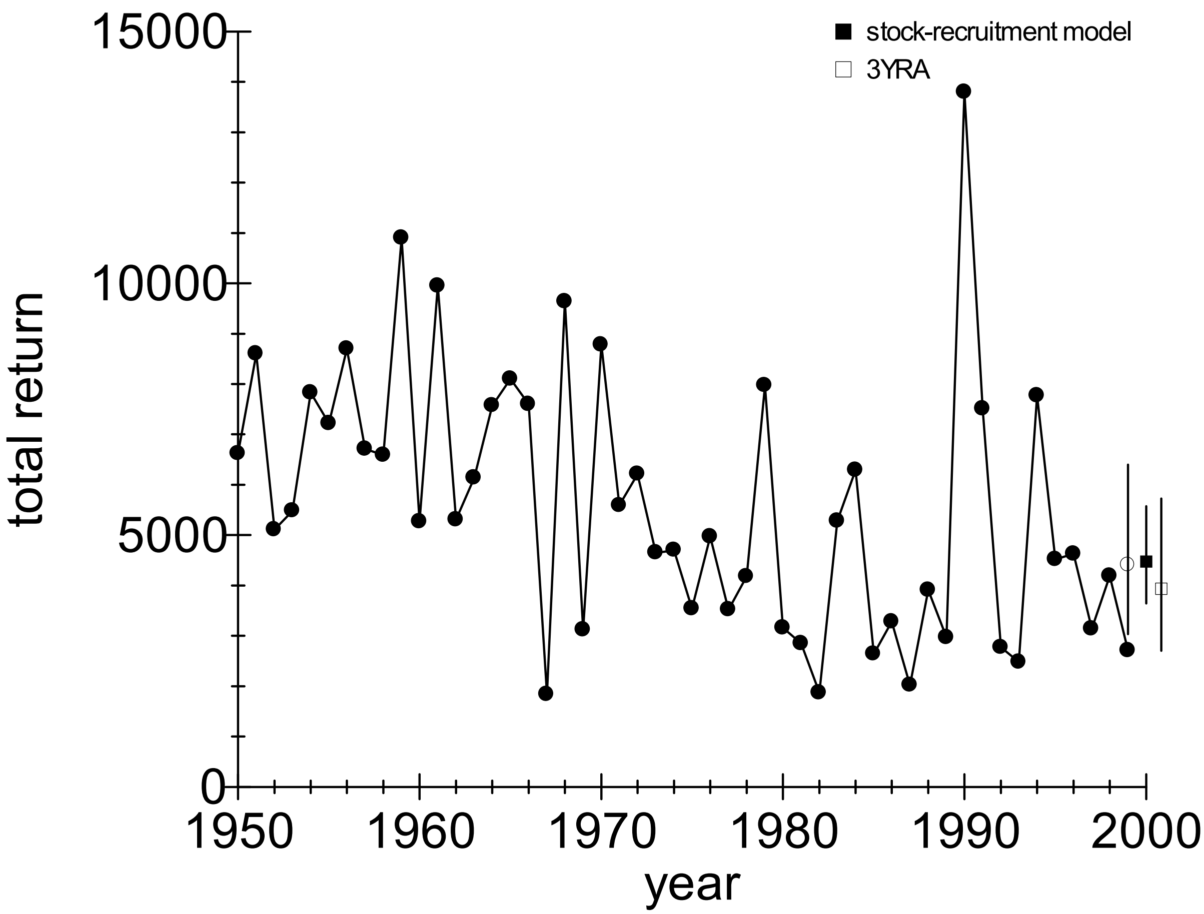

Figure 15. Total return to the average stream of the Bella Coola (Area 8) aggregate. The 3YRA forecast for 1999 and the S-R and 3YRA forecasts for 2000 with associated 50% CI are shown.

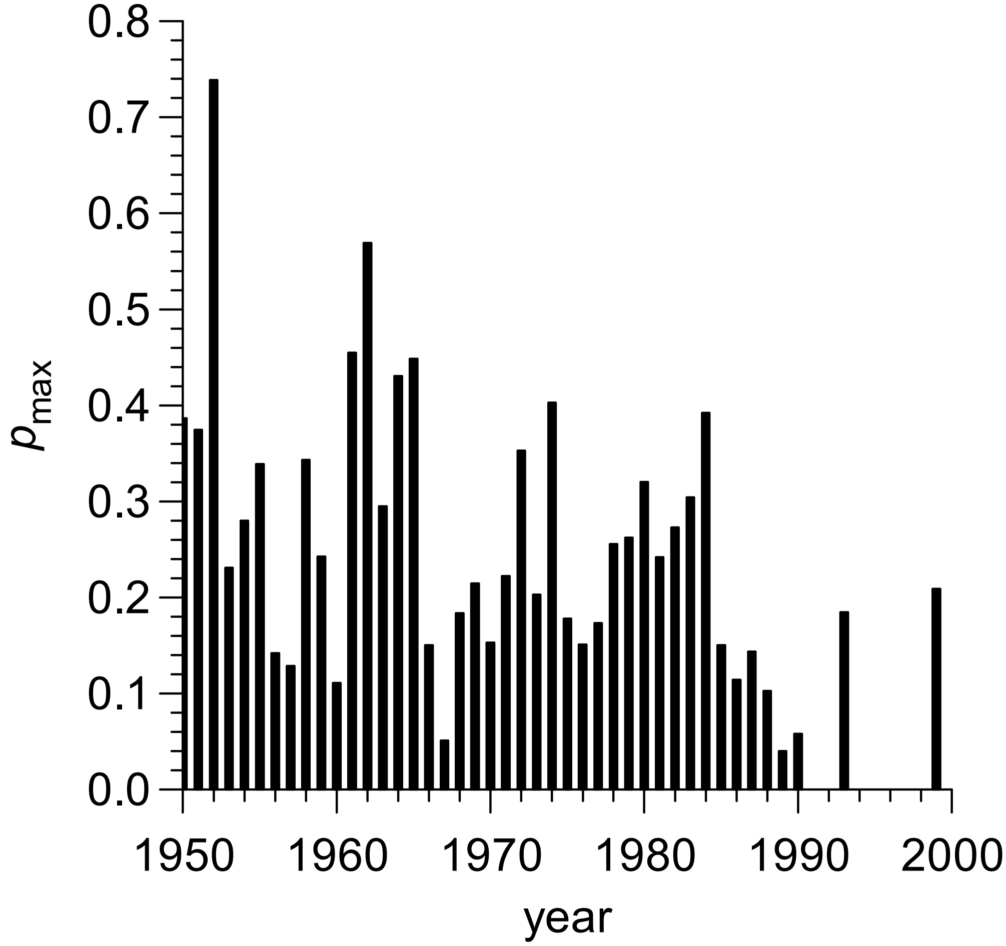

Figure 16. Standarized escapement index for the Area 9 and 10 coho aggregate of the Central Coast. There is insufficient data to enable a reconstruction of total abundance.

