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# Assessment of Recruitment Forecasting Methods for Major Sockeye and Pink Salmon Stocks in Northern British Columbia

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V9R 5K6

1997

**Canadian Technical Report of Fisheries and Aquatic Sciences 2187**

Fisheries and Oceans / Pêches et Océans

Canada

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# ASSESSMENT OF RECRUITMENT FORECASTING METHODS FOR MAJOR SOCKEYE AND PINK SALMON STOCKS IN NORTHERN BRITISH COLUMBIA

by

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Cat. No. Fs 97-6/2187E ISSN 0706-6457

Correct citation for this publication:

Wood, C.C., D.T. Rutherford, D. Peacock, S. Cox-Rogers, and L. Jantz. 1997. Assessment of recruitment forecasting methods for major sockeye and pink salmon stocks in northern British Columbia. Can. Tech. Rep. Fish. Aquat. Sci. 2187: 85 p.

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# ABSTRACT

Wood, C.C., D.T. Rutherford, D. Peacock, S. Cox-Rogers, and L. Jantz. 1997. Assessment of recruitment forecasting methods for major sockeye and pink salmon stocks in northern British Columbia. Can. Tech. Rep. Fish. Aquat. Sci. 2187: 85 p.

The relative performance and utility of ten basic procedures for forecasting adult recruitment in Pacific salmon was assessed for four major stocks in northern British Columbia: sockeye salmon in Area 10 (Long Lake), Area 9 (Owikeno Lake), and Area 4 (Skeena River) , and pink salmon in Area 8 (Bella Coola). These stocks were selected because adequate data were available on spawning escapements, catches, and in some cases juvenile (freshwater) production. Many of the procedures examined have been used previously and most are based on known biological relationships. Algorithms for each model provided forecasts of stock size one year in advance and were evaluated by hindcasting stock size in previous years using only the data that would have been available at that time. This retrospective analysis provides a robust measure of how well the various forecasting algorithms would have worked had they actually been used.

None of the forecasting models performed well consistently, and none proved superior across all stocks, or across all performance criteria within any one stock. For sockeye salmon, the simple 5-yr average stock size method performed as well or better than more complicated models, and accordingly this method was used to forecast sockeye recruitment to six additional stocks in 1997. For pink salmon, the non-linear (Ricker) stock-recruitment model rated slightly better than other methods and was used to forecast pink salmon returns for four additional stocks in 1997. Forecasts for 1997 are documented as cumulative probability distributions to specify the probability of all possible run sizes.

# RÉSUMÉ

Wood, C.C., D.T. Rutherford, D. Peacock, S. Cox-Rogers, and L. Jantz. 1997. Assessment of recruitment forecasting methods for major sockeye and pink salmon stocks in northern British Columbia. Can. Tech. Rep. Fish. Aquat. Sci. 2187: 85 p.

La performance et l'utilité relatives de dix méthodes élémentaires de prévision du recrutement de saumons du Pacifique adultes ont été évaluées dans le cas de quatre stocks importants du nord de la Colombie-Britannique : le saumon rouge de la zone 10 (lac Long), de la zone 9 (lac Owikeno) et de la zone 4 (rivière Skeena), et le saumon rose de la zone 8 (Bella Coola). Ces stocks ont été choisis en raison de l'existence de données suffisantes sur les échappées de géniteurs, les captures et, dans certains cas, la production de juvéniles (en eau douce). Un grand nombre des méthodes étudiées ont déjà été utilisées et presque toutes sont fondées sur des rapports biologiques connus. Les algorithmes de chaque modèle ont fourni des prévisions de la taille du stock un an à l'avance et étaient évalués par une prévision *a posteriori* de la taille du stock au cours des années précédentes en utilisant seulement les données qui auraient été disponibles à ce moment. Grâce à cette analyse rétrospective, on obtient une mesure robuste des résultats qui auraient été obtenus par les différents algorithmes de prévision s'ils avaient été réellement utilisés.

Aucun des modèles de prévision n'a donné de bons résultats régulièrement, et aucun ne s'est révélé supérieur pour tous les stocks, ou pour tous les critères de performance pour un stock. Dans le cas du saumon rouge, la méthode de la moyenne arithmétique sur cinq ans donnait d'aussi bons résultats, voire de meilleurs, que des modèles plus compliqués; cette méthode a donc été utilisée pour prévoir le recrutement de six autres stocks en 1997. Dans le cas du saumon rose, le modèle non linéaire stock-recrutement (modèle de Ricker) permettait une estimation légèrement meilleure que d'autres méthodes et il a été utilisé pour prévoir les retours de quatre autres stocks en 1997. Les prévisions pour 1997 sont établies sous forme de distributions stochastiques cumulatives afin de préciser la probabilité de toutes les tailles de remonte possibles.

# PREFACE

Material in this report has been compiled from two working papers (Wood et al. 1995b, 1996) previously reviewed and approved by the Pacific Stock Assessment Review Committee. Our first objective in preparing this report was to provide published documentation of assessments summarizing the rationale behind forecasting methods applied in 1997. Our second objective was to publish stock assessment data required for these analyses, including recently revised data for Nass and Skeena river sockeye salmon. By making these data more readily available to other investigators, we hope to simplifiy and improve future stock assessment analyses. Electronic files are available from the senior author.

# INTRODUCTION

The ability to forecast Pacific salmon returns prior to the fishing season has long been considered an important goal for fisheries research. By reducing uncertainty in future harvest opportunities, reliable forecasts would facilitate stock management and help to resolve social and economic issues that interfere with efficent utilization. Preseason recruitment forecasts have been prepared routinely each year for many salmon stocks in northern British Columbia using a variety of simple methods. Although these methods are usually based on biologically reasonable and statistically significant relationships, their performance has seldom been evaluated rigorously. Notable exceptions include analyses by Henderson et al. (1987) for Long Lake sockeye and Noakes et al. (1990) and Welch et al. (1994) for Fraser River sockeye. In general, these investigators reported that forecasting performance was poor and that confidence intervals were so large that forecasts were of little practical use.

In this report, we assess the relative performance and utility of some basic procedures for forecasting adult returns to four stocks in northern British Columbia. These include sockeye salmon runs to Area 10 (Long Lake), Area 9 (Owikeno Lake), and the Area 4 (Skeena River), and even-year pink salmon returns to Area 8 (the Bella Coola system) (see Figure 1). These stocks were selected because adequate data were available on spawning escapements, catches, and in some cases juvenile (freshwater) production, enabling us to compare the performance of a variety of simple biological and non-biological models.

This report also documents preseason 1997 run size forecasts for nine sockeye and five pink salmon stocks or stock groupings in northern British Columbia. These forecasts are based on the simple methods recommended in this report and were endorsed by the Pacific Stock Assessment Review Committee (Wood et al. 1995b, 1996). Our approach is based on three guiding principles:

1) *The entity being forecasted must be measurable*. We did not attempt to forecast run sizes for stocks where run 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 run reconstruction procedures. In other cases, we forecasted the aggregate run 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 run sizes*. Information about the uncertainty of the forecast is more important to managers following

the precautionary principle than a point estimate of the most likely run 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.* Retrospective analyses were performed for three sockeye salmon stocks (Long Lake, Owikeno Lake, and Skeena River) and one pink salmon stock (Area 8) (see Wood et al. 1995b) for which relatively reliable data were available to compare competing methods. Data for the other stocks were considered insufficient or too unreliable to warrant similar analyses. Within each species, the method that performed best in a retrospective analysis was applied to additional stocks as data permitted.

# METHODS

## SOURCES OF DATA

All data used to generate 1997 forecasts are from Wood et al. (1996) and are included as Table 1. Data used in retrospective analyses are from Wood et al. (1995b) and are included as Appendix A. In some cases, data used for the retrospective analyses were subsequently revised both in the Salmon Escapement Database (SEDS, Serbic 1991) and in the catch data base for Nass and Skeena. Table 1 and Appendix B include the corrected data for Area 8 pink salmon, and Nass and Skeena river sockeye salmon. Conclusions from the retrospective analyses remain valid because values were revised by <2% in all cases except 1992 (up to 7%).

### Sockeye Salmon

Data for Long Lake sockeye salmon are from Rutherford and Wood (1995). These data are considered to be the most reliable catch and escapement data available for any salmon stock in northern B.C. because escapements are enumerated through a weir (since 1972) and virtually the entire catch is taken by a terminal fishery within Smith Inlet. Juvenile abundance data have been collected by hydroacoustic survey since the late 1970s and we had hoped to evaluate their utility in forecasting. Unfortunately, because of potential mixed-species problems, the reliability of the juvenile abundance estimates was still being evaluated at the time of writing (K. Hyatt, DFO, Nanaimo, pers. comm.).

Data for Owikeno Lake sockeye are from Rutherford et al. (1995). The catch data are considered reliable because almost all Owikeno sockeye are harvested by the terminal fishery in Rivers Inlet. Escapements are determined only by visual survey under generally poor viewing conditions, and consequently, the escapement data may be very unreliable.

Total stock and escapement data for the Nass River (Area 3) and Skeena River (Area 4) sockeye salmon have been compiled for 1970-1996 by the responsible manager (L. Jantz). The Skeena River escapement includes visual abundance estimates of unknown reliability in over 50 spawning sites. However, most (>90%) of the Skeena River sockeye escapement is enumerated reliably at the Babine River counting fence installed in the 1940s (West and Mason 1987). It is important to recognize, especially for stock-recruitment analysis, that the escapement to Babine Lake is a potentially misleading index of reproductive potential. Since 1970, with the return of sockeye produced by artificial spawning channels in Fulton River and Pinkut Creek, typically less than half the Babine Lake escapement has spawned in non-enhanced streams. Moreover, since the 1980s, typically one third of all fish counted through the Babine Lake fence was surplus to spawning capacity in the enhanced streams; these fish contributed little to future recruitment because they were prevented from entering their natal stream (Wood et al. 1995a). The sockeye smolts enumerated by mark-recapture as they leave the Nilkitkwa-Babine lake system are thought to represent over 90% of freshwater production from the entire Skeena River system.

The Nass River sockeye salmon escapement includes reliable counts for the Meziadin Lake fishway (constructed in 1966), visual survey estimates for several other lake systems, and estimates derived from stock composition analysis for Bowser Lake. Overall, the Nass sockeye escapement is considered to be relatively reliable because, on average, Meziadin Lake accounts for two thirds of the total (Rutherford et al. 1994; Southgate, *in press*).

Nass and Skeena river sockeye salmon are caught in a complex array of mixed-stock fisheries in southern Southeast Alaska and throughout northern British Columbia. Catch data for both river systems were compiled for 1970-1996 based on run reconstructions by Gazey and English (1996) for 1982-1992 and stock composition estimates for 1982-1983 from a joint Canada-U.S. tagging study. Catch data for Skeena River sockeye are considered to be relatively reliable because these sockeye are predominant in the mixed-stock catches. For the same reason, errors in estimating the catch of Nass River sockeye could be large relative to the size of the run, and these data were not considered reliable enough to warrant retrospective analysis.

Recent total stock size data 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 SEDS (Serbic 1991) whereas 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).

Escapements of sockeye salmon to Kitlope Lake, Kimsquit Lake and the Atnarko River are taken from SEDS and are considered to be of intermediate reliability. Total run sizes for these stocks were estimated very approximately as escapement/(1-average exploitation rate) using an average exploitation rate for each stock estimated in run reconstructions for the period 1970-1982 (Starr et al. 1984).

Pink Salmon

Total net catch and escapements for pink salmon by statistical area are from the DFO Commercial Salmon Catch Database (Holmes and Whitfield 1991) and SEDS, respectively.

Over 90% of pink salmon production from Area 8 originates in the Atnarko River, a tributary to the Bella Coola River. Escapements to the Atnarko River are estimated visually from a tower and are considered to be reliable relative to other visual counts, although less reliable than weir counts. In addition, indices of fry recruitment have been recorded since 1980 based on hydraulic sampling at the Snootli Creek Hatchery (data supplied by R. Hilland, Project Manager, P.O. Box 95, Bella Coola, B.C.). These indices represent the average number of live eggs and alevins per square foot of spawning gravel.

No forecasts are provided for pink 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 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 preseason forecasts for any of these statistical areas.

FORECASTING MODELS

As a minimum requirement, preseason forecasting models had to generate forecasts for 1997 with information available before October 1996. In practice, this requirement often precludes the use of sibling age class models because recent age composition data may not be available in time for analysis.

We compared the performance of ten different models, many of which have been used previously to forecast salmon recruitment. All assume lognormal error structure as generally recommended for these types of analyses (Peterman 1981; Hilborn and Walters 1992). Model parameters were estimated using the NONLIN (for nonlinear models) and MGLH (for linear models) modules of SYSTAT (Wilkinson 1990).

Non-Biological Models

The simplest possible forecast is the average of past observations of stock size in each calendar year. No biological assumptions, understanding, or sampling data are required beyond the record of numerical abundance for each calendar year. Following Welch et al. (1994), we consider this to represent the "zero level" of forecasting skill. However we distinguished the use of the long-term average (Model 1) from the common practice of using the most recent 5-yr average (Model 2). In both cases, the objective was to forecast stock size ($N_t$) by calendar year (CY) where t refers to the year of return.

Model 1) Long-term average stock size (*AVGCY*)

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

Model 2) Recent 5-yr average stock size (*5YAVGCY*)

$$\ln(N_{t+1}) = a + \varepsilon_t \qquad \text{where } a = \sum \ln(N_i)/5 \quad \text{for } i=t-4 \text{ to } t$$

Models 3 and 4 correspond to models 1 and 2 , except that abundance data were compiled as total returns ($R_t$) resulting from the spawning event in year t (the brood year, BY) using age composition data. Note that for northern sockeye stocks with two or more dominant age classes it is necessary to forecast returns by brood year two years in advance.

Model 3) Long-term average returns (*AVGBY*)

$$\ln(R_{t+1}) = a + \varepsilon_t \qquad \text{where } a = \sum \ln(R_i)/(t-1) \quad \text{for } i=1 \text{ to } t-1$$

Model 4) Recent 5-yr average returns (*5YAVGBY*)

$$\ln(R_{t+1}) = a + \varepsilon_t \qquad \text{where } a = \sum \ln(R_i)/5 \quad \text{for } i=t-5 \text{ to } t-1$$

Biological Models

The remaining forecasting models include linear or non-linear relationships between adult returns and earlier indices of abundance for the same brood year.

Models 5 and 6 are linear stock-recruitment (LSR, or average-rate-of-return) models where the independent variables is spawning escapement ($S_t$) or the resulting juvenile abundance in freshwater ($J_t$), respectively, in brood year t.

Model 5) Average rate of return from escapement (*LSRESC*)

$R_t = aS_t$ where a is estimated from

$\ln(R_t) = \ln(aS_t) + \varepsilon_t$

Model 6) Average rate of return from juveniles (*LSRJUV*)

$R_t = aJ_t$ where a is estimated from

$\ln(R_t) = \ln(aJ_t) + \varepsilon_t$

Models 7 and 8 are the nonlinear (Ricker) stock-recruitment models (NLSR) corresponding to models 5 and 6, respectively.

Model 7) Returns from escapement (*NLSRESC*)

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

$\ln(R_t/S_t) = a + bS_t + \varepsilon_t$

Model 8) Returns from juveniles (*NLSRJUV*)

$R_t = J_t\, e^{a + bJt}$ where a and b are estimated from

$\ln(R_t/J_t) = a + bJ_t + \varepsilon_t$

Models 9 and 10 are sibling return models (SIB) where the independent variable is the return of a younger age 3 ($R_{3,t}$) or age 4 ($R_{4,t}$) class from the same escapement in brood year t. The hypothesis is that the total return from a particular brood year is largely determined by events affecting survival early in the life history, prior to the return of the younger age class, and thus shared by all age classes. If we assume that the proportion of fish destined to mature and return at the younger age is constant (i.e., a fixed biological attribute of the stock), then all residual error in the model is associated with year-to-year variations in survival of the older age class after the younger age class has returned. These assumptions lead to a linear sibling model:

Model 9) Linear sibling model (*LSIB*)

$R_{5,t} = a\ R_{4,t}$ where a is estimated from

$\ln(R_{5,t}) = \ln(a\ R_{4,t}) + \varepsilon_t$

A more complicated model is required if the maturation schedule is not constant so that the proportion of fish in the cohort destined to mature at a particular age varies from brood year to brood year. The nonlinear (power) model recommended by Bocking and Peterman (1988) should be flexible enough to provide an empirical fit to situations where the assumption of constant maturation rate is inappropriate.

Model 10) Nonlinear sibling model (*NLSIB*)

$R_{5,t} = c\ (R_{4,t})^b$ where $c = e^a$ and a and b are estimated from

$\ln(R_{5,t}) = a + b \ln(R_{4,t}) + \varepsilon_t$

In the case of Skeena River sockeye where age 3 sockeye are abundant, we also predicted age 4 returns from age 3 returns the previous year using models 9 and 10 fitted separately to the age 3 and age 4 return data.

Sibling forecasts for calendar year t+1 require that age composition data be available for returns in calendar year t. Age composition data for year t were used to compute forecasts for year t+1 in retrospective analyses. However, for logistical reasons, age composition data are not usually available in time for analysis and PSARC review so that sibling models were not used to generate forecasts for 1996 or 1997.

<u>Computing Forecasts of Stock Size from Forecasts of Returns by Brood Year</u>

Pink salmon all return at age 2 and consequently the forecast of stock size N in calendar year t+1 is the same as the forecast for returns R from brood year t-1. Hence, models 3 and 4 are equivalent to models 1 and 2.

Sockeye in northern B.C. return predominantly at age 4 and age 5, and consequently, forecasts depend on returns from two different brood years ($R_{t-4}$ and $R_{t-3}$). Next year's stock size ($N_{t+1}$) was calculated as the sum of age 4 returns from brood year t-3 and age 5 returns from brood year t-4. However, to do this it was also necessary to forecast (or assume) what proportion of sockeye would return at age 4 from brood years t-3 and t-4 ($q^4_{t-3}$ and $q^4_{t-4}$, respectively). For simplicity in models 3 through 8, we assumed that these proportions were constant and equal to the long-term average, $q^4_{t-4} = q^4_{t-3} = q^4 = \sum q^4_i / t$ for i=1 to t.

Forecasts for brood years t-3 and t-4 were straightforward for models 5 through 8 because escapement or juvenile indices were available for both brood years. For models 3 and 4, we simply forecasted average returns for an additional year by assuming that $R_{t-3}$ would equal $R_{t-4}$. Under this assumption, and the previous assumption of average age composition by brood year ($q^4$), it turns out for models 3 and 4 that the forecast for $N_{t+1}$ equals the forecast for $R_{t-4}$:

$$N_{t+1} = (1-q^4)\,R_{t-4} + q^4R_{t-3} = R_{t-4} - q^4\,R_{t-4} + q^4R_{t-3} = R_{t-4}$$

Such assumptions about age composition were inappropriate for the sibling models (9 and 10) since they would invalidate the biological rationale and/or error structure of the models. For Long Lake and Owikeno Lake sockeye, we forecasted $R_{5,t-4}$ using sibling models and assumed average recruitment of age 4 sockeye, i.e., $R_{4,t-3} = \Sigma\, R_{4,i}\,/\,(t-4)$ for i=1,t-4. For Skeena River sockeye, we forecasted $R_{4,t-3}$ using a second sibling model based on age 3 return data ($R_{3,t-3}$). Sibling forecasts for all sockeye stocks included only age 4 and age 5 returns.

## RETROSPECTIVE ANALYSES

For each model, the algorithms described in the previous sections enabled us to compute forecasts of stock size one year in advance. In the retrospective analysis, identical procedures were followed to hindcast stock size in previous years, using only the data that would have been available at that time. For example, Appendix Table A1.6 was completed from the bottom up, first by computing a forecast for 1996 using all data available up to and including 1995, then by computing the forecast for 1995 using all data up to and including 1994, and so on. Hence, these retrospective analyses provide a robust measure of how well the various forecasting algorithms would have worked had they actually been used.

## EVALUATING PERFORMANCE OF FORECASTING MODELS

Following Noakes et al. (1990), four criteria were used to assess the relative performance of the different forecasting methods averaged across the years examined (i=1, n).

i) Root Mean Squared Error

$$RMSE = \{\Sigma\,(R_{i,forecast} - R_{i,observed})^2 / n\}^{0.5}$$

ii) Mean Absolute Deviation

$$MAD = 1/n * \Sigma\,|\,R_{i,forecast} - R_{i,observed}\,|$$

iii) Mean Absolute Percent Error

$$MAPE = 100/n * \sum | R_{i,forecast} - R_{i,observed} | / R_{i,observed}$$

iv) Cumulative Over or Under Prediction

$$COUP = \sum R_{i,forecast} - R_{i,observed}$$

We judged the RMSE criterion to be the most relevant indicator of performance because it best evaluates the ability of an algorithm to forecast unusually large or small stock sizes. To facilitate comparison, we standardized scores under each criterion so that the highest (worst) score within a comparison was defined as 100, and competing scores were expressed as a percentage of the worst score. For the COUP criterion, scores were standardized to the highest absolute error but scores retained the sign of the error.

PROBABILITY DISTRIBUTIONS FOR 1997 FORECASTS

The 1997 forecasts ($N_{1997}$) are based on the forecasting method that performed best for the species in question in the retrospective analyses. Probability distributions for the 1997 forecasts were computed by assuming that residuals in the log-transformed domain are normally distributed. Forecasted run sizes corresponding to risk averse probability reference points of 90%, 75%, and 50% were then transformed back to the arithmetic scale. The modal (most likely) run size in the log-transformed domain corresponds to the median (50%) value in the original (arithmetic) scale. 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 *AVGCY* model and the most recent five years for the *5YAVGCY* model). For the regression models, means and standard deviations for the forecasted log transformed stock sizes were computed as:

$$E[\ln(R_t)] = a + b\, X_{1997} + \ln(X_{1997})$$

$$SD[\ln(R_t)] = s_{y.x}\{1 + 1/n + (X_{1997} - X_{mean})/ \sum(X_i - X_{mean})^2\}^{0.5}$$

where *a* and *b* are the regression parameters, $s_{y.x}$ is the standard error of the estimate, $X_{1997}$ is the independent variable (spawning escapement for the brood returning in 1997), $X_{mean}$ is the average value of the independent variable, and n is the number of data points in the regression (Draper and Smith, 1966).

# RESULTS

## TRENDS IN STOCK SIZE

### Sockeye Salmon

Areas 1-2: 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 were greater in 1996 than in 1995 (Figure 2A).

Areas 3-4: Escapements to the Nass and Skeena rivers have generally remained stable at or above targets during the last decade and total returns have increased. Runs in 1996 exceeded those in 1995 for both stocks, and the return of 6.9 million sockeye salmon to the Skeena River set a new record.

Areas 6-8: Escapements (and hence computed total runs sizes) for the Kitlope, Kimsquit, and Atnarko stocks show no obvious trend. Escapements in 1996 were above the long-term average in the Kimsquit and Atnarko stocks, and close to (but below) the long-term average in the Kitlope stock.

Areas 9-10: Total returns to Owikeno and Long lakes have declined since 1992, and those in the three most recent years (1994-1996) have been particularly disappointing. Escapements to both lakes are at or near record low levels, despite the fact that escapements had been generally increasing until 1991 in Owikeno Lake, and until 1992 in Long Lake. Recent poor returns have been attributed to poor marine survival of the 1991 brood year given that presmolt abundance in Owikeno Lake in 1992-93 was above the long-term average (Rutherford et al. 1995; Anon 1996). This has been confirmed by the poor returns of age 5 sockeye to both systems in 1996.

### Pink Salmon

Odd-year pink salmon abundance in areas 6-10 has generally decreased over the last decade from a high or peak abundance in the early 1980s (Figure 2B). However, total stocks increased slightly in 1995 over 1993 in Areas 6, 9, 10. Abundance in Area 2E has continued to decline, and large stock sizes have not been observed since the 1960s. Even-year abundance has shown a similar pattern of general decline with recent increases in all areas except Area 10 (Figure 2C)

### Correlations Among Stocks

significant positive correlations occur between adjacent stocks. For example. in sockeye salmon (Figure 3A), significant correlations were detected in only three comparisons ($p<0.0024$ to account for 21 comparisons, excluding the short time series for Yakoun and Skidegate lakes). Two of these involved adjacent stocks: Nass and Skeena ($r=0.68$, $p<0.0002$) and Long and Owikeno ($r= 0.63$, $p<0.0007$ ); the other involved the Long and Kitlope stocks ($r=0.59$, $p<0.002$). In pink salmon, the only significant correlation was between the adjacent areas 6 and 8 ($r=0.72$, $p<0.0002$) (Figure 3B). Negative associations were observed among some sockeye and pink salmon stocks, but none were statistically significant ($p>0.19$).

