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Trends in Abundance and Pre-season 2000 Stock Size Forecasts for Major Sockeye, Pink, and Chum Salmon Stocks in the Central Coast and Selected Salmon Stocks in Northern British Columbia

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ABSTRACT

This research paper includes pre-season 2000 stock size forecasts for nine sockeye, five pink, and five chum salmon stocks or stock groupings in central and northern British Columbia, statistical areas 1-10. The recommended forecasts are based on simple models that have been evaluated in a previous working paper (S95-12).

The recent 5-yr mean model is a simple time-series approach that effectively accommodates gradual changes (autocorrelated anomalies) in productivity. For northern populations of sockeye salmon this model has performed as well, or better than other models because variations in the independent variables used by other models have been small, and their effects have been obscured by other factors. However, for Skeena River sockeye, the 5-yr mean model should again be rejected in favour of the "sibling age-class" model that includes the effect of measured record low smolt production from the 1995 brood year. For Rivers and Smith Inlet sockeye the 5-yr mean model should also be rejected because it performed very poorly in 1999. Alternative models were evaluated that incorporate the measured effects of the extremely poor 1994 and 1995 brood year (1996 and 1997 sea-entry years) marine survival, and the possibility of continued poor survival in 1998 sea-entry year. Although the average sibling/smolt forecast is statistically the best model, we recommend the "like sea-entry 1996" sibling/smolt forecast be used to guide management decisions in 2000 following the precautionary approach.

RÉSUMÉ

Le présent document de recherche présente des prévisions d'effectifs d'avant-saison pour 2000 pour neuf stocks ou groupes de stocks de saumon rouge, cinq de saumon rose et cinq de saumon kéta dans le centre et le nord de la Colombie-Britannique, des zones statistiques 1 à 10. Les prévisions sont fondées sur des modèles simples qui ont été évalués dans le cadre d'un document de recherche précédent (S95-12).

Le modèle de la moyenne des cinq dernières années est une méthode simple par séries chronologiques qui permet de traiter efficacement des changements graduels (anomalies autocorrélées) de la productivité. Dans le cas des populations de saumon rouge du nord, ce modèle a donné des résultats aussi bons, sinon meilleurs, que les autres modèles car les variations des variables indépendantes utilisées pour les autres modèles ont été petites et leurs effets ont été masqués par d'autres facteurs. Mais pour le saumon rouge de Skeena River, le modèle de la moyenne quinquennale devrait encore être rejeté en faveur du modèle fondé sur les classes d'âge jumelles qui tient compte des effets de la production faible record de saumoneaux de l'année de génération 1995. Ce modèle devrait aussi être rejeté pour le saumon rouge de Smith Inlet et Rivers Inlet car il a donné de piètres résultats en 1999. On a évalué d'autres modèles qui tiennent compte des effets mesurés de la survie en mer extrêmement faible des années de génération 1994 et 1995 (arrivée en mer en 1996 et 1997) et de la possibilité que la survie continue d'être médiocre pour l'année d'arrivée en mer 1998. Bien que le modèle de prévision de la moyenne des classes d'âge jumelles de saumoneaux soit le meilleur du point de vue statistique, nous recommandons d'utiliser la prévision des classes d'âge jumelles de saumoneaux fondée sur l'année d'arrivée en mer 1996 afin de guider les décisions de gestion en 2000 selon le principe de précaution.

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1.0 INTRODUCTION

This working paper includes pre-season 2000 stock size forecasts for nine sockeye, five pink, and five chum salmon stocks or stock groupings in northern British Columbia, statistical areas 1-10 (Fig. 1). The forecasts are based on simple methods assessed and recommended in previous working papers (Wood et al. 1995, 1996). Our approach again involves three guiding principles:

1) *The entity being forecasted must be measurable*. We did not attempt to forecast stock sizes for stocks where stock size could not be measured with reasonable accuracy. In most cases, catches in mixed-stock fisheries cannot be (or have not been) apportioned reliably to individual populations, so we were unable to forecast returns to individual populations or rivers. Exceptions include the Skeena River, Nass River, Atnarko River, Kitlope Lake, and Kimsquit Lake sockeye salmon stocks where catches have been estimated using stock reconstruction procedures (section 2.1). In other cases, we forecasted the aggregate stock size for stock groupings defined at an appropriate spatial scale (typically statistical area) such that total catch for the aggregate was known reliably. We argue that forecasts at any finer spatial scale have no value without specifying some procedure for measuring (or estimating) actual returns.

2) *A forecast should specify the probability of all possible stock sizes*. Information about the uncertainty of the forecast is more important to managers following a precautionary approach than a point estimate of the most likely stock size. Forecasts that do not include a measure of uncertainty are likely to be misleading. We argue that simple, robust forecasting methods that properly represent uncertainty are preferable to more complicated methods that do not include a measure of uncertainty.

3) *Forecasting methods should be selected for their predictive power (measured in retrospective analyses), not on how well the underlying models fit historical data.* With one exception noted below, all forecasts recommended in this working paper are based on procedures that performed best in retrospective analyses for three sockeye salmon stocks (Long Lake, Owikeno Lake, and Skeena River), one pink salmon stock (Area 8), and one chum salmon stock (Area 8) (Wood et al. 1995, 1996). Within each species, the method that performed best in the retrospective analysis was applied to additional stocks as data permitted.

Sockeye fry recruitment and smolt production in Babine Lake (Skeena River) was dramatically reduced by parasitic infections at the Babine Lake Development Project sites in 1994 and 1995 (Wood et al. 1998). To be precautionary, and to include biological information relevant to these abnormal conditions, forecasts for Skeena River sockeye in 1998 and 1999 were based on the smolt and sibling age-class models rather than the 5-yr average model. These biological forecasting models are used again to forecast Skeena sockeye recruitment from brood years returning in 2000.

Sockeye returns to Rivers and Smith Inlet in 1999 were well below forecast and reached record lows of 4,257 and 5,900 respectively. These low returns reflect exceptionally poor marine survival of smolts entering the ocean in 1996 and probably 1997 too. If these conditions continue, the 5-yr mean model will overestimate returns for these stocks again in 2000. Accordingly, forecasts were also computed under the pessimistic scenario that conditions for marine survival have not improved, and under the optimistic scenario that marine survival has returned to the long term average.

2.0 METHODS

2.1 Sources of Data

Data used to generate and evaluate forecasts presented in this working paper are compiled in the Appendix Tables with the exception of pre-smolt data. Pre-smolt data for Owikeno Lake is from Rutherford et al. (1998) with updated information provided by the author. Pre-smolt data for Long Lake was provided by Kim Hyatt (DFO, Pacific Biological Station, Nanaimo, B.C.). Data for Owikeno Lake (Area 9) sockeye, Long Lake (Area 10) sockeye, and Area 8 pink salmon are from Wood et al. (1997) updated with preliminary 1999 data provided by the responsible managers in Fisheries and Oceans, Canada (DFO).

Recent total stock size information for sockeye salmon returning to the Haida Gwaii/Queen Charlotte Islands was provided by Pat Fairweather (Haida Fisheries Program (HFP), Skidegate, B.C., pers. comm.). This information is now collected through joint HFP/DFO research funded principally through the Aboriginal Fisheries Strategy. Total catches (in food fisheries) have been recorded since 1992 for Yakoun Lake and since 1983 for Skidegate Lake. For consistency, we used foot survey estimates of escapements to Yakoun Lake throughout the time series; estimates prior to 1993 are visual estimates from the Salmon Escapement Database System (SEDS, Serbic 1991), more recent estimates involve area-under-the-curve estimation and are considered to be more reliable. Escapements to Skidegate Lake prior to 1983 are from SEDS, those from 1983 to 1993 are from a counting plate program (counts interpolated during unmonitored periods), and those since 1994 are full fence counts (no unmonitored periods).

Total stock and escapement data for Nass River (Area 3) and Skeena River (Area 4) sockeye salmon were compiled for 1970-1999 by the responsible manager (L. Jantz, DFO Prince Rupert, B.C., pers. comm.). These data include reconstructed catches of Nass and Skeena sockeye salmon in mixed-stock fisheries in Alaska and northern British Columbia, based on stock reconstructions for 1982-1992 reported by Gazey and English (1996) and stock composition estimates for 1982-1983 from a joint Canada-U.S. tagging study. Sockeye smolt abundance data is from Wood et al. (1998).

Escapements of sockeye salmon to Kitlope Lake, Kimsquit Lake and the Atnarko River are taken from SEDS. Total stock sizes for these stocks were estimated very approximately as escapement/(1 - average exploitation rate) using an average exploitation rate for each stock estimated in stock reconstructions for the period 1970-1982 (Starr et al. 1984). However, in 1999 harvest rate of sockeye in lower Area 8 fisheries was drastically reduced through minimum mesh size restrictions imposed in response to sockeye conservation concerns in neighbouring Rivers and Smith Inlet. Harvest rate for Area 8 sockeye (Kimsquit and Atnarko) was estimated to be 15% in 1999 (L. Enderud. pers. com).

Total catch and escapements for pink and chum salmon by statistical area are from the DFO Commercial Salmon Catch Database (Holmes and Whitfield 1991) and SEDS, respectively. Age composition data for Area 8 chum salmon were provided by the responsible manager Lyle Enderud (DFO, Bella Coola, B.C., pers. comm.).

No forecasts are provided for pink and chum salmon stocks in statistical areas 1, 2W, 3, 4, 5, and 7. Stocks in areas 2W, 5, and 7 were excluded because catches recorded from these areas are dominated by salmon returning to larger stocks in adjacent areas. Stocks in areas 1, 3, and 4 were excluded primarily because catches in these most northern areas include a substantial proportion of pink and chum salmon returning to Alaska. No reliable method exists to apportion catches in these fisheries to stocks in the respective statistical areas (Gazey and English 1996). We concluded that total stock size could not be estimated reliably enough to warrant pre-season forecasts for any of these statistical areas.

2.2 Forecasting Models

A minimum requirement for forecasting models in this context was that forecasts for 2000 could be generated with data available at the time of analysis in early 2000. This requirement often precluded the use of sibling age class models because 1999 age composition data were not yet available. Of the ten models considered by Wood et al. (1995), five are used in this working paper. All assume lognormal error structure as generally recommended for these types of analyses (Peterman 1981; Hilborn and Walters 1992). Model parameters were estimated using SYSTAT (Wilkinson 1990).

2.2.1. *Sockeye salmon*. Following previous recommendations endorsed by PSARC, the recent 5-yr average stock size model (previously labelled *5YAVGCY*, Wood et al. 1995) with log-normal error structure was used to forecast stock sizes in 2000 for all sockeye stocks. The forecast for the Kimsquit stock is based on stock size data from 1992, 1993, 1996, 1997, 1999 because no escapement data were available for three recent years (1994, 1995, and 1998).

Wood et al. (1995) concluded that average stock size methods, particularly the recent 5-yr average stock size model, rated best for sockeye stocks under the root mean square error

(RMSE) criterion that they judged to be most important. Average methods also rated best in two of the three sockeye stocks under the mean absolute deviation (MAD) criterion. A practical advantage of these methods is that no biological assumptions, understanding, or sampling data are required beyond the record of numerical abundance for each calendar year. Accordingly, Welch et al. (1994) considered these models to represent a base or "zero level" of forecasting skill. On the other hand, they are "honest" and rigorous models in that they take the historical distribution of stock sizes into account, assuming only that the future will be like the past.

The 5-yr average stock size forecast is given by:

$$\mathbf{ln(N_{t+1}) = a + e_t}$$

where N_t is total stock size in year t, ε_t is a normal variate with mean 0 and variance σ^2, and *a* is the most recent 5-yr average = $\sum \ln(N_i)/5$ for i= t-4 to t.

Two additional, biological models were used to forecast Skeena River, Rivers Inlet, and Smith Inlet sockeye salmon returns in 1999: The first is a non-linear stock-recruitment relationship based on observed smolt production (the "smolt" model)

$$\mathbf{ln(R_t) = a + bln(J_t) + e}$$

where R_t is the adult return and J_t is the smolt abundance for brood year t.

The second is a non-linear sibling age-class model (Bocking and Peterman 1988) based on observed returns of a younger age class from the same brood year

$$\mathbf{ln(R_{t,k+1}) = a + bln(R_{t,k}) + e}$$

where $R_{t,k}$ is the adult return at age k in brood year t.

2.2.2 *Pink salmon*. Brood year escapement data and the non-linear Ricker stock-recruitment model (*NLSRESC*) were used to forecast pink salmon returns. This escapement model performed considerably better than the average stock size models in the retrospective analysis for Area 8 pink salmon (Wood et al. 1995). Returns (R) from a spawning escapement (S) in brood year t are given by:

$\mathbf{R_t = S_t\ e^{a + bSt}}$ where parameters *a* and *b* are estimated from

$$\mathbf{ln(R_t/S_t) = a + bS_t + e_t}$$

2.2.3 *Chum salmon*. The long-term average stock size model was also used to forecast all chum salmon stock sizes in 1999 because it performed as well or better than competing models in a retrospective analysis for Area 8 chum salmon (Wood et al. 1996).

The long-term average stock size forecast is given by:

$$\mathbf{ln(N_{t+1}) = a + e_t} \qquad \text{where } a = \sum \ln(N_i)/t \quad \text{for } i=1 \text{ to } t$$

2.3. Probability Distributions for 2000 Forecasts

Probability distributions for the 2000 stock size forecasts were computed by assuming that errors in the forecasted (log-transformed) stock size are normally distributed. Forecasted stock sizes in the log-transformed domain corresponding to risk averse probability reference points of 90%, 75%, and 50% were computed from the student's *t* inverse distribution function (tif) in SYSTAT using sample means and standard deviations. Forecasted stock sizes in the log-transformed domain were then transformed back to the arithmetic scale for each probability reference point. Note that the modal (most likely) stock size in the log-transformed domain corresponds to the median (50%) value in the original arithmetic scale. Similarly, cumulative probability distribution plots were generated from the student's *t* distribution function (tcf) in SYSTAT using sample means and standard deviations in the log-transformed domain.

For the average models, standard deviations were computed from the series used to compute the forecasts (i.e., all years for the long-term average model and the most recent five years for the 5-yr average model). For the regression-based escapement, smolt, and sibling models, means and standard deviations for the forecasted log-transformed stock sizes were computed as:

$$\mathbf{E[ln(R_t)] = a + b\, X_{2000} + ln(X_{2000})}$$

$$\mathbf{SD[(ln(R_t)] = s_{y.x}\{(1 + 1/n + (X_{2000} - X_{mean})^2)/ \sum (X_i - X_{mean})^2\}^{0.5}}$$

where *a* and *b* are the regression parameters, $s_{y.x}$ is the standard error of the estimate, X_{2000} is the independent variable (e.g., spawning escapement for the brood returning in 2000), X_{mean} is the average value of the independent variable, and n is the number of data points in the regression (Draper and Smith, 1966).

3.0 RESULTS

3.1 Trends in Stock Size

3.1.1 *Sockeye salmon*. Escapement accounts for most of the total stock in Yakoun and Skidegate lakes in recent years. In response to concerns about declining escapements to both lakes, fishing effort (and catch) have been restricted since 1993 under management plans developed by the Council of Haida Nations in consultation with DFO. Escapement and stock size in both lakes have generally increased since 1993 and are now close to the long-term (geometric) mean (Figure 2A).

Escapements to the Skeena and Nass rivers generally met or exceeded targets during the last decade and total stock size generally exceeded the long-term mean with record high levels achieved in 1992-93 (Nass) and 1996 (Skeena). As forecast, however, the total stock of Skeena sockeye declined in 1998 reaching record low levels (since spawning channels) in 1999. Escapement targets were not achieved in either year. The total stock of Nass sockeye also declined in 1998 but increased in 1999 and remains near the long-term (geometric) mean.

Escapements (and hence computed total runs sizes) for Kitlope and Kimsquit sockeye salmon stocks declined sharply in 1999 and were well below the long-term mean escapement. Sockeye salmon escapement to the Atnarko River was only slightly below the long-term mean but total stock size declined dramatically. Note that this decline in stock size results from assuming that harvest rate has decreased to 15% because total stock cannot be measured directly.

Total stock sizes of Owikeno and Long lake sockeye have been below escapement targets in most years since 1993 and stock sizes reached record lows in 1999. Escapements to both lakes are now at critically low levels, despite the fact that commercial fisheries on these stocks have been closed since 1996 (Owikeno) and 1997 (Long). The general decline has been attributed to poor marine survival for all brood years since 1990 (Rutherford et al. 1998) and exceptionally poor survival for the 1994 brood year (1996 sea-entry year). Escapements had been generally increasing until 1991 in Owikeno Lake, and until 1992 in Long Lake; similarly, indices of juvenile (freshwater) production for both lakes had been near historical levels until after escapements fell well below targets *as a result of* poor marine survival (Rutherford et al. 1995, 1998; Anon 1996). Survival of smolts entering the ocean in 1997 (brood year 1995) was also very poor judging by the low numbers of age 4 adults returning to both Owikeno and Long lake in 1999.

3.1.2 *Pink salmon*. Even-year pink salmon stock size was generally high throughout the 1960's through to the mid 1970's. Total stock sizes in all areas decreased to below average levels in the early 1980's then increased again in the late 1980's early 1990's. Recent total stock sizes in areas 6, 8, 9, 10 have generally decreased and are now below long-term (geometric) mean levels (Figure 2B). In contrast, total stock size in area 2E has remained relatively constant throughout the 1990's.