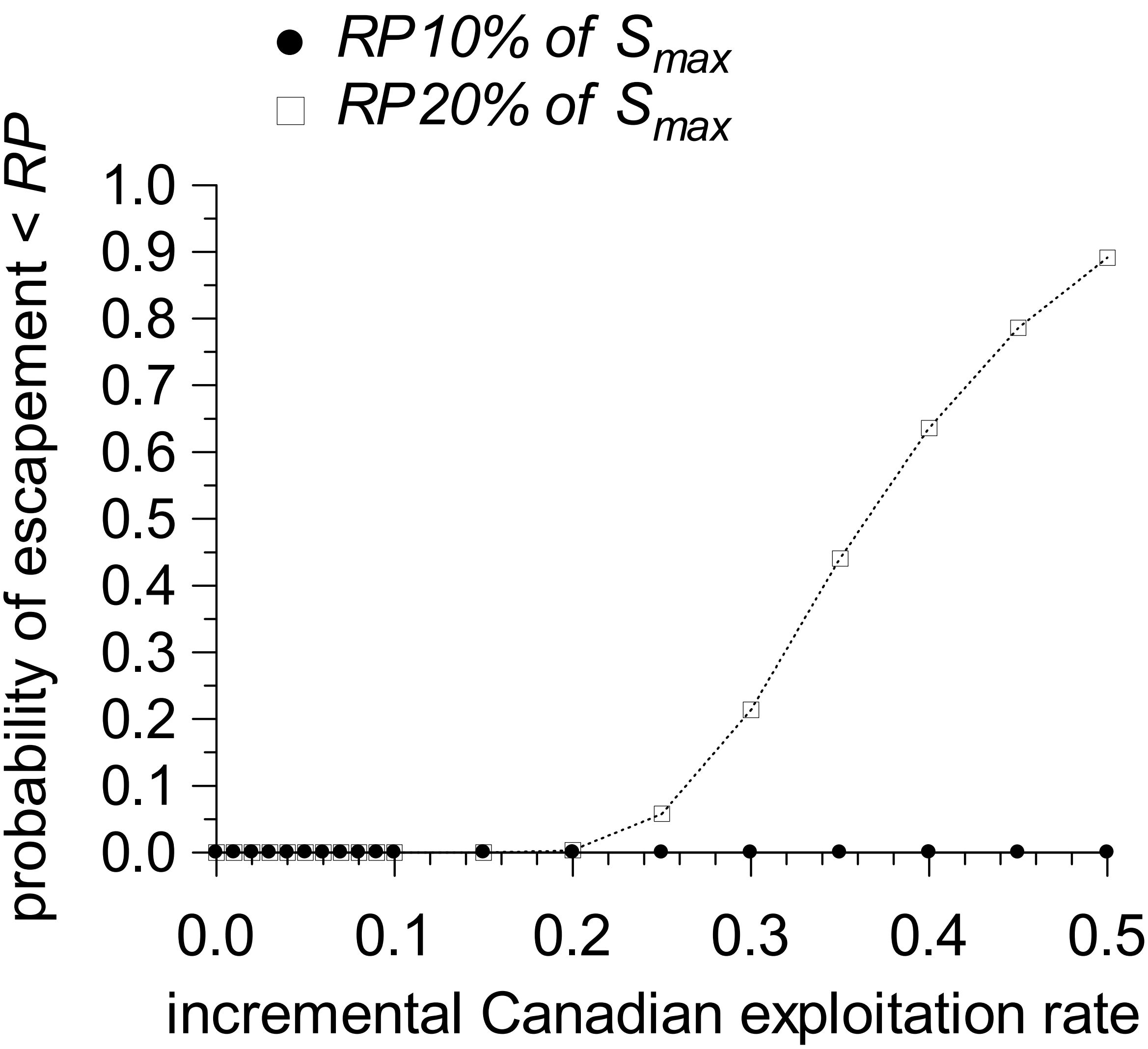

Figure 17. For the Babine Lake aggregate the impacts of incremental Canadian fishing on probabilities of escapement falling below two reference points derived from the stock-recruitment carrying capacity.