## STOCK RECRUITMENT RELATIONSHIPS

### Sockeye Salmon

On average, total returns increased with spawning escapement for all sockeye salmon stocks considered (Figure 4). No statistically significant evidence for density-dependent survival was found in any stock using adult escapement as the independent variable in non-linear (Ricker) stock-recruitment relationships. Negative b parameters were observed in every case, as expected biologically, but escapement explained only 11 to 19% of the measured variation in the rate of return per spawner ($0.106<p<0.217$, *F*-tests).

A statistically significant non-linear relationship was detected between Babine-Nilkitkwa Lake sockeye smolt production and subsequent adult returns to the Skeena River ($p<0.04$, $r^2=0.24$) (Figure 4C). This implies that smolt survival outside the natal lake system has been lower in years of high abundance, perhaps because growth in Babine Lake is density-dependent so that smolts are smaller in years of high abundance (see Wood et al.,1995a).

### Pink Salmon

Pink salmon returns were positively correlated with spawning escapements in all five stocks examined (Figure 5). In all non-linear regressions (the *NLSRESC* model), the *b* parameters were significantly negative ($0.003<p<0.05$) suggesting some degree of density-dependence. Alternatively, these negative slopes may simply be the result of error in measuring escapement, the independent variable.

To the extent that stock-specific effects of spawning escapement have been removed, residuals from stock-recruitment curves could reveal the influence of climate or other factors affecting survival that might be shared among stocks. However, statistically signficant correlations were detected only between adjacent Areas 6 and 8 (Figure 6). This correlation was evident in log-transformed total returns even without removing the effect of escapement.

## SIBLING AGE CLASS RELATIONSHIPS IN SOCKEYE SALMON

Positive correlations existed between returns from sibling age classes in all three sockeye stocks examined (Figure 7). The sibling relationships were statistically significant in Owikeno Lake ($p<0.001$, $r^2=0.40$) and Skeena River sockeye ($p<0.001$, $r^2=0.555$ for age 3 vs age 4 and $p<0.003$, $r^2=0.39$ for age 4 vs age 5) but not in Long Lake sockeye ($p>0.11$, $r^2=0.34$).

## PERFORMANCE AND SELECTION OF FORECASTING MODELS

### Retrospective Analyses

Detailed results are documented in Appendix tables A1.6 for Long Lake sockeye, A2.6 for Owikeno Lake sockeye, A3.6 for Skeena River sockeye, and A4.4 for Area 8 pink salmon. Overall scores for each model are summarized in Table 2 according to the critierion used for evaluation. To facilitate comparison of actual performance, we also plotted retrospective forecasts as trends for a subset of the models (Figure 8 and 9). The subset of models includes the recent 5-yr average methods, and the best model (either linear or non-linear) under the RMSE criterion for each type of biological model -- those based on spawning escapements, juvenile abundance, or sibling age class abundance.

By inspection of Figures 8 and 9 , it is obvious that none of the forecasting models performed well consistently, and none performed much better than the 5-yr average methods, the zero level of forecasting performance. No method emerged as having been most successful across all sockeye stocks, or across all criteria within any one stock. This was true both for comparisons across all years and for those across the last 10 years. Average methods, particularly the *5YAVGCY* method rated best across sockeye stocks within the RMSE criterion that we judged to be most important. Average methods also rated best in two of the three sockeye stocks under the MAD criterion. The linear sibling age method (*LSIB*) rated slightly better than the average methods under the MAPE criterion. Because no method was consistently best for all sockeye stocks, we concluded that of the methods evaluated, the *5YAVGCY* method should be used to forecast 1996 and 1997 returns to all sockeye stocks in northern B.C. This method rated best under the RMSE criterion for both Long Lake and Skeena River sockeye, for which more reliable data exist to support forecasting models than elsewhere in northern B.C.

None of the methods successfully forecasted the extremely large and small Area 8 pink salmon returns. The non-linear stock-recruitment method (*NLRSESC*) rated slightly better than the average methods under the RMSE criterion that is sensitive to large deviations, as well as under the MAD and MAPE criteria. We concluded that the *NLRSESC* method should be used to forecast pink salmon returns in 1996 and 1997.

## Evaluation of Forecasts for 1996

The 1996 preseason forecast for Area 8 pink salmon proved to be relatively accurate (Table 3). The estimated return in 1996 (2.5 million fish) fell within a 35% confidence interval for the forecast, or conversely, the probability of a greater deviation exceeded 65%. Even so, the simpler long-term average (*AVGCY)* model performed better than the escapement-based model actually used, giving a median forecast of 2.86 million fish.

Preseason forecasts for sockeye salmon stocks in 1996 performed poorly. Record high returns to the Skeena River, and near record low returns to both Owikeno and Long lakes could not have been predicted by the average models, and were only just included by 94%, 96%, and 92% confidence intervals, respectively. However, none of the other models evaluated by Wood et al. (1995b) performed much better. In fact, the adopted *5YAVGCY* model performed better than alternative models for the Skeena River, and performed second best, about the same as the best (*LSRESC*) model, for Owikeno Lake. The only model that proved superior for Long Lake was the simple long-term average (*AVGCY).*

## FORECASTS FOR 1997

Preseason run size forecasts for 1997 are summarized for three probability reference points (Table 4). True run 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. True run 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 comparsions with historical returns in Figures 10 (sockeye salmon) and 11 (pink salmon).

For most stocks, median forecasts do not deviate from the most recently observed returns (1996 for sockeye, 1995 for odd-year pink salmon) by more than 50% (Table 2). However, substantially larger runs (>70% change) are forecasted for sockeye salmon in Long and Owikeno lakes and pink salmon in Area 9.

# DISCUSSION

Our evaluation of forecasting performance in 1996 and in previous years by retrospective analysis, demonstrates once again that forecasts of salmon run size are typically very imprecise. The poor forecasting performance for northern salmon stocks cannot be attributed entirely to unreliable data. The catch and escapement data for Long Lake sockeye are among the most reliable for any salmon stock examined, and yet the variability in recruitment is large enough to obscure basic biological stock-recruitment and sibling age class relationships. Thus, it should not be surprising that forecast performance is also extremely poor.

These analyses also demonstrate that simple average models can work as well or better than those incorporating biological data. Biological relationships such as stock-recruitment 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, these relationships typically explain only a small fraction of the total variation in survival observed from brood to brood. This is sometimes because the observed range of variation in the biological variables is small. For example, escapement data were not found to be useful in forecasting returns to sockeye salmon stocks in northern British Columbia where escapements have been fairly stable, in part because they comprise at least two major age classes. In contrast, escapement data have been more useful in predicting returns of pink salmon and some sockeye salmon stocks in the Fraser River where escapements vary by several orders of magnitude (cyclic dominance) due to the predominantly single age at return (e.g., Cass et al. 1994; Cass and Blackbourn 1996). For northern British Columbia stocks, there is little recourse but to characterize the remaining (unexplained) variation as random, and to estimate the parameters for an appropriate random process.

No time series models other than the recent 5-yr running average were evaluated in this study. A more sophisticated time series approach is unlikely to improve forecasts for Long Lake sockeye and Area 8 pink salmon because no significant autocorrelations or partial autocorrelations were detected at any lag time in either the log-transformed stock size (by calendar year) or return (by brood year) series. Both log-transformed series appeared to be stationary and indistinguishable from Gaussian (white) noise. On the other hand, time series analyses may prove worthwhile for the Owikeno Lake and Skeena River sockeye stocks. A single significant ($p<0.05$) positive autocorrelation was detected at a lag of five years in the log-transformed, apparently stationary stock size series for Owikeno Lake sockeye. The Skeena sockeye log-transformed stock size series required differencing to make it stationary, after which a significant negative autocorrelation was detected at a lag of one year.

Where preseason forecasts are imprecise, managers must rely on other means of estimating abundance in-season to achieve escapement or harvest rate objectives. It is therefore imperative that preseason forecasts include probability distributions to inform managers about the level of precision that can be expected, and to help them manage risk aversely. It is also desirable that a true notion of the imprecision of forecasts be communicated to clients.

We argue that it is pointless, and a waste of analytical effort, to forecast stock sizes that cannot be estimated reliably, either in principle or in practice. This is why we have not developed forecasts for pink salmon stocks in areas 1, 2W, 3, 4, 5, and 7, have not developed forecasts for pink salmon stocks in areas 1, 2W, 3, 4, 5, and 7, and why our forecasts of pink salmon abundance are for stock-groupings at a relatively large spatial scale (statistical area). Forecasts can be computed at much finer spatial scales using escapement-based methods, but such forecasts cannot be evaluated. Moreover, their utility is questionable unless rules can be specified (e.g., run reconstruction) to relate the forecasted quantity to events that will actually be observed. Where such rules can be specified, total stock size can be estimated, and forecasts may be warranted. In fact, this was our approach to forecasting run sizes for the Nass, Skeena, Kitlope, Kimsquit, and Atnarko sockeye salmon stocks.

We suggest that scientific enterprise in forecasting be directed at making progress where progress can be made. Survival to recruitment, and hence run size, is the cumulative outcome of a series of unknown random processes. Thus, it is surely conceit to think that run size could be predicted consistently and reliably for any single stock in a particular year using only indices observed at least one year in advance. On the other hand, even simple forecasting models can be used to adequately characterize the probability of various possible run sizes. If these probabilities are correctly specified, forecasts should be unbiased and useful *on average*, whether over a number of different stocks, or over a series of years within a stock.

We also suggest that forecasting research should focus on identifying *long-term trends* in the probability distributions for forecasts. Decadal or longer-term shifts in environmental conditions probably affect salmon survival in ways that significantly alter the parameters for the forecast probability distributions; consequently long-term forecasts will likely be biased as well as imprecise. It follows that an understanding of long-term cycles in environmental conditions that affect survival may be the only hope for developing forecasts that will be useful in predicting long-term average stock sizes.

Significant correlations in stock size among some geographically adjacent stocks suggest that local coastal environmental conditions can affect the survival of adjacent stocks in the same way. Knowledge of these conditions could be incorporated into forecasting models (e.g., Cass and Blackbourn 1996). The relative success of the recent 5-year average (*5YAVGCY*) method also suggests that these shared, presumably local marine effects persist for a few years, and that long-term forecasting of environmental shifts might be feasible.

## ACKNOWLEDGEMENTS

We are grateful to Lyle Enderud for providing preliminary catch data for statistical areas 6-10, to Russ Hilland for providing indices of juvenile pink salmon abundance for the Bella Coola River, and to Brian Spilsted for assistance in compiling data. PSARC Working Papers are cited with permission of principal author.

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Table 1A. 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 1997 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 | . | . | 254401 | 1486243 | 46875 | 45455 | 7000 | 121269 | . |
| 1971 | . | . | 420853 | 1983222 | 46875 | 181818 | 110000 | 618438 | . |
| 1972 | . | . | 412256 | 1735617 | 10938 | 59091 | 27000 | 603006 | 135645 |
| 1973 | . | . | 863635 | 2448390 | 62500 | 154545 | 7000 | 2745156 | 464372 |
| 1974 | . | . | 567711 | 2552057 | 62500 | 100000 | 10000 | 675599 | 438718 |
| 1975 | . | . | 184785 | 1518749 | 31250 | 81818 | 70000 | 520633 | 115640 |
| 1976 | . | . | 402247 | 1504761 | 12500 | 54545 | 50000 | 913067 | 153120 |
| 1977 | . | . | 967633 | 2496644 | 46875 | 54545 | 20000 | 852419 | 183456 |
| 1978 | . | . | 486222 | 1184299 | 15625 | 36364 | 24000 | 960908 | 317486 |
| 1979 | . | . | 456417 | 2924595 | 15625 | 32727 | 16000 | 325853 | 31279 |
| 1980 | . | . | 395227 | 1473109 | 37500 | 43636 | 15000 | 313528 | 131784 |
| 1981 | . | . | 616424 | 3679645 | 31250 | 72727 | 10000 | 851781 | 368700 |
| 1982 | . | . | 881337 | 3785048 | 62500 | 36364 | 24000 | 862180 | 506632 |
| 1983 | . | 9990 | 571503 | 2149794 | 46875 | 45455 | 60000 | 671663 | 330865 |
| 1984 | . | 20095 | 417576 | 2392288 | 28125 | 81818 | 20000 | 268180 | 110172 |
| 1985 | . | 29121 | 691011 | 5132530 | 53125 | 90909 | 30000 | 684973 | 619178 |
| 1986 | . | . | 435704 | 1785674 | 62500 | 36318 | 32000 | 1163069 | 568854 |
| 1987 | . | 17862 | 423631 | 2329397 | 78125 | 55964 | 44000 | 920554 | 394926 |
| 1988 | . | 25190 | 295824 | 3855686 | 25000 | 54545 | 20000 | 875018 | 508731 |
| 1989 | . | 14427 | 374107 | 2609613 | 50000 | 27273 | 24400 | 438921 | 238631 |
| 1990 | . | 10814 | 321242 | 2628803 | 25000 | 36364 | 14800 | 820781 | 207579 |
| 1991 | . | 17455 | 906283 | 3668724 | 62500 | 95455 | 54000 | 514726 | 834550 |
| 1992 | 4968 | 22720 | 1700908 | 4423945 | 62500 | 74545 | 26000 | 851073 | 942816 |
| 1993 | 4155 | 11994 | 1662981 | 4894865 | 25000 | 27273 | 26000 | 393529 | 504156 |
| 1994 | 13216 | 3689 | 592243 | 2719696 | 48438 | 45455 | n/i[a] | 131639 | 157830 |
| 1995 | 4772 | 12108 | 939970 | 4763587 | 26250 | 100000 | n/i[a] | 118426 | 72188 |
| 1996 | 11459 | 19174 | 1045109 | 6865840 | 53125 | 81818 | 40000 | 65000 | 62513 |

[a] not inspected

Table 1B. Escapements and total returns by brood year for major pink salmon stocks in northern British Columbia.

| Odd Brood Years | Area 2E | | Area 6 | | Area 8 | | Area 9 | | Area 10 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Esc | Returns | Esc | Returns | Esc | Returns | Esc | Returns | Esc | Returns |
| 1951 | 29775 | 26320 | 633825 | 268624 | 988170 | 945174 | 116025 | 151714 | 3500 | 30507 |
| 1953 | 25775 | 52914 | 121085 | 525712 | 428149 | 527098 | 44000 | 112781 | 15025 | 45401 |
| 1955 | 23275 | 173854 | 151325 | 237338 | 350294 | 919621 | 9300 | 57704 | 22500 | 19367 |
| 1957 | 46275 | 147003 | 62025 | 378121 | 571783 | 957270 | 7600 | 56435 | 7500 | 23176 |
| 1959 | 142275 | 58577 | 241975 | 1712843 | 530050 | 2982897 | 19250 | 149091 | 15025 | 46655 |
| 1961 | 42325 | 115404 | 670475 | 2834382 | 1249004 | 2767395 | 22450 | 52111 | 7500 | 11105 |
| 1963 | 115400 | 45916 | 1329750 | 1738302 | 748425 | 801298 | 16775 | 48717 | 7500 | 35067 |
| 1965 | 45700 | 75310 | 509150 | 196107 | 222100 | 86327 | 18875 | 30773 | 7500 | 113660 |
| 1967 | 71950 | 146157 | 95525 | 139840 | 66310 | 77984 | 100 | 23618 | 3500 | 6044 |
| 1969 | 120425 | 27440 | 105415 | 606805 | 59925 | 292963 | 525 | 58840 | 400 | 7315 |
| 1971 | 26700 | 34616 | 366450 | 633713 | 257150 | 223655 | 34205 | 99605 | 4000 | 11423 |
| 1973 | 34225 | 26029 | 233040 | 348925 | 166875 | 240528 | 9765 | 114207 | 5030 | 4062 |
| 1975 | 20365 | 11514 | 309079 | 546787 | 150100 | 529519 | 87150 | 237780 | 1300 | 38128 |
| 1977 | 8580 | 21788 | 142690 | 1214701 | 434690 | 1805033 | 47600 | 73012 | 20100 | 36953 |
| 1979 | 21788 | 9430 | 489720 | 1627895 | 1123325 | 2345963 | 49350 | 196893 | 30250 | 88264 |
| 1981 | 9246 | 13244 | 377395 | 4045529 | 737360 | 2206176 | 93050 | 136113 | 65037 | 47849 |
| 1983 | 13244 | 29366 | 476792 | 2552286 | 1420270 | 4009013 | 124275 | 352638 | 45271 | 42418 |
| 1985 | 19985 | 35799 | 1044801 | 1603737 | 2793620 | 780237 | 276700 | 173077 | 35600 | 29091 |
| 1987 | 35565 | 25977 | 673618 | 623256 | 383056 | 680921 | 65187 | 30260 | 18233 | 29325 |
| 1989 | 23264 | 14207 | 579398 | 1141704 | 522529 | 2513506 | 25624 | 6987 | 28106 | 25055 |
| 1991 | 14071 | 18346 | 611916 | 286001 | 2399345 | 1442572 | 4986 | 15384 | 15133 | 22128 |
| 1993 | 18141 | 3879 | 277786 | 618138 | 1184713 | 853534 | 13100 | 18631 | 10075 | 26657 |
| 1995 | 3844 | | 593594 | | 629099 | | 18000 | | 26525 | |

| 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 | | 966985 | | 1844345 | | 333200 | | 6400 | |

Table 2. Summary of performance scores for the forecasting models evaluated under four criteria and over all years (from Appendix A). Scores are expressed as percentages of the worst score (100) within each comparison; the best (lowest) scores are in bold print.

| Forecast Method | AREA 9 (LONG) SOCKEYE Evaluation Criteria RMSE | MAD | MAPE | COUP | AREA 10 (OWIKENO) SOCKEYE Evaluation Criteria RMSE | MAD | MAPE | COUP |
|---|---|---|---|---|---|---|---|---|
| Non-biological: | | | | | | | | |
| *AVGCY* | 71 | 60 | 57 | -100 | 87 | 84 | 78 | 35 |
| *5YAVGCY* | **66** | **60** | 65 | -53 | 87 | 80 | 77 | -24 |
| *AVGBY* | 76 | 66 | 75 | **16** | 96 | 85 | 86 | **-17** |
| *5YAVGBY* | 100 | 100 | 100 | **-16** | **40** | **46** | 100 | 21 |
| Biological: | | | | | | | | |
| *LSRESC* *LSRJUV* | 80 | 75 | 85 | 19 | 100 | 100 | 90 | 100 |
| *NLSRESC* *NLSRJUV* | 85 | 83 | 88 | **16** | 95 | 96 | 90 | 72 |
| *LSIB* | 82 | 74 | **54** | 25 | 77 | 64 | **42** | -79 |
| *NLSIB* | 89 | 81 | 61 | 25 | 89 | 76 | 51 | -97 |

| Forecast Method | AREA 4 (SKEENA) SOCKEYE Evaluation Criteria RMSE | MAD | MAPE | COUP | AREA 8 PINK SALMON Evaluation Criteria RMSE | MAD | MAPE | COUP |
|---|---|---|---|---|---|---|---|---|
| Non-biological: | | | | | | | | |
| *AVGCY* | 45 | 45 | 42 | -96 | 0.11 | 0.12 | 0.6 | -0.5 |
| *5YAVGCY* | **41** | 45 | 46 | -43 | 0.13 | 0.15 | 0.7 | -0.3 |
| *AVGBY* | 55 | 58 | 49 | -100 | 0.11 | 0.12 | 0.6 | -0.5 |
| *5YAVGBY* | 49 | 49 | 38 | -68 | 0.13 | 0.15 | 0.7 | -0.3 |
| Biological: | | | | | | | | |
| *LSRESC* | 42 | **43** | **36** | -40 | 0.14 | 0.17 | 1.1 | 0.3 |
| *LSRJUV* | 44 | 48 | 42 | -40 | 0.15 | 0.23 | 0.6 | **-0.1** |
| *NLSRESC* | 100 | 100 | 100 | **-6** | **0.09** | **0.10** | **0.5** | -0.2 |
| *NLSRJUV* | 58 | 59 | 47 | -62 | 100.00 | 100.00 | 100.0 | 100.0 |
| *LSIB* | 49 | 46 | 45 | -49 | N/A | N/A | N/A | N/A |
| *NLSIB* | 54 | 57 | 50 | -77 | N/A | N/A | N/A | N/A |

Table 3. Performance of pre-season run size forecasts for 1996.

| | | | Run Size (millions of fish) | | | Probability | Method giving best |
|---|---|---|---|---|---|---|---|
| | | | median | actual | | of greater | median forecast[c] |
| Species | Stock | Method | forecast | run | deviation[a] | deviation[b] | (and value) |
| Sockeye | Long | *5YAVGCY* | 0.35 | 0.06 | -0.29 | 0.08 | AVGCY (0.26) |
| | Owikeno | *5YAVGCY* | 0.45 | 0.07 | -0.38 | 0.04 | LSRESC (0.43) |
| | Skeena | *5YAVGCY* | 4.09 | 6.89 | 2.80 | 0.06 | 5YAVGCY |
| Pink | Area 8 | *NLSRESC* | 1.55 | 2.50 | 0.95 | 0.65 | AVGCY (2.86) |

[a] observed run size - median forecast

[b] probability of a greater absolute deviation from median forecast under the forecast probability distribution

[c] of those presented in Appendix A (tables 1.6, 2.6, 3.6, and 4.4)

Table 4. Summary of pre-season run size forecasts for 1997

| Species | Statistical Area | River or Lake | Escapement Target | Forecasts for reference probabilities[a] 50% | 75% | 90% |
|---|---|---|---|---|---|---|
| Sockeye | 1 | Yakoun | [b] | 7,300 | 5,000 | 3,300 |
| | 2 | Skidegate | 9,525 | 12,000 | 7,000 | 4,000 |
| | 3 | Nass | 245,700 | 1,100,000 | 800,000 | 580,000 |
| | 4 | Skeena | 1,159,011 | 4,500,000 | 3,500,000 | 2,700,000 |
| | 6 | Kitlope | 20,000 | 40,000 | 29,000 | 21,000 |
| | 8 | Atnarko | 75,000 | 60,000 | 40,000 | 26,000 |
| | | Kimsquit | 30,000 | 25,000 | 15,000 | 8,500 |
| | 9 | Owikeno | 200,000[c] | 200,000 | 94,000 | 41,000 |
| | 10 | Long | 200,000 | 200,000 | 83,000 | 30,000 |
| Pink | 2E | all | 720,909 | 6,100 | 1,900 | 660 |
| | 6 | all | 1,447,200 | 1,100,000 | 500,000 | 300,000 |
| | 8 | all | 1,475,400 | 2,200,000 | 1,100,000 | 590,000 |
| | 9 | all | 342,450 | 84,000 | 30,000 | 12,000 |
| | 10 | all | 65,600 | 46,000 | 24,000 | 13,000 |

[a] probability that the actual run size will exceed the specified forecast

[b] 5000-10000 (under review)

[c] minimum; target increases with run size according to management plan.