3.1.3 *Chum salmon*. Chum salmon abundance peaked in the late 1980s in most areas, declined in the early 1990s, then increased to intermediate levels by 1995 (Figure 2C). Total stock sizes declined in 1996 and 1997 but increased in 1998 for most areas.

3.2 Performance of 1999 Forecasts for Sockeye Salmon

Pre-season forecasts of sockeye stock sizes in 1999 (based on the same methods used to forecast stock sizes in 1999, section 2.2), are compared with preliminary estimates of actual stock sizes in Table 1. Actual stock size was below the median forecast for all sockeye salmon stocks measured south of statistical area 4. Percentage deviations (error) from the median forecasts ranged from less than 2% in the north (Skidegate sockeye) to –2437% in the south (Owikeno sockeye). Observed stock size fell within the 90% confidence intervals of the recommended forecasts for all sockeye stocks measured in statistical areas 1 to 4 but outside the 90% confidence intervals for all stocks measured in areas 6 to 10. Observed stock sizes for pink and chum salmon fell within the 90% confidence intervals of the recommended forecasts in all areas except area 10.

3.3 Forecasts for 2000

3.3.1 F*orecasts for Skeena sockeye salmon*. Forecasts of Skeena River sockeye salmon returns in 2000 from three alternative models are summarized in Table 2A. The 5-yr average stock size model predicts a median stock size of 2.5 million sockeye, above the long-term (geometric) mean. The smolt model predicts a slightly lower median stock size of 2.3 million sockeye reflecting the poor smolt (freshwater) production from the 1995 brood year (Fig. 3). The sibling year-class model, endorsed by PSARC in 1999, predicts a median stock size of only 1.9 million sockeye (Fig. 4).

The 5-yr average model has performed as well or better than other models under typical situations where variation in the independent variables used by other models has been small, and their effects have been obscured by other factors. In the present case, however, the independent variables for the 1995 brood year in the alternative models are again at or near the extreme low end of their historical ranges. Therefore, as for the 1999 forecast, we recommend that the 5-yr mean model be rejected in favour of the biological models that can include our knowledge of the abnormally low freshwater production from the 1995 brood year.

The sibling model performed well (31% error) and better than the 5-yr mean or smolt models in 1999. It is recommended again in the present case because its predictions reflect the poor freshwater production from the 1995 brood year. This recommendation is also consistent with the precautionary approach to fisheries management because the sibling model again predicts the lowest stock size in 2000.

3.3.2 *Alternative forecasts for Rivers and Smith Inlet sockeye salmon.* Forecasts for Rivers and Smith Inlet sockeye salmon returns in 2000 from three alternative models are summarized in Table 2B and 2C. The 75% risk adverse and the median (50%) forecasts are well below the escapement targets set for these stocks suggesting that conservation measures be considered for 2000. The forecast 5 yr average is likely optimistic because the forecasting model used assumes future conditions will be similar to the previous 5 years and does not explicitly incorporate inferences of extremely poor survival based on age 4 returns in 1999.

Poor returns at age 4 in 1999 suggest that Rivers and Smith Inlet sockeye entering the ocean in 1997 fared no better that the cohort of the previous year. Other index stocks in the vicinity for which reliable data exist (Keogh R. steelhead, west coast Vancouver Island chinook) also suggest that survival was poor for sea-entry year 1997 (Fig 2D). Accordingly, we used the sibling model to forecast age 5 returns in 2000, just as for Skeena sockeye. Because age 3 data are unavailable for Rivers and Smith Inlet sockeye, we relied on the smolt model to forecast age 4 returns in 2000. Note that these forecasts take into account the observed poor survival for sea-entry year 1997, but assume average age at maturation and average smolt survival for sea-entry year 1998, consequently, the sibling/smolt forecast is likely optimistic.

A third pessimistic model assumes the observed proportion age 4 (49.5% compared with long-term average of 33.5%) and the record low survival rate measured for the 1996 sea-entry year also applies to sea-entry 1998. Thus, these pessimistic scenario forecasts are point estimates so there is no empirical basis for computing measures of uncertainty. In fact, these point estimates fall outside the 90% confidence interval based on the recent 5-yr mean forecast despite the fact that the record low 1999 stock sizes were included in these forecasts. This illustrates how exceptionally low recent survival has been.

Although the sibling/smolt forecast is statistically the best model, we recommend the like 1996 sea-entry forecast be used to guide management decisions following the precautionary approach. It is important that the asymmetry of consequences of overestimating versus underestimating run size be recognized. Recruitment from two consecutive year classes appears to have already failed in which case any harvest could compromise conservation of these stocks if marine survival continues to be poor. Marine survival rates have declined generally since sea-entry year 1992 and we do not understand why. As yet there is no scientific basis to support the argument that conditions returned to normal prior to sea-entry year 1998.

3.3.3 *Recommended forecasts.* Recommended pre-season stock size forecasts for 2000 are summarized in Table 3 for three probability reference points. Actual stock sizes are predicted to exceed the median (50%) forecast reference point 50% of the time (i.e., 1 time out of 2). The other reference points are provided to facilitate risk averse management decisions. Actual stock sizes are predicted to exceed the lowest (90%) reference point 9 times out of 10, and to exceed the intermediate (75%) reference point, 3 times out of 4. The full cumulative probability distribution for these forecasts is presented graphically in comparisons with historical returns in Figures 5 (sockeye salmon), 6 (pink salmon), and 7 (chum salmon).

4.0 DISCUSSION

Previous evaluations of forecasting performance for northern BC salmon stocks have demonstrated that simple average models can work as well or better than those incorporating biological data (Wood et al. 1995, 1996). Biological relationships such as stock-recruitment relationships often explain a statistically significant amount of variation in historical data, reflecting real biological processes that should be considered in decisions involving *average* levels of productivity. However, they typically explain only a small fraction of the total variation in survival observed from brood to brood in northern BC stocks. This may be because the observed range of variation in the biological variables has been small in northern stocks (Areas 1-10) until recently. Also, uncertainty in predicting age at maturation in northern sockeye and chum salmon stocks introduces error when developing forecasts of total stock size in a calendar year from forecasts of returns by brood year. Even so, the smolt and sibling year class models correctly predicted the low abundance of Skeena sockeye in 1998 and 1999 where the 5-yr average model did not (Table 1). Clearly, these biological models can be effective given adequate contrast in the independent variables.

This contrast also appears to be emerging with respect to marine survival of sockeye stocks in Areas 6 to 10. Following this logic, measurements of real biological processes were considered and included in the pre-season forecasts for Rivers and Smith Inlet sockeye stocks. Although overall marine survival cannot yet be computed for the 1997 sea-entry year, the congruence in rates of return for age 4 fish strongly suggests that marine survival was well below average for central coast stocks. This would be the second consecutive year of recruitment failure Rivers and Smith Inlets. The age structure of these stocks is such that three more years of continued poor marine will likely have severe consequences for the viability of these stocks. On the other hand, the strength of returns in more northerly stocks from the 1997 sea-entry year suggests that subsequent marine survival has returned to above average levels in the north (Fig. 8).

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Table 1. Comparison of pre-season forecasts and observed stock sizes in 1999. Observed values are preliminary estimates. Deviations outside 90% confidence intervals area shown in bold font.

Species	Area	Stock	Method	Run size median Forecast	Run size observed (preliminary)	Forecast error[a]	Percent error	Probability of greater deviation[b]
Sockeye	1	Yakoun	5-yr average	9,000	8,812	-188	-2%	50%
	2E	Skidegate	5-yr average	11,000	11,750	750	6%	43%
	3	Nass	5-yr average	767,000	760,495	-6,505	-1%	49%
	4	Skeena	sibling	578,000	843,702	265,702	31%	33%
			5-yr average[c]	3,199,020	843,702	-2,355,318	-279%	**7%**
	6	Kitlope	5-yr average	42,000	18,750	-23,250	-124%	**2%**
	8	Atnarko	5-yr average	59,000	29,412	-29,588	-101%	**8%**
	8	Kimsquit	average	20,000	1,176	-18,824	-1601%	**<1%**
	9	Owikeno	5-yr average	108,000	4,257	-103,743	-2437%	**<1%**
	10	Long	5-yr average	70,000	5,900	-64,100	-1086%	**<1%**
Pink	2E	all	Ricker[d]	5,000	7,188	2,188	30%	37%
	6	all	Ricker[d]	766,000	662,095	-103,905	-16%	44%
	8	all	Ricker[d]	1,663,000	1,062,932	-600,068	-56%	28%
	9	all	Ricker[d]	162,000	118,550	-43,450	-37%	42%
	10	all	Ricker[d]	7,000	100	-6,900	-6900%	**<1%**
Chum	2E	all	Average	318,000	347,676	29,676	9%	45%
	6	all	Average	269,000	199,119	-69,881	-35%	31%
	8	all	Average	432,000	362,058	-69,942	-19%	38%
	9	all	Average	41,000	76,780	35,780	47%	24%
	10	all	Average	37,000	9,100	-27,900	-307%	**3%**

[a] observed stock size - median forecast
[b] probability of a greater absolute deviation from median forecast under forecast probability distribution
[c] not recommended; included only for comparison
[d] NLSRESC model of Wood et al. (1995).

Table 2A. Summary of pre-season forecasts for Skeena River sockeye salmon stock size in 2000 from three alternative models.

Model	Brood Year	Forecasts for reference probabilities[a] 25%	**50%**	75%	90%
5-yr mean	1995+1996	5,144,507	**2,552,190**	1,264,971	597,228
Smolt	1995		486,000		
	1996		1,798,000		
	1995+1996	3,522,845	**2,283,754**	1,477,847	992,104
Sibling	1995		770,000		
	1996		1,142,000		
	1995+1996	2,686,633	**1,912,271**	1,358,920	995,423

Table 2B: Summary of pre-season forecasts for Rivers Inlet sockeye salmon stock size in 2000 from three alternative models.

Model	Brood Year	Forecasts for reference probabilities 25%	50%	75%	90%
5-yr mean	1995+1996	187,262	**59,146**	18,652	5,431
Sibling	1995		11,592		
Smolt	1996		112,322		
Total	1995+1996	302,712	**141,893**	66,268	33,129
Like 1996 sea-entry[a] Sibling	1995		2,084		
Like 1996 sea-entry[a] Smolt	1996		143		
Total	1995+1996		**2,227**		

Table 2C. Summary of pre-season forecasts for Smith Inlet sockeye salmon stock size in 2000 from three alternative models.

Model	Brood Year	Forecasts for reference probabilities 25%	50%	75%	90%
5-yr mean	1995+1996	91,779	**41,878**	19,089	8,240
Sibling	1995		6,750		
Smolt	1996		72,940		
Total	1995+1996	205,567	**91,596**	40,720	19,072
Like 1996 sea-entry[a] Sibling	1995		2,111		
Like 1996 sea-entry[a] Smolt	1996		1,811		
Total	1995+1996		**3,922**		

[a] assumes age at maturation for 1995 brood year and smolt survival for 1996 brood year same as for 1994 brood year which entered the ocean in 1996.

Table 3. Summary of recommended pre-season stock size forecasts for 2000. Bold print is used to flag stock size forecasts that are well below escapement targets in stocks whose status has been reviewed previously by PSARC.

Species	Statistical Area	River or Lake	Escapement Target	Forecasts for reference probabilities[a] 25%	50%	75%	90%	Forecasting Model
Sockeye	1	Yakoun	under review	10,600	8,200	6,300	4,800	5-yr average
	2	Skidegate	9,525	15,900	13,200	11,100	9,100	5-yr average
	3	Nass	200,000	961,400	810,400	682,800	568,500	5-yr average
	4	Skeena	900,000	2,686,633	1,912,000	1,359,000	995,000	sibling
	6	Kitlope	20,000	48,700	35,100	25,300	17,900	5-yr average
	8	Atnarko	75,000	80,200	54,500	37,100	24,500	5-yr average
	8	Kimsquit	30,000	36,100	12,600	4,400	1,400	5-yr average
	9	Owikeno	200,000	302,700	141,900	66,300	33,100	Sibling/Smolt
	9	**Owikeno**[c]	200,000		**2,200**			Like 1996 sea-entry
	10	Long	200,000	205,600	91,600	40,700	19,000	Sibling/Smolt
	10	**Long**[c]	200,000		**3,900**			Like 1996 sea-entry
Pink	2E	all	731,225	1,464,800	910,900	566,200	364,500	Ricker[b]
	6	all	1,447,200	2,310,400	929,800	577,800	371,800	Ricker[b]
	8	all	1,475,400	3,720,800	2,308,600	1,432,300	920,400	Ricker[b]
	9	all	342,450	710,100	441,500	274,500	176,700	Ricker[b]
	10	all	65,600	6,000	3,700	2,300	1,500	Ricker[b]
Chum	2E	all	453,025	495,800	319,200	205,700	137,200	average
	6	all	518,350	421,800	266,600	168,700	110,600	average
	8	all	267,450	660,400	442,600	297,000	205,600	average
	9	all	150,700	75,300	42,100	23,500	13,800	average
	10	all	98,500	62,500	35,300	19,900	11,700	average

[a] probability that the actual stock size will exceed the specified forecast
[b] NLSRESC model of Wood et. al. (1995)
[c] recommended forecast for management decisions under precautionary approach

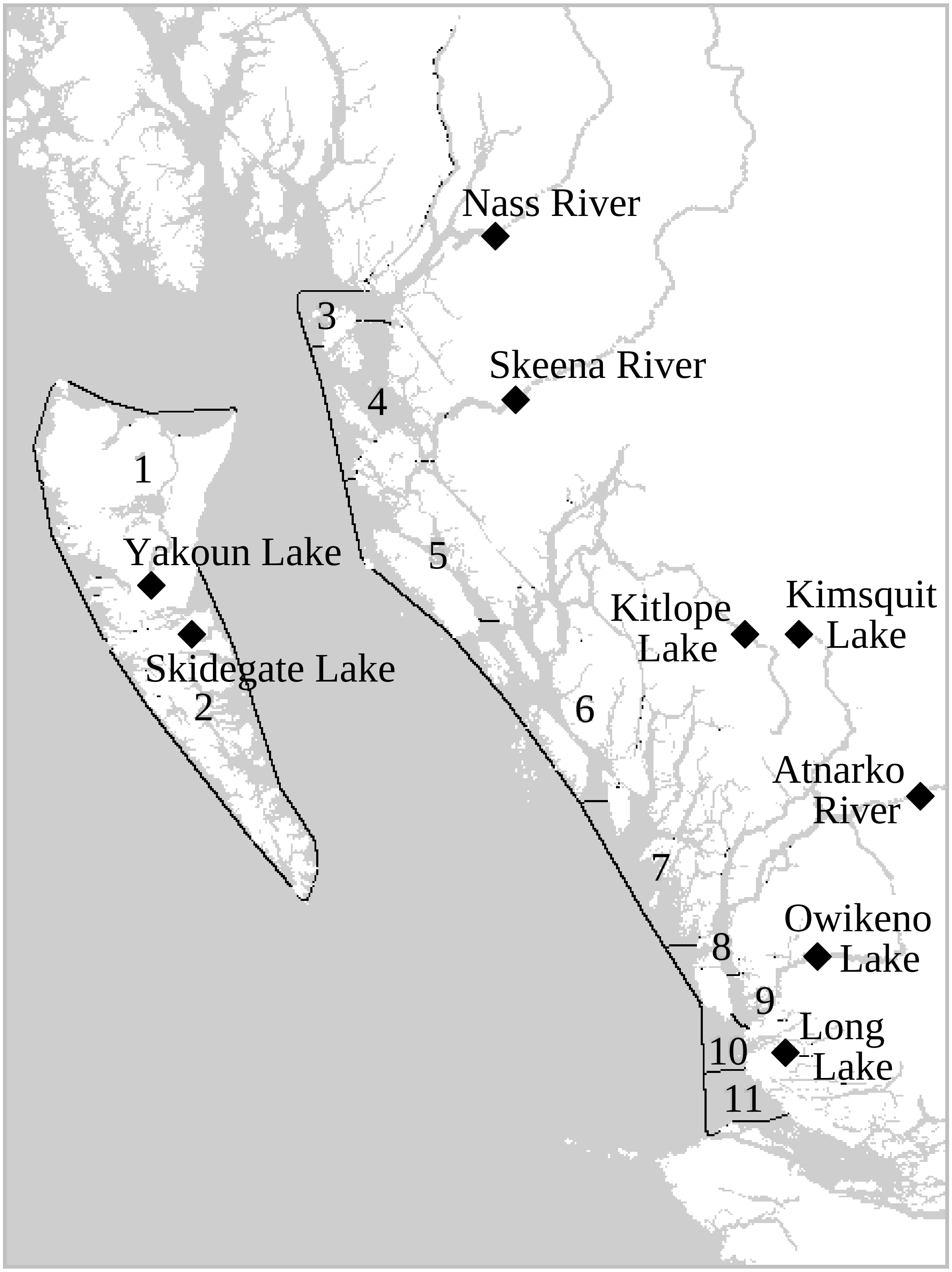


Figure 1. Map of northern British Columbia showing locations of salmon stocks and statistical areas.