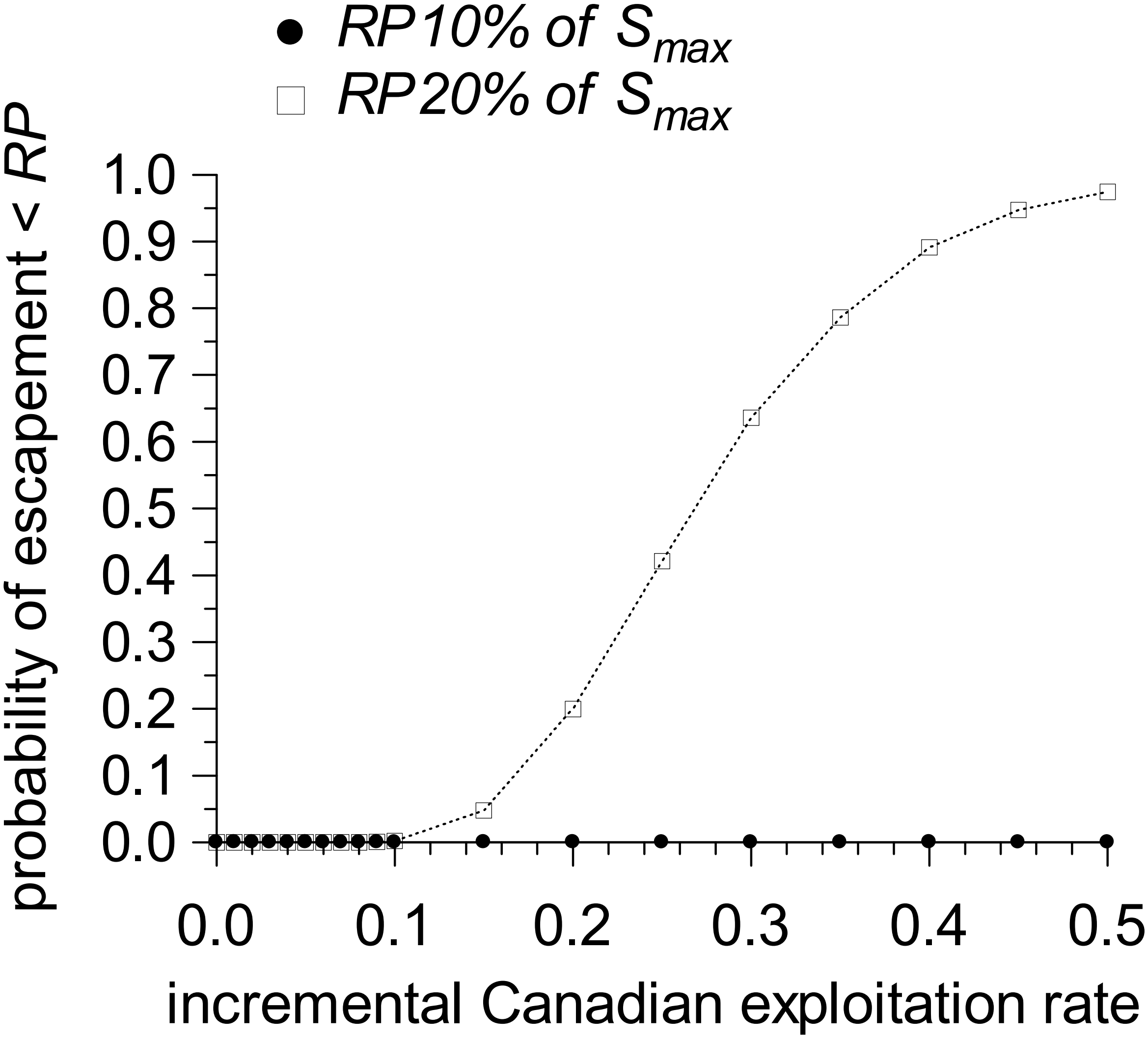

Figure 18. For the Area 4-upper aggregate the impacts of incremental Canadian fishing on probabilities of escapement falling below two reference points derived from the stock-recruitment carrying capacity.

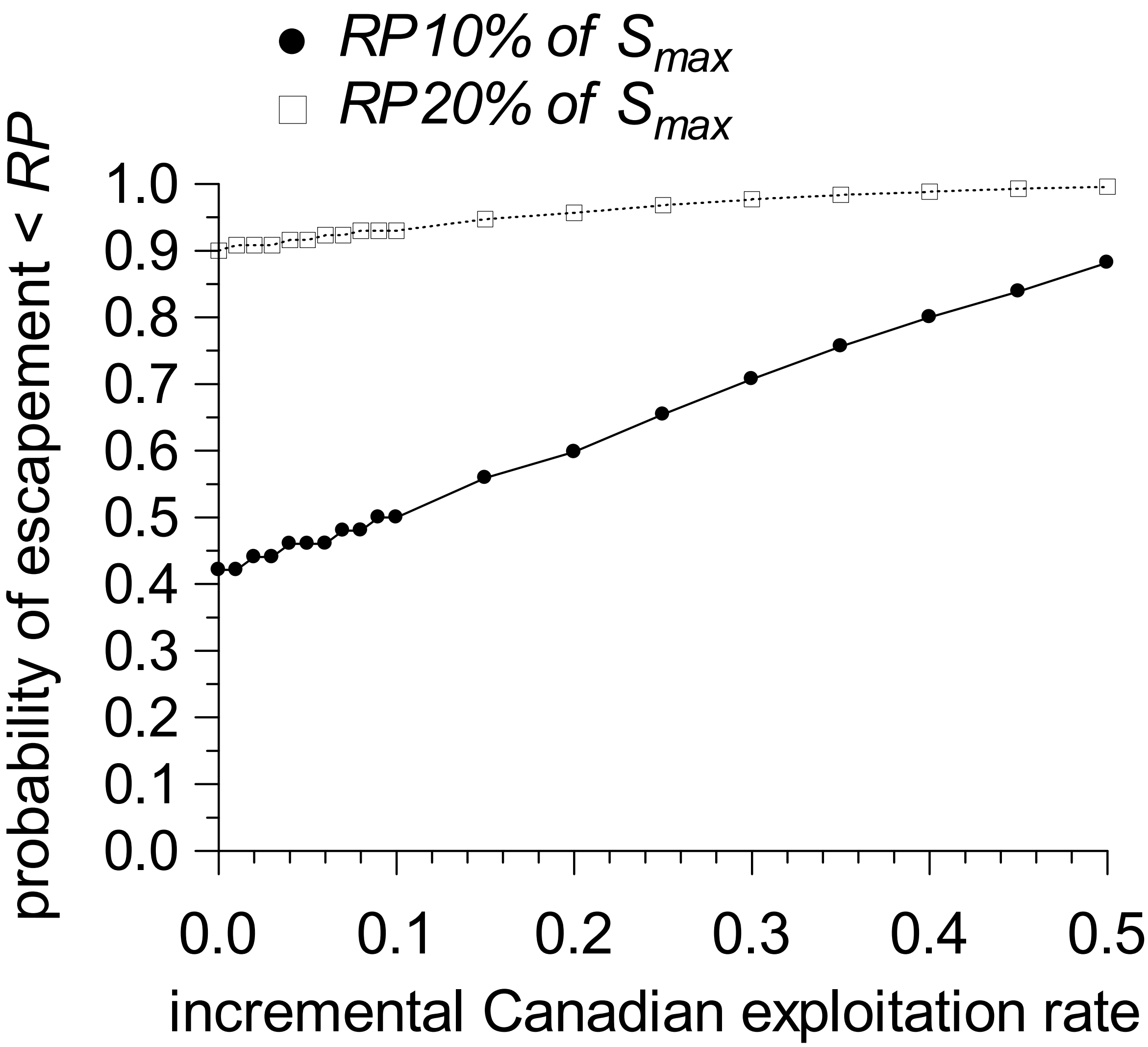

Figure 19. For the Area 6 aggregate the impacts of incremental Canadian fishing on probabilities of escapement falling below two reference points derived from the stock-recruitment carrying capacity.