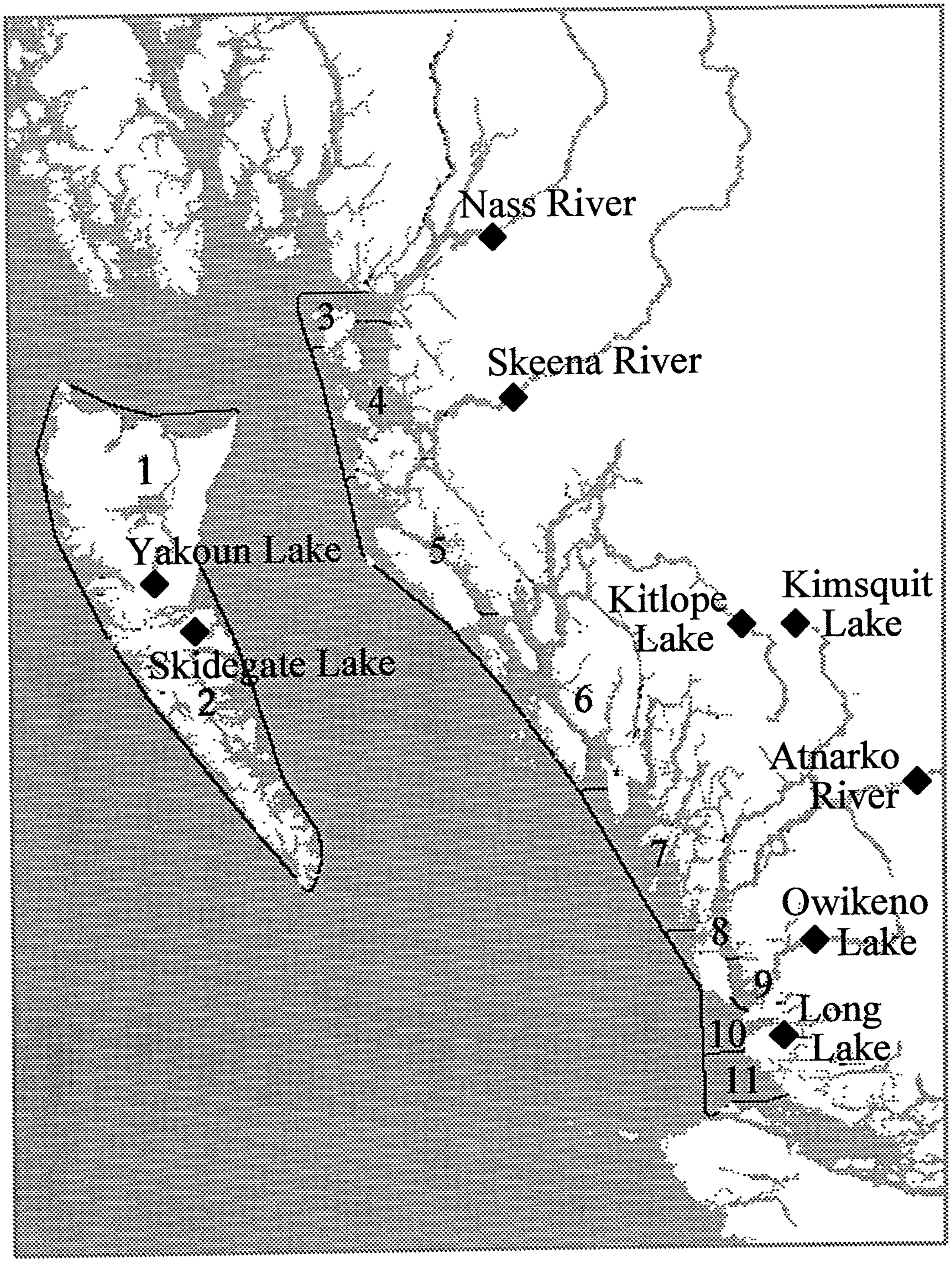



Figure 1. Map of northern British Columbia showing statistical areas and location of sockeye salmon stocks considered in this report.

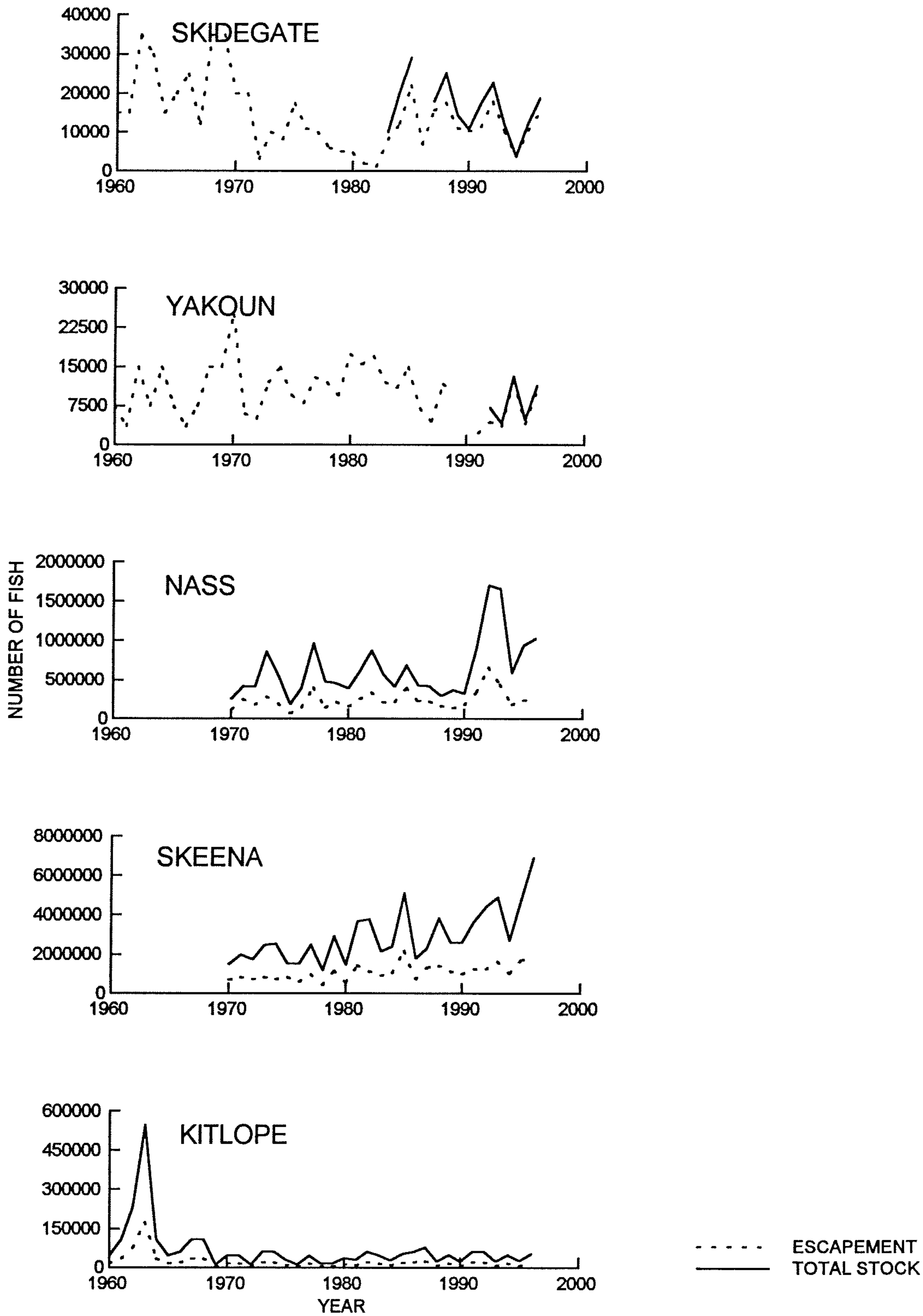



Figure 2A. Trends in spawning escapement and total stock size for sockeye salmon stocks.

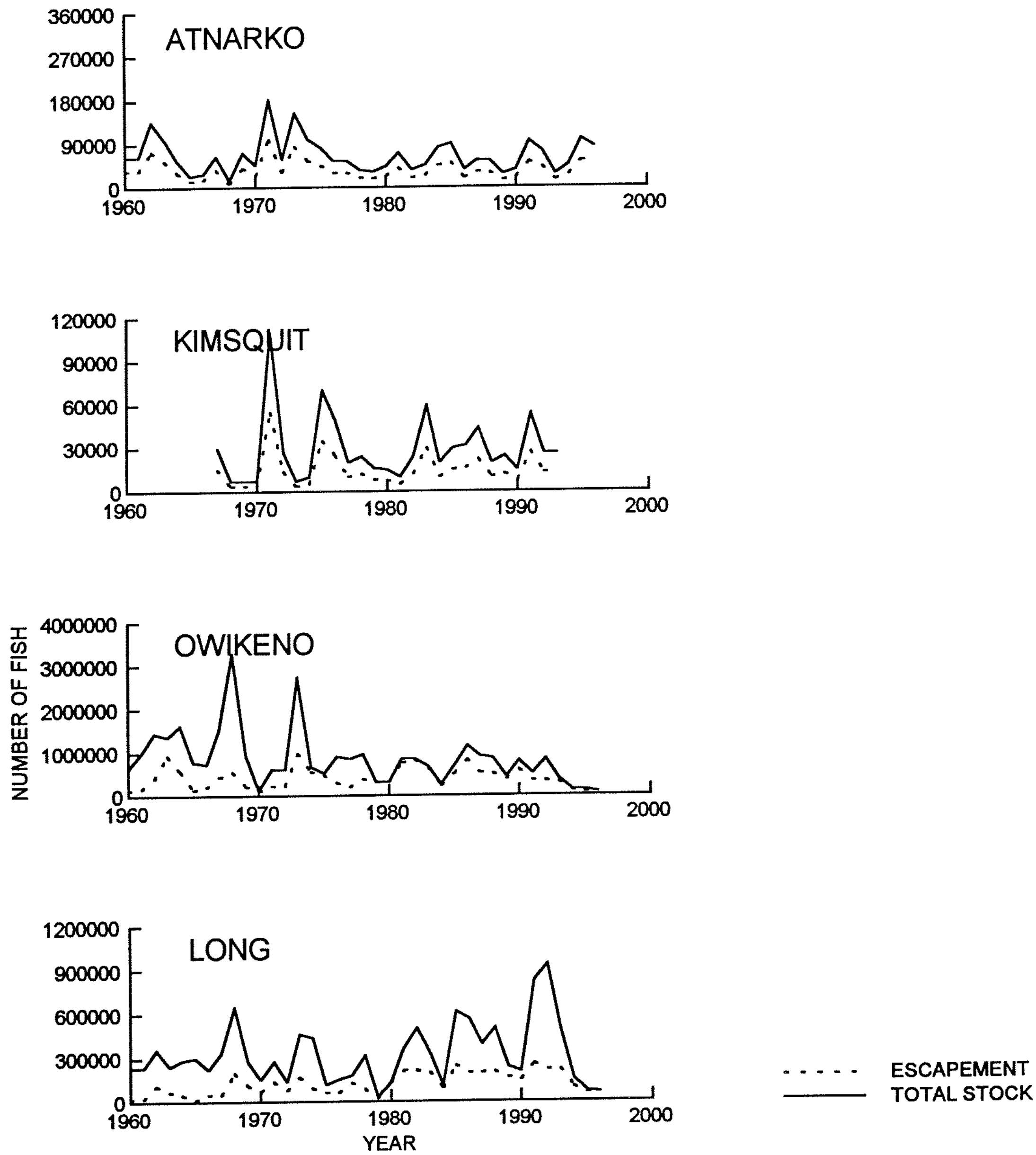



Figure 2A. (cont'd)

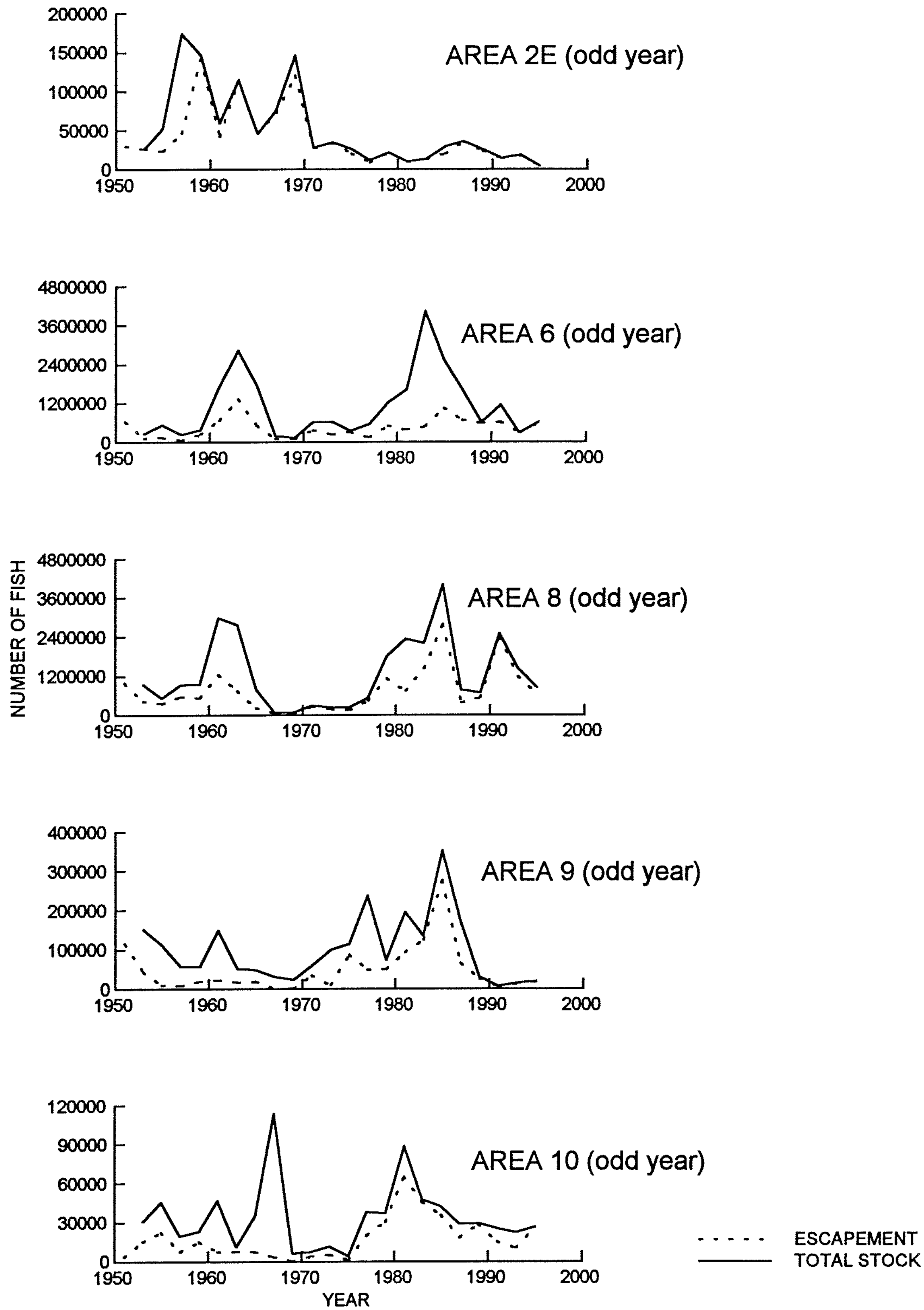



Figure 2B. Trends in spawning escapement and total stock size for odd-year pink salmon stocks.

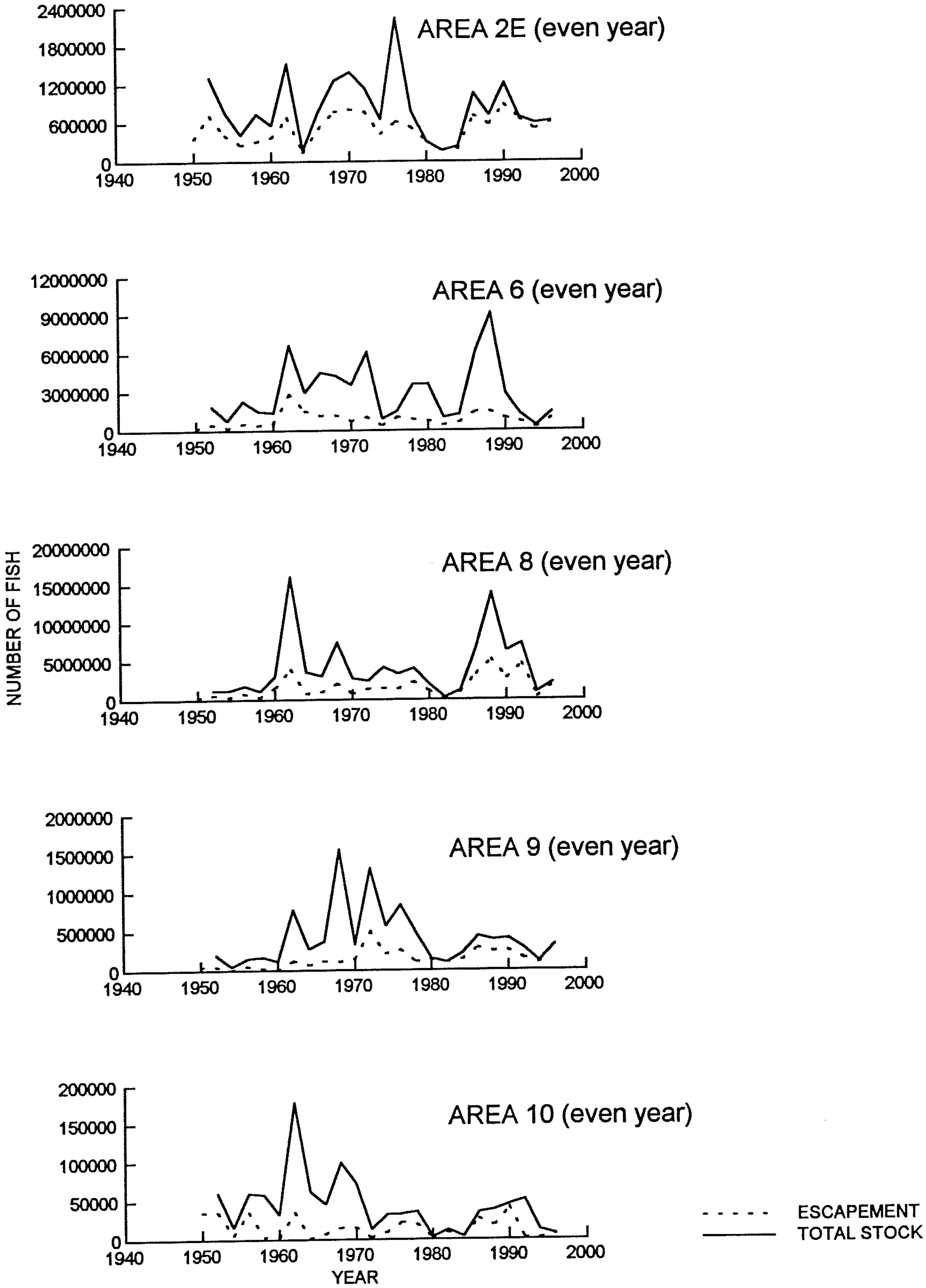



Figure 2C. Trends in spawning escapement and total stock size for even-year pink salmon stocks.

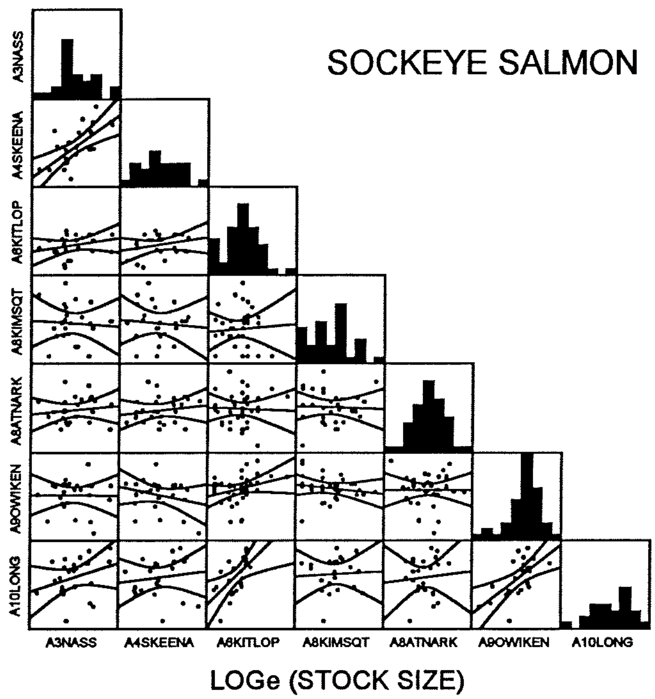



Figure 3A. Distribution of log-transformed stock sizes and correlations in stock size among sockeye salmon stocks. Labels along axes denote statistical areas from north to south: Area 3 (Nass), Area 4 (Skeena), Area 6 (Kitlope), Area 8 (Kimsquit, Atnarko), Area 9 (Owikeno), Area 10 (Long).

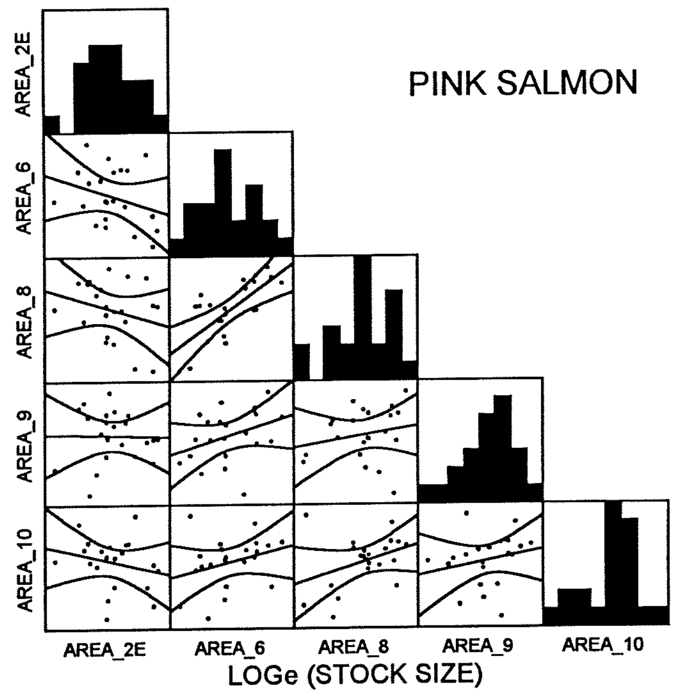



Figure 3B. Distribution of log-transformed stock sizes and correlations in stock size among pink salmon stocks. Labels on axes denote statistical areas from north to south.

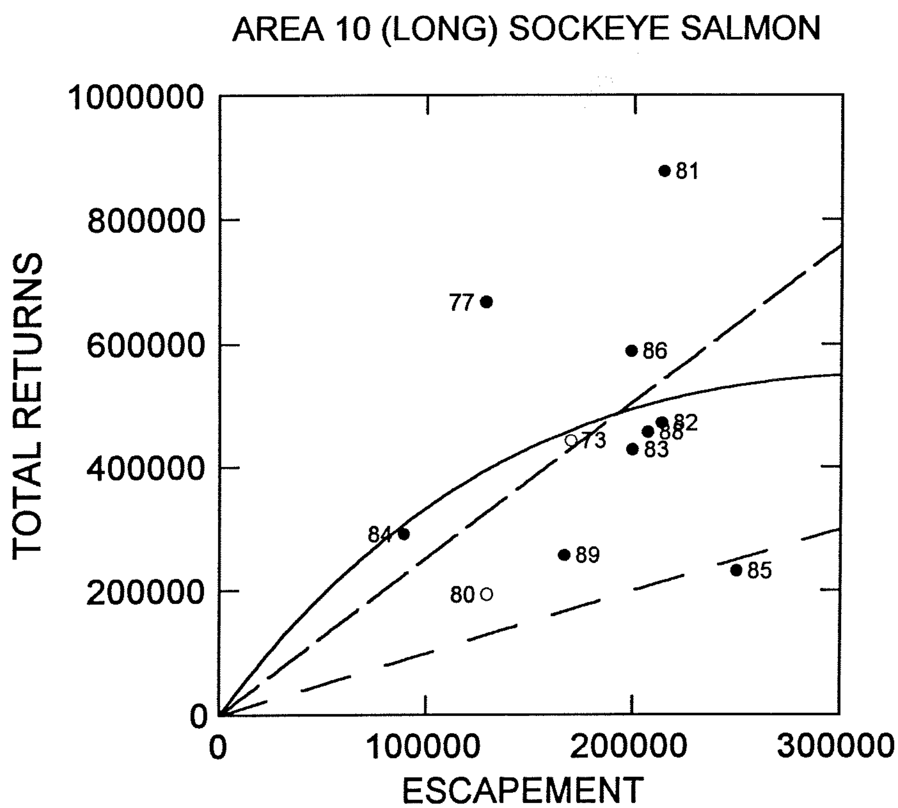



Figure 4A. Stock recruitment relationship for Area 10 (Long Lake) sockeye salmon. Numbers denote brood years. Solid line represents the NLSRESC model; broken line, the LSRESC model; dashed line, replacement. Open circles denote unfertilized years that were excluded in fitting models.