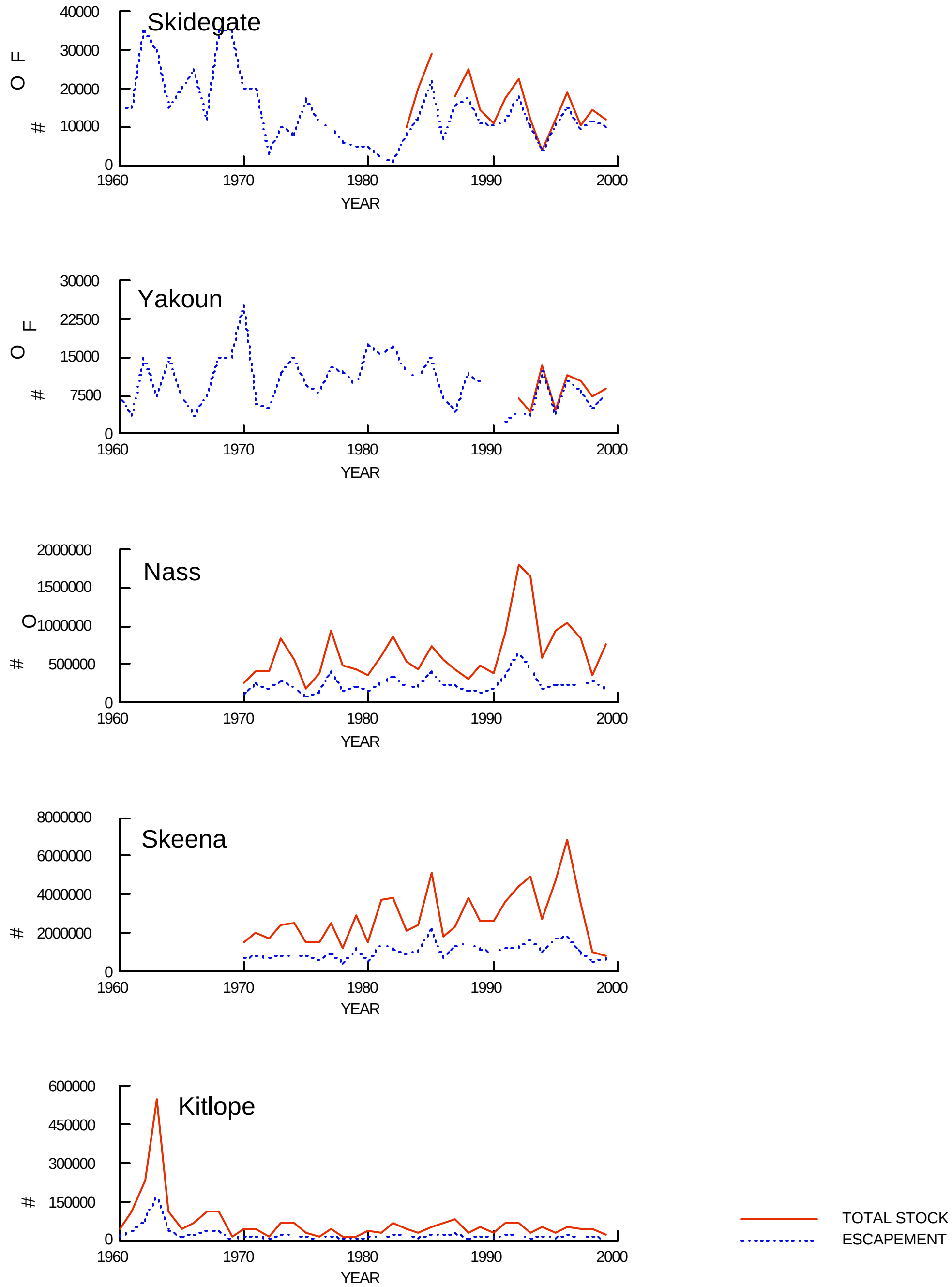


Figure 2A. Trends in spawning escapement and total stock size for sockeye salmon stocks.

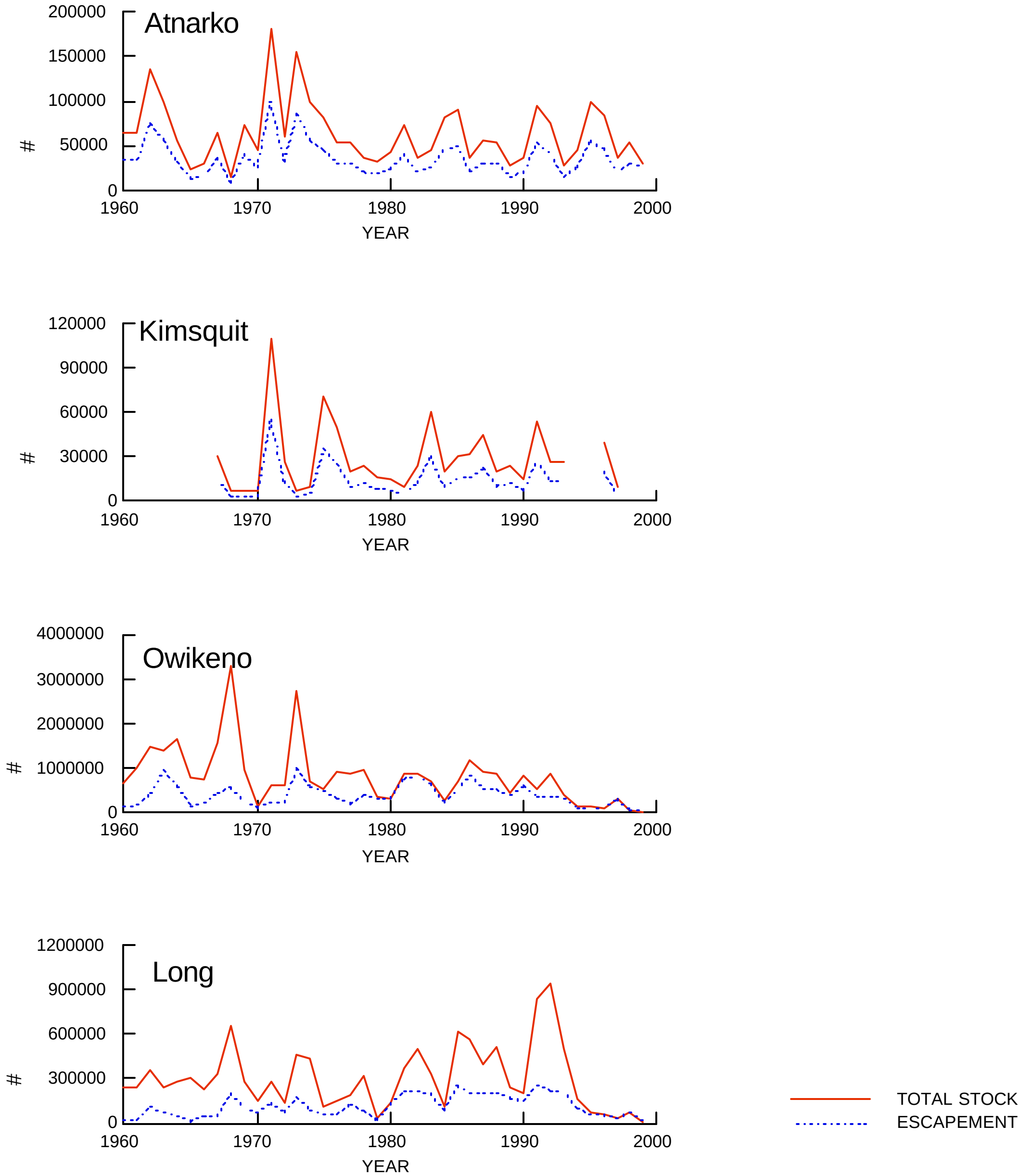


Figure 2A. (continued)

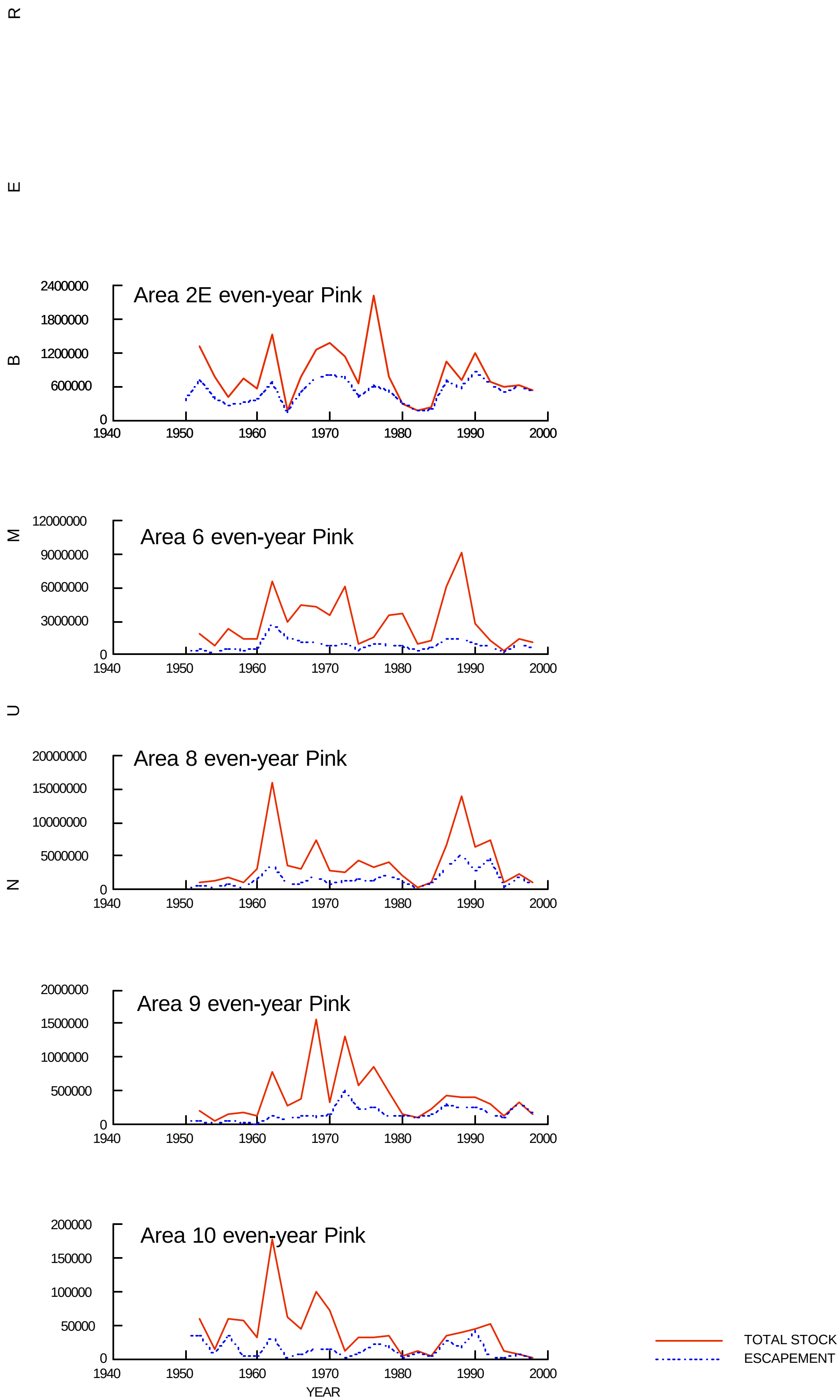


Figure 2B. Trends in spawning escapement and total stock size for even-year pink salmon stocks

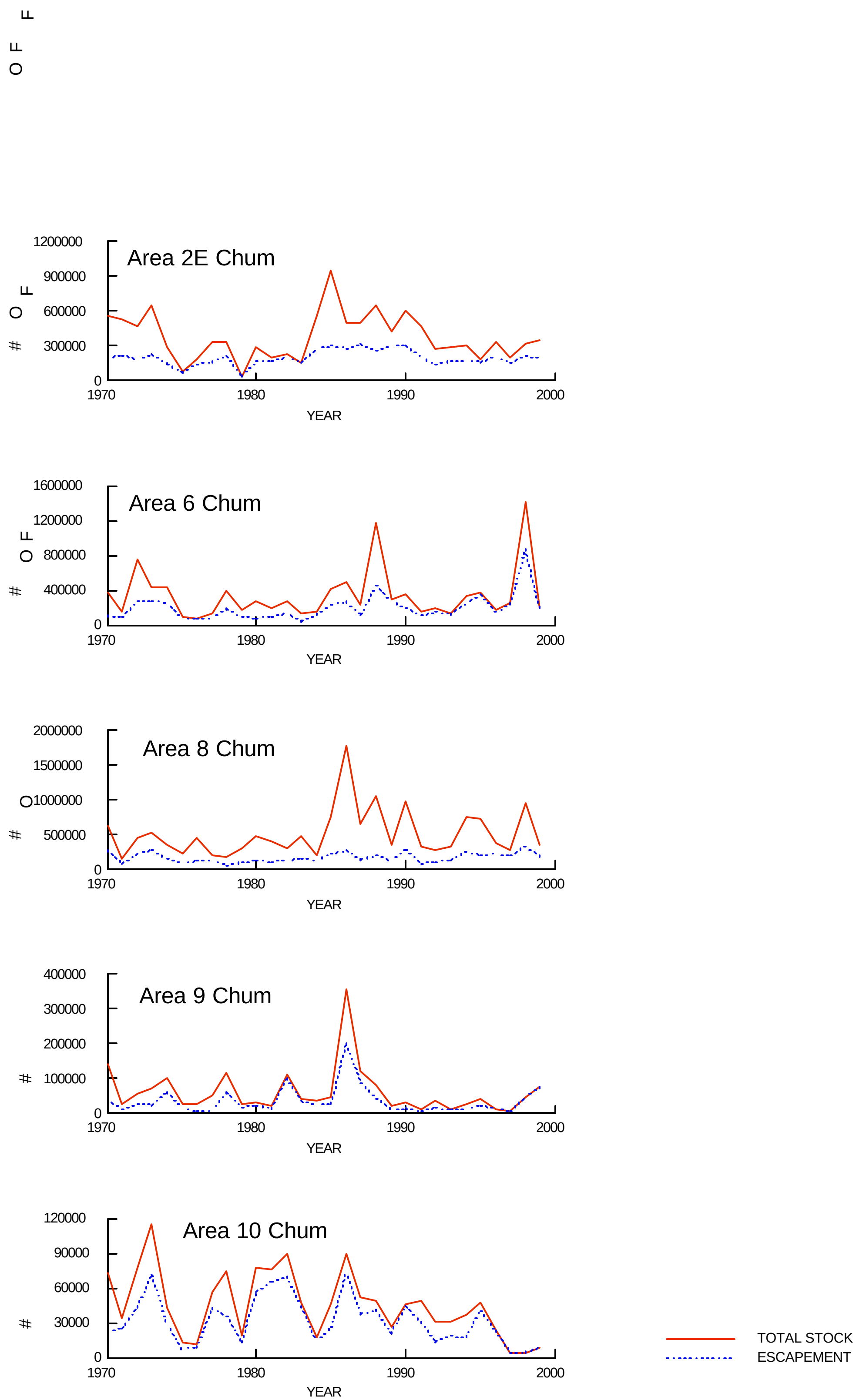


Figure 2C. Trends in spawning escapement and total stock size for chum salmon.