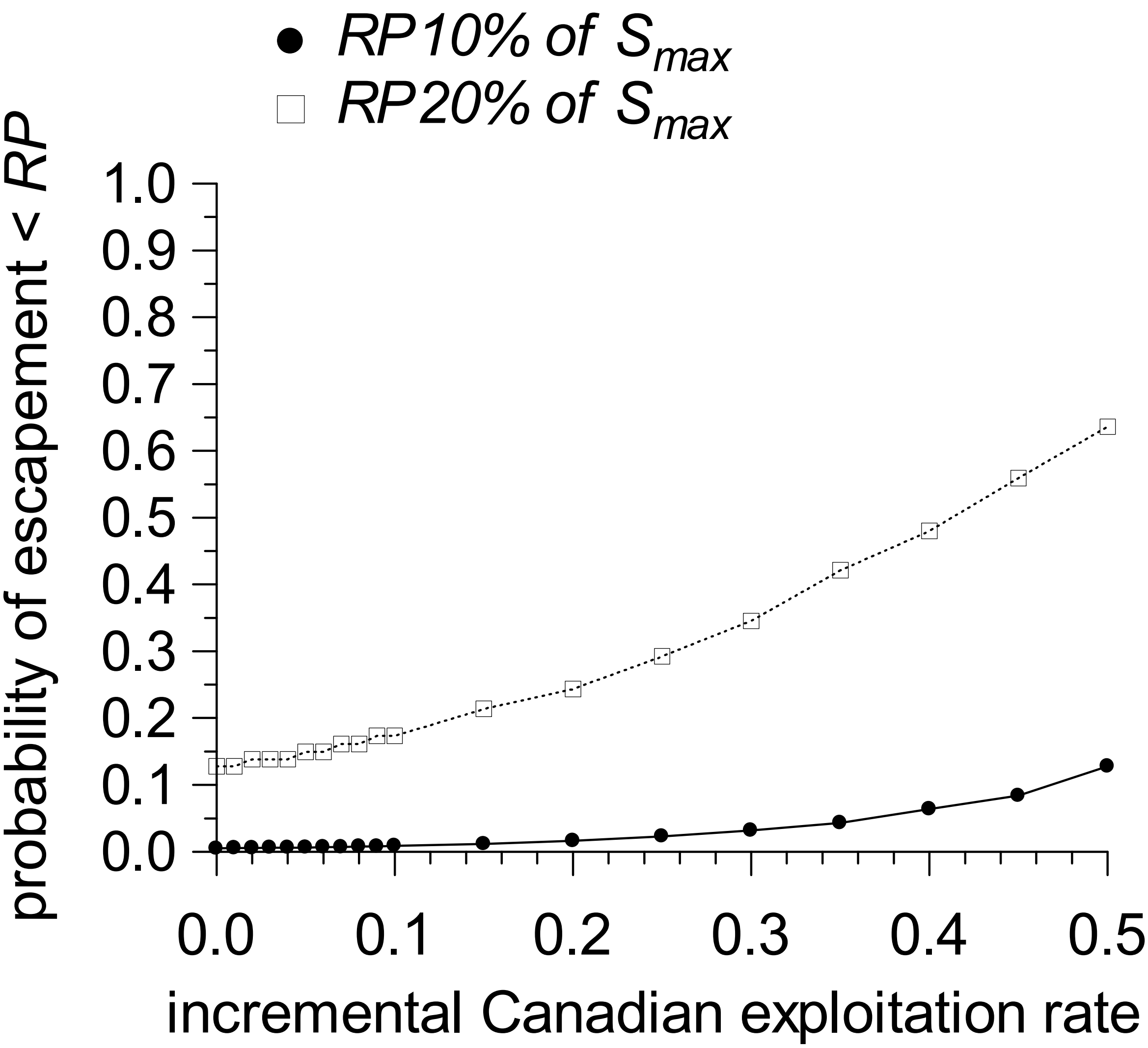

Figure 20. For the Area 7 aggregate the impacts of incremental Canadian fishing on probabilities of escapement falling below two reference points derived from the stock-recruitment carrying capacity.