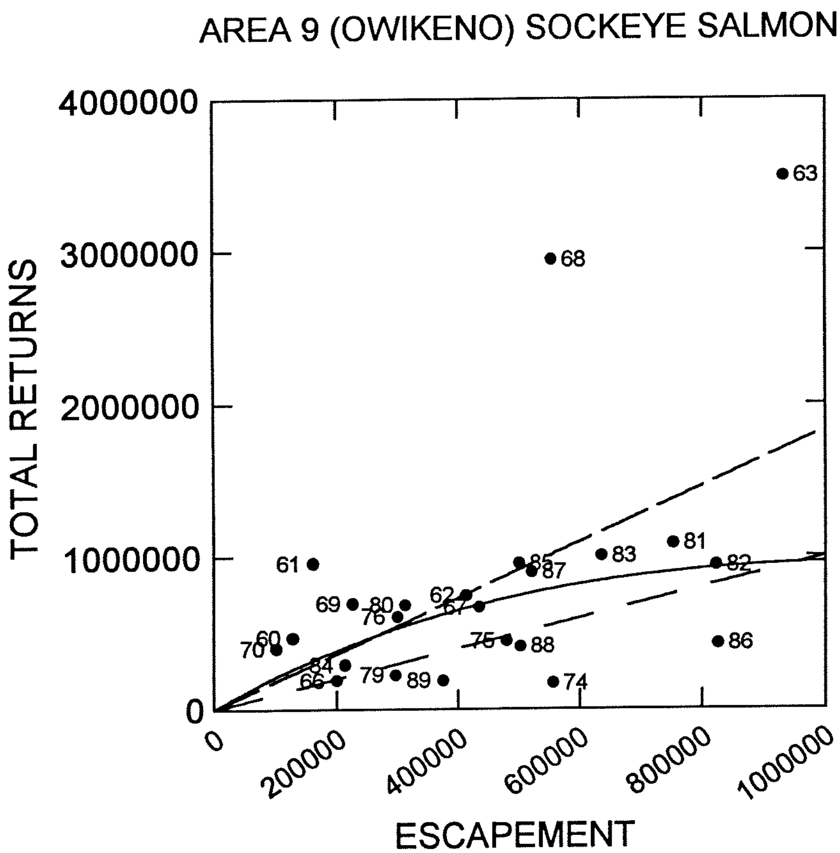



Figure 4B. Stock recruitment relationship for Area 9 (Owikeno Lake) sockeye salmon. Numbers denote brood years. Solid line represents the NLSRESC model; broken line, the LSRESC model; dashed line, replacement.

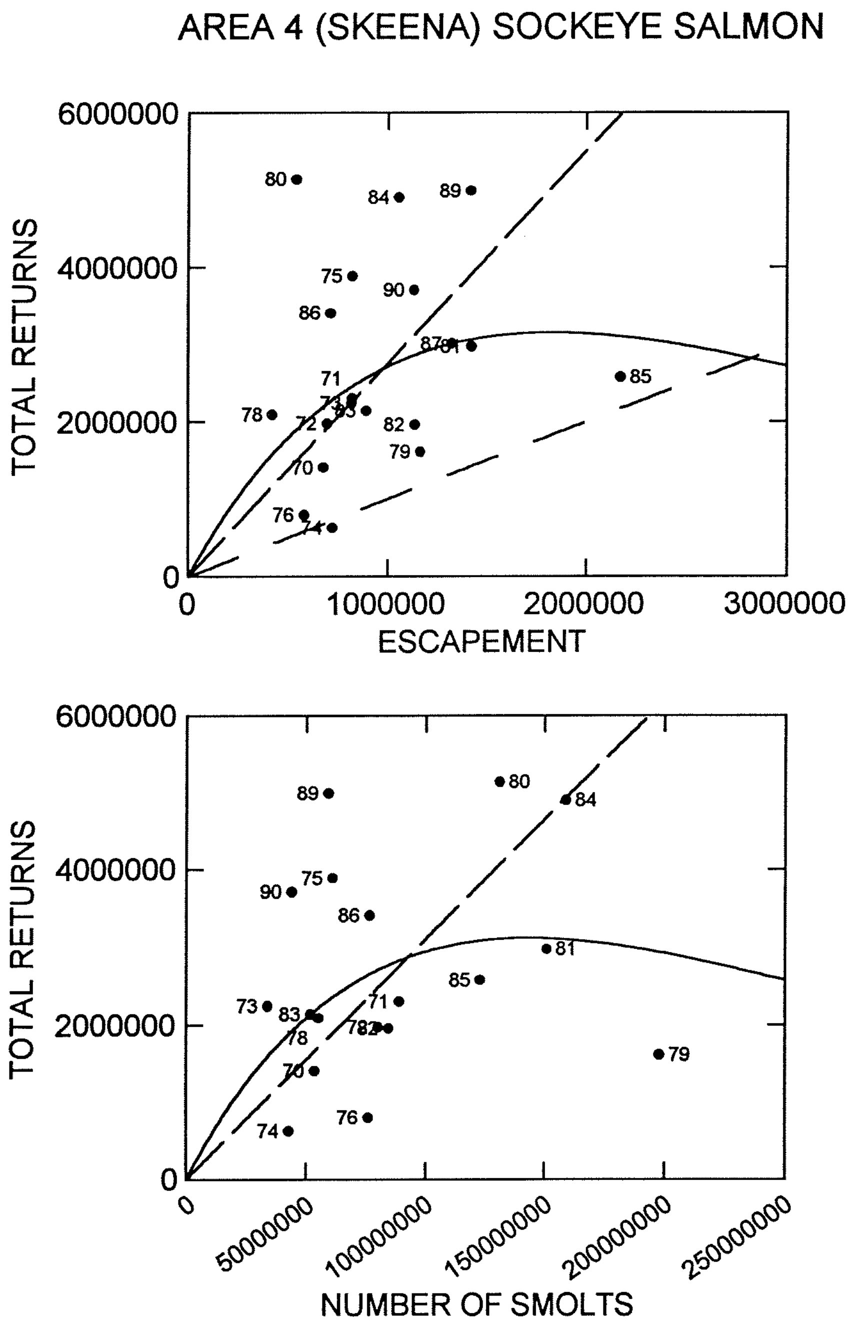



Figure 4C. Stock recruitment relationships for Area 4 (Skeena River) sockeye salmon based on escapement (top frame) and juvenile abundance (bottom frame). Numbers denote brood years. Solid lines represent non-linear models (NLSRESC and NLSRJUV); broken lines, linear models (LSRESC and LSRJUV); dashed lines, replacement.

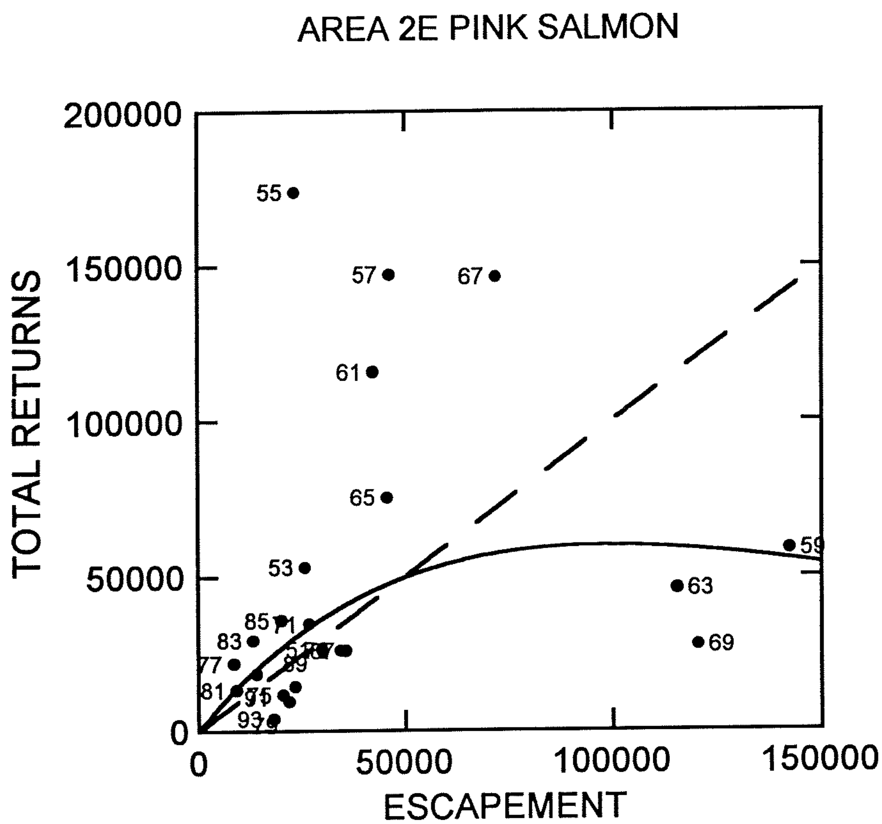



Figure 5A. Stock recruitment relationship for odd-year Area 2E pink salmon. Solid curve represents the NLSRESC model used to generate the 1997 forecast; dashed line, replacement.

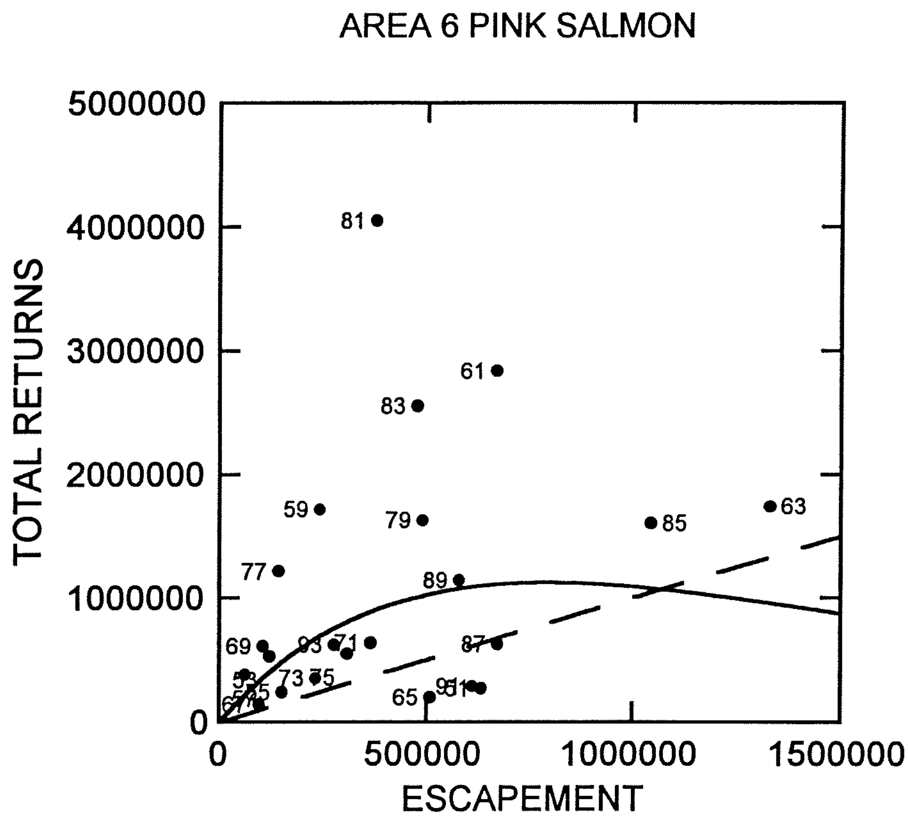



Figure 5B. Stock recruitment relationship for odd-year Area 6 pink salmon. Solid curve represents the NLSRESC model used to generate the 1997 forecast; dashed line, replacement.

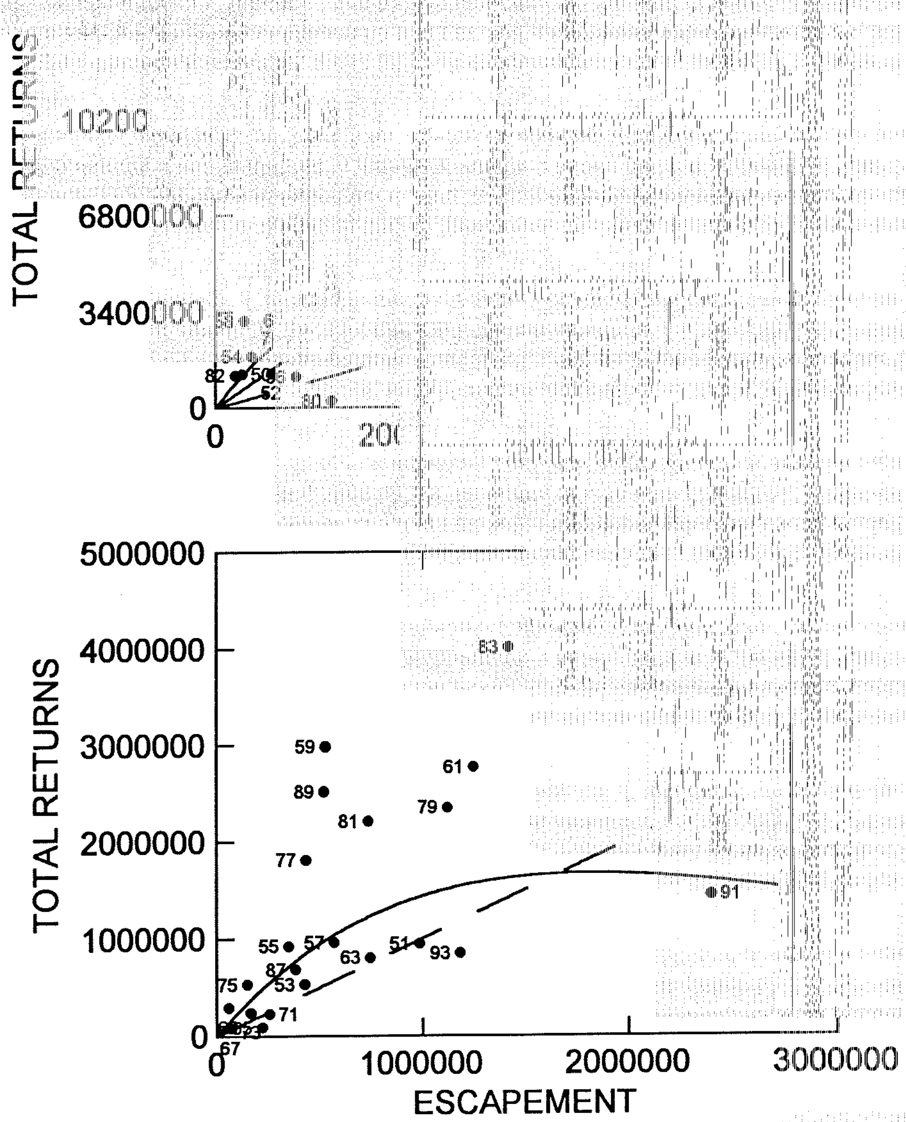



Figure 5C. Stock recruitment relationships for Area 8 pink salmon in even (top frame) ar
odd years (bottom frame). Numbers denote brood years. Solid lines represent the NLSRI
models used to generate the 1996 and 1997 forecasts; broken lines, the LSRESC model
(even-year only); and dashed lines, replacement.

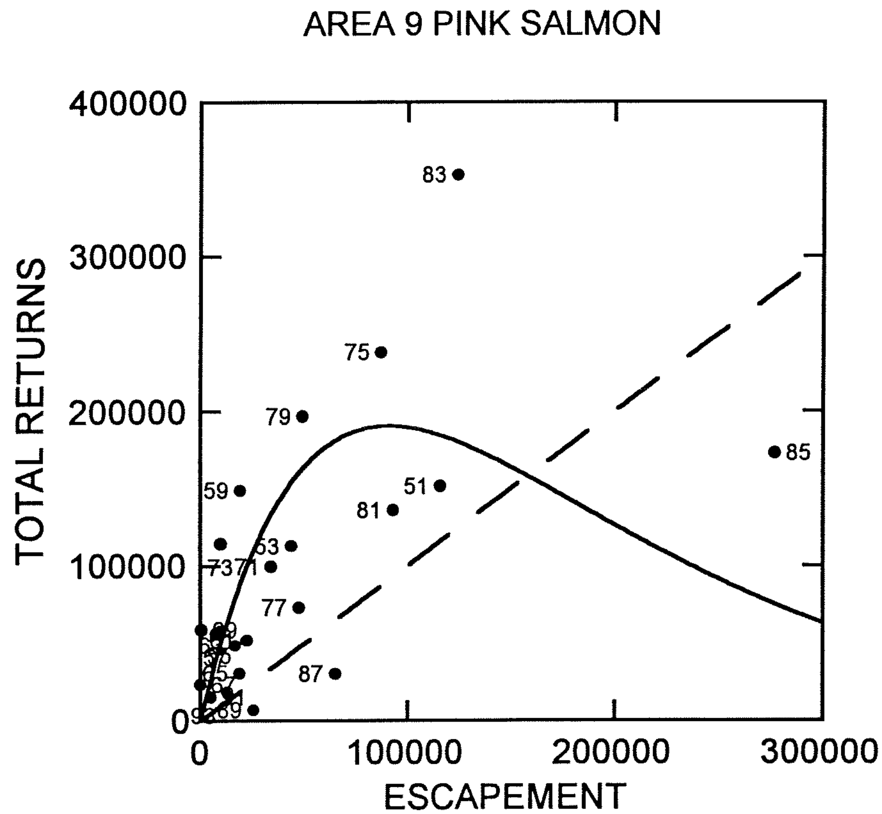



Figure 5D. Stock recruitment relationship for odd-year Area 9 pink salmon. Solid curve represents the NLSRESC model used to generate the 1997 forecasts; dashed line, replacement.

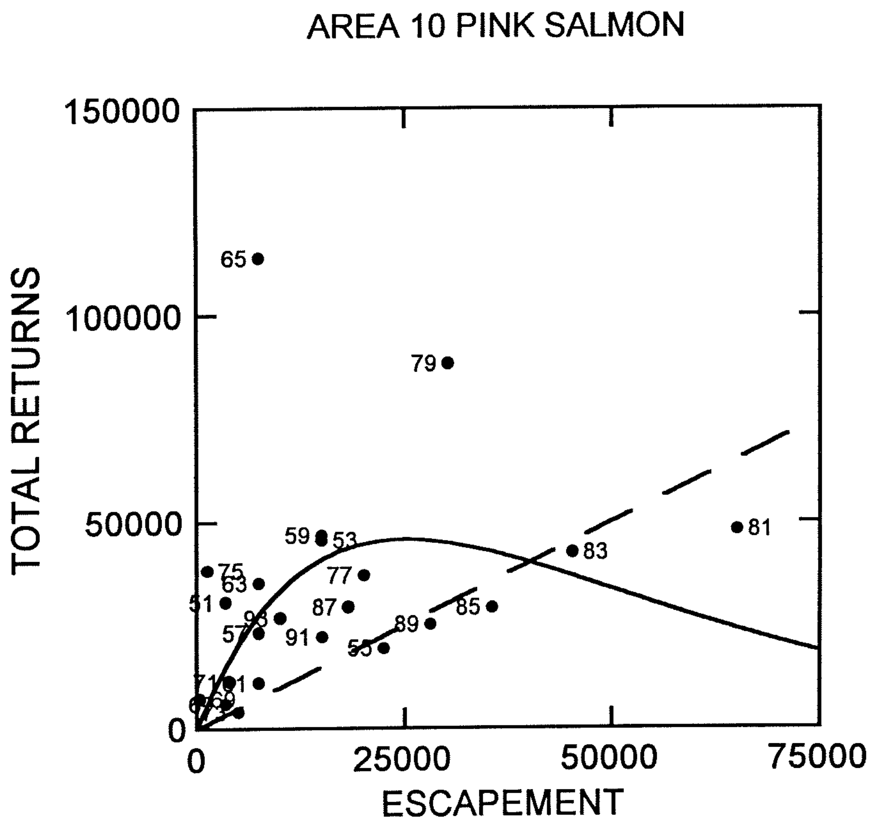



Figure 5E. Stock recruitment relationship for odd-year Area 10 pink salmon. Solid curve represents the NLSRESC model used to generate the 1997 forecast; dashed line, replacement.

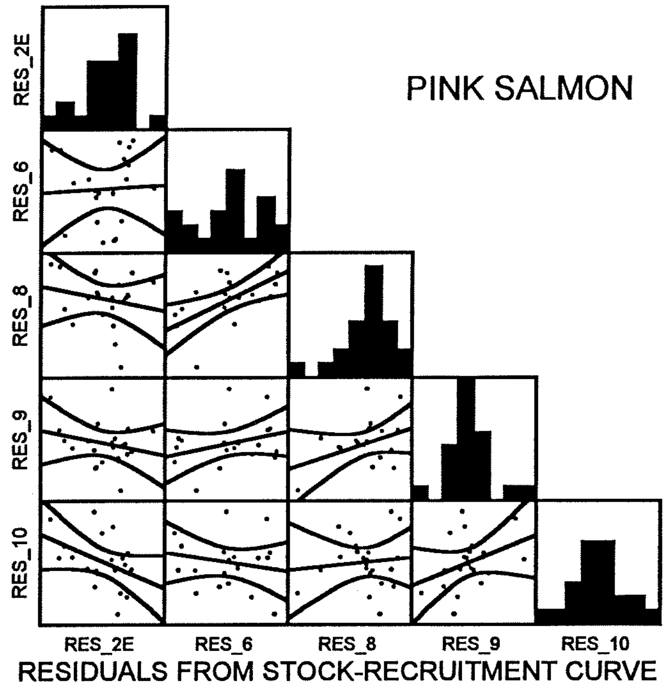



Figure 6. Distribution of residuals from stock-recruitment curves in Figure 5 and correlations in residuals among odd-year pink salmon stocks. Labels on axes denote statistical areas from north to south.

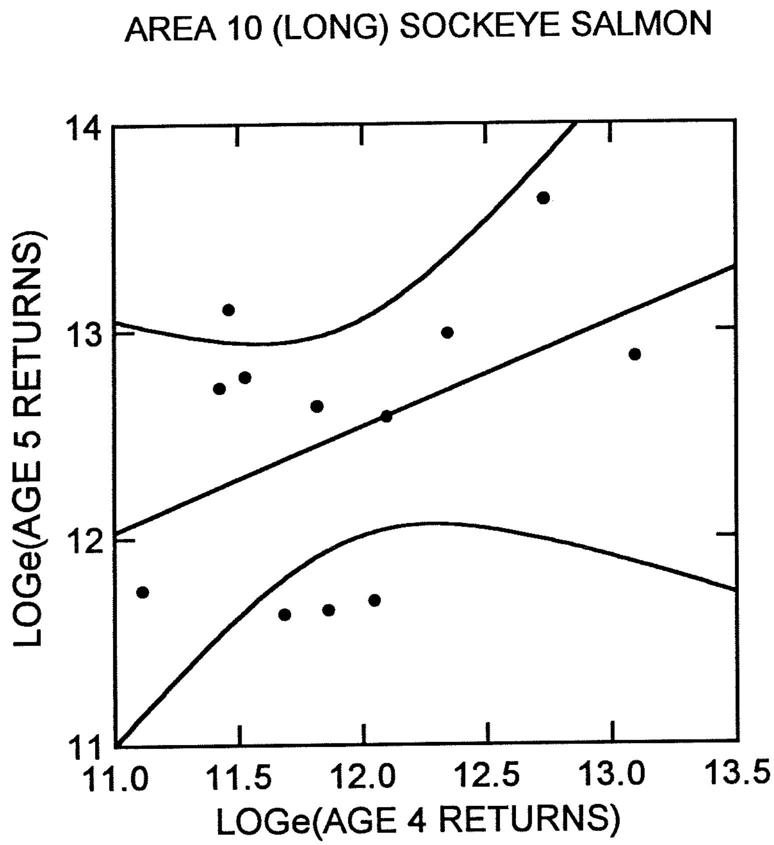



Figure 7A. Sibling age class regression (LSIB model) for Area 10 (Long Lake) sockeye salmon.