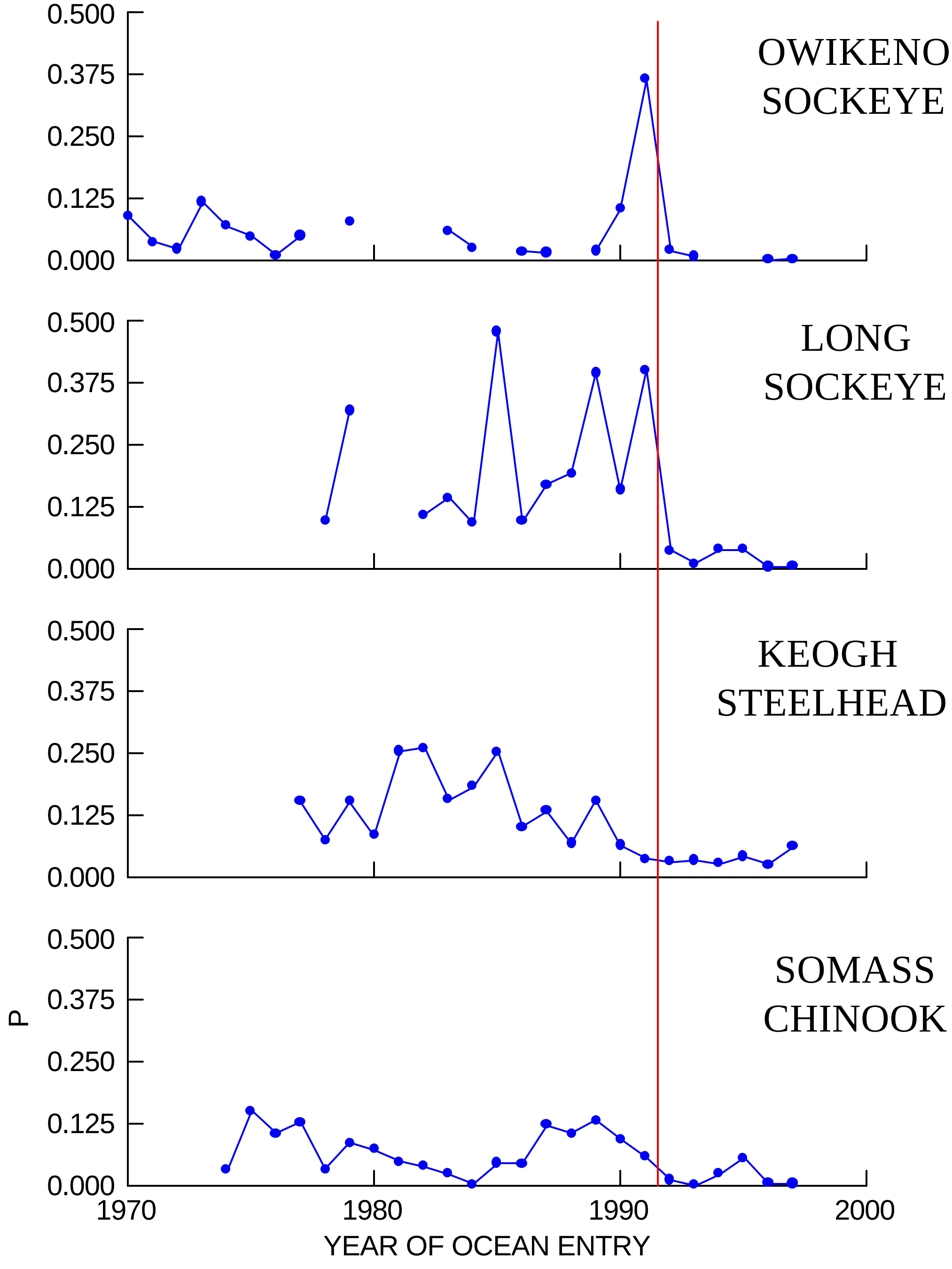


Figure 2D. Trends in marine survival of salmon index stocks. Keogh R. steelhead data from Smith et al. (2000); Somass R. chinook data for 1973-1982 from Chinook Technical Committee Report (99/2) and years 1983-1996 from Riddell et. al. (2000)

O

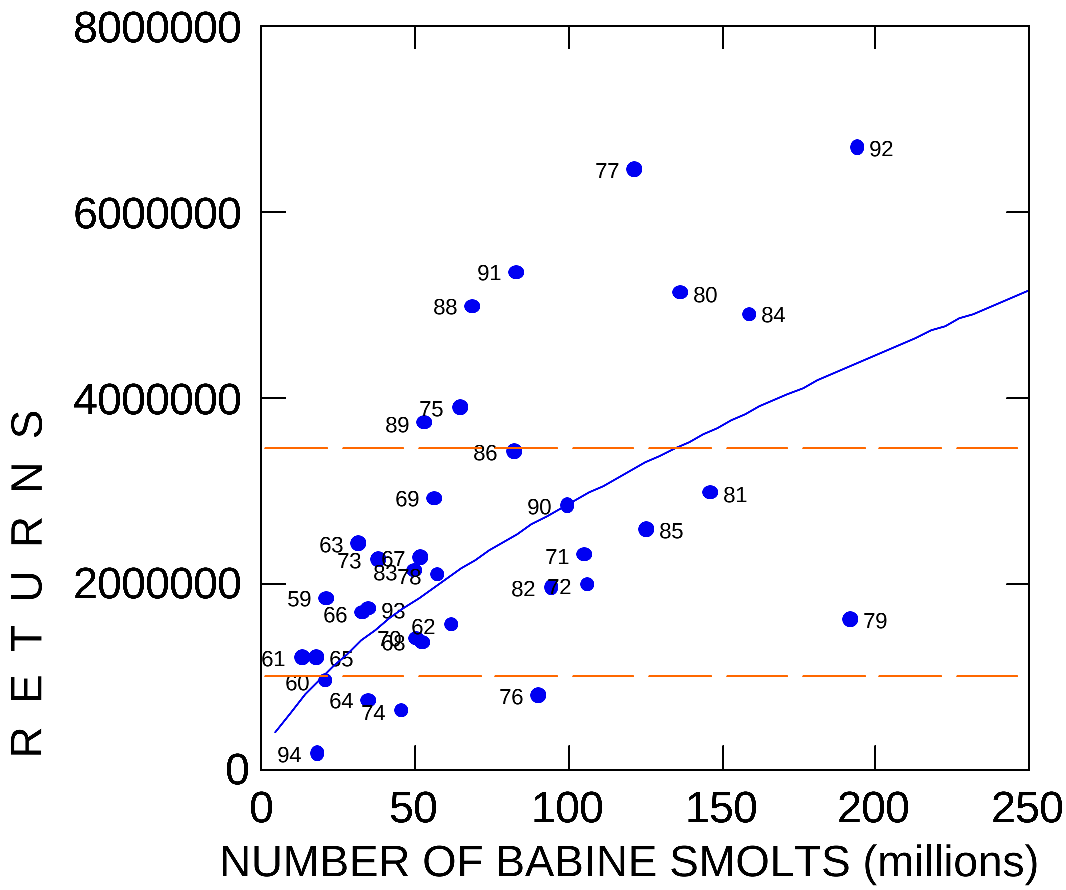


Figure 3. Model for forecasting total returns of age sub-2 Skeena sockeye from Babine smolt abundance. Lower dashed line indicates low total returns expected from poor smolt production for brood year 1995, upper dashed line indicates above average returns from strong smolt production for brood year 1996; all labels refer to brood years.

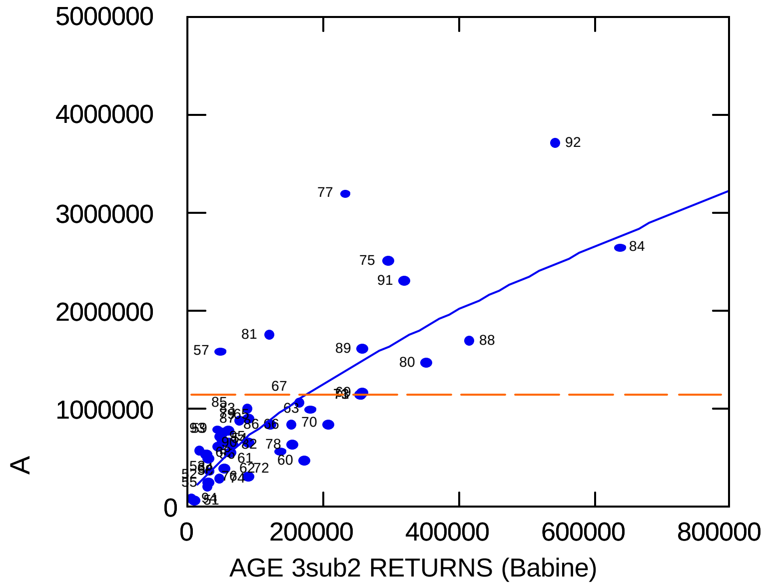


Figure 4A. Sibling model for forecasting total returns of age 4_2 Skeena sockeye from age 3_2 (“jack”) returns from the same brood year enumerated at the Babine fence. Dashed lines indicate total returns expected given observed jack returns from brood year 1996; all labels refer to brood years.

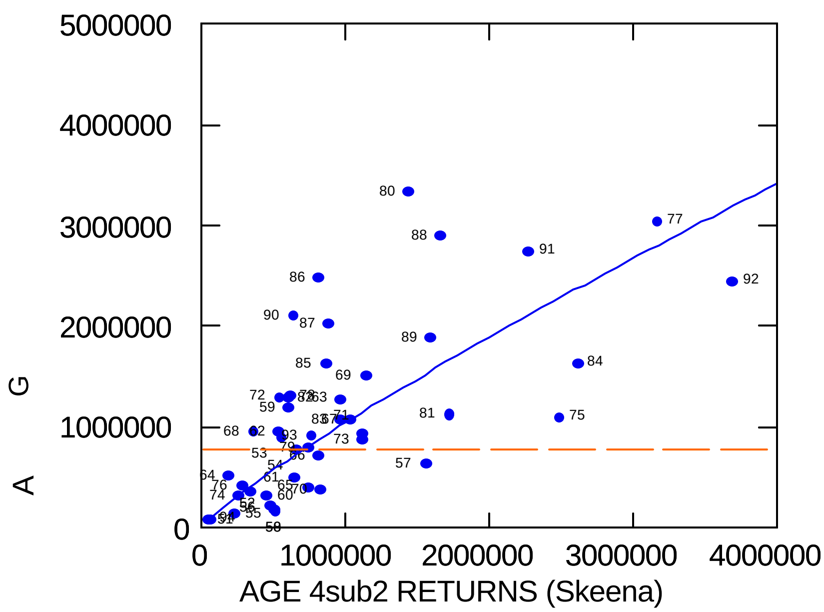


Figure 4B. Sibling model for forecasting total returns of age 5_2 Skeena sockeye from age 4_2 returns from the same brood year. Dashed lines indicate age 5_2 returns expected given age 4_2 returns from brood year 1995; all labels refer to brood years.

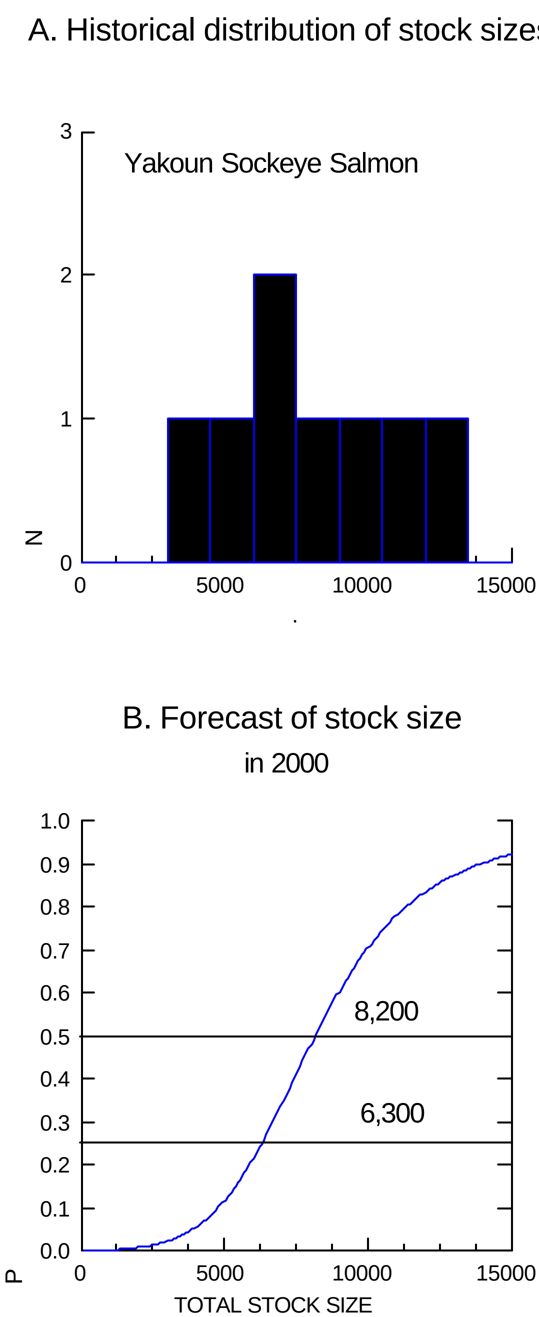


Figure 5A. The forecasted cumulative probability distribution for total stock size in 2000 for **Yakoun Lake sockeye** salmon as compared with the historical distribution of total stock size.

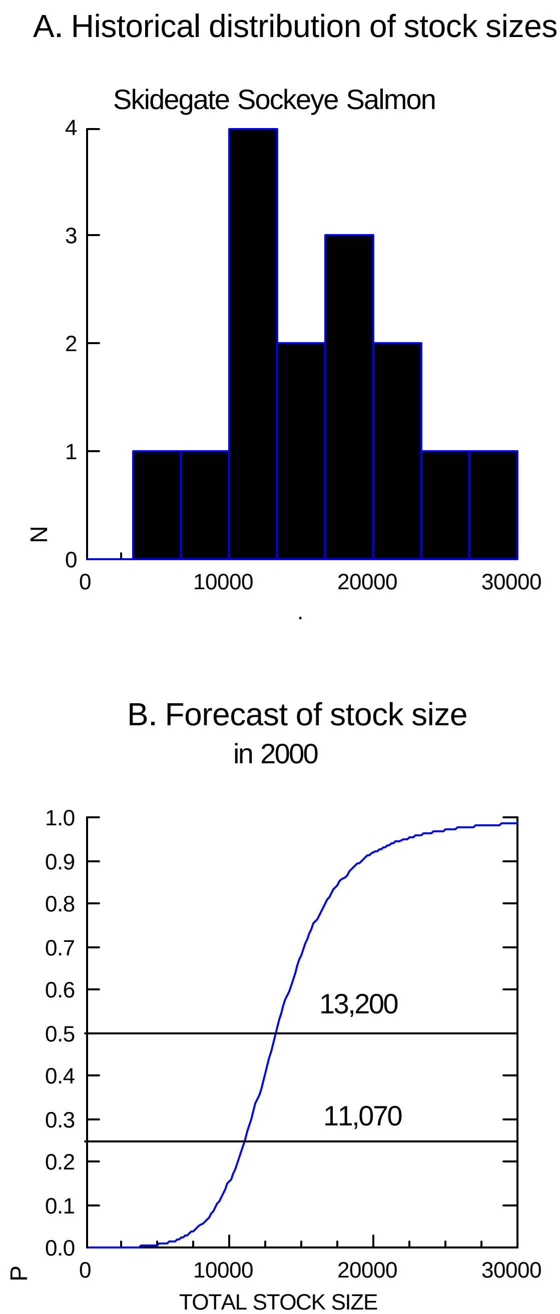


Figure 5B. The forecasted cumulative probability distribution for total stock size in 2000 for **Skidegate Lake sockeye** salmon as compared with the historical distribution of total stock size.

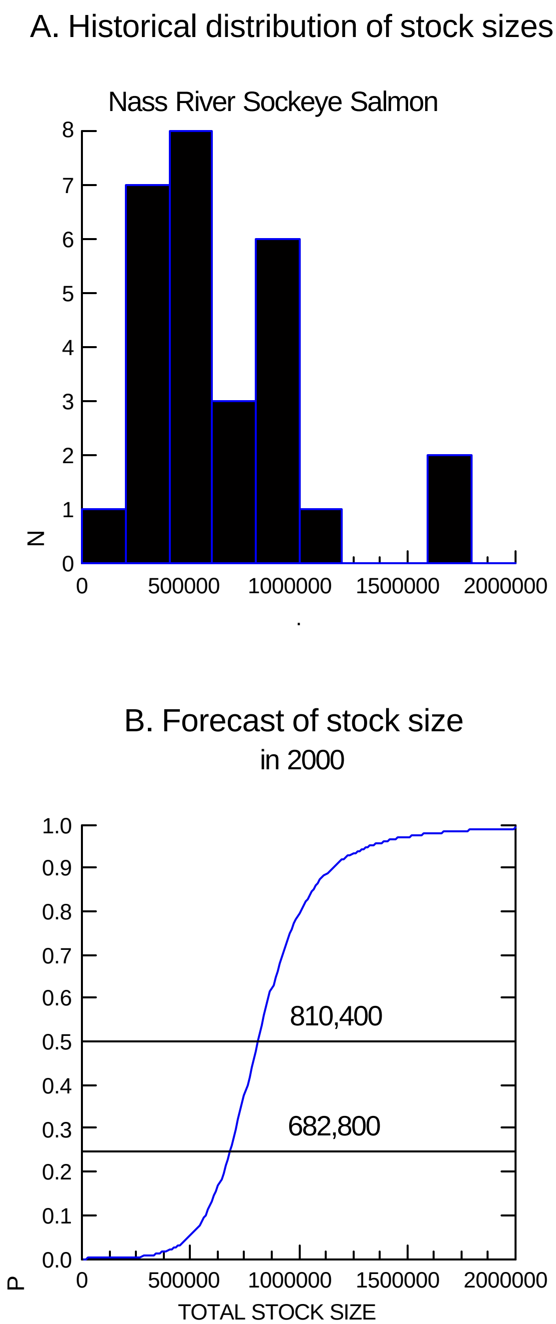


Figure 5C. The forecasted cumulative probability distribution for total stock size in 2000 for **Nass River sockeye** salmon as compared with the historical distribution of total stock size.

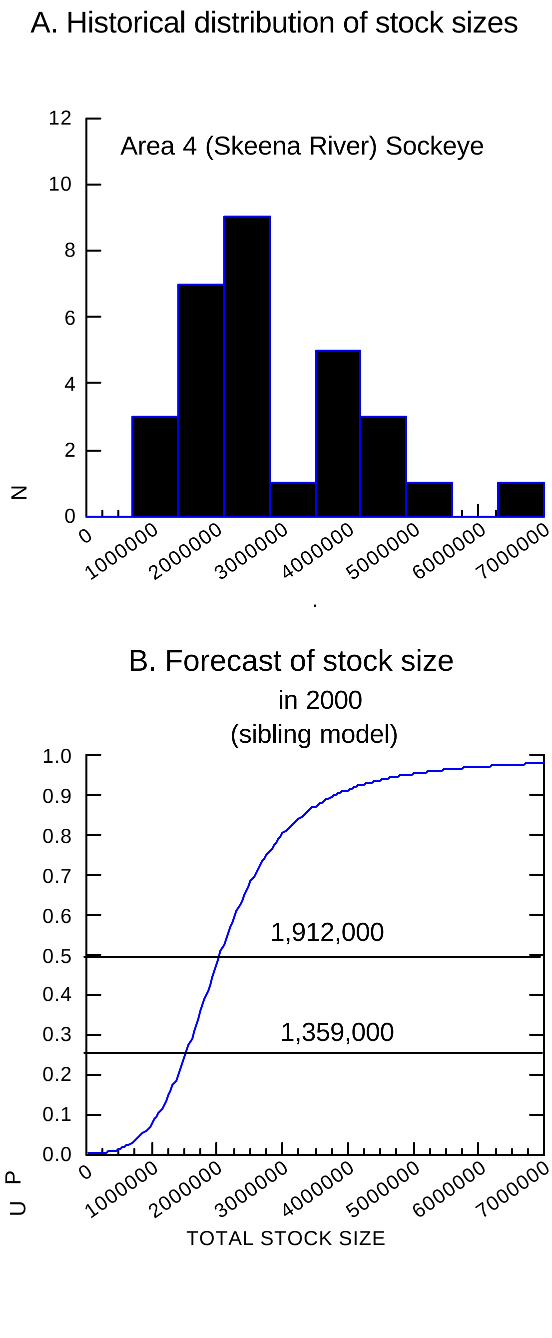


Figure 5D. The forecasted cumulative probability distribution for total stock size in 2000 for **Skeena River sockeye** salmon as compared with the historical distribution of total stock size.