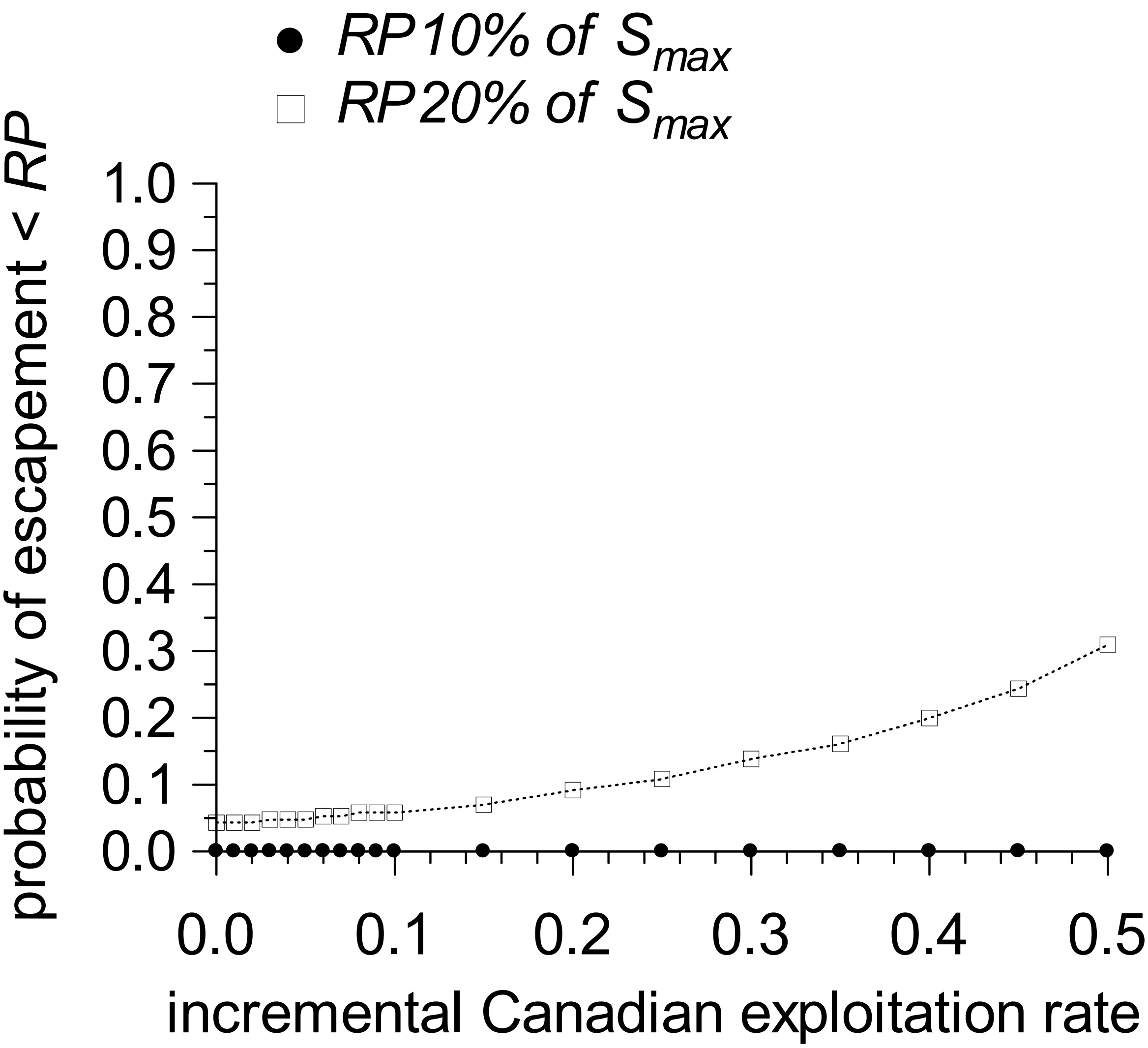

Figure 21. For the Area 8 aggregate the impacts of incremental Canadian fishing on probabilities of escapement falling below two reference points derived from the stock-recruitment carrying capacity.

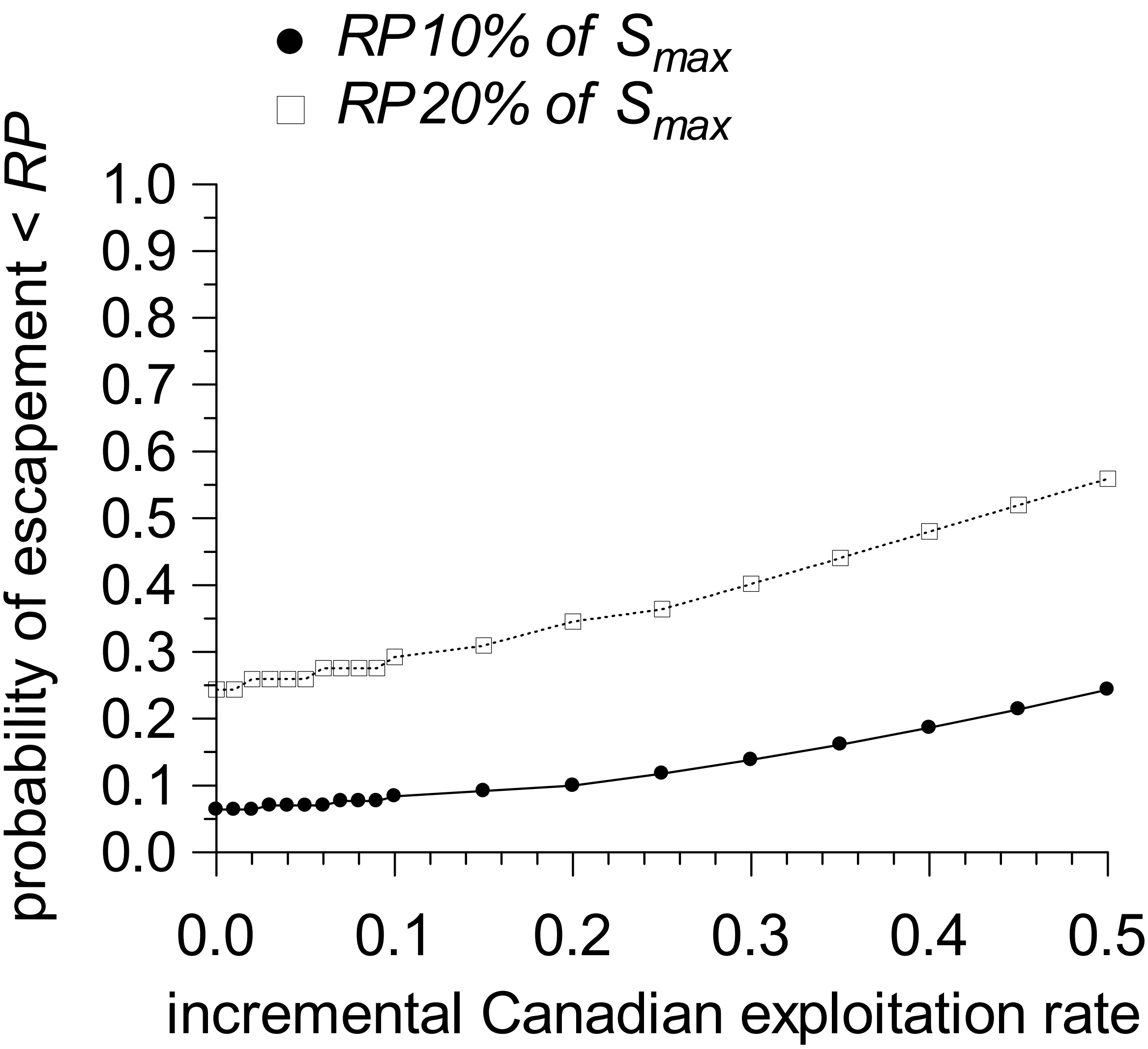

Figure 22. For the QCIW (Area 2W) aggregate the impacts of incremental Canadian fishing on probabilities of escapement falling below two reference points derived from the stock-recruitment carrying capacity.