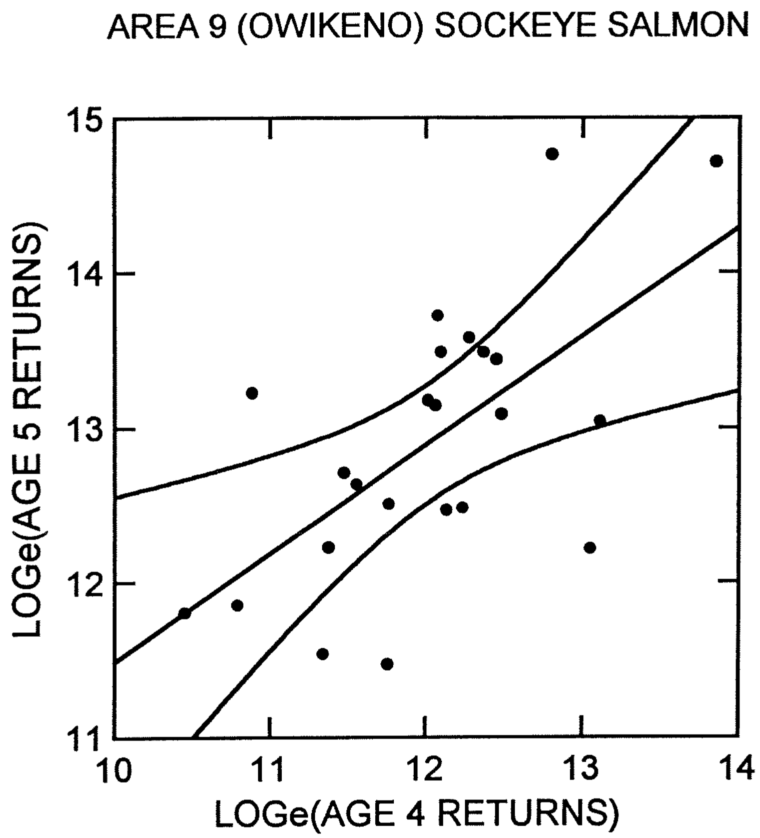



Figure 7B. Sibling age class regression (LSIB model) for Area 9 (Owikeno Lake) sockeye salmon.

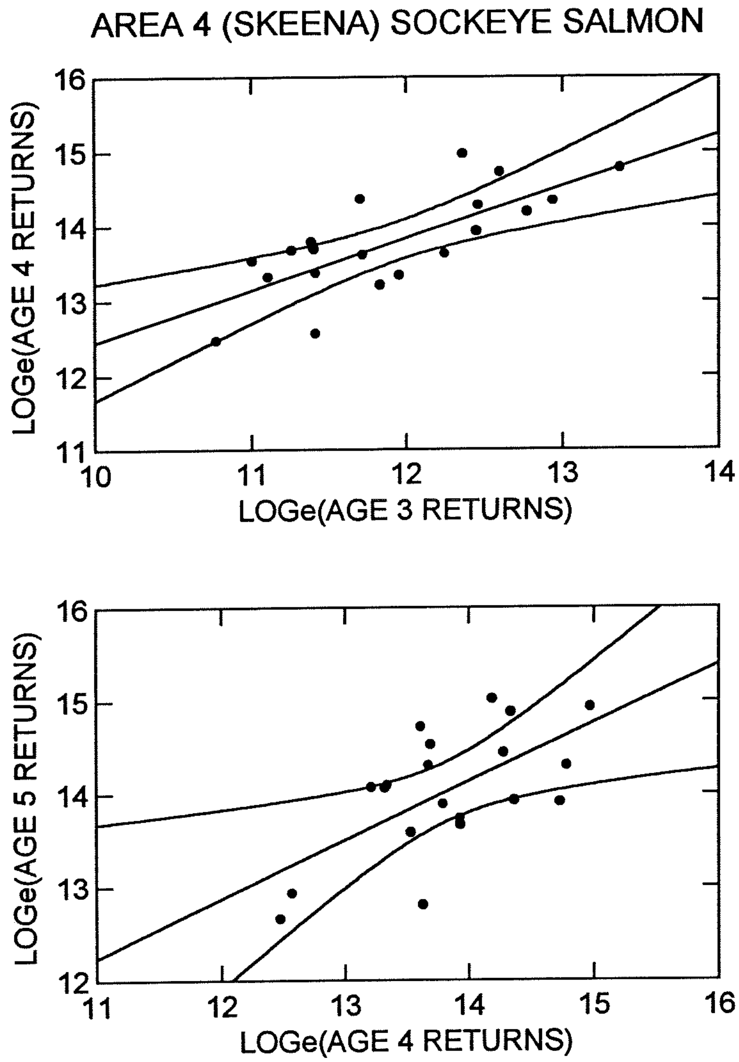



Figure 7C. Sibling age class regressions (LSIB model) for Area 4 (Skeena River) sockeye salmon.

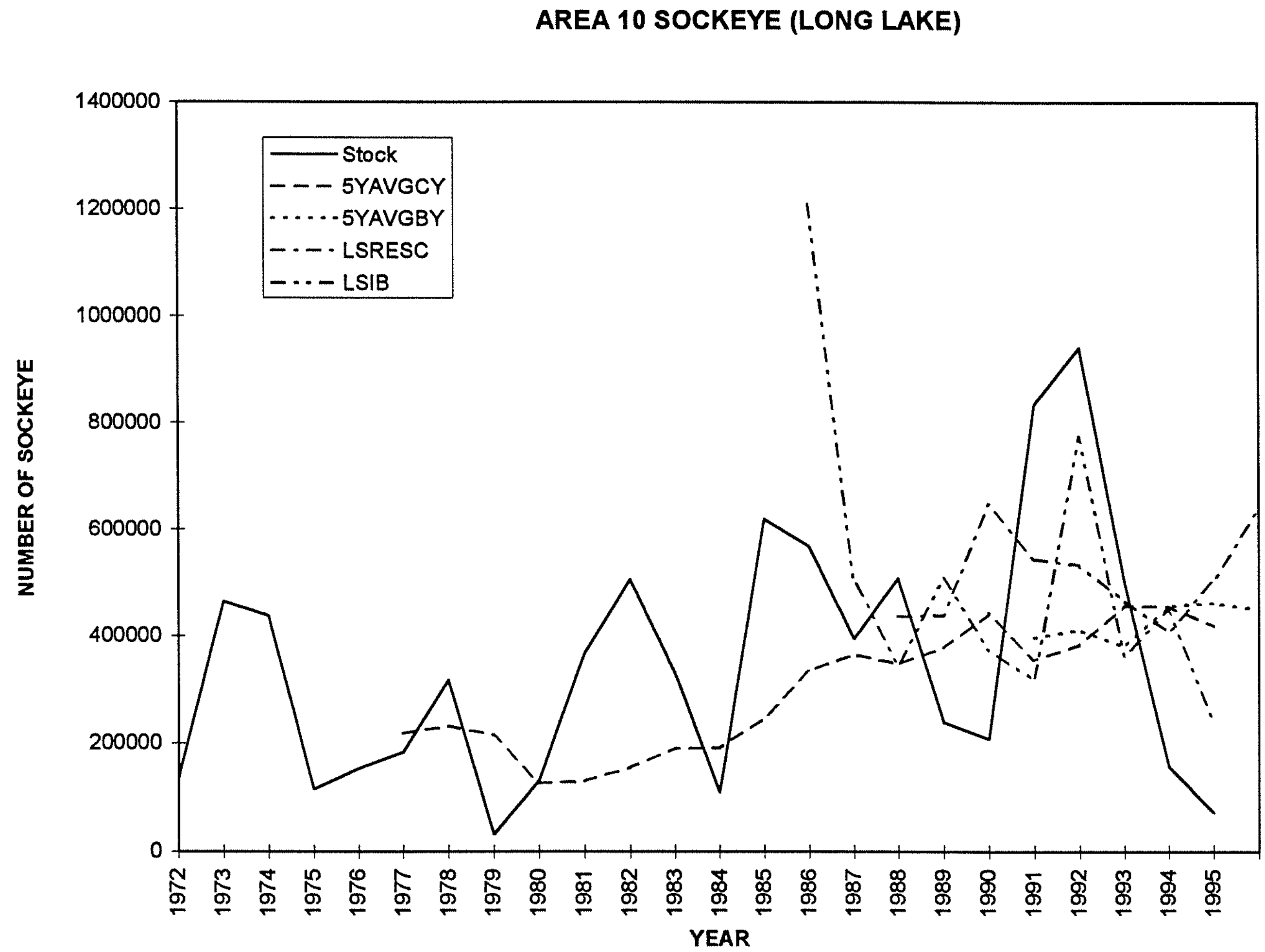



Figure 8A. Performance of selected forecasting methods in retrospective analysis for Area 10 (Long Lake) sockeye salmon.

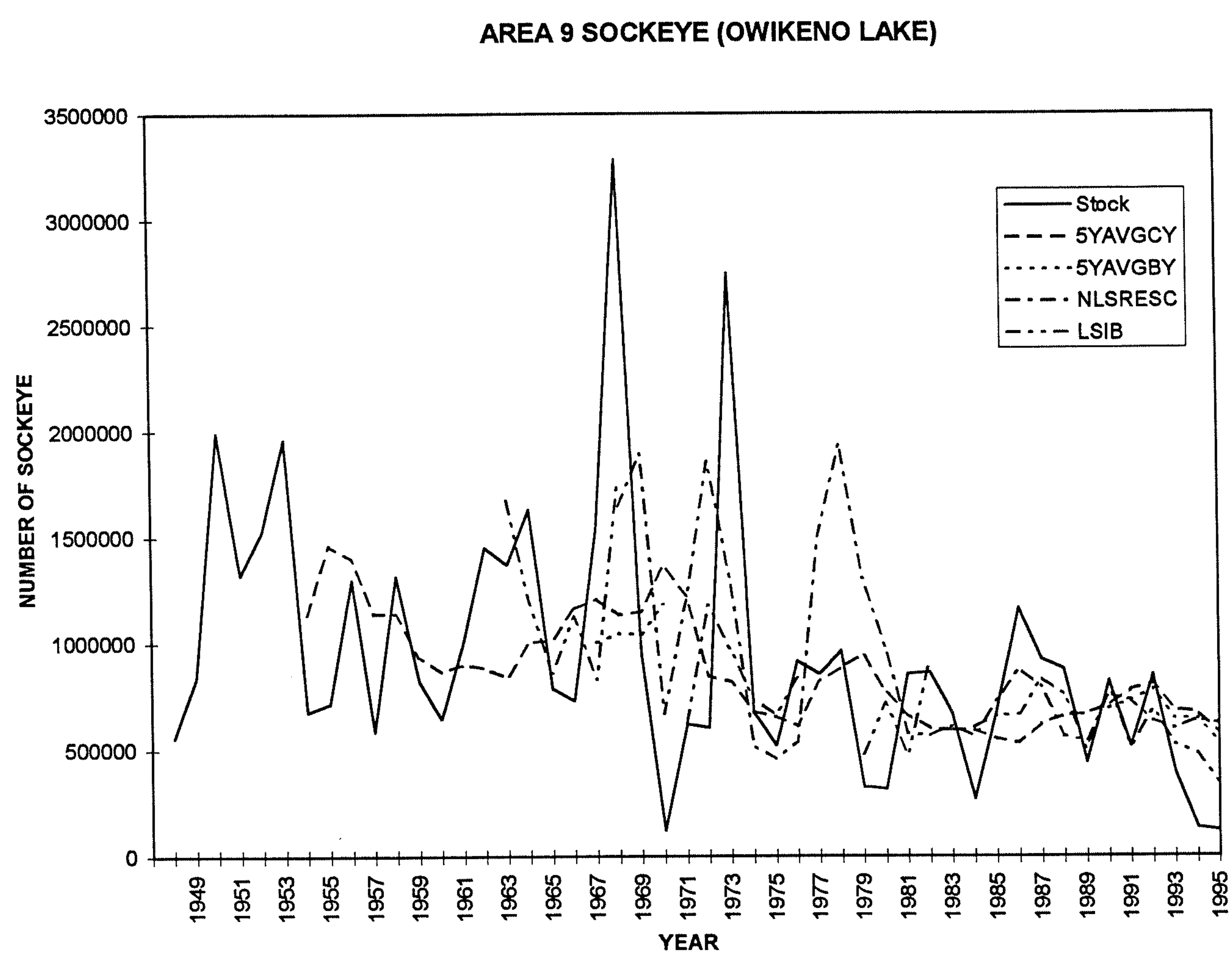



Figure 8B. Performance of selected forecasting models in retrospective analysis for Area 9 (Owikeno Lake) sockeye salmon.

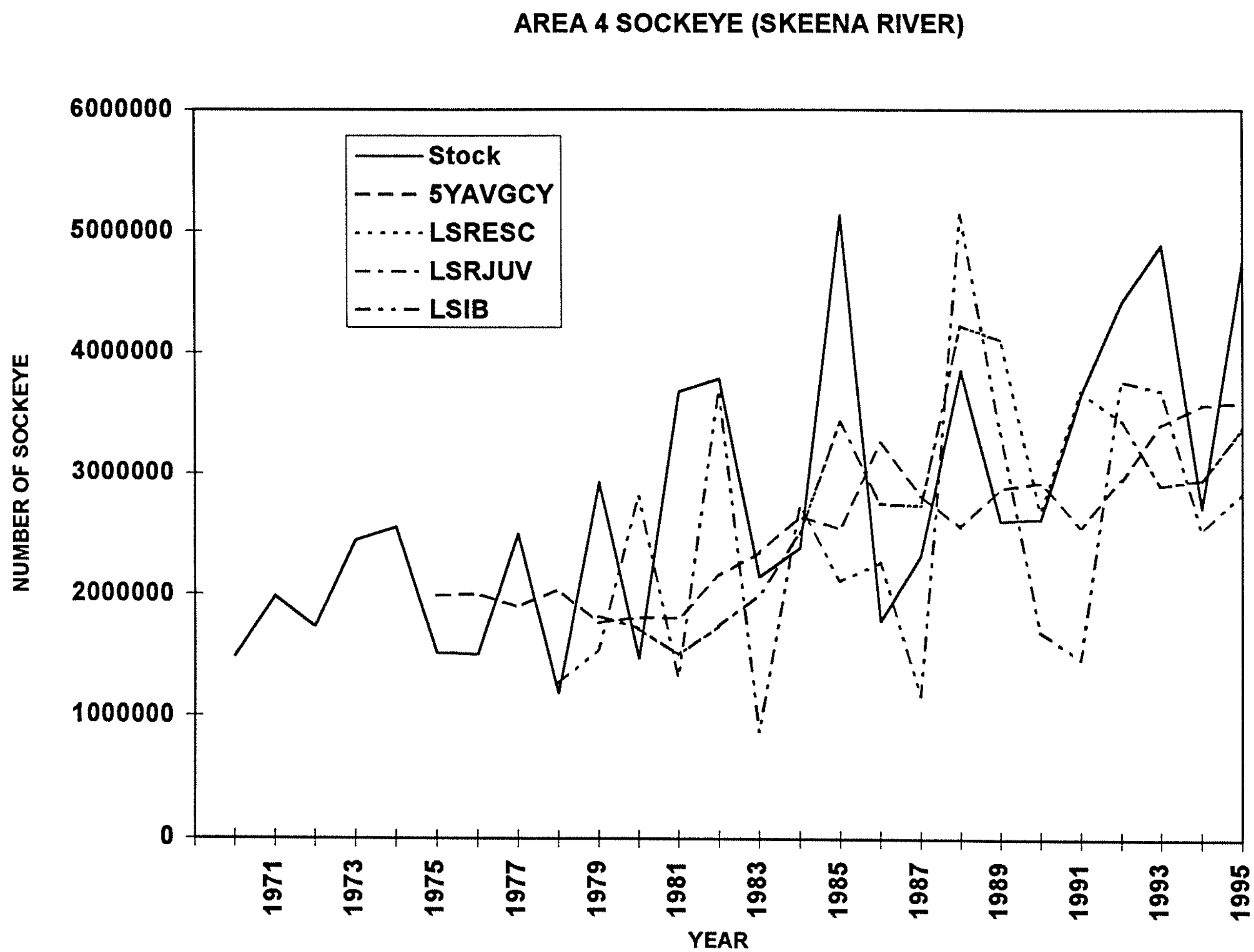



Figure 8C. Performance of selected forecasting models in retrospective analysis for Area 4 (Skeena River) sockeye salmon.

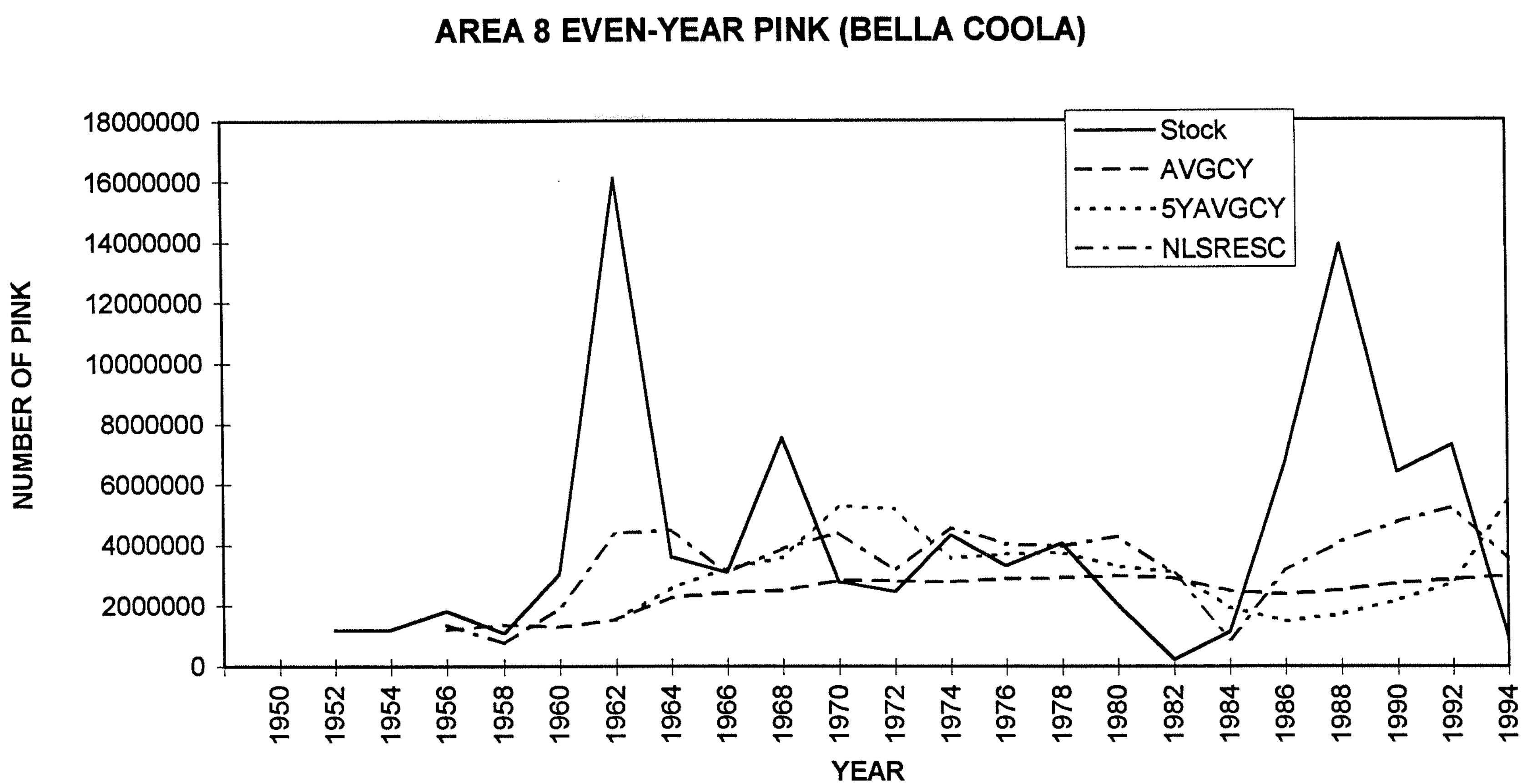
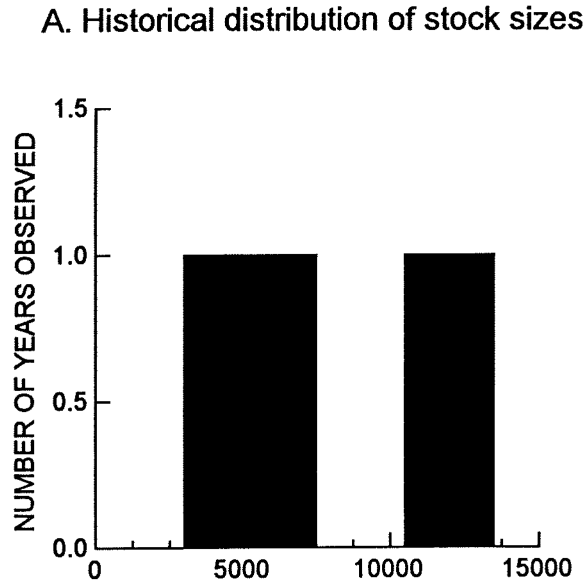



Figure 9. Performance of selected forecasting models in retrospective analysis for Area 8 (Bella Coola) pink salmon in even years.



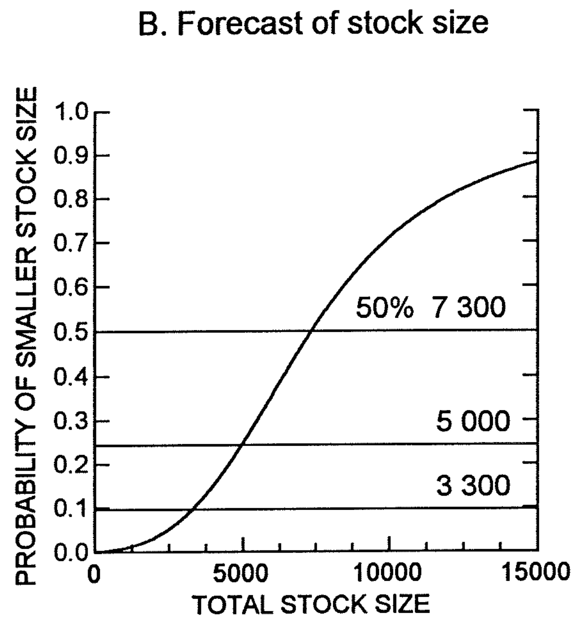




Figure 10A. The forecasted cumulative probability distribution for total stock size in 1997 for **Yakoun Lake sockeye salmon** as compared with the historical distribution of total stock size.