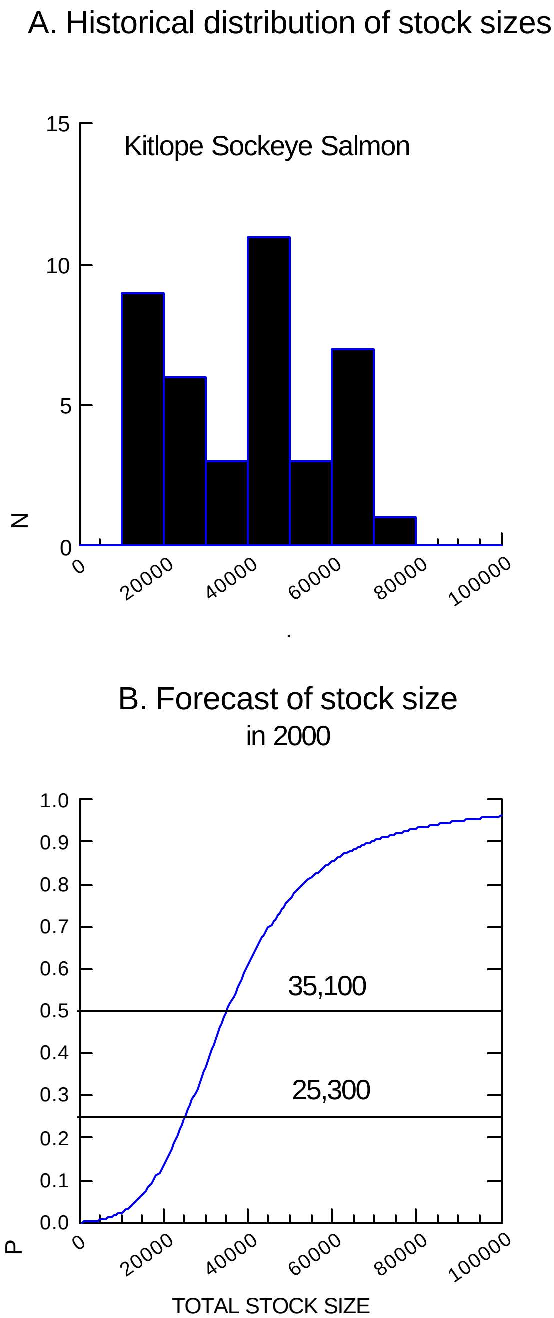


Figure 5E. The forecasted cumulative probability distribution for total stock size in 2000 for **Kitlope Lake sockeye** salmon as compared with the historical distribution of total stock size.

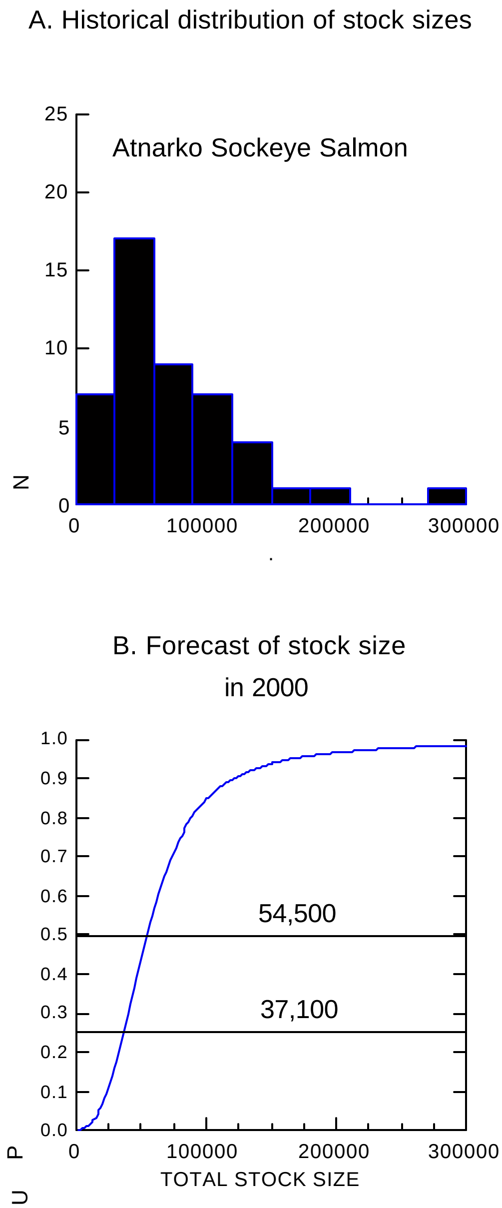


Figure 5F. The forecasted cumulative probability distribution for total stock size in 2000 for **Atnarko River sockeye** salmon as compared with the historical distribution of total stock size.

R

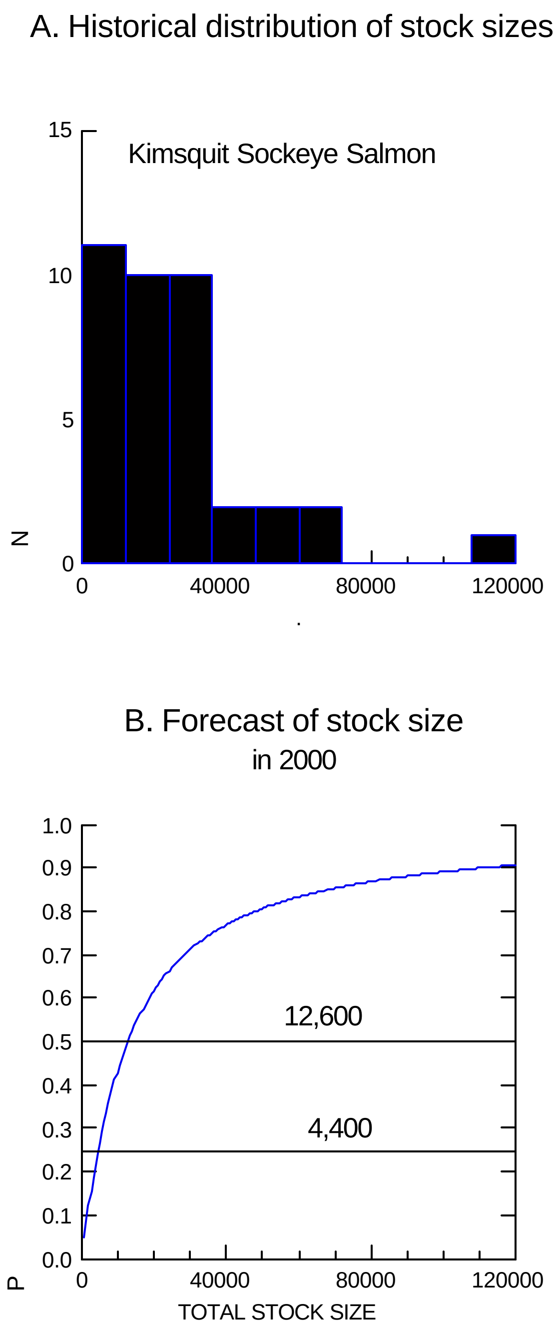


Figure 5G. The forecasted cumulative probability distribution for total stock size in 2000 for **Kimsquit Lake sockeye** salmon as compared with the historical distribution of total stock size.

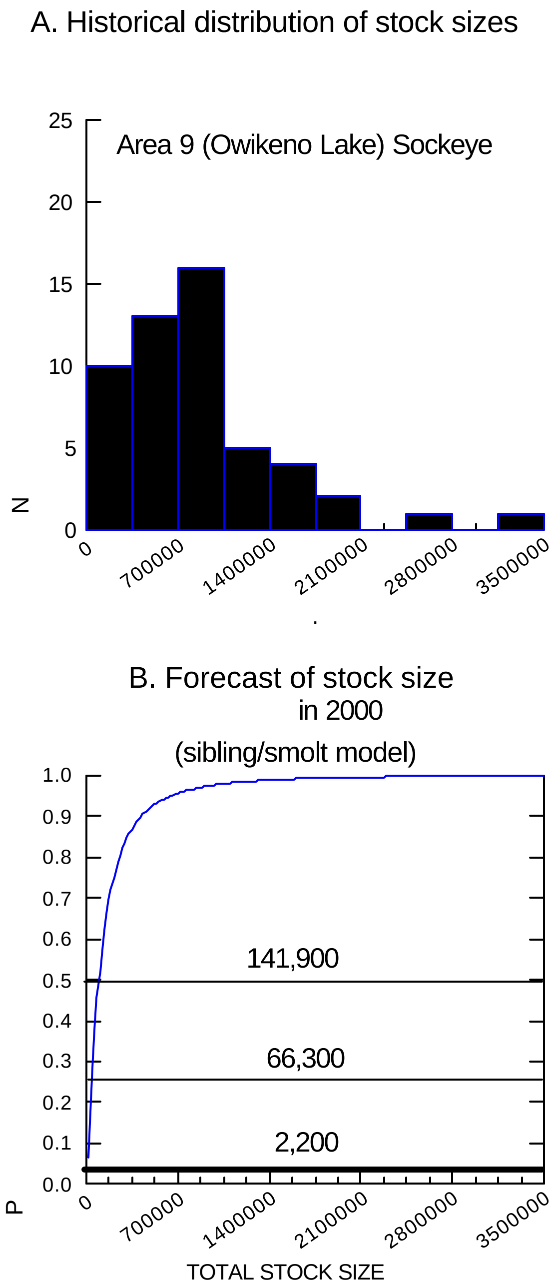


Figure 5H. The forecasted cumulative probability distribution, based on sibling/smolt model, for total stock size in 2000 for **Owikeno Lake sockeye** salmon as compared with the historical distribution of total stock size. Bold horizontal line indicates point estimate for "like 1996 sea-entry" model.

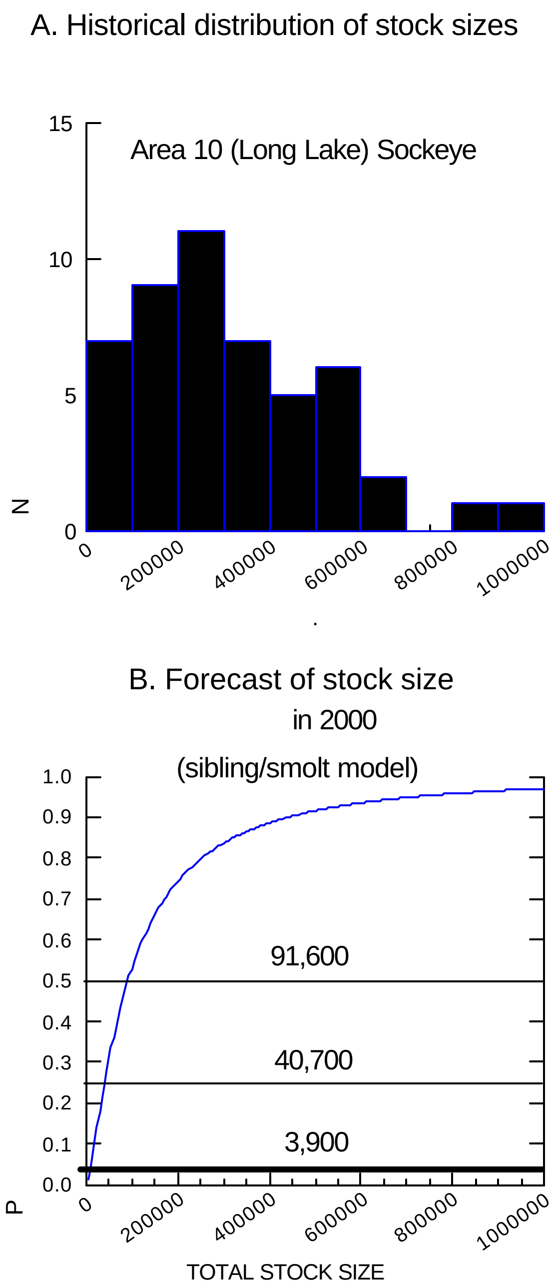
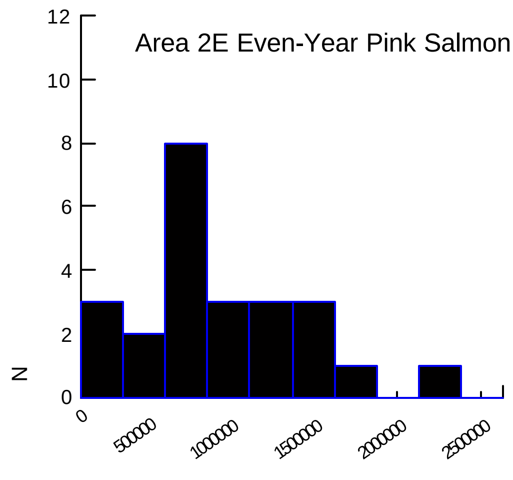


Figure 5I. The forecasted cumulative probability distribution, based on sibling/smolt model, for total stock size in 2000 for **Long Lake sockeye** salmon as compared with the historical distribution of total stock size. Bold horizontal line indicates point estimate for "like 1996 sea-entry" model.

A. Historical distribution of stock sizes



B. Forecast of stock size in 2000

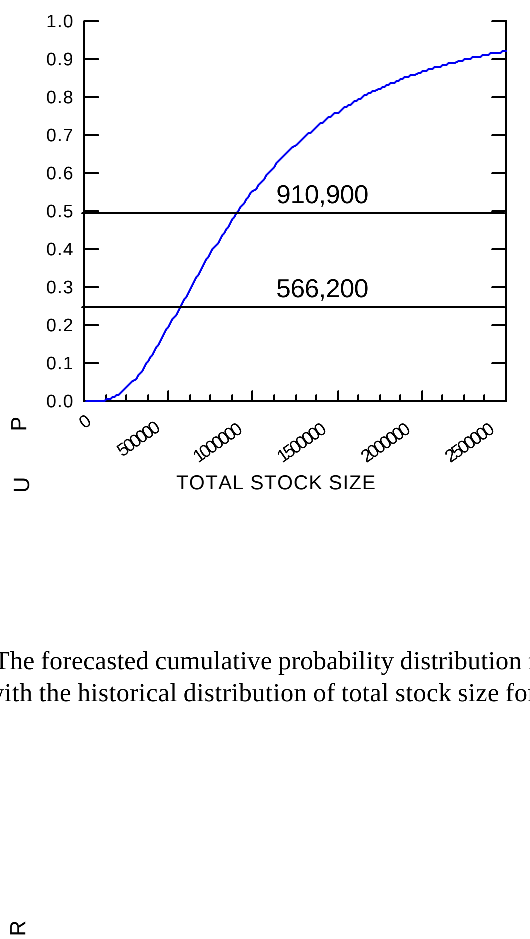


Figure 6A. The forecasted cumulative probability distribution for total stock size in 2000 for **Area 2E pink salmon** as compared with the historical distribution of total stock size for even years.

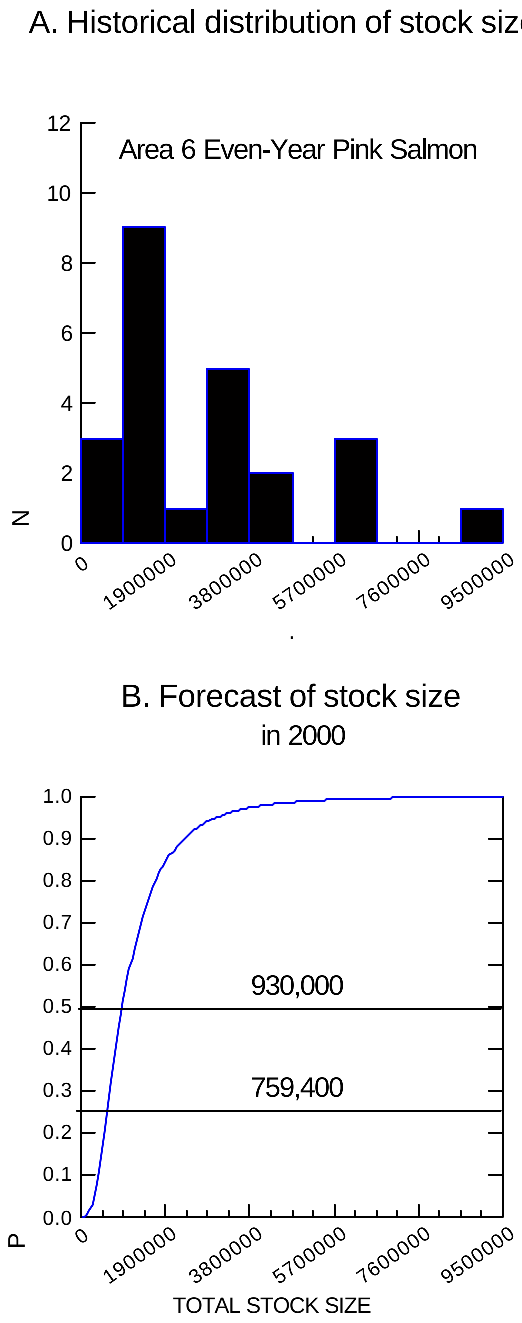


Figure 6B. The forecasted cumulative probability distribution for total stock size in 2000 for **Area 6 pink salmon** as compared with the historical distribution of total stock size for even years.