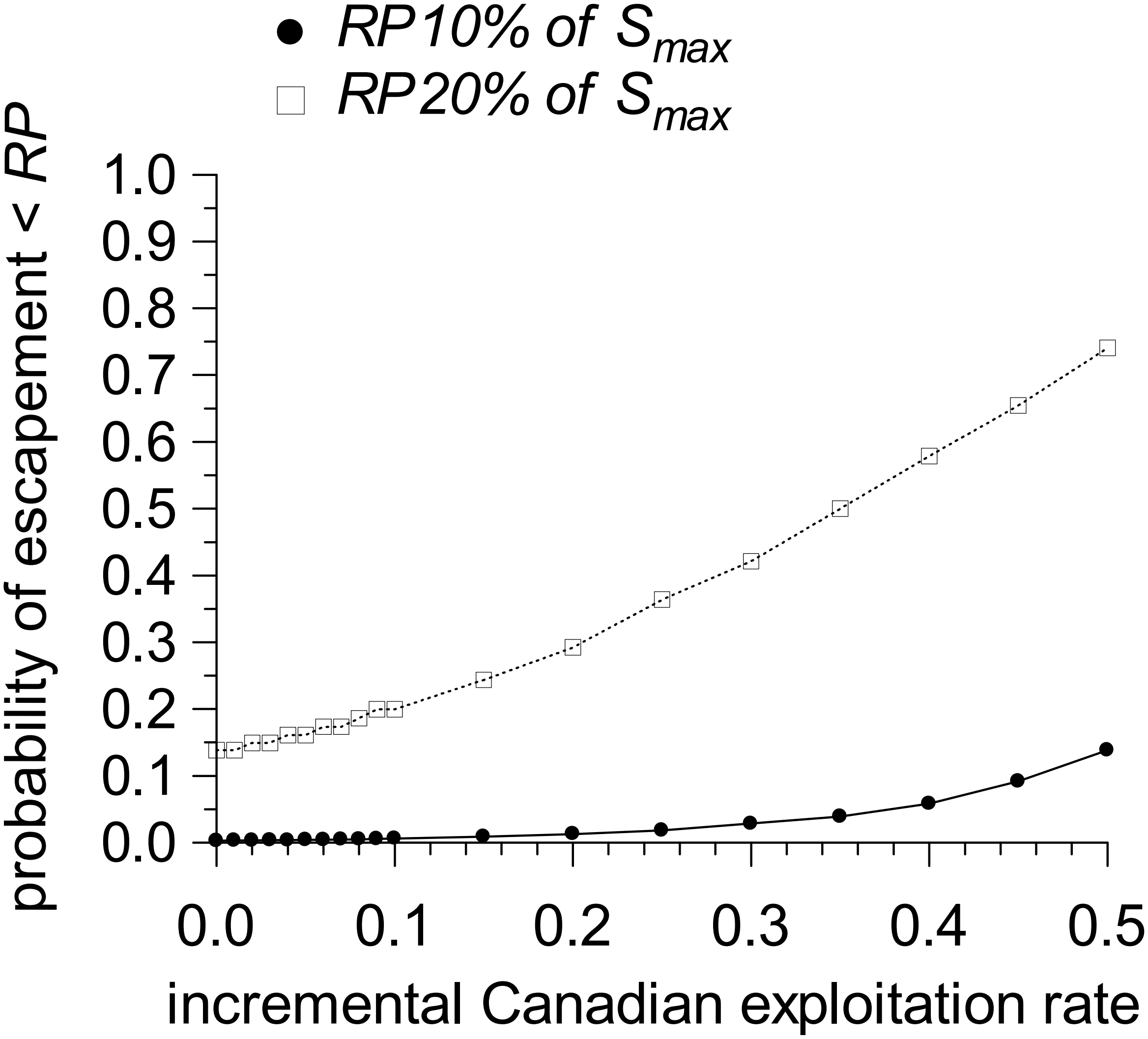

Figure 23. For the QCIE (Area 2E) aggregate the impacts of incremental Canadian fishing on probabilities of escapement falling below two reference points derived from the stock-recruitment carrying capacity.

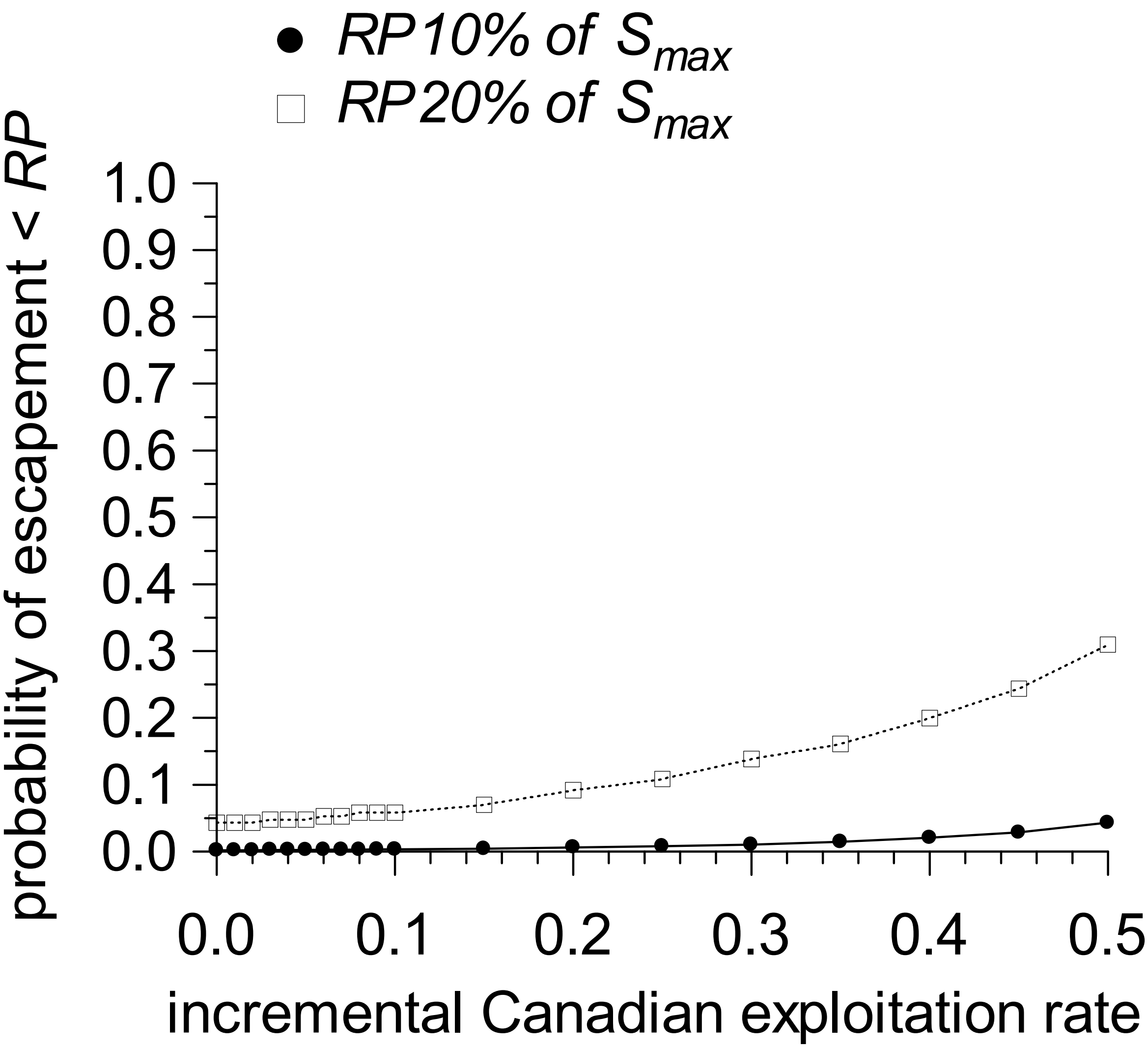

Figure 24. For the Area 5 aggregate the impacts of incremental Canadian fishing on probabilities of escapement falling below two reference points derived from the stock-recruitment carrying capacity.