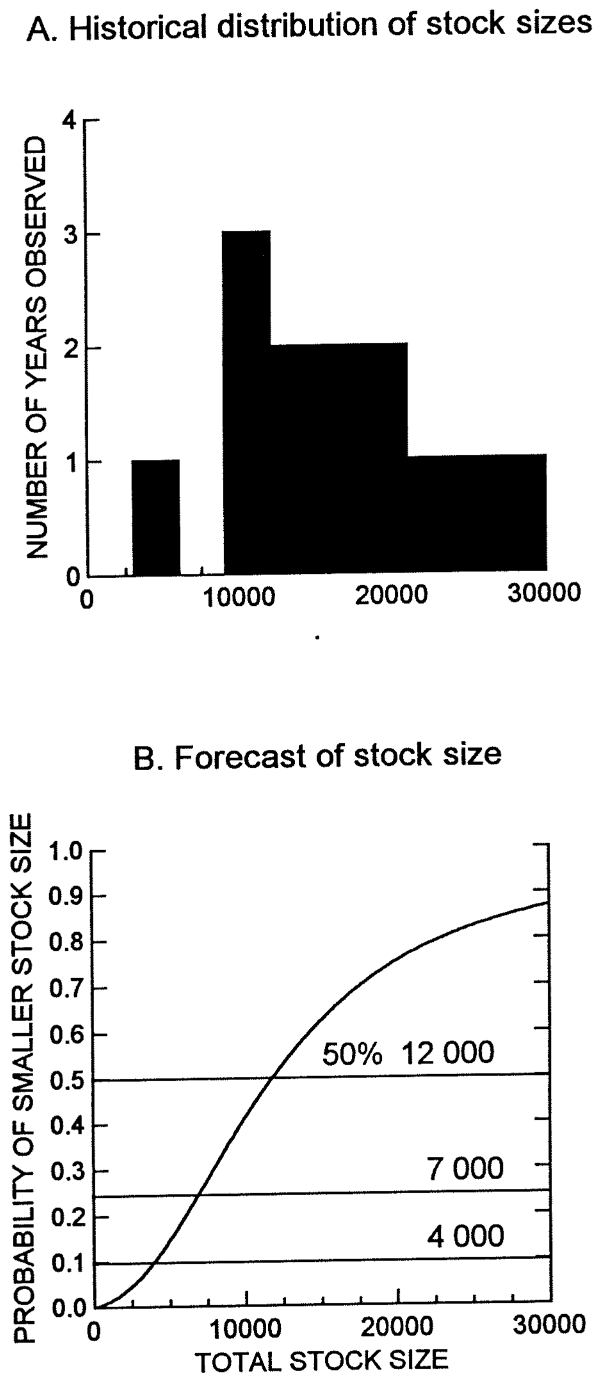
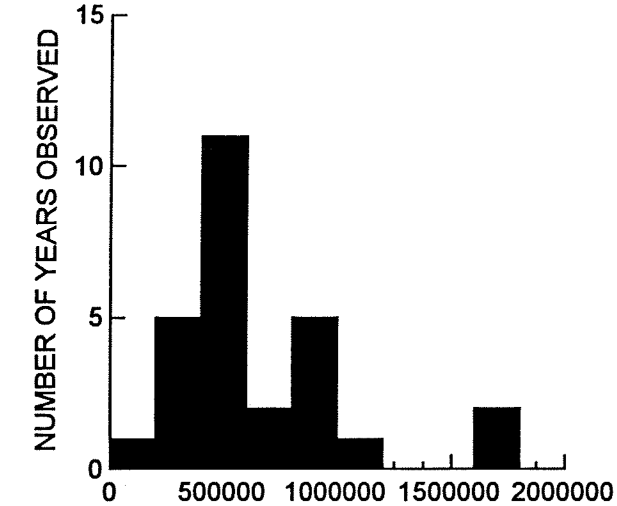



Figure 10B. The forecasted cumulative probability distribution for total stock size in 1997 for **Skidegate Lake sockeye salmon** as compared with the historical distribution of total stock size.

A. Historical distribution of stock sizes




B. Forecast of stock size

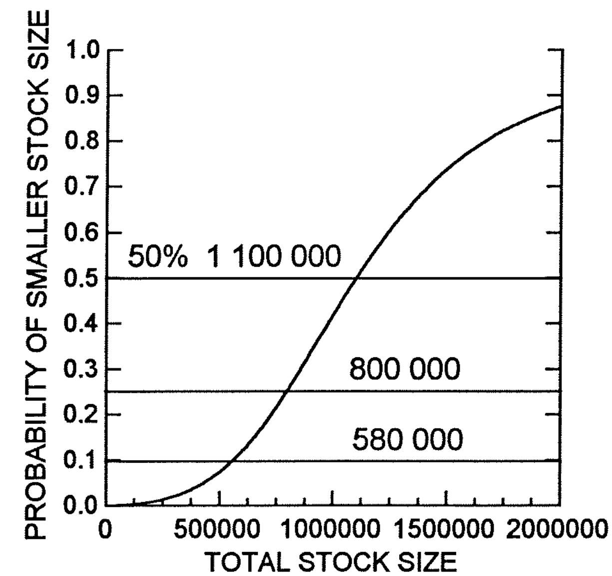



Figure 10C. The forecasted cumulative probability distribution for total stock size in 1997 for **Area 3 (Nass River) sockeye salmon** as compared with the historical distribution of total stock size.

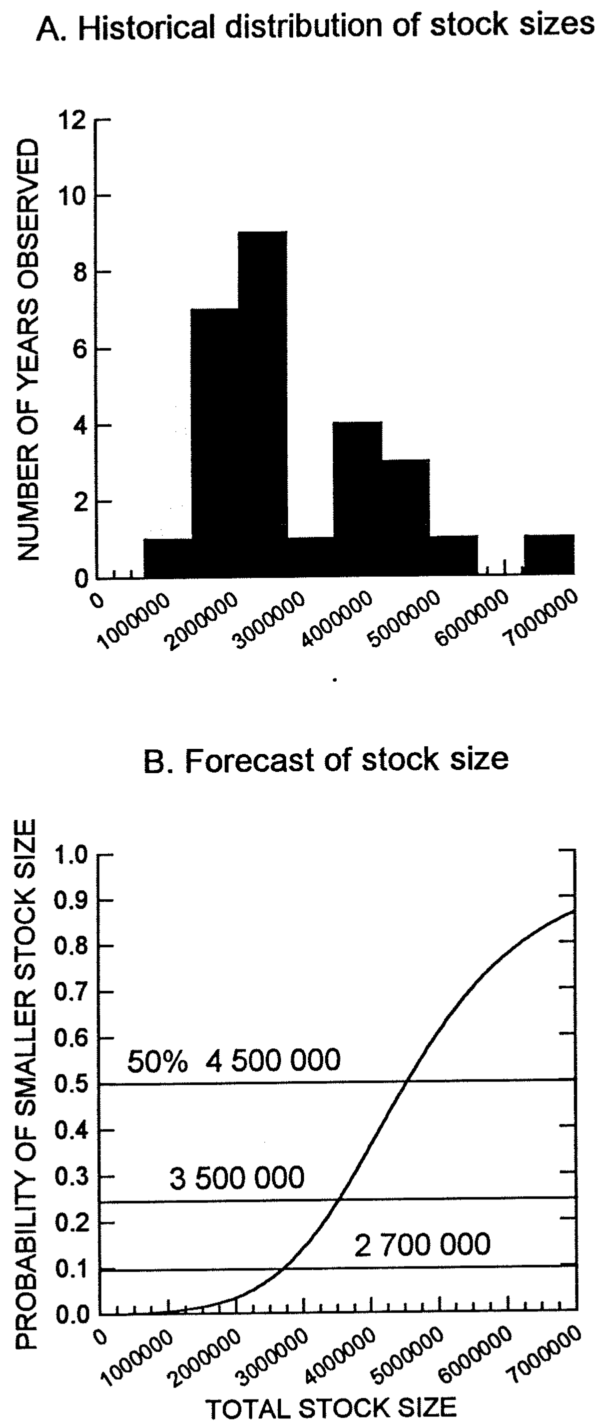



Figure 10D. The forecasted cumulative probability distribution for total stock size in 1997 for **Area 4 (Skeena River) sockeye salmon** as compared with the historical distribution of total stock size.

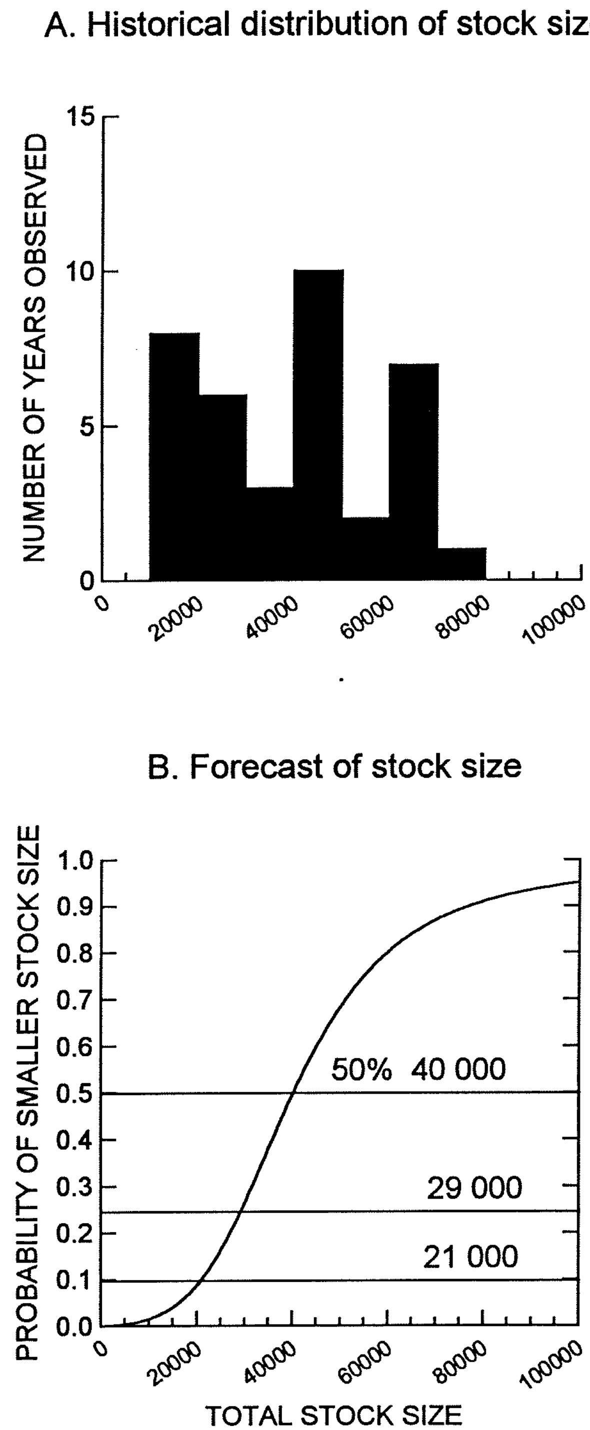



Figure 10E. The forecasted cumulative probability distribution for total stock size in 1997 for **Kitlope Lake sockeye salmon** as compared with the historical distribution of total stock size.

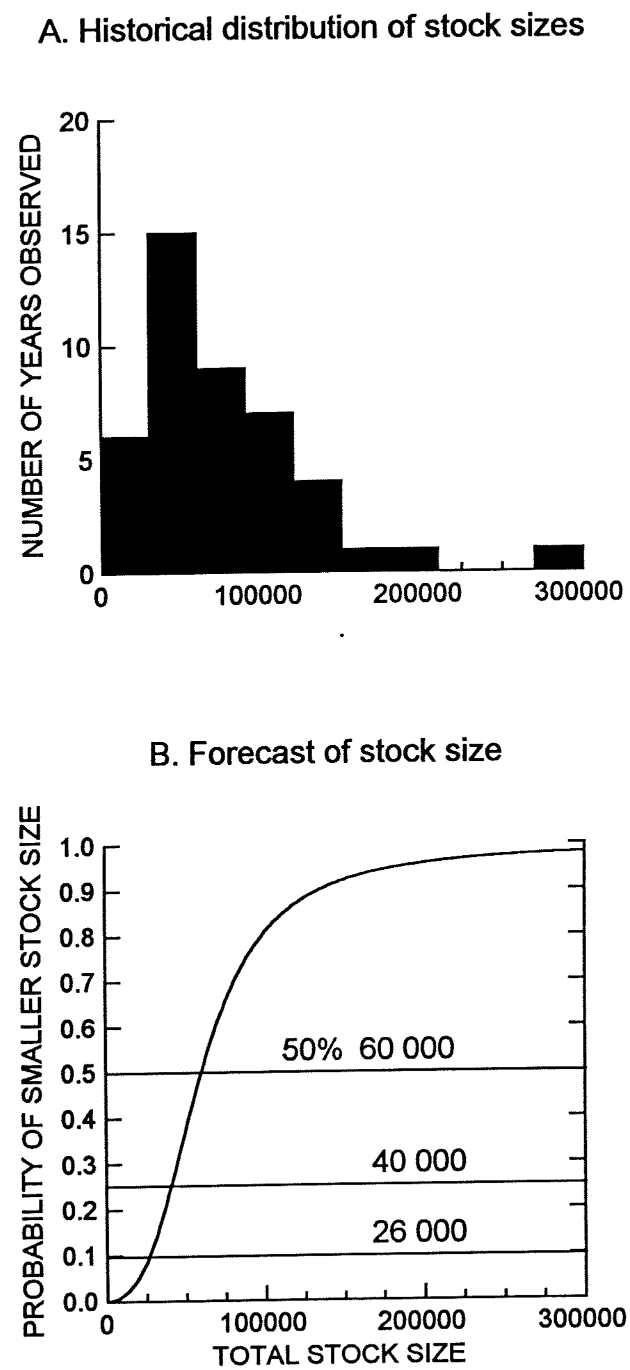



Figure 10F. The forecasted cumulative probability distribution for total stock size in 1997 for **Atnarko River sockeye salmon** as compared with the historical distribution of total stock size.

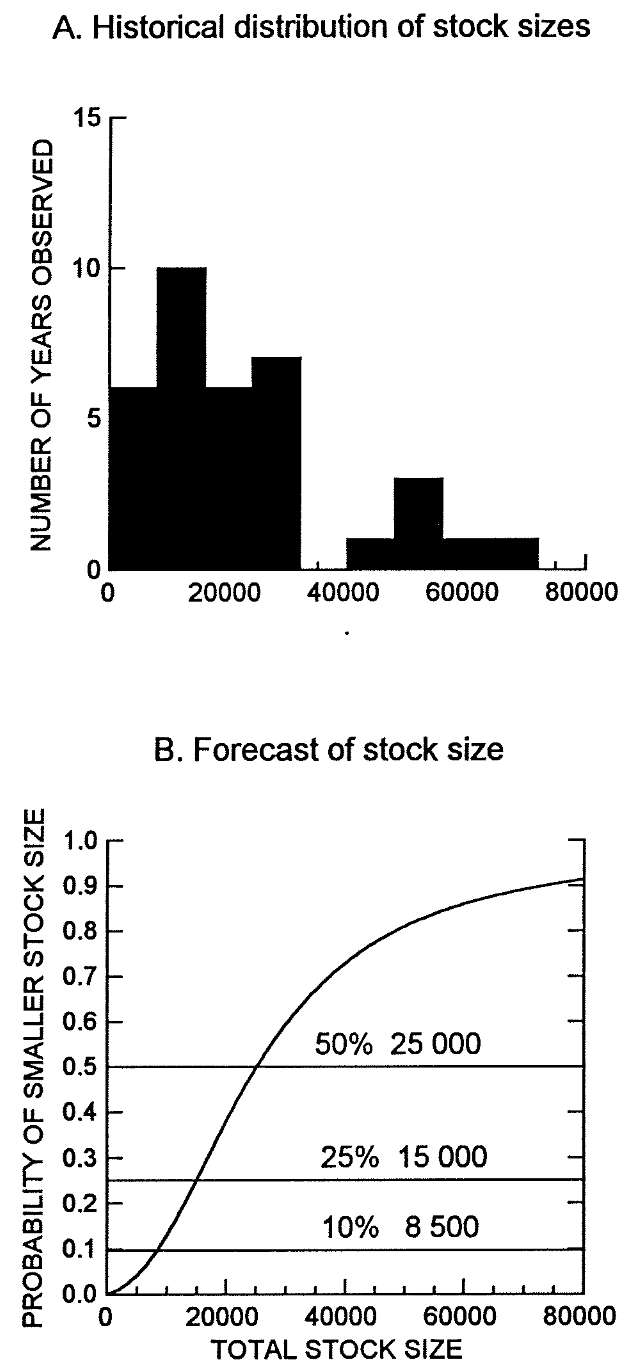



Figure 10G. The forecasted cumulative probability distribution for total stock size in 1997 for **Kimsquit Lake sockeye salmon** as compared with the historical distribution of total stock size.

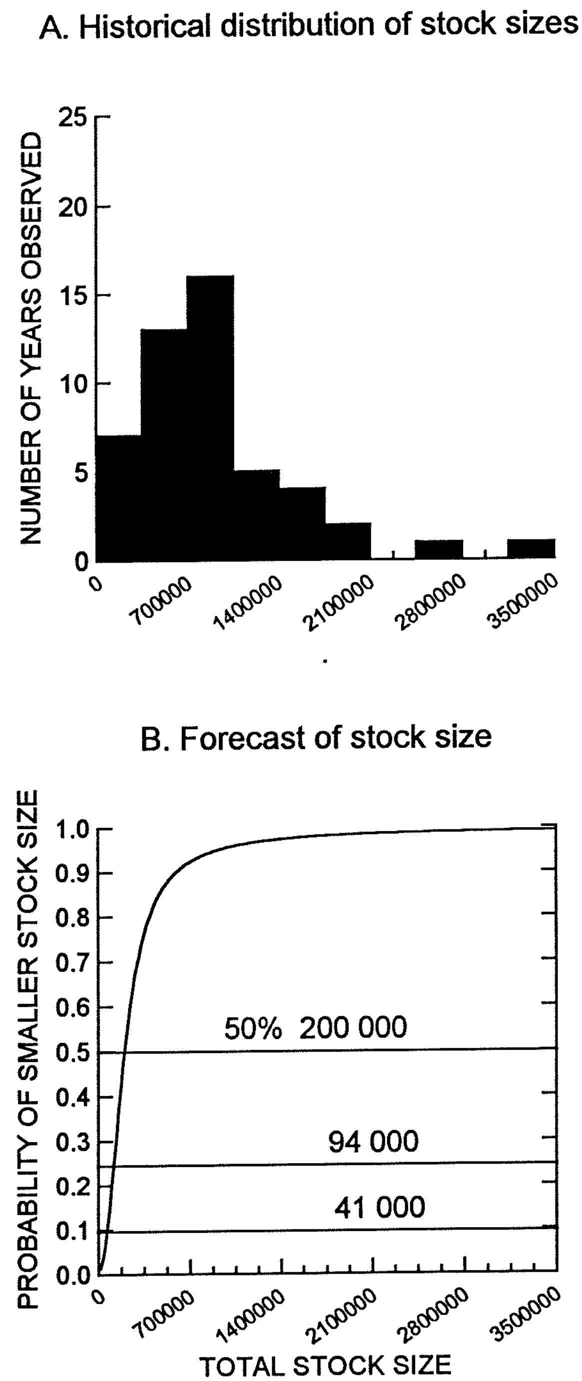



Figure 10H. The forecasted cumulative probability distribution for total stock size in 1997 for **Area 9 (Owikeno Lake) sockeye salmon** as compared with the historical distribution of total stock size.

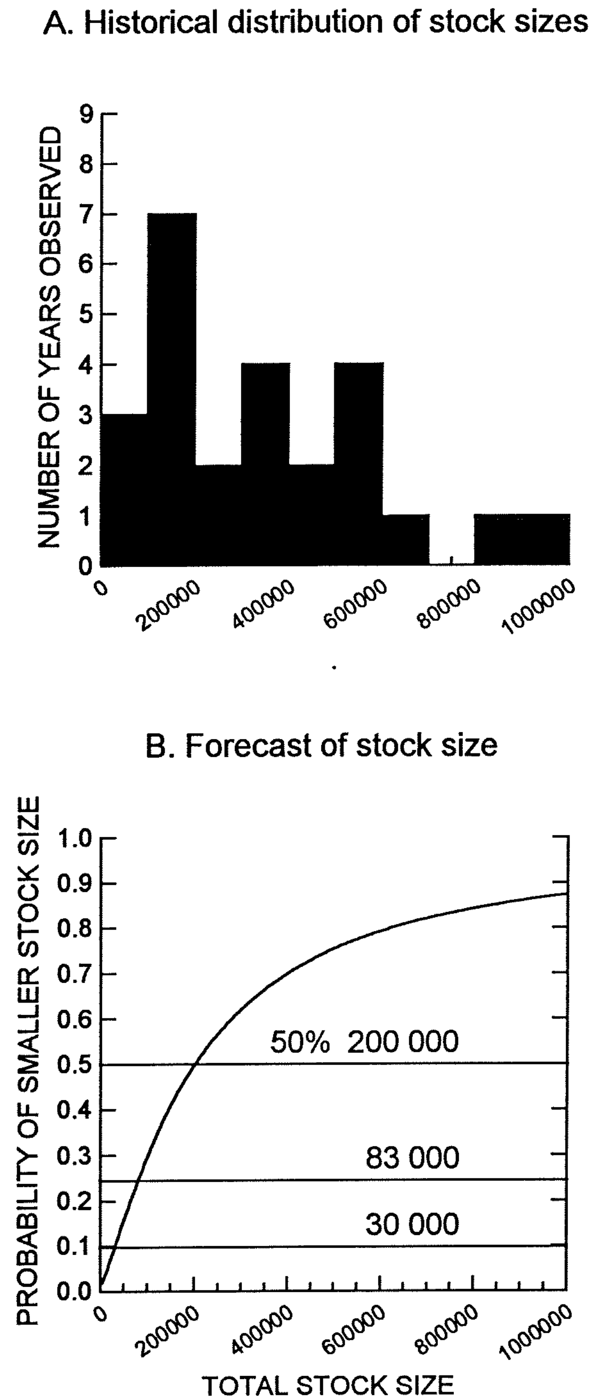



Figure 10l. The forecasted cumulative probability distribution for total stock size in 1997 for **Area 10 (Long Lake) sockeye salmon** as compared with the historical distribution of total stock size.

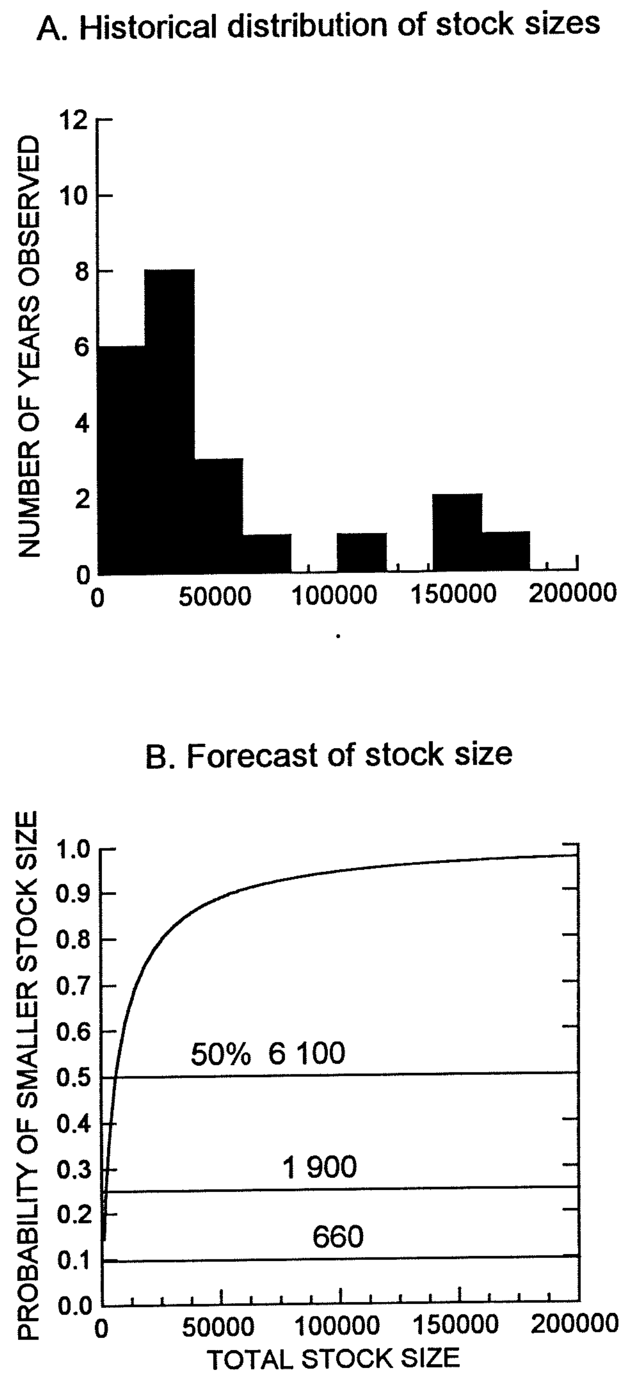



Figure 11A. The forecasted cumulative probability distribution for total stock size in 1997 for **Area 2E pink salmon** as compared with the historical distribution of total stock size for odd years.