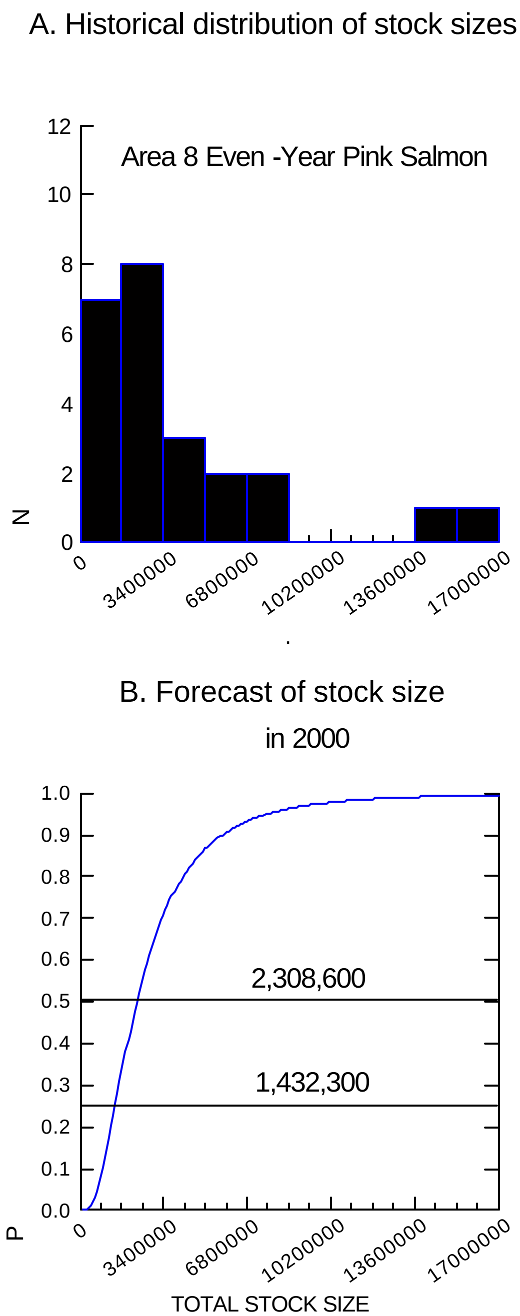
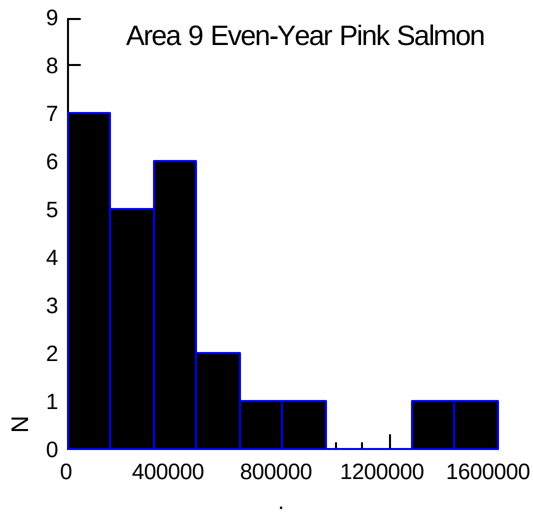


Figure 6C. The forecasted cumulative probability distribution for total stock size in 2000 for **Area 8 pink salmon** as compared with the historical distribution of total stock size for even years.

A. Historical distribution of stock sizes



B. Forecast of stock size in 2000

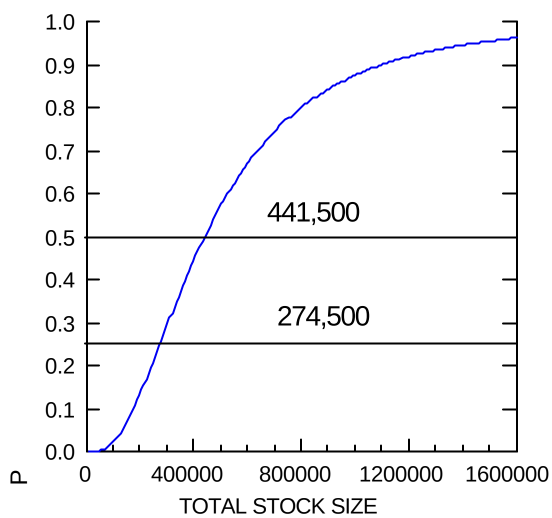


Figure 6D. The forecasted cumulative probability distribution for total stock size in 2000 for **Area 9 pink salmon** as compared with the historical distribution of total stock size for even years.

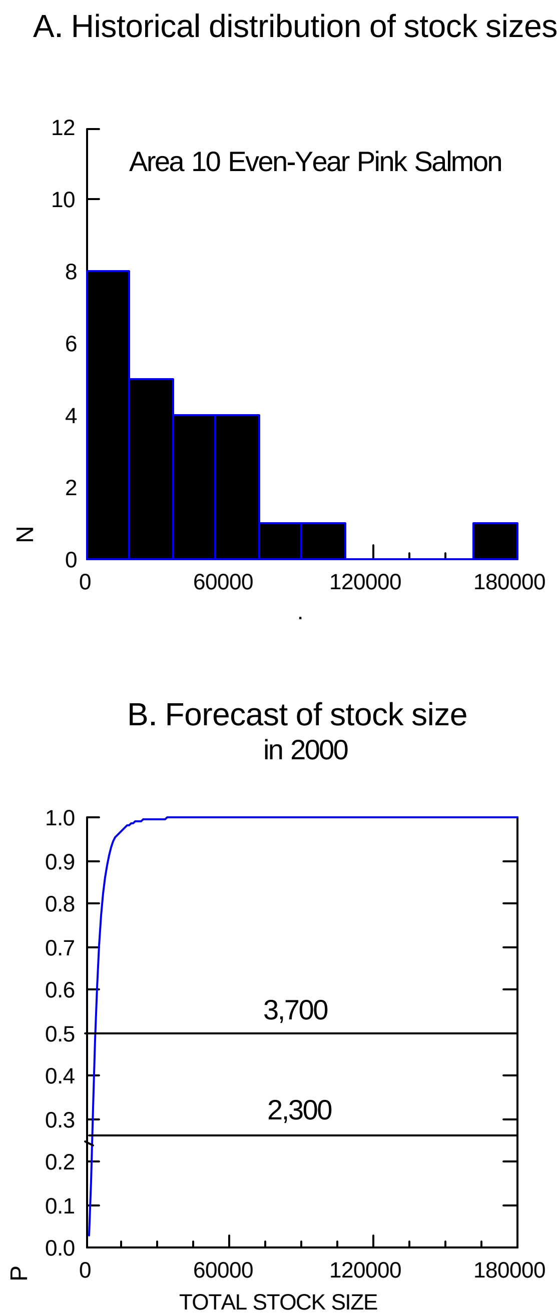


Figure 6E. The forecasted cumulative probability distribution for total stock size in 2000 for **Area 10 pink salmon** as compared with the historical distribution of total stock size for even years.

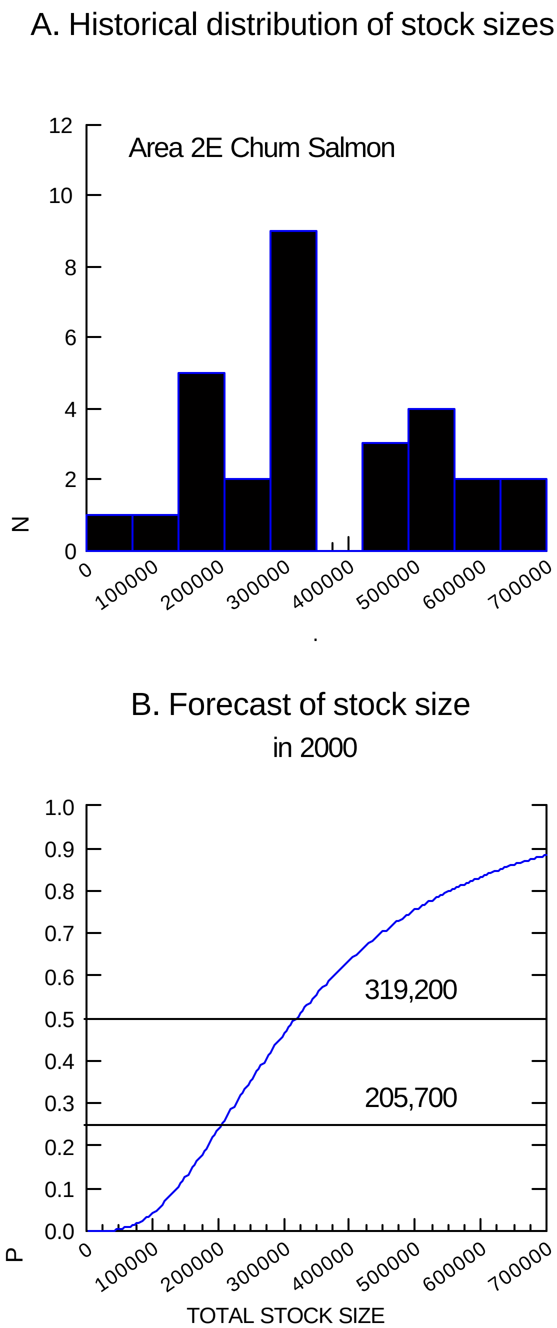
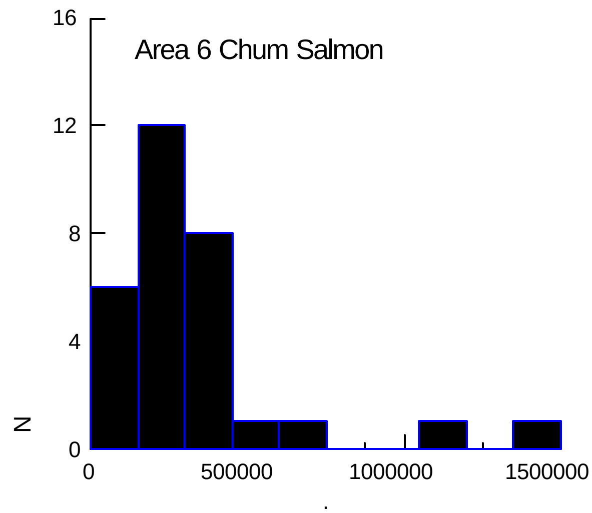


Figure 7A. The forecasted cumulative probability distribution for total stock size in 2000 for **Area 2E chum salmon** as compared with the historical distribution of total stock size.

A. Historical distribution of stock sizes



B. Forecast of stock size
in 2000

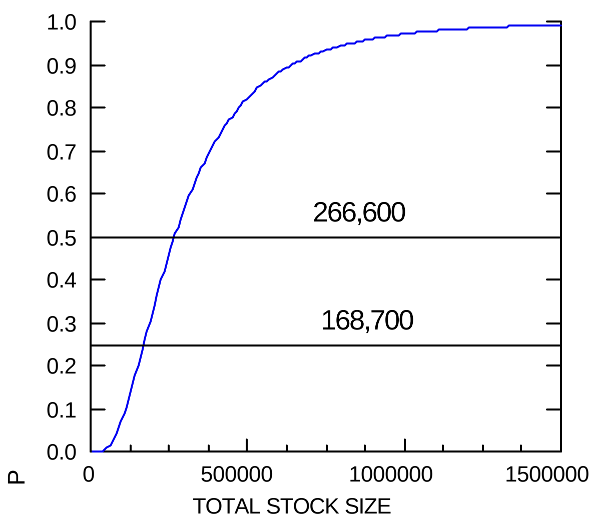


Figure 7B. The forecasted cumulative probability distribution for total stock size in 2000 for **Area 6 chum salmon** as compared with the historical distribution of total stock size.

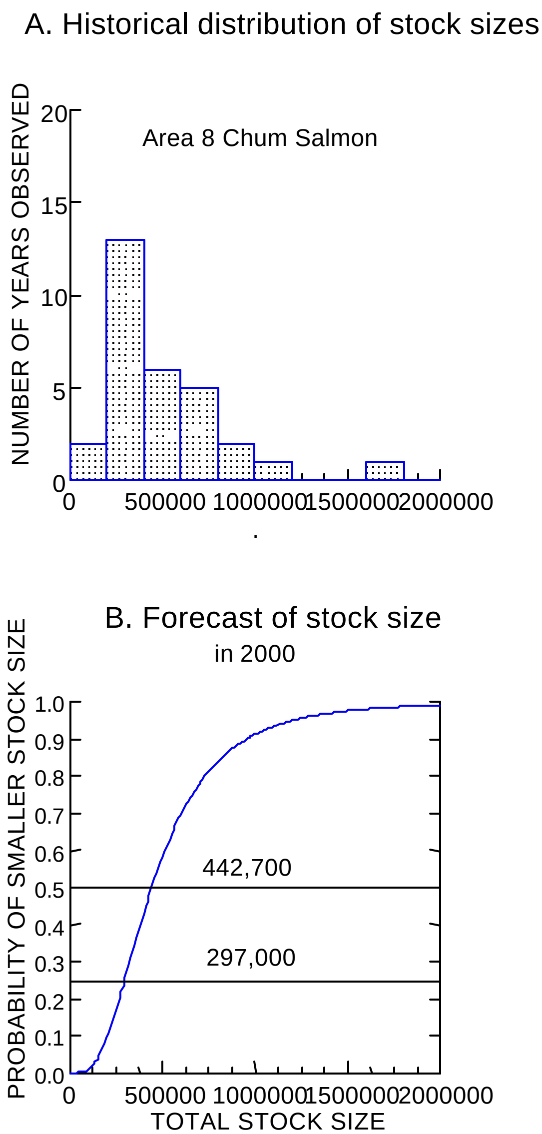


Figure 7C. The forecasted cumulative probability distribution for total stock size in 2000 for **Area 8 chum salmon** as compared with the historical distribution of total stock size.

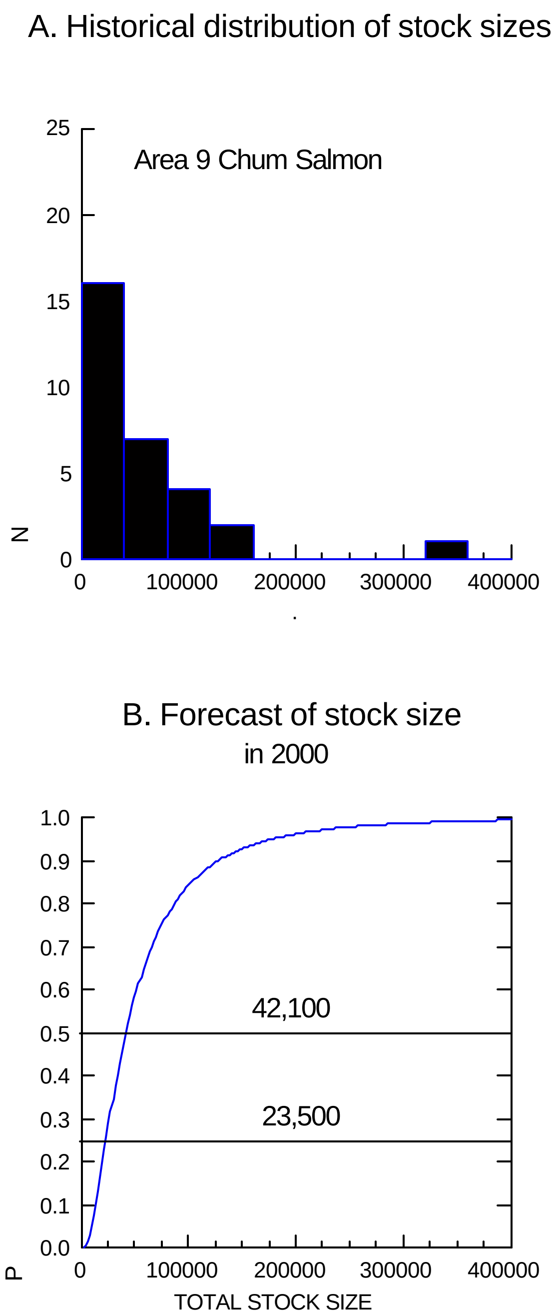


Figure 7D. The forecasted cumulative probability distribution for total stock size in 2000 for **Area 9 chum salmon** as compared with the historical distribution of total stock size.