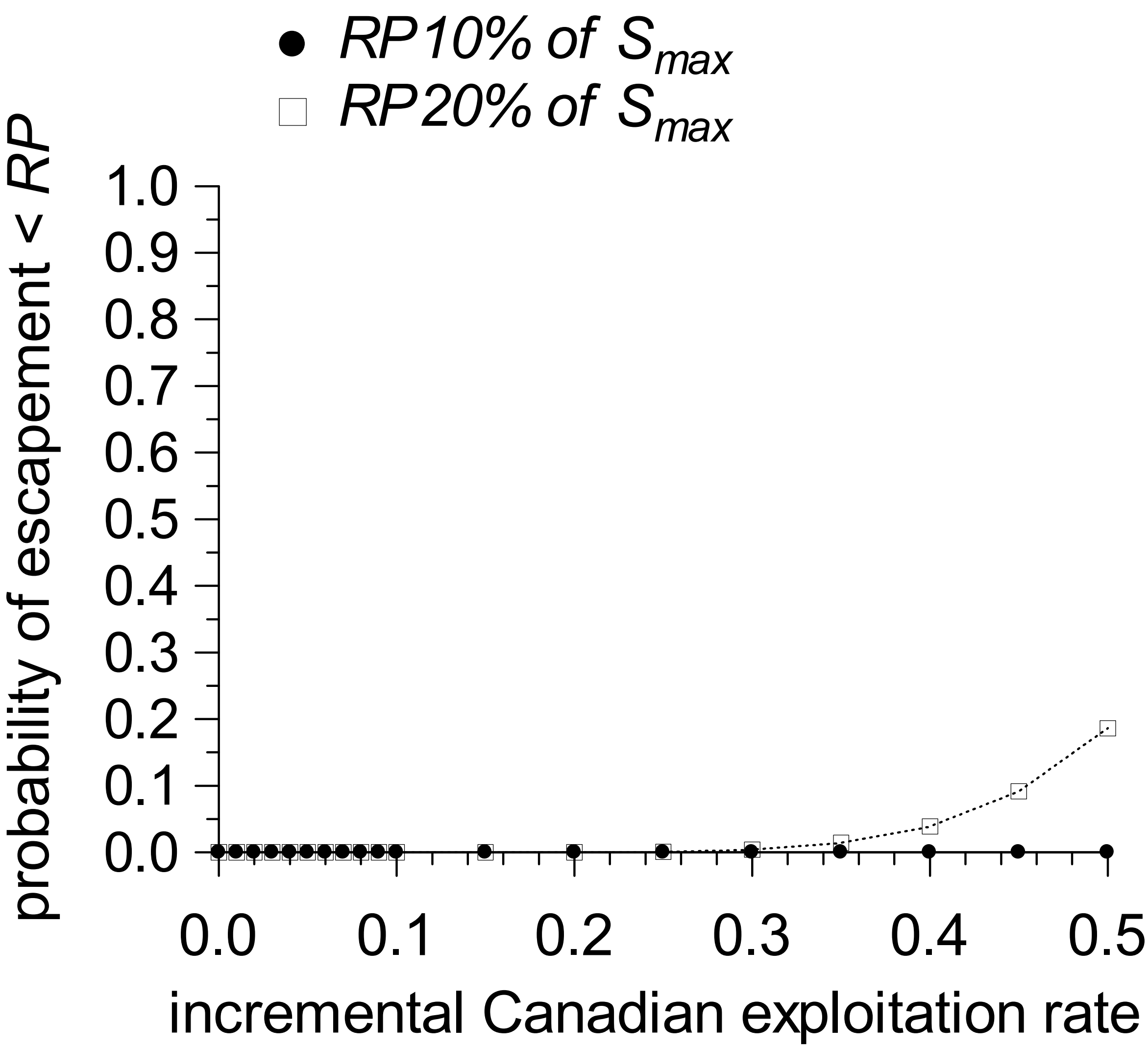

Figure 25. For the Area 3 aggregate the impacts of incremental Canadian fishing on probabilities of escapement falling below two reference points derived from the stock-recruitment carrying capacity.