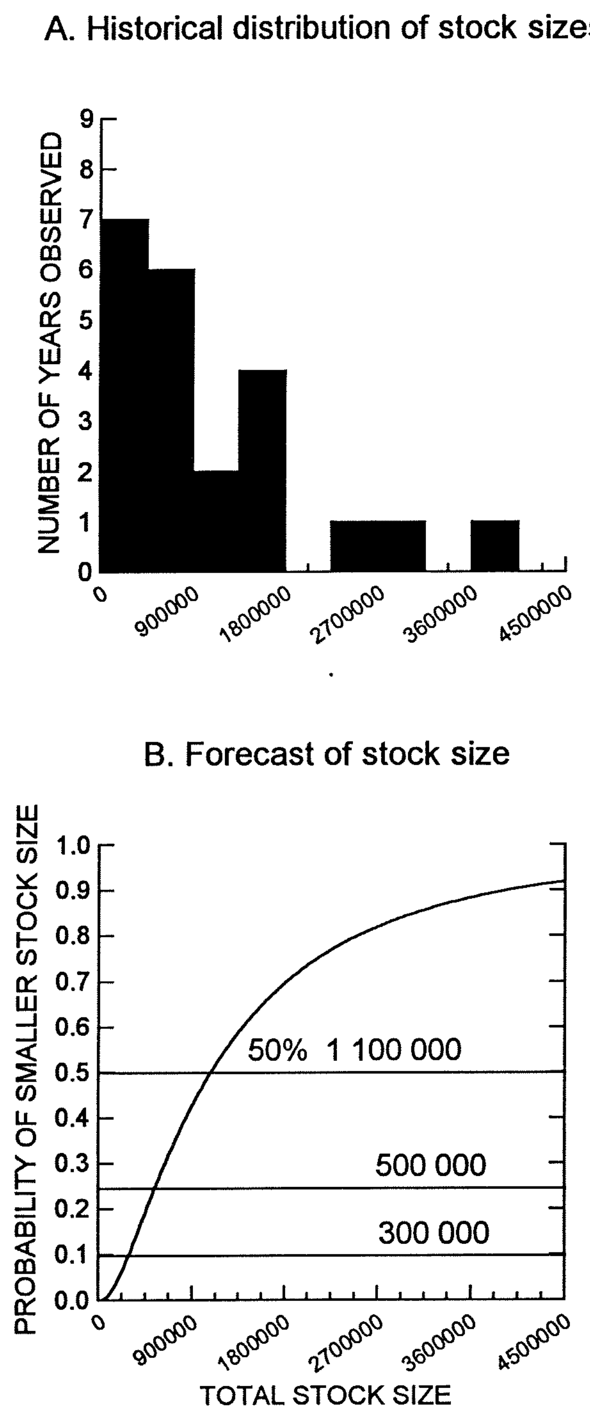
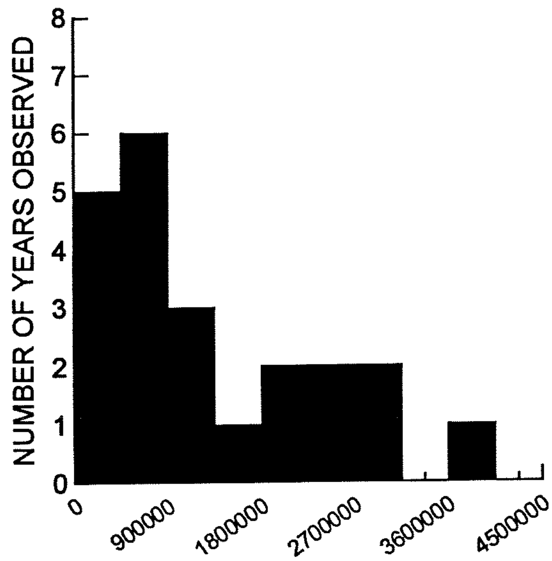



Figure 11B. The forecasted cumulative probability distribution for total stock size in 1997 for **Area 6 pink salmon** as compared with the historical distribution of total stock size for odd years.

A. Historical distribution of stock sizes




B. Forecast of stock size

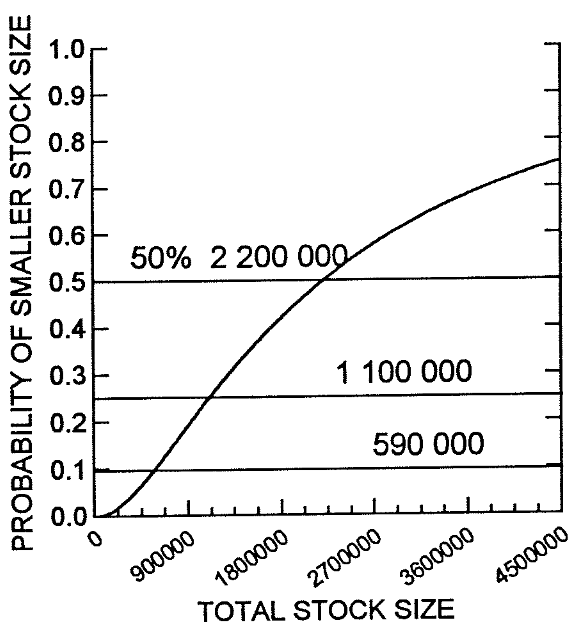



Figure 11C. The forecasted cumulative probability distribution for total stock size in 1997 for **Area 8 pink salmon** as compared with the historical distribution of total stock size for odd years.

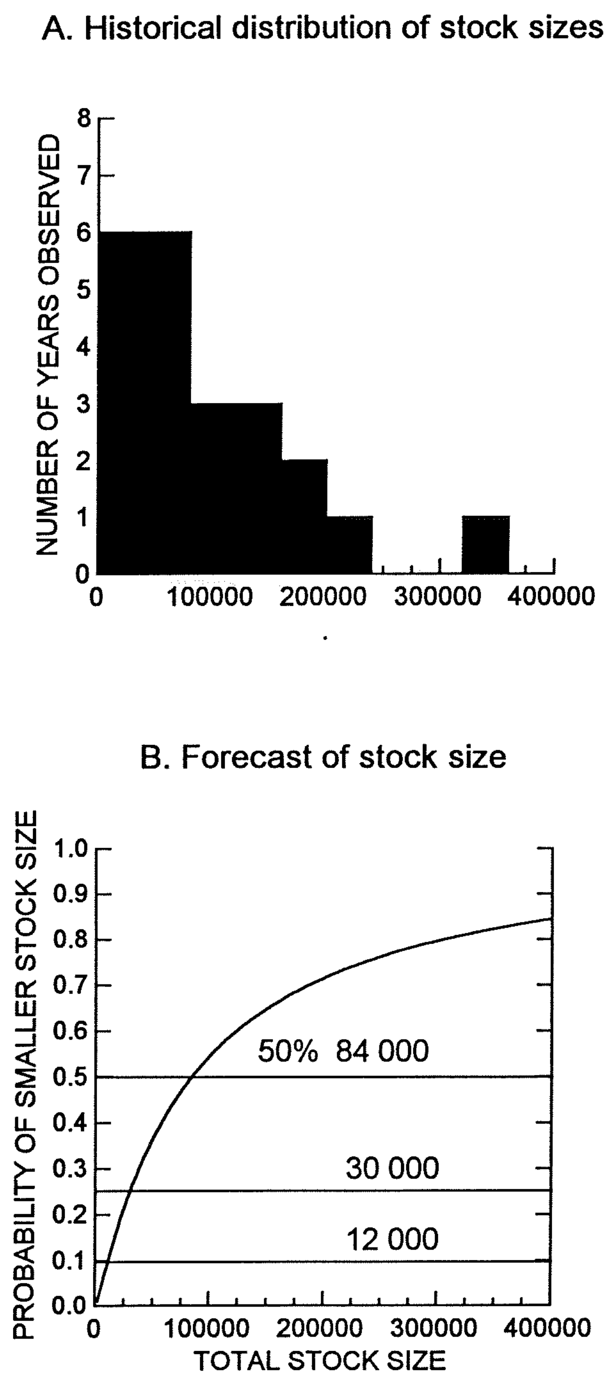
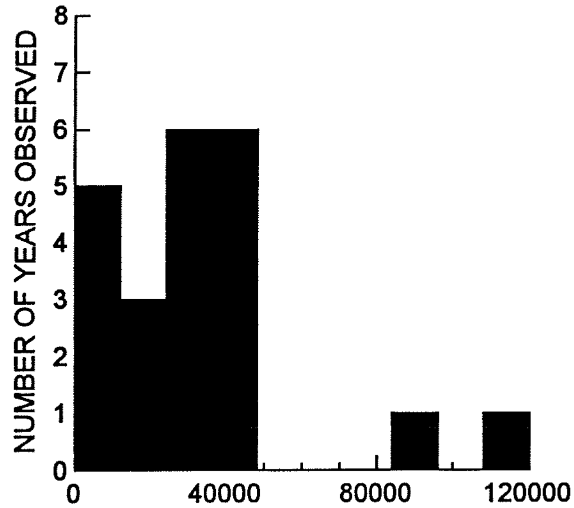



Figure 11D. The forecasted cumulative probability distribution for total stock size in 1997 for **Area 9 pink salmon** as compared with the historical distribution of total stock size for odd years.

A. Historical distribution of stock sizes




B. Forecast of stock size

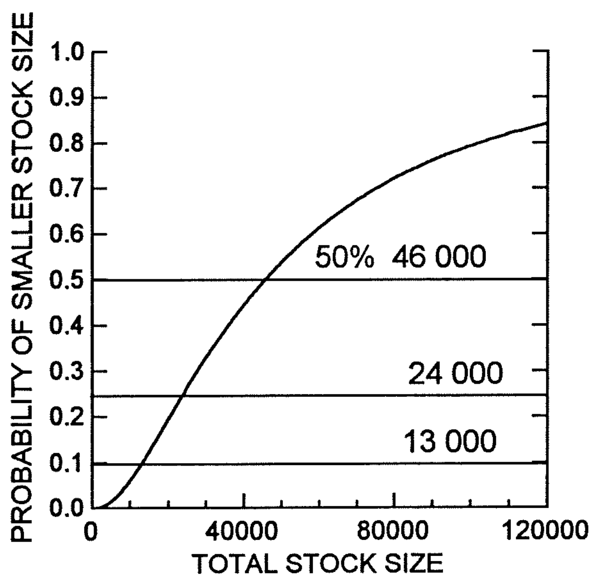



Figure 11E. The forecasted cumulative probability distribution for total stock size in 1997 for **Area 10 pink salmon** as compared with the historical distribution of total stock size for odd years.

Appendix A1. Area 10 (Long Lake) sockeye salmon.

Table A1.1 Spawning escapement, total stock and age composition data by calendar year.

| Calendar Year | Escapement | Total Stock | Age Composition: Escapement Samples % age 4 | Age Composition: Escapement Samples % age 5 | Age Composition: Catch Samples % age 4 | Age Composition: Catch Samples % age 5 |
|---|---|---|---|---|---|---|
| 1972 | 76248 | 135645 | 66.3 | 32.5 | 71.0 | 28.4 |
| 1973 | 169753 | 464372 | 7.6 | 92.4 | 14.8 | 83.2 |
| 1974 | 91013 | 438718 | | | 8.7 | 83.1 |
| 1975 | 62967 | 115640 | 44.0 | 56.0 | 23.0 | 76.0 |
| 1976 | 60919 | 153120 | | | | |
| 1977 | 128601 | 183456 | 75.0 | 22.5 | 71.4 | 27.9 |
| 1978 | 84105 | 317486 | 3.6 | 95.2 | 2.6 | 97.2 |
| 1979 | 20257 | 31279 | | | | |
| 1980 | 129435 | 131784 | 22.8 | 77.2 | | |
| 1981 | 214345 | 368700 | 67.2 | 32.2 | 55.6 | 44.4 |
| 1982 | 213674 | 506632 | 11.1 | 88.5 | 15.2 | 84.5 |
| 1983 | 199653 | 330865 | | | | |
| 1984 | 89012 | 110172 | 62.7 | 36.6 | 52.7 | 47.3 |
| 1985 | 250000 | 619178 | 78.7 | 20.4 | | |
| 1986 | 199000 | 568854 | 31.6 | 68.4 | | |
| 1987 | 200000 | 394926 | 15.0 | 79.0 | 31.6 | 68.4 |
| 1988 | 207000 | 508731 | 42.0 | 57.0 | 27.8 | 72.2 |
| 1989 | 166810 | 238631 | 59.0 | 41.0 | 28.2 | 71.8 |
| 1990 | 149000 | 207579 | 57.0 | 43.0 | 17.3 | 82.7 |
| 1991 | 260000 | 834550 | 42.0 | 57.0 | 40.0 | 60.0 |
| 1992 | 220000 | 942816 | 34.0 | 63.0 | 3.7 | 96.3 |
| 1993 | 220000 | 504156 | 36.0 | 63.0 | 22.0 | 76.0 |
| 1994 | 100000 | 157830 | 29.0 | 69.0 | 20.0 | 79.0 |
| 1995[a] | 56244 | 72188 | 11.0 | 89.0 | 28.0 | 70.0 |

[a] Preliminary data used for 1995.

Appendix A1. Area 10 (Long Lake) sockeye salmon.

Table A1.2 Escapement and brood year returns by age class.

| Brood Year | Escapement | Juvenile[a] Abundance | Adult Returns Age 4 | Adult Returns Age 5 | Adult Returns Total |
|---|---|---|---|---|---|
| 1972 | 76248 | | | | |
| 1973 | 169753 | | 135617 | 306914 | 442532 |
| 1974 | 91013 | | | | |
| 1975 | 62967 | | | | |
| 1976 | 60919 | | | | |
| 1977 | 128601 | | 229861 | 436651 | 666512 |
| 1978 | 84105 | | | | |
| 1979 | 20257 | | | | |
| 1980 | 129435 | | 66962 | 126312 | 193274 |
| 1981 | 214345 | | 487293 | 389096 | 876389 |
| 1982 | 213674 | | 179758 | 291329 | 471087 |
| 1983 | 199653 | | 91597 | 335840 | 427436 |
| 1984 | 89012 | | 170821 | 119960 | 290781 |
| 1985 | 250000 | | 118671 | 112515 | 231186 |
| 1986 | 199000 | | 95064 | 492930 | 587994 |
| 1987 | 200000 | | 339020 | 834672 | 1173692 |
| 1988 | 207000 | | 101544 | 354559 | 456103 |
| 1989 | 166810 | | 141714 | 114686 | 256400 |
| 1990 | 149000 | | 40566 | | |
| 1991 | 260000 | | | | |
| 1992 | 220000 | | | | |
| 1993 | 220000 | | | | |
| 1994 | 100000 | | | | |
| 1995[b] | 56244 | | | | |

[a] Presmolt abundance estimates from hydroacoustic surveys unavailable at time of analysis.

[b] Preliminary escapement estimate used for 1995.

Appendix A1. Area 10 (Long Lake) sockeye salmon.

Table A1.3 Retrospective forecasts of total stock by calendar year from non-biological models. Parameter estimates are means of log-transformed total stock data.

| Year | Total Stock | Forecasts | | Parameter Est. (a) | | Standard Deviation | |
|---|---|---|---|---|---|---|---|
| | | *AVGCY* | *5YAVGCY* | *AVGCY* | *5YAVGCY* | *AVGCY* | *5YAVGCY* |
| 1972 | 135645 | | | | | | |
| 1973 | 464372 | | | | | | |
| 1974 | 438718 | 250978 | | 12.433 | | 0.870 | |
| 1975 | 115640 | 302333 | | 12.619 | | 0.695 | |
| 1976 | 153120 | 237761 | | 12.379 | | 0.743 | |
| 1977 | 183456 | 217730 | 217730 | 12.291 | 12.291 | 0.673 | 0.673 |
| 1978 | 317486 | 211603 | 231284 | 12.262 | 12.351 | 0.606 | 0.632 |
| 1979 | 31279 | 224230 | 214346 | 12.320 | 12.275 | 0.574 | 0.544 |
| 1980 | 131784 | 175292 | 126395 | 12.074 | 11.747 | 0.876 | 0.863 |
| 1981 | 368700 | 169823 | 129742 | 12.043 | 11.773 | 0.825 | 0.862 |
| 1982 | 506632 | 183512 | 154671 | 12.120 | 11.949 | 0.816 | 0.985 |
| 1983 | 330865 | 201260 | 189514 | 12.212 | 12.152 | 0.832 | 1.124 |
| 1984 | 110172 | 209773 | 191085 | 12.254 | 12.160 | 0.806 | 1.129 |
| 1985 | 619178 | 199634 | 245805 | 12.204 | 12.412 | 0.792 | 0.672 |
| 1986 | 568854 | 216445 | 334951 | 12.285 | 12.722 | 0.819 | 0.670 |
| 1987 | 394926 | 230847 | 365297 | 12.350 | 12.808 | 0.828 | 0.712 |
| 1988 | 508731 | 238726 | 347545 | 12.383 | 12.759 | 0.811 | 0.692 |
| 1989 | 238631 | 249590 | 378772 | 12.428 | 12.845 | 0.806 | 0.711 |
| 1990 | 207579 | 248969 | 442089 | 12.425 | 12.999 | 0.782 | 0.384 |
| 1991 | 834550 | 246598 | 355290 | 12.416 | 12.781 | 0.761 | 0.450 |
| 1992 | 942816 | 262097 | 383595 | 12.476 | 12.857 | 0.790 | 0.567 |
| 1993 | 504156 | 278571 | 456516 | 12.537 | 13.031 | 0.819 | 0.697 |
| 1994 | 157830 | 286185 | 455691 | 12.564 | 13.030 | 0.809 | 0.697 |
| 1995[a] | 81290 | 278875 | 419530 | 12.539 | 12.947 | 0.800 | 0.808 |
| 1996 | | 263605 | 339641 | 12.482 | 12.736 | 0.830 | 1.117 |

[a] Preliminary total stock estimate used for 1995.

Appendix A1. Area 10 (Long Lake) sockeye salmon.

Table A1.4 Retrospective forecasts of total returns by brood year.

| | | Forecasts | | | | Parameter Estimates | | | | | Standard Deviation | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Brood Yr. | Non-Biological Models | | Biological Models | | Non-Biological Models | | Biological Models | | | | |
| Year | Return | AVGBY | 5YAVGBY | LSRESC | NLSRESC | AVGBY | 5YAVGBY | LSRESC | NLSRESC | | AVGBY | 5YAVGBY |
| | | | | | | a | a | a | a | $b*10^{-5}$ | | |
| 1972 | | | | | | | | | | | | |
| 1973 | 442532 | | | | | | | | | | | |
| 1974 | | | | | | | | | | | | |
| 1975 | | | | | | | | | | | | |
| 1976 | | | | | | | | | | | | |
| 1977 | 666512 | | | | | | | | | | | |
| 1978 | | | | | | | | | | | | |
| 1979 | | 543095 | | | | 13.205 | | | | | 0.290 | |
| 1980 | 193274 | 543095 | | | | 13.205 | | | | | 0.290 | |
| 1981 | 876389 | 543095 | | | | 13.205 | | | | | 0.290 | |
| 1982 | 471087 | 384865 | | | | 12.861 | | | | | 0.631 | |
| 1983 | 427436 | 472776 | | 543455 | 489446 | 13.066 | | 2.722 | 1.296 | -0.2 | 0.659 | 0.659 |
| 1984 | 290781 | 472438 | | 268282 | 203328 | 13.066 | | 3.014 | 0.470 | 0.4 | 0.571 | 0.658 |
| 1985 | 231186 | 464622 | | 707750 | 782474 | 13.049 | | 2.831 | 0.891 | 0.1 | 0.512 | 0.572 |
| 1986 | 587994 | 434533 | 397449 | 537698 | 541479 | 12.982 | 12.893 | 2.702 | 1.001 | 0.0 | 0.500 | 0.548 |
| 1987 | 1173692 | 401574 | 411945 | 555400 | 536098 | 12.903 | 12.929 | 2.777 | 1.186 | -0.1 | 0.514 | 0.553 |
| 1988 | 456103 | 418954 | 380342 | 500940 | 401304 | 12.946 | 12.849 | 2.420 | 1.697 | -0.5 | 0.497 | 0.536 |
| 1989 | 256400 | 464414 | 456526 | 412688 | 456969 | 13.049 | 13.031 | 2.474 | 1.675 | -0.4 | 0.571 | 0.631 |
| 1990 | | 463652 | 462491 | 401853 | 476252 | 13.047 | 13.044 | 2.697 | 1.609 | -0.3 | 0.542 | 0.590 |
| 1991 | | 441319 | 450997 | 688480 | 464835 | 12.998 | 13.019 | 2.648 | 1.621 | -0.4 | 0.544 | 0.546 |
| 1992 | | 393507 | 380936 | 556820 | 512668 | 12.883 | 12.850 | 2.531 | 1.506 | -0.3 | 0.665 | 0.546 |
| 1993 | | | | | | | | | | | | |
| 1994 | | | | | | | | | | | | |
| 1995 | | | | | | | | | | | | |
| 1996 | | | | | | | | | | | | |

Appendix A1. Area 10 (Long Lake) sockeye salmon.

Table A1.5 Retrospective forecasts of age-5 returns by brood year using sibling models.

| Brood | Age -5 returns | | | Parameter Estimates | | |
|---|---|---|---|---|---|---|
| | Actual | Forecasted | | | | |
| Year | Returns | *LSIB* | *NLSIB* | *LSIB* | *NLSIB* | |
| | | | | a | a | b |
| 1972 | | | | | | |
| 1973 | 306914 | | | | | |
| 1974 | | | | | | |
| 1975 | | | | | | |
| 1976 | | | | | | |
| 1977 | 436651 | | | | | |
| 1978 | | | | | | |
| 1979 | | | | | | |
| 1980 | | | | | | |
| 1981 | 389096 | 978972 | 1011104 | 2.009 | 0.468 | 1.020 |
| 1982 | 291329 | 286714 | 285912 | 1.595 | 5.691 | 0.568 |
| 1983 | 335840 | 146555 | 195729 | 1.600 | 5.695 | 0.568 |
| 1984 | 119960 | 313799 | 303647 | 1.837 | 7.238 | 0.447 |
| 1985 | 112515 | 190112 | 227392 | 1.602 | 7.357 | 0.426 |
| 1986 | 492930 | 142596 | 181805 | 1.500 | 6.391 | 0.499 |
| 1987 | 834672 | 583792 | 336280 | 1.722 | 8.358 | 0.343 |
| 1988 | 354559 | 181155 | 223427 | 1.784 | 6.057 | 0.543 |
| 1989 | 114686 | 268832 | 281016 | 1.897 | 6.734 | 0.490 |
| 1990 | | 71680 | 137892 | 1.767 | 6.444 | 0.508 |

Appendix A1. Area 10 (Long Lake) sockeye salmon.