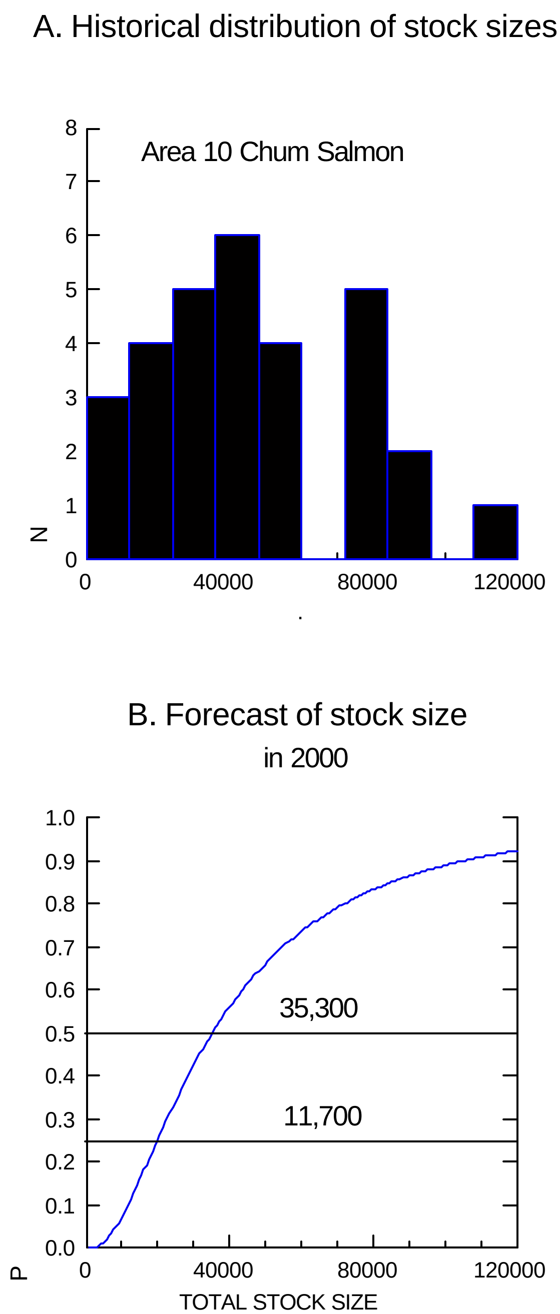


Figure 7E. The forecasted cumulative probability distribution for total stock size in 2000 for **Area 10 chum salmon** as compared with the historical distribution of total stock size.

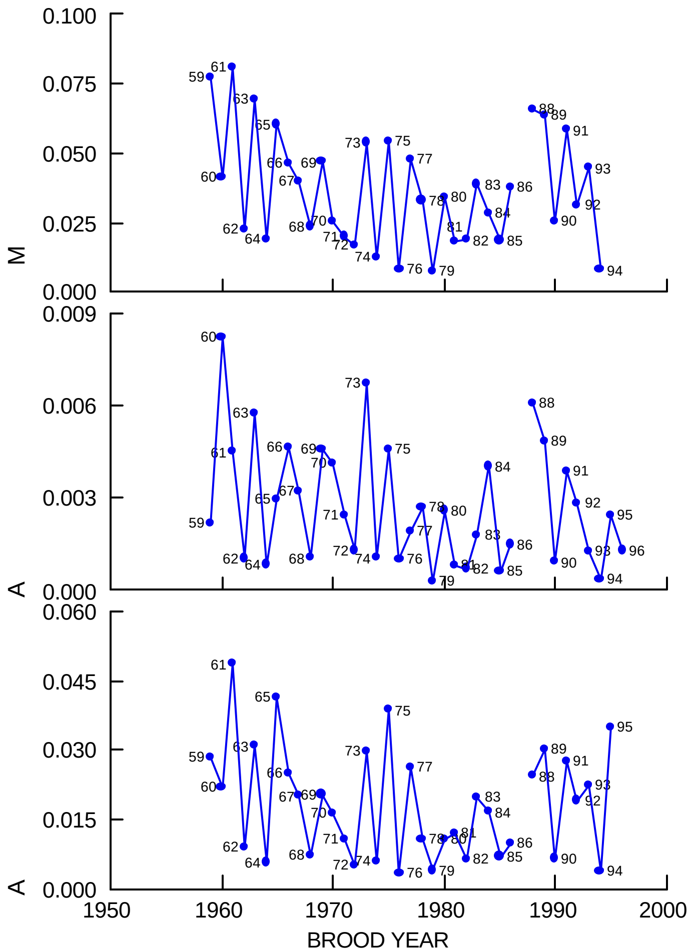


Figure 8. Trends in marine survival and smolt-to-adult return rates by age class in Skeena sockeye salmon. Note poor survival for 1994 brood year (1996 sea-entry), and early indications from age 3 and age 4 returns that marine survival has returned to normal. Marine survival for the 1995 brood year is likely underestimated because an upper bound for smolt abundance (20 million) was used instead of the "best" estimate of 10 million (see Appendix 5B).

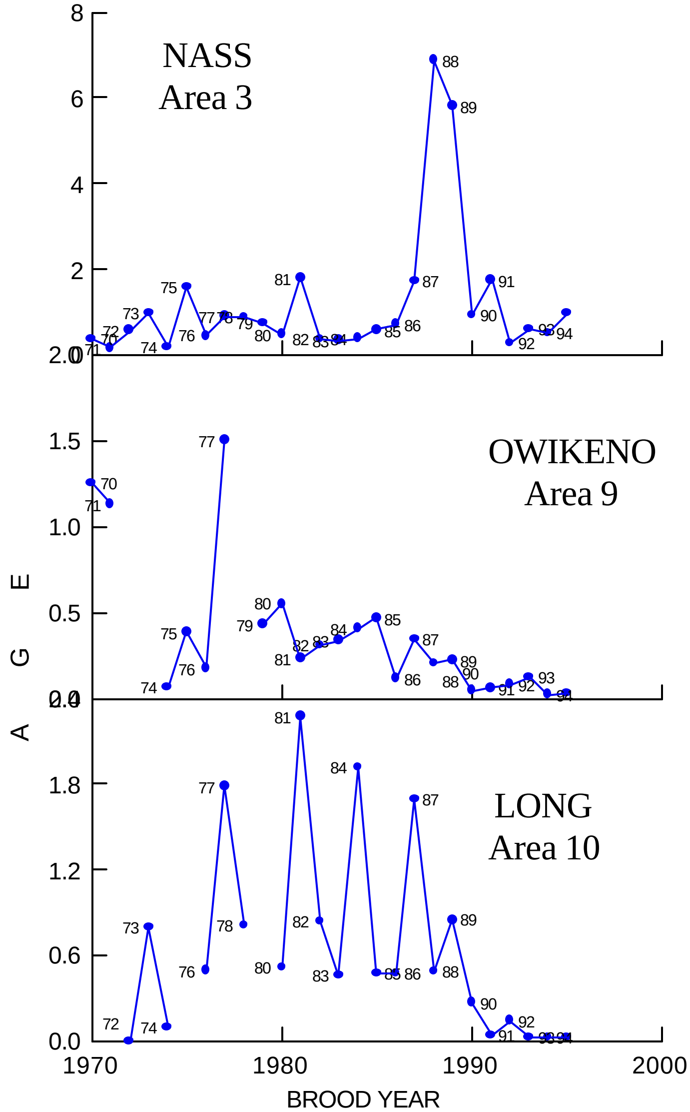


Figure 9. Trends in marine survival and smolt-to-adult return rates by age class in Nass, Owikeno and Long Lake sockeye salmon.

Appendix1. Total stock size (by calendar year) for major sockeye salmon stocks in northern British Columbia (statistical areas 1-10). These data were used to generate 2000 forecasts.

	Area 1	Area2	Area 3	Area 4	Area 6	Area 8		Area 9	Area 10
Year	Yakoun	Skidegate	Nass	Skeena	Kitlope	Atnarko	Kimsquit	Owikeno	Long
1948	.	.	.	.	.	.	.	557000	.
1949	.	.	.	.	.	.	.	840000	.
1950	.	.	.	.	.	.	.	1994000	.
1951	.	.	.	.	.	.	.	1320995	.
1952	.	.	.	.	.	.	.	1521222	.
1953	.	.	.	.	46875	118182	15000	1962285	.
1954	.	.	.	.	109375	96364	24000	679464	.
1955	.	.	.	.	10938	136364	10000	717145	.
1956	.	.	.	.	10938	136364	15000	1295832	.
1957	.	.	.	.	23438	272727	15000	586876	.
1958	.	.	.	.	46875	27273	.	1314295	.
1959	.	.	.	.	10938	136364	7000	819919	.
1960	.	.	.	.	46875	63636	15000	645303	.
1961	.	.	.	.	109375	63636	.	1004803	.
1962	.	.	.	.	234375	136364	7000	1449417	.
1963	.	.	.	.	546875	100000	.	1369959	.
1964	.	.	.	.	109375	56364	.	1627491	.
1965	.	.	.	.	46875	23636	.	785124	.
1966	.	.	.	.	62500	29091	.	728212	.
1967	.	.	.	.	109375	65455	30000	1538088	.
1968	.	.	.	.	109375	14545	7000	3282552	.
1969	.	.	.	.	10938	72727	7000	953330	.
1970	.	.	255242	1486243	46875	45455	7000	121269	.
1971	.	.	414691	1983222	46875	181818	110000	618438	.
1972	.	.	396279	1735617	10938	59091	27000	603006	135645
1973	.	.	846455	2448390	62500	154545	7000	2745156	464372
1974	.	.	567323	2552057	62500	100000	10000	675599	438718
1975	.	.	180975	1518749	31250	81818	70000	520633	115640
1976	.	.	391005	1504761	12500	54545	50000	913067	153120
1977	.	.	943012	2496644	46875	54545	20000	852419	183456
1978	.	.	485736	1184299	15625	36364	24000	960908	317486
1979	.	.	435966	2924595	15625	32727	16000	325853	31279
1980	.	.	358734	1473109	37500	43636	15000	313528	131784
1981	.	.	605623	3679645	31250	72727	10000	851781	368700
1982	.	.	858970	3785048	62500	36364	24000	862180	506632
1983	.	9990	522613	2149794	46875	45455	60000	671663	330865
1984	.	20095	421759	2392288	28125	81818	20000	268180	110172
1985	.	29121	734846	5132530	53125	90909	30000	684973	619178
1986	.	.	555858	1785674	62500	36318	32000	1163069	568854
1987	.	17862	428567	2329397	78125	55964	44000	920554	394926
1988	.	25190	308661	3855686	25000	54545	20000	875018	508731
1989	.	14427	475580	2609613	50000	27273	24400	438921	238631
1990	.	10814	375698	2628803	25000	36364	14800	820781	207579
1991	.	17455	908239	3668724	62500	95455	54000	514726	834550
1992	4968	22720	1797213	4423945	62500	74545	26000	851073	942816
1993	4155	11994	1653306	4894865	25000	27273	26000	393529	504156
1994	13216	3689	578233	2719696	48438	45455	n/i[a]	131639	157830
1995	4772	12108	933581	4763587	26250	100000	n/i[a]	118426	72188
1996	11459	19174	1045109	6865841	53125	81818	40000	65000	62513
1997	10494	10218	827716	3556646	46875	36364	10000	275000	32000
1998	7175	14642	569000	1039753	43750	54545	n/i[a]	52000	76000
1999	8812	11750	760495	84370	18750	29412	1176	4257	5900

[a] not inspected

Appendix 2. Escapements and total returns by brood year for major pink salmon stocks in northern British Columbia

Even Brood Years	Area 2E		Area 6		Area 8		Area 9		Area 10	
	Esc	Returns	Esc	Returns	Esc	Returns	Esc	Returns	Esc	Returns
1950	357250	1308886	204475	1857245	260607	1184321	47325	201300	35000	60045
1952	715050	760820	480550	790776	545285	1202636	44750	47740	35000	15486
1954	406000	415466	210900	2268593	351377	1810229	5950	146839	6000	60268
1956	261600	737242	537025	1494357	781075	1085035	52700	172410	35025	58280
1958	312900	566682	416075	1364354	283409	3052160	24125	113765	3500	32504
1960	370695	1521054	568175	6628074	1571365	16054130	5850	779725	3500	178056
1962	677450	176450	2822725	2938383	3910088	3594019	121925	276440	35000	62418
1964	138795	784772	1509225	4485553	763125	3059852	68850	375247	1500	45219
1966	509375	1253940	1139500	4249942	939850	7445618	118650	1559608	7500	99633
1968	769343	1385866	1182300	3544637	2095000	2743461	111050	329876	15025	72553
1970	808360	1143270	753700	6112824	731100	2440872	144175	1312599	15000	12944
1972	766950	644725	1023900	926590	1356100	4235820	502400	574490	2525	32198
1974	423171	2233200	400925	1508328	1469900	3289431	214850	843770	9000	33058
1976	615100	774886	1021288	3581343	1382200	4053951	259600	482834	22100	35492
1978	528385	306175	853855	3615575	2293475	2011075	109650	146707	19000	3259
1980	305172	164302	740109	984038	1127725	234527	135800	101945	2500	12407
1982	164203	235476	403265	1240064	195590	1138273	100000	217843	9031	3993
1984	191850	1056906	638853	6073829	967210	6692273	138102	440594	3516	34894
1986	703761	710545	1429760	9159518	3271535	13911814	289815	390930	26570	38630
1988	572303	1211585	1448578	2854805	5204570	6394899	242146	410564	18113	45456
1990	876177	677869	954619	1247838	2759835	7322763	257195	291525	41065	51701
1992	654261	586623	700798	353503	4614400	929656	158585	116530	2100	11907
1994	501810	624372	237024	1420773	367790	2210851	97550	333200	2030	6803
1996	603737	542613	966985	1185593	1844345	1113772	333200	155500	6400	600
1998	521926		571968		626245		155500		600	

Appendix 3. Catch, escapements, and total stock sizes by calendar year for major chum salmon stocks.

	Area 2E			Area 6			Area 8			Area 9			Area10		
Year	Catch	Esc.	Total Stock	Catch	Esc.	Total Stock	Catch	Esc.	Total Stock	Catch	Esc.	Total Stock	Catch	Esc.	Total Stock
1970	363650	198975	562625	271918	105650	377568	356960	275400	0	103742	38600	142342	49918	22500	72418
1971	302139	222350	524489	66559	90300	156859	60822	82875	632360	16710	11855	28565	8727	25000	33727
1972	281488	185780	467268	471859	271600	743459	233774	221375	143697	27460	27581	55041	33725	43250	76975
1973	430620	225350	655970	162619	278750	441369	251346	277775	455149	46569	24425	70994	43276	71500	114776
1974	149922	146440	296362	166520	258640	425160	198966	146800	529121	40904	62075	102979	13800	28500	42300
1975	1943	72562	74505	16751	79296	96047	134748	83575	345766	8266	16600	24866	5569	7500	13069
1976	47459	143420	190879	13286	67340	80626	334007	125000	218323	20853	6345	27198	3599	8500	12099
1977	170523	161075	331598	55327	85810	141137	79773	122950	459007	41995	9790	51785	13774	42500	56274
1978	115316	213567	328883	218343	185255	403598	139244	49135	202723	56344	60800	117144	38460	36000	74460
1979	0	43541	43541	88625	87805	176430	210658	99485	188379	9088	18550	27638	5488	13750	19238
1980	122390	165416	287806	200687	82862	283549	343122	123475	310143	9638	23675	33313	20221	57000	77221
1981	36774	164924	201698	96144	93410	189554	303752	107090	466597	7142	12650	19792	10990	65500	76490
1982	28719	202713	231432	142275	135783	278058	182418	129380	410842	11362	102180	113542	20129	70000	90129
1983	0	156082	156082	82258	44080	126338	331478	155045	311798	4630	34976	39606	3914	44000	47914
1984	280670	277596	558266	30727	119254	149981	70876	132260	486523	11403	26689	38092	3128	14200	17328
1985	646300	302505	948805	166290	238901	405191	536992	220865	203136	18055	28653	46708	20710	26000	46710
1986	217155	279928	497083	225590	264410	490000	1516253	266222	757857	155491	201220	356711	15168	73600	88768
1987	191195	315766	506961	116374	114661	231035	521523	138170	1782475	36167	87923	124090	14164	37500	51664
1988	392795	259102	651897	711050	460488	1171538	846088	201537	659693	39786	44423	84209	7979	41000	48979
1989	133933	296627	430560	14877	272988	287865	237269	121789	1047625	9343	10363	19706	6236	21000	27236
1990	297597	303826	601423	153301	196086	349387	688027	285515	359058	18495	14830	33325	2261	44350	46611
1991	265050	204360	469410	50747	105896	156643	235164	84607	973542	5920	7182	13102	18123	30500	48623
1992	132633	138668	271301	42227	152379	194606	155939	112447	319771	20458	16450	36908	17574	13750	31324
1993	114335	170494	284829	11599	119877	131476	186621	133188	268386	3455	9960	13415	12640	18600	31240
1994	128433	176768	305201	75142	249626	324768	492143	244997	319809	9899	15465	25364	19123	17800	36923
1995	23705	160361	184066	27842	351653	379495	708638	204550	913188	17803	24345	42148	6333	40730	47063
1996	122613	207949	330562	29578	148427	178005	275764	219339	495103	0	12400	12400	1181	23150	24331
1997	50406	154101	204507	12015	235056	247071	234803	196375	431178	0	6985	6985	0	4600	4600
1998	108263	216005	324268	541969	864236	1406205	641715	331335	973050	0	47450	47450	0	4515	4515
1999	158414	189262	347676	45830	153286	199116	178258	183800	362058	0	76780	76780	0	9100	9100

Appendix 4A. Escapement, total stock sizes, and age composition by calendar year for **Area 3 (Nass River)** sockeye salmon. Age 3 fish and first nation catch excluded.