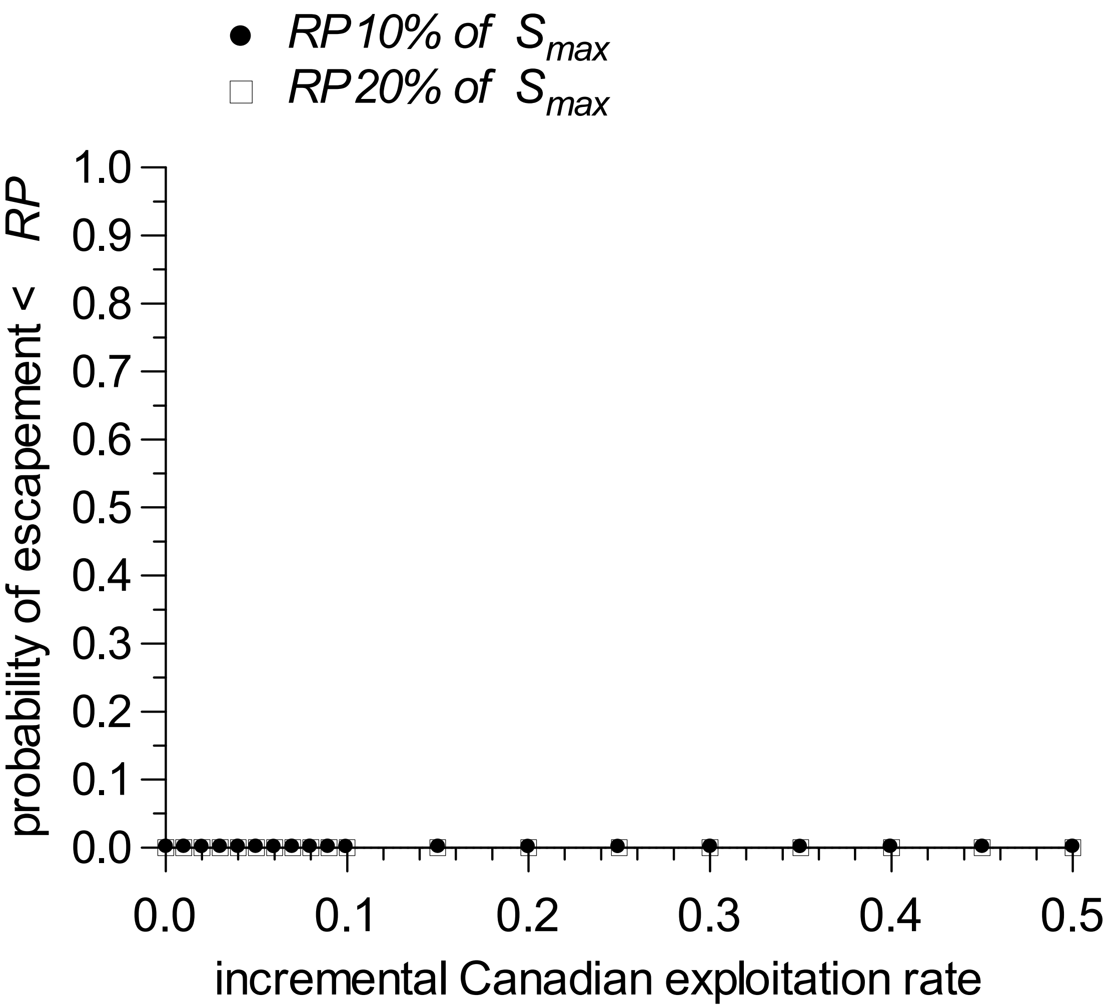

Figure 26. For the QCIN (Area 1) aggregate the impacts of incremental Canadian fishing on probabilities of escapement falling below two reference points derived from the stock-recruitment carrying capacity.

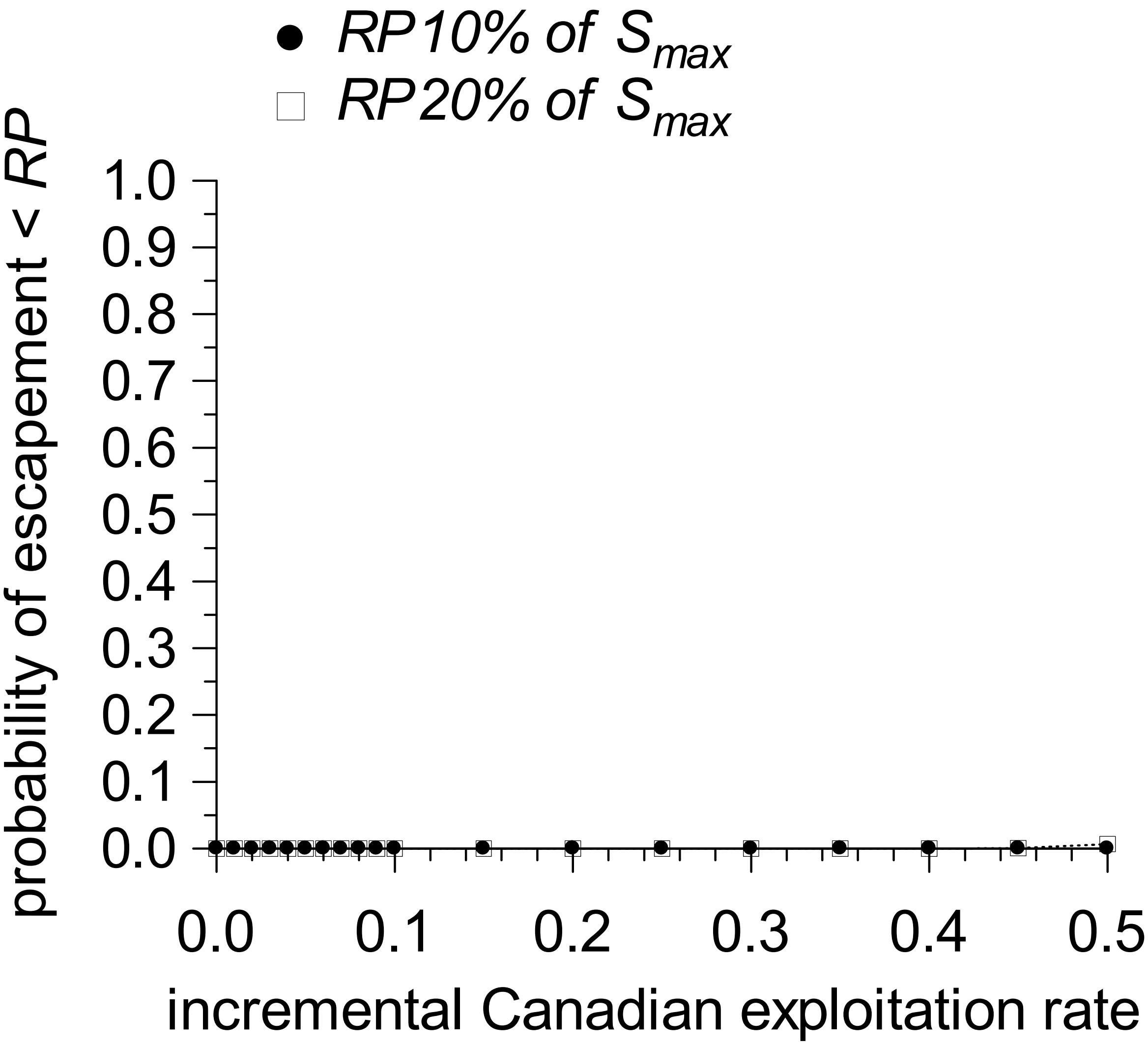

Figure 27. For the lower Skeena (Area 4-lower) aggregate the impacts of incremental Canadian fishing on probabilities of escapement falling below two reference points derived from the stock-recruitment carrying capacity.