		Total	Age Composition		
Year	Escapement	Stock	% age 4	% age 5	% age 6
1970	113953	255242	24.0	71.1	4.9
1971	246774	414691	30.6	66.6	2.8
1972	177216	396279	19.1	64.8	16.1
1973	284082	846455	43.6	53.8	2.7
1974	193203	567323	7.3	80.2	12.5
1975	70874	180975	22.7	72.5	4.7
1976	142805	391005	25.9	70.3	3.8
1977	399821	943012	29.4	65.9	4.7
1978	147218	485736	7.4	80.6	12.0
1979	212890	435966	24.8	71.4	3.8
1980	155265	358734	17.3	77.3	5.3
1981	255643	605623	57.1	41.5	1.3
1982	306070	858970	14.9	80.8	4.3
1983	185100	522613	30.4	61.1	8.5
1984	182350	421759	17.6	73.6	8.7
1985	361208	734846	59.8	34.2	6.1
1986	187226	555858	20.1	70.1	9.8
1987	184212	428567	14.4	79.1	6.5
1988	136760	308661	22.5	70.2	7.3
1989	112607	475580	43.5	48.6	7.9
1990	155472	375698	29.1	64.7	6.2
1991	269848	908239	34.4	60.2	5.4
1992	645964	1797213	51.8	43.9	4.3
1993	440740	1653306	39.1	56.6	4.2
1994	179262	578233	25.5	67.8	6.7
1995	237991	933581	47.7	47.1	5.2
1996	219825	1045109	18.4	72.7	8.8
1997	237312	898998	29.7	61.4	8.9
1998	280000	557406	19.6	73.5	6.9
1999[a]	180848	760495	31.0	60.0	7.0

[a] preliminary estimates

Appendix 4B. Escapements and brood year returns by age class for **Area 3 (Nass River)** sockeye salmon. Age 3 fish and First Nation catch excluded.

Brood Year	Escapement	Adult Returns Age 4	Age 5	Age 6	Total
1970	113953	41456	131281	14915	187652
1971	246774	41164	274913	44537	360614
1972	177216	101178	621575	58093	780845
1973	284082	276901	391518	16486	684905
1974	193203	36125	311404	19027	366556
1975	70874	108076	277474	8034	393583
1976	142805	62233	251519	37159	350911
1977	399821	346070	693916	44591	1084577
1978	147218	127895	319185	36794	483874
1979	212890	158837	310623	44742	514202
1980	155265	74342	250996	54518	379855
1981	255643	439109	389494	27951	856554
1982	306070	111846	339014	22587	473447
1983	185100	61602	216723	37795	316120
1984	182350	69351	231134	23394	323880
1985	361208	206651	242921	49267	498839
1986	187226	109382	546805	77646	733834
1987	184212	312167	788814	70012	1170993
1988	136760	930753	936150	38630	1905532
1989	112607	647144	392247	48467	1087858
1990	155472	147357	439593	90247	677196
1991	269848	445521	742494	91583	1279598
1992	645964	188150	476232	39000	703382
1993	440740	259901	408000	49602[a]	717503[a]
1994	179262	108000	456045[a]		
1995	237991	235414[a]			
1996	219825				
1997	237312				
1998	280000				
1998	180848[a]				

[a] preliminary estimates

Appendix 5A. Escapements, total stock sizes, and age composition by calendar year for **Area 4 (Skeena River)** sockeye salmon. Age 3 fish excluded.

Year	Escapement	Total Stock	Age Composition % age 4	% age 5	% other
1970	678652	1486243	62.3	30.5	7.2
1971	821850	1983222	56.9	38.3	4.8
1972	697237	1735617	24.2	71.0	4.8
1973	820196	2448390	47.1	43.2	9.7
1974	723898	2552057	32.6	63.8	3.6
1975	822633	1518749	74.2	24.0	1.8
1976	575590	1504761	36.5	61.5	2.1
1977	951805	2496644	45.3	51.8	2.9
1978	424075	1184299	22.3	73.0	4.7
1979	1166236	2924595	85.4	10.7	3.9
1980	542164	1473109	19.6	74.2	6.3
1981	1424509	3679645	86.3	11.2	2.5
1982	1140737	3785048	16.4	80.3	3.3
1983	893724	2149794	35.1	61.0	3.9
1984	1055215	2392288	60.7	33.0	6.3
1985	2174806	5132530	33.8	64.7	1.5
1986	716312	1785674	34.2	62.5	3.2
1987	1324128	2329397	42.0	54.8	3.2
1988	1417543	3855686	68.1	27.8	4.1
1989	1137994	2609613	33.4	62.5	4.1
1990	989566	2628803	31.1	61.9	7.0
1991	1232568	3668724	24.2	67.6	8.2
1992	1550109	4423945	37.8	45.7	16.5
1993	1629426	4894865	32.7	59.2	8.2
1994	1026816	2719696	23.8	68.9	7.4
1995	1720292	4763587	48.0	44.1	7.9
1996	1782357	6865841	53.7	39.8	6.5
1997	985662	3556646	21.7	68.7	9.6
1998	531600	1039753	6.1	87.1	6.9
1999	650000	843702	82.8	10.0	7.2

Appendix 5B. Escapements, smolt production, and brood year returns by age class for **Area 4 (Skeena River)** age 1.* sockeye salmon.

Brood Year	Escapement	Smolts[a]	Adult Returns Age 3	Age 4	Age 5	Total
1970	678652	50811	208350	831757	364197	1404304
1971	821850	105240	256772	1127097	924801	2308670
1972	697237	106201	137396	548679	1293885	1979959
1973	820196	38098	255458	1131537	864870	2251865
1974	723898	45618	47697	263777	313432	624906
1975	822633	64724	296274	2498508	1092804	3887586
1976	582652	90374	90509	288034	411161	789704
1977	951805	121540	233886	3177365	3039052	6450304
1978	424075	57505	155395	621563	1310373	2087331
1979	1166236	192043	60223	755494	788985	1604702
1980	541964	136566	353135	1451716	3323273	5128123
1981	1424209	146245	120752	1733185	1116550	2970487
1982	1140246	94609	66714	611270	1276820	1954804
1983	893724	49837	88125	977637	1070368	2136130
1984	1055215	159048	638641	2627321	1630157	4896120
1985	2174806	125634	77631	871807	1627596	2577034
1986	714307	82337	122711	817553	2480221	3420485
1987	1324128		89631	887664	2020415	2997710
1988	1417593	68835	416049	1671873	2895397	4983319
1989	1137994	53385	258240	1598624	1873677	3730540
1990	989482	99651	90580	646101	2099914	2836594
1991	1232578	83096	320804	2286244	2740730	5347777
1992	1236158	194134	542895	3733813	2443606	6720314
1993	1629426	34797	43480	771953	905453	1720886
1994	1026806	18091	6348	63043	84370	153761
1995	1720311	10000[b]	48500	698585		
1996	1794033	135500	174650			
1997	985662	82239				

[a] in thousands of fish

[b] Program terminated early due to flooding. Smolt estimate to 28 May was 8.3 million. The median date for (50%) smolt migration since 1990 has ranged from 15 to 31 May, averaging 24 May. Accordingly, an approximate total run for 1997 was estimated by doubling the estimate to 24 May (3.9 million) and rounding up to one significant digit (10 million). Based in historical timing, it seems unlikely that the total smolt migration exceeded 20 million in 1997, but see Figure 8.

Appendix 6A. Escapements, total stock sizes, and age composition by calendar year for **Area 9 (Owikeno Lake)** sockeye salmon.

		Total	Proportion of escapement			Proportion of catch		
Year	Escapement	Stock	Age 1.2	Age 1.3	Other	Age 1.2	Age 1.3	Other
1948	105273	557000				0.55	0.45	0.00
1949	236880	840000				0.84	0.15	0.00
1950	444662	1994000				0.13	0.89	0.00
1951	304500	1320995				0.38	0.61	0.01
1952	582500	1521222				0.41	0.59	0.02
1953	440000	1962285				0.73	0.27	0.02
1954	103800	679464				0.60	0.40	0.02
1955	132900	717145				0.45	0.56	0.01
1956	223500	1295832				0.10	0.92	0.00
1957	212900	586876				0.65	0.35	0.00
1958	296750	1314295				0.28	0.71	0.00
1959	380500	819919				0.19	0.79	0.01
1960	128800	645303	0.43	0.57	0.00	0.38	0.57	0.04
1961	161850	1004803	0.31	0.69	0.00	0.49	0.49	0.02
1962	413500	1449417	0.53	0.47	0.00	0.90	0.09	0.00
1963	932500	1369959	0.47	0.52	0.01	0.37	0.60	0.02
1964	573900	1627491	0.12	0.86	0.01	0.13	0.79	0.07
1965	140150	785124	0.36	0.64	0.00	0.69	0.27	0.01
1966	200000	728212	0.42	0.58	0.00	0.34	0.65	0.00
1967	435250	1538088	0.40	0.60	0.00	0.78	0.20	0.01
1968	555000	3282552				0.07	0.90	0.03
1969	226000	953330				0.35	0.61	0.02
1970	102250	121269	0.40	0.50	0.05	0.40	0.49	0.05
1971	215900	618438	0.76	0.22	0.02	0.75	0.23	0.01
1972	224000	603006	0.81	0.14	0.01	0.48	0.45	0.04
1973	985000	2745156	0.06	0.94	0.00	0.06	0.94	0.00
1974	557025	675599	0.19	0.78	0.01	0.19	0.78	0.01
1975	480002	520633	0.47	0.52	0.01	0.47	0.52	0.01
1976	300000	913067				0.47	0.51	0.00
1977	192600	852419				0.44	0.54	0.00
1978	383000	960908	0.03	0.95	0.02	0.04	0.94	0.02
1979	297525	325853	0.57	0.41	0.02	0.57	0.41	0.02
1980	313000	313528	0.17	0.83	0.00	0.17	0.83	0.00
1981	753075	851781	0.34	0.65	0.00	0.34	0.65	0.00
1982	823000	862180				0.12	0.85	0.00
1983	636502	671663	0.19	0.80	0.01	0.19	0.80	0.01
1984	214301	268180	0.62	0.38	0.00	0.74	0.26	0.00
1985	500430	684973	0.21	0.79	0.00	0.38	0.62	0.00
1986	825626	1163069	0.17	0.83	0.00	0.34	0.66	0.00
1987	521700	920554	0.09	0.87	0.00	0.42	0.58	0.00
1988	503000	875018	0.04	0.96	0.00	0.18	0.82	0.00
1989	375175	438921	0.56	0.44	0.00	0.39	0.61	0.00
1990	586500	820781	0.12	0.88	0.00	0.11	0.86	0.03
1991	346500	514726	0.39	0.61	0.00	0.26	0.71	0.02
1992	343005	851073	0.17	0.76	0.03	0.09	0.90	0.01
1993	311000	393529	0.18	0.82	0.00	0.34	0.63	0.03
1994	91500	131639	0.14	0.84	0.02	0.34	0.63	0.03
1995	73000	118426	0.06	0.94	0.00	0.35	0.65	0.00
1996	65000	67697	0.38	0.59	0.02			
1997	275000	276984	0.14	0.84	0.02			
1998	52000	54161	0.04	0.96	0.00			
1999	3600	4257	0.48	0.52	0.00			

Appendix 6B. Escapements and brood year returns by age class for **Area 9 (Owikeno Lake)** age 1.* sockeye salmon

Brood Year	Escapement	Smolt	Adult Returns Age 4	Age 5	Total
1948	105273	.	623701	529817	1153518
1949	236880	.	1432468	271786	1704254
1950	444662	.	407678	401601	809280
1951	304500	10399172	322715	1192165	1514881
1952	582500	7090290	129583	205407	334990
1953	440000	11009144	381469	933149	1314619
1954	103800	2072439	368003	647736	1015739
1955	132900	1981246	155785	367823	523607
1956	223500	2393427	251655	524723	776379
1957	212900	739875	463220	287578	750798
1958	296750	9532683	1151480	747375	1898856
1959	380500	13800795	600135	1325891	1926026
1960	128800	7277055	205835	263839	469674
1961	161850	6717568	495486	459338	954824
1962	413500	3577722	263592	481718	745310
1963	932500	24648750	1034314	2954297	3988610
1964	573900	32941267	229779	581531	811310
1965	140150	1886506	333666	60444	394110
1966	200000	16522551	48508	140082	188589
1967	435250	1607574	465988	201913	667900
1968	555000	32941267	363363	2580447	2943810
1969	226000	19196466	164709	526967	691677
1970	102250	18629124	128364	270729	399093
1971	215900	6078307	244698	465664	710362
1972	224000	12997099	429141	460306	889448
1973	985000	27514859	375064	907084	1282148
1974	557025	20383509	34606	133600	168206
1975	480002	9250949	185736	260228	445964
1976	300000	.	53300	553658	606957
1977	192600	13127722	289606	732853	1022459
1978	383000	.	103462	537330	640792
1979	297525	.	127616	95443	223059
1980	313000	.	172737	509756	682493
1981	753075	18443761	175217	907982	1083199
1982	823000	39437857	255087	685214	940301
1983	636502	.	214472	787935	1002406
1984	214301	18078551	87083	203962	291045
1985	500430	69736662	234959	717602	952561
1986	825626	.	96151	330805	426956
1987	521700	50689875	178874	717945	896819
1988	503000	3993732	104037	307013	411050
1989	375175	509017	84040	102148	186187
1990	586500	6771524	26457	98147	124604
1991	346500	8977542	20279	35879	56159
1992	343005	.	29110	229897	259006
1993	311000	.	38778	51995	90772
1994	91500	7400247	2166	2214	4380
1995	73000	3385452	2043		
1996	65000	681304			
1997	275000	3019697			
1998	52000	351586			
1999	3600				

Appendix 7A. Escapements, total stock sizes, and age composition by calendar year for **Area 10 (Long Lake)** sockeye salmon.

		Total	Proportion of escapement			Proportion of catch		
Year	Escapement	Stock	Age 1.2	Age 1.3	Other	Age 1.2	Age 1.3	Other
1972	76248	135645	0.66	0.33	0.01	0.71	0.28	0.01
1973	169753	464372	0.08	0.92	0.00	0.15	0.83	0.02
1974	91013	438718				0.09	0.83	0.08
1975	62967	115640	0.44	0.56	0.00	0.23	0.76	0.01
1976	60919	153120						
1977	128601	183456	0.75	0.23	0.03	0.71	0.28	0.01
1978	84105	317486	0.04	0.95	0.01	0.03	0.97	0.00
1979	20257	31279						
1980	129435	131784	0.23	0.77	0.00			
1981	214345	368700	0.67	0.32	0.01	0.56	0.44	0.00
1982	213674	506632	0.11	0.89	0.00	0.15	0.85	0.00
1983	199653	330865						
1984	89012	110172	0.63	0.37	0.01	0.53	0.47	0.00
1985	250000	619178	0.79	0.20	0.01			
1986	199000	568854	0.32	0.68	0.00			
1987	200000	394926	0.15	0.79	0.06	0.32	0.68	0.00
1988	207000	508731	0.42	0.57	0.01	0.28	0.72	0.00
1989	166810	238631	0.59	0.41	0.00	0.28	0.72	0.00
1990	149000	207579	0.57	0.43	0.00	0.17	0.83	0.00
1991	260000	834550	0.42	0.57	0.01	0.40	0.60	0.00
1992	220000	942816	0.34	0.63	0.03	0.04	0.96	0.00
1993	220000	504156	0.36	0.63	0.01	0.22	0.76	0.02
1994	100000	157830	0.29	0.69	0.02	0.20	0.79	0.01
1995	56244	72188	0.11	0.89	0.00	0.28	0.70	0.02
1996	54000	61918	0.51	0.49	0.00	0.48	0.51	0.01
1997	32000	32000	0.20	0.79	0.01 .	.	.	
1998	76000	76170	0.04	0.94	0.02 .	.	.	
1999	5900	5900	0.28	0.66	0.06 .	.	.	

Appendix 7B. Escapements and brood year returns by age class for
Area 10 (Long Lake) age 1.* sockeye salmon

Brood			Adult Returns		
Year	Escapement	Smolt [a]	Age 4	Age 5	Total
1972	76248			44240	
1973	169753		135617	306914	442532
1974	91013		9096		
1975	62967			101733	
1976	60919	1756200	30051	137553	167604
1977	128601	2092300	229861	436651	666512
1978	84105	2945311	68247		
1979	20257	324400		42587	
1980	129435	1803100	66962	126312	193274
1981	214345	6170800	487293	389096	876389
1982	213674	5174900	179758	291329	471087
1983	199653	893900	91597	335840	427436
1984	89012	3041700	170821	119960	290781
1985	250000	1376200	118671	112515	231186
1986	199000	3073900	95064	492930	587994
1987	200000	2972800	339020	834672	1173692
1988	207000	2885500	101544	354559	456103
1989	166810	639900	141714	114686	256400
1990	149000	2918700	40566	61218	101784
1991	260000	4423800	10651	30444	41095
1992	220000	1491504	31395	25280	56675
1993	220000	2077800	6400	71600	78000
1994	100000	2864803	3047	3894	6941
1995	56244	1465625	1652		
1996	54000	2105148			
1997	32000	3455961			
1998	76000	.			
1999	5900	.			

[a] preliminary smolt estimates from K. Hyatt (Pacific Biological Stn, pers.com.)