Table A1.6 Summary of retrospective forecasts of total stock size by calendar year.

| Year | Actual Stock | Non-Biological Models | | | | Biological Models | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | *AVGCY* | *5YAVGCY* | *AVGBY* | *5YAVGBY* | *LSRESC* | *NLSRESC* | *LSIB* | *NLSIB* |
| 1972 | 135645 | | | | | | | | |
| 1973 | 464372 | | | | | | | | |
| 1974 | 438718 | 250978 | | | | | | | |
| 1975 | 115640 | 302333 | | | | | | | |
| 1976 | 153120 | 237761 | | | | | | | |
| 1977 | 183456 | 217730 | 217730 | | | | | | |
| 1978 | 317486 | 211603 | 231284 | | | | | | |
| 1979 | 31279 | 224230 | 214346 | | | | | | |
| 1980 | 131784 | 175292 | 126395 | | | | | | |
| 1981 | 368700 | 169823 | 129742 | | | | | | |
| 1982 | 506632 | 183512 | 154671 | | | | | | |
| 1983 | 330865 | 201260 | 189514 | | | | | | |
| 1984 | 110172 | 209773 | 191085 | 543095 | | | | | |
| 1985 | 619178 | 199634 | 245805 | 543095 | | | | | |
| 1986 | 568854 | 216445 | 334951 | 543095 | | | | 1208905 | 1241037 |
| 1987 | 394926 | 230847 | 365297 | 384865 | | | | 506612 | 505810 |
| 1988 | 508731 | 238726 | 347545 | 472776 | | 436563 | 378303 | 345069 | 394243 |
| 1989 | 238631 | 249590 | 378772 | 289567 | | 438391 | 427503 | 508357 | 498206 |
| 1990 | 207579 | 248969 | 442089 | 464622 | | 646824 | 696130 | 375184 | 412465 |
| 1991 | 834550 | 246598 | 355290 | 434533 | 397449 | 544620 | 539375 | 317668 | 356877 |
| 1992 | 942816 | 262097 | 383595 | 401574 | 411945 | 533272 | 481330 | 775259 | 527746 |
| 1993 | 504156 | 278571 | 456516 | 418954 | 380342 | 467481 | 422408 | 364447 | 406719 |
| 1994 | 157830 | 286185 | 455691 | 464414 | 456526 | 408678 | 464105 | 448659 | 460843 |
| 1995 | 72188 | 278875 | 419530 | 463652 | 462491 | 504091 | 472179 | 240795 | 307007 |
| 1996 | 61918 | 263605 | 339641 | 423484 | 450997 | 639367 | 482678 | | |
| All Years | | | | | | | | | |
| RMSE | | 271399 | 261506 | 284515 | 382038 | 304270 | 326333 | 312656 | 338156 |
| MAD | | 212481 | 211904 | 217772 | 356157 | 266259 | 294066 | 263631 | 289003 |
| MAPE | | 91 | 105 | 119 | 173 | 144 | 149 | 89 | 101 |
| COUP (*10$^6$) | | -2.62 | -1.39 | 0.26 | -0.40 | 0.51 | 0.41 | 0.66 | 0.68 |
| 1986-1995[a] | | | | | | | | | |
| RMSE | | 338378 | 301705 | 278958 | 382038 | 304270 | 326333 | 312656 | 338156 |
| MAD | | 266814 | 253069 | 210426 | 356157 | 266259 | 294066 | 263631 | 289003 |
| MAPE | | 92 | 131 | 127 | 173 | 144 | 149 | 111 | 127 |
| COUP (*10$^6$) | | -1.89 | -0.49 | -0.09 | -0.40 | 0.51 | 0.41 | 0.66 | 0.68 |

[a] except *5YAVGBY* method, 1991-1995; *LSRESC* and *NLSRESC*, 1988-1995.

Appendix A2. Area 9 (Owikeno Lake) sockeye salmon.

Table A2.1 Spawning escapement, total stock and age composition data by calendar year

| Calendar Year | Escapement | Total Stock | Age Composition: Escapement Samples % age 4 | Escapement Samples % age 5 | Catch Samples % age 4 | Catch Samples % age 5 |
|---|---|---|---|---|---|---|
| 1948 | 105273 | 557000 | | | 55.0 | 45.0 |
| 1949 | 236880 | 840000 | | | 84.0 | 15.0 |
| 1950 | 444662 | 1994000 | | | 13.0 | 89.0 |
| 1951 | 304500 | 1320995 | | | 38.0 | 61.0 |
| 1952 | 582500 | 1521222 | | | 41.0 | 59.0 |
| 1953 | 440000 | 1962285 | | | 73.0 | 27.0 |
| 1954 | 103800 | 679464 | | | 60.0 | 40.0 |
| 1955 | 132900 | 717145 | | | 45.0 | 56.0 |
| 1956 | 223500 | 1295832 | | | 10.0 | 92.0 |
| 1957 | 212900 | 586876 | | | 65.0 | 35.0 |
| 1958 | 296750 | 1314295 | | | 28.0 | 71.0 |
| 1959 | 380500 | 819919 | | | 19.0 | 79.0 |
| 1960 | 128800 | 645303 | 43.0 | 57.0 | 38.0 | 57.0 |
| 1961 | 161850 | 1004803 | 31.0 | 69.0 | 49.0 | 49.0 |
| 1962 | 413500 | 1449417 | 53.0 | 47.0 | 90.0 | 9.0 |
| 1963 | 932500 | 1369959 | 47.0 | 52.0 | 37.0 | 60.0 |
| 1964 | 573900 | 1627491 | 12.0 | 86.0 | 13.0 | 79.0 |
| 1965 | 140150 | 785124 | 36.0 | 64.0 | 69.0 | 27.0 |
| 1966 | 200000 | 728212 | 42.0 | 58.0 | 34.0 | 65.0 |
| 1967 | 435250 | 1538088 | 40.0 | 60.0 | 78.0 | 20.0 |
| 1968 | 555000 | 3282552 | | | 7.0 | 90.0 |
| 1969 | 226000 | 953330 | | | 35.0 | 61.0 |
| 1970 | 102250 | 121269 | 40.0 | 50.0 | 40.0 | 49.0 |
| 1971 | 215900 | 618438 | 76.0 | 22.0 | 75.0 | 23.0 |
| 1972 | 224000 | 603006 | 81.0 | 14.0 | 48.0 | 45.0 |
| 1973 | 985000 | 2745156 | 6.0 | 94.0 | 6.0 | 94.0 |
| 1974 | 557025 | 675599 | 19.0 | 78.0 | 19.0 | 78.0 |
| 1975 | 480002 | 520633 | 47.0 | 52.0 | 47.0 | 52.0 |
| 1976 | 300000 | 913067 | | | 47.0 | 51.0 |
| 1977 | 192600 | 852419 | | | 44.0 | 54.0 |
| 1978 | 383000 | 960908 | 3.0 | 95.0 | 4.0 | 94.0 |
| 1979 | 297525 | 325853 | 57.0 | 41.0 | 57.0 | 41.0 |
| 1980 | 313000 | 313528 | 17.0 | 83.0 | 17.0 | 83.0 |
| 1981 | 753075 | 851781 | 34.0 | 65.0 | 34.0 | 65.0 |
| 1982 | 823000 | 862180 | | | 12.0 | 85.0 |
| 1983 | 636502 | 671663 | 19.0 | 80.0 | 19.0 | 80.0 |
| 1984 | 214301 | 268180 | 62.0 | 38.0 | 74.0 | 26.0 |
| 1985 | 500430 | 684973 | 21.0 | 79.0 | 38.0 | 62.0 |
| 1986 | 825626 | 1163069 | 17.0 | 83.0 | 34.0 | 66.0 |
| 1987 | 521700 | 920554 | 9.0 | 87.0 | 42.0 | 58.0 |
| 1988 | 503000 | 875018 | 4.0 | 96.0 | 18.0 | 82.0 |
| 1989 | 375175 | 438921 | 56.0 | 44.0 | 39.0 | 61.0 |
| 1990 | 586500 | 820781 | 12.0 | 88.0 | 11.0 | 86.0 |
| 1991 | 346500 | 514726 | 39.0 | 61.0 | 26.0 | 71.0 |
| 1992 | 343005 | 851073 | 17.0 | 76.0 | 9.0 | 90.0 |
| 1993 | 311000 | 394146 | 18.0 | 82.0 | 34.0 | 63.0 |
| 1994 | 91500 | 131820 | 14.0 | 84.0 | 34.0 | 63.0 |

Appendix A2. Area 9 (Owikeno Lake) sockeye salmon.

Table A2.2 Escapement and brood year returns by age class.

| Brood Year | Escapement | Adult Returns Age 4 | Age 5 | Total |
|---|---|---|---|---|
| 1948 | 105273 | | | |
| 1949 | 236880 | | | |
| 1950 | 444662 | | | |
| 1951 | 304500 | | | |
| 1952 | 582500 | | | |
| 1953 | 440000 | | | |
| 1954 | 103800 | | | |
| 1955 | 132900 | | 367823 | |
| 1956 | 223500 | 251655 | 524723 | 776379 |
| 1957 | 212900 | 463220 | 287578 | 750798 |
| 1958 | 296750 | 1151480 | 747375 | 1898856 |
| 1959 | 380500 | 600135 | 1325891 | 1926026 |
| 1960 | 128800 | 205835 | 263839 | 469674 |
| 1961 | 161850 | 495486 | 459338 | 954824 |
| 1962 | 413500 | 263592 | 481718 | 745310 |
| 1963 | 932500 | 1034314 | 2454797 | 3489110 |
| 1964 | 573900 | | | |
| 1965 | 140150 | | 60444 | |
| 1966 | 200000 | 48508 | 140082 | 188589 |
| 1967 | 435250 | 465988 | 201913 | 667900 |
| 1968 | 555000 | 363363 | 2580447 | 2943810 |
| 1969 | 226000 | 164709 | 526967 | 691677 |
| 1970 | 102250 | 128364 | 270729 | 399093 |
| 1971 | 215900 | 244698 | | |
| 1972 | 224000 | | | |
| 1973 | 985000 | | 907084 | |
| 1974 | 557025 | 34606 | 133600 | 168206 |
| 1975 | 480002 | 185736 | 260228 | 445964 |
| 1976 | 300000 | 53300 | 553658 | 606957 |
| 1977 | 192600 | 289606 | | |
| 1978 | 383000 | | 537330 | |
| 1979 | 297525 | 127616 | 95443 | 223059 |
| 1980 | 313000 | 172737 | 509756 | 682493 |
| 1981 | 753075 | 175217 | 907982 | 1083199 |
| 1982 | 823000 | 255087 | 685214 | 940301 |
| 1983 | 636502 | 214472 | 787935 | 1002406 |
| 1984 | 214301 | 87083 | 203962 | 291045 |
| 1985 | 500430 | 234959 | 717602 | 952561 |
| 1986 | 825626 | 96151 | 330805 | 426956 |
| 1987 | 521700 | 178874 | 717945 | 896819 |
| 1988 | 503000 | 104037 | 307013 | 411050 |
| 1989 | 375175 | 84040 | 102148 | 186187 |
| 1990 | 586500 | 26457 | 98147 | 124604 |
| 1991 | 346500 | 20279 | 34450 | 54729 |
| 1992 | 343005 | 27950 | | |
| 1993 | 311000 | | | |
| 1994 | 91500 | | | |
| 1995 | | | | |

Appendix A2. Area 9 (Owikeno Lake) sockeye salmon

Table A2.3 Retrospective forecasts of total stock by calendar year from non-biological models. Parameter estimates are means of log-transformed total stock data.

| Year | Total Stock | Forecasts | | Parameter Est. (a) | | Standard Deviation | |
|---|---|---|---|---|---|---|---|
| | | *AVGCY* | *5YAVGCY* | *AVGCY* | *5YAVGCY* | *AVGCY* | *5YAVGCY* |
| 1948 | 557000 | | | | | | |
| 1949 | 840000 | | | | | | |
| 1950 | 1994000 | | | | | | |
| 1951 | 1320995 | 684018 | | 13.436 | | 0.291 | |
| 1952 | 1521222 | 977132 | | 13.792 | | 0.651 | |
| 1953 | 1962285 | 1053635 | | 13.868 | | 0.552 | |
| 1954 | 679464 | 1133942 | 1133942 | 13.941 | 13.941 | 0.506 | 0.506 |
| 1955 | 717145 | 1242470 | 1458720 | 14.033 | 14.193 | 0.505 | 0.354 |
| 1956 | 1295832 | 1139831 | 1398136 | 13.946 | 14.151 | 0.514 | 0.439 |
| 1957 | 586876 | 1075687 | 1139530 | 13.888 | 13.946 | 0.503 | 0.470 |
| 1958 | 1314295 | 1098173 | 1135156 | 13.909 | 13.942 | 0.475 | 0.468 |
| 1959 | 819919 | 1031474 | 938266 | 13.846 | 13.752 | 0.490 | 0.511 |
| 1960 | 645303 | 1054448 | 865989 | 13.869 | 13.672 | 0.470 | 0.382 |
| 1961 | 1004803 | 1032573 | 899152 | 13.848 | 13.709 | 0.454 | 0.360 |
| 1962 | 1449417 | 995901 | 880369 | 13.811 | 13.688 | 0.454 | 0.379 |
| 1963 | 1369959 | 996534 | 836702 | 13.812 | 13.637 | 0.436 | 0.328 |
| 1964 | 1627491 | 1021737 | 1002537 | 13.837 | 13.818 | 0.431 | 0.333 |
| 1965 | 785124 | 1040638 | 1010889 | 13.855 | 13.826 | 0.423 | 0.342 |
| 1966 | 728212 | 1068376 | 1159452 | 13.882 | 13.963 | 0.424 | 0.373 |
| 1967 | 1538088 | 1050248 | 1205835 | 13.865 | 14.003 | 0.418 | 0.299 |
| 1968 | 3282552 | 1030200 | 1130637 | 13.845 | 13.938 | 0.414 | 0.373 |
| 1969 | 953330 | 1051053 | 1144144 | 13.865 | 13.950 | 0.413 | 0.384 |
| 1970 | 121269 | 1109625 | 1362641 | 13.920 | 14.125 | 0.473 | 0.616 |
| 1971 | 618438 | 1101994 | 1224409 | 13.913 | 14.018 | 0.463 | 0.623 |
| 1972 | 603006 | 1001171 | 842731 | 13.817 | 13.644 | 0.645 | 1.225 |
| 1973 | 2745156 | 981276 | 815636 | 13.797 | 13.612 | 0.639 | 1.232 |
| 1974 | 675599 | 962349 | 676339 | 13.777 | 13.424 | 0.633 | 1.182 |
| 1975 | 520633 | 1001939 | 652583 | 13.817 | 13.389 | 0.653 | 1.124 |
| 1976 | 913067 | 987421 | 609151 | 13.803 | 13.320 | 0.645 | 1.105 |
| 1977 | 852419 | 965106 | 815232 | 13.780 | 13.611 | 0.644 | 0.685 |
| 1978 | 960908 | 963263 | 881297 | 13.778 | 13.689 | 0.633 | 0.668 |
| 1979 | 325853 | 959346 | 944471 | 13.774 | 13.758 | 0.622 | 0.636 |
| 1980 | 313528 | 959396 | 765617 | 13.774 | 13.548 | 0.612 | 0.254 |
| 1981 | 851781 | 927561 | 661726 | 13.740 | 13.403 | 0.631 | 0.465 |
| 1982 | 862180 | 897569 | 597898 | 13.707 | 13.301 | 0.649 | 0.573 |
| 1983 | 671663 | 896188 | 589647 | 13.706 | 13.287 | 0.640 | 0.561 |
| 1984 | 268180 | 895198 | 590991 | 13.705 | 13.290 | 0.630 | 0.563 |
| 1985 | 684973 | 888082 | 550142 | 13.697 | 13.218 | 0.623 | 0.506 |
| 1986 | 1163069 | 859802 | 529122 | 13.664 | 13.179 | 0.645 | 0.561 |
| 1987 | 920554 | 854674 | 618636 | 13.658 | 13.335 | 0.637 | 0.482 |
| 1988 | 875018 | 861452 | 658402 | 13.666 | 13.398 | 0.631 | 0.549 |
| 1989 | 438921 | 862883 | 667085 | 13.668 | 13.411 | 0.623 | 0.558 |
| 1990 | 820781 | 863176 | 703322 | 13.668 | 13.464 | 0.615 | 0.571 |
| 1991 | 514726 | 849389 | 776151 | 13.652 | 13.562 | 0.616 | 0.370 |
| 1992 | 851073 | 848712 | 804743 | 13.651 | 13.598 | 0.609 | 0.364 |
| 1993 | 393529 | 839121 | 683677 | 13.640 | 13.435 | 0.606 | 0.339 |
| 1994 | 131639 | 839384 | 673030 | 13.640 | 13.420 | 0.600 | 0.323 |
| 1995 | | 825675 | 573623 | 13.624 | 13.260 | 0.603 | 0.357 |
| 1996 | | 794040 | 450844 | 13.585 | 13.019 | 0.654 | 0.761 |

Appendix A2. Area 9 (Owikeno Lake) sockeye salmon.

Table A2.4 Retrospective forecasts of total returns by brood year.

| Year | Brood Yr. Returns | Forecasts AVGBY | Forecasts 5YAVGBY | Forecasts LSRESC | Forecasts NLSRESC | Parameter Estimates AVGBY a | Parameter Estimates 5YAVGBY a | Parameter Estimates LSRESC a | Parameter Estimates NLSRESC a | Parameter Estimates NLSRESC $b*10^{-5}$ | Standard Deviation AVGBY | Standard Deviation 5YAVGBY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1955 | | | | | | | | | | | | |
| 1956 | 776379 | | | | | | | | | | | |
| 1957 | 750798 | | | | | | | | | | | |
| 1958 | 1898856 | | | | | | | | | | | |
| 1959 | 1926026 | 763481 | | | | 13.546 | | | | | 0.024 | |
| 1960 | 469674 | 1034418 | | | | 13.849 | | 3.500 | 1.563 | -0.1 | 0.526 | |
| 1961 | 954824 | 1208336 | | | | 14.005 | | 4.280 | -0.393 | 0.8 | 0.530 | |
| 1962 | 745310 | 1000252 | 1000252 | | | 13.816 | 13.816 | 4.463 | 0.746 | 0.3 | 0.624 | 0.624 |
| 1963 | 3489110 | 992533 | 1042508 | | | 13.808 | 13.857 | 4.286 | 0.952 | 0.2 | 0.559 | 0.610 |
| 1964 | | 952736 | 1040979 | 2594602 | 3495932 | 13.767 | 13.856 | 4.521 | 1.233 | 0.1 | 0.521 | 0.611 |
| 1965 | | 1120573 | 1175673 | 555555 | 678961 | 13.929 | 13.977 | 3.964 | 1.718 | -0.1 | 0.666 | 0.794 |
| 1966 | 188589 | 1120573 | | 787200 | 863779 | 13.929 | | 3.936 | 1.463 | 0.0 | 0.666 | |
| 1967 | 667900 | 1120573 | | 1713144 | 1879800 | 13.929 | | 3.936 | 1.463 | 0.0 | 0.666 | |
| 1968 | 2943810 | 919282 | | 2184480 | 2396988 | 13.731 | | 3.936 | 1.463 | 0.0 | 0.861 | |
| 1969 | 691677 | 890379 | | 758908 | 730358 | 13.699 | | 3.358 | 1.173 | 0.0 | 0.818 | |
| 1970 | 399093 | 992630 | | 317486 | 438527 | 13.808 | | 3.105 | 1.456 | 0.0 | 0.856 | |
| 1971 | | 963194 | | 703834 | 664354 | 13.778 | | 3.260 | 1.124 | 0.0 | 0.822 | |
| 1972 | | 900077 | 633903 | 726432 | 684471 | 13.710 | 13.360 | 3.243 | 1.117 | 0.0 | 0.824 | 1.006 |
| 1973 | | 900077 | | 3239665 | 3148375 | 13.710 | | 3.289 | 1.162 | 0.0 | 0.824 | |
| 1974 | 168206 | 900077 | | 1832055 | 1780430 | 13.710 | | 3.289 | 1.162 | 0.0 | 0.824 | |
| 1975 | 445964 | 900077 | | 1578727 | 1534240 | 13.710 | | 3.289 | 1.162 | 0.0 | 0.824 | |
| 1976 | 606957 | 798451 | | 986700 | 958896 | 13.590 | | 3.289 | 1.162 | 0.0 | 0.910 | |
| 1977 | | 768043 | | 534272 | 559484 | 13.552 | | 2.774 | 1.259 | -0.1 | 0.890 | |
| 1978 | | 756826 | | 987374 | 919688 | 13.537 | | 2.578 | 1.259 | -0.1 | 0.862 | |
| 1979 | 223059 | 756826 | | 755714 | 758220 | 13.537 | | 2.540 | 1.233 | -0.1 | 0.862 | |
| 1980 | 682493 | 756826 | | 795020 | 785408 | 13.537 | | 2.540 | 1.233 | -0.1 | 0.862 | |
| 1981 | 1083199 | 704345 | | 1912811 | 1216934 | 13.465 | | 2.540 | 1.233 | -0.1 | 0.885 | |
| 1982 | 940301 | 703113 | | 1945572 | 1114272 | 13.463 | | 2.364 | 1.126 | -0.1 | 0.859 | |
| 1983 | 1002406 | 719289 | | 1497689 | 1030177 | 13.486 | | 2.353 | 1.118 | -0.1 | 0.841 | |
| 1984 | 291045 | 728990 | | 491392 | 540276 | 13.499 | | 2.293 | 1.139 | -0.1 | 0.820 | |
| 1985 | 952561 | 740131 | 689140 | 1108452 | 982438 | 13.515 | 13.443 | 2.215 | 1.175 | -0.1 | 0.803 | 0.655 |
| 1986 | 426956 | 709387 | 726801 | 1799039 | 1175579 | 13.472 | 13.496 | 2.179 | 1.179 | -0.1 | 0.808 | 0.541 |
| 1987 | 896819 | 718537 | 776917 | 1112786 | 937665 | 13.485 | 13.563 | 2.133 | 1.108 | -0.1 | 0.792 | 0.552 |
| 1988 | 411050 | 703120 | 644925 | 1067366 | 920199 | 13.463 | 13.377 | 2.122 | 1.107 | -0.1 | 0.782 | 0.568 |
| 1989 | 186187 | 709997 | 638847 | 753351 | 854245 | 13.473 | 13.367 | 2.008 | 1.198 | -0.1 | 0.767 | 0.561 |
| 1990 | 124604 | 695228 | 534524 | 1166549 | 1081033 | 13.452 | 13.189 | 1.989 | 1.198 | -0.1 | 0.759 | 0.522 |
| 1991 | | 662118 | 488838 | 665973 | 803826 | 13.403 | 13.100 | 1.922 | 1.188 | -0.1 | 0.786 | 0.670 |
| 1992 | | 662118 | 325457 | 627013 | 742290 | 13.403 | 12.693 | 1.828 | 1.115 | -0.1 | 0.834 | 0.819 |
| 1993 | | | | | | | | | | | | |
| 1994 | | | | | | | | | | | | |
| 1995 | | | | | | | | | | | | |

Appendix A2. Area 9 (Owikeno Lake) sockeye salmon.

Table A2.5 Retrospective forecasts of age-5 returns by brood year using sibling models.

| | Age-5 returns | | | Parameter Estimates | | |
|---|---|---|---|---|---|---|
| | | Forecasted | | | | |
| Brood Year | Actual Returns | *LSIB* | *NLSIB* | *LSIB* a | *NLSIB* a | b |
| 1955 | 367823 | | | | | |
| 1956 | 524723 | | | | | |
| 1957 | 287578 | | | | | |
| 1958 | 747375 | 1310385 | 116522 | 1.138 | 25.427 | -0.986 |
| 1959 | 1325891 | 566527 | 505475 | 0.944 | 9.195 | 0.296 |
| 1960 | 263839 | 240209 | 425940 | 1.167 | 8.166 | 0.392 |
| 1961 | 459338 | 589133 | 562011 | 1.189 | 5.568 | 0.585 |
| 1962 | 481718 | 300759 | 378602 | 1.141 | 5.667 | 0.575 |
| 1963 | 2454797 | 1261863 | 815174 | 1.220 | 6.368 | 0.523 |
| 1964 | | | | | | |
| 1965 | 60444 | | | | | |
| 1966 | 140082 | 64321 | 95713 | 1.326 | 2.557 | 0.826 |
| 1967 | 201913 | 673818 | 628117 | 1.446 | 3.927 | 0.722 |
| 1968 | 2580447 | 465831 | 469570 | 1.282 | 4.251 | 0.688 |
| 1969 | 526967 | 246735 | 318747 | 1.498 | 4.468 | 0.683 |
| 1970 | 270729 | 204740 | 293547 | 1.595 | 5.097 | 0.637 |
| 1971 | | 398857 | 437144 | 1.630 | 4.985 | 0.645 |
| 1972 | | | | | | |
| 1973 | 907084 | | | | | |
| 1974 | 133600 | 56408 | 123798 | 1.630 | 4.985 | 0.645 |
| 1975 | 260228 | 322067 | 369070 | 1.734 | 5.127 | 0.634 |
| 1976 | 553658 | 91089 | 162120 | 1.709 | 4.987 | 0.644 |
| 1977 | | 554015 | 507803 | 1.913 | 6.485 | 0.529 |
| 1978 | 537330 | | | | | |
| 1979 | 95443 | 244129 | 329172 | 1.913 | 6.485 | 0.529 |
| 1980 | 509756 | 312654 | 355105 | 1.810 | 5.858 | 0.574 |
| 1981 | 907982 | 325903 | 366556 | 1.860 | 5.954 | 0.568 |
| 1982 | 685214 | 500736 | 473518 | 1.963 | 6.171 | 0.554 |
| 1983 | 787935 | 427657 | 440072 | 1.994 | 6.157 | 0.557 |
| 1984 | 203962 | 178782 | 274008 | 2.053 | 6.208 | 0.555 |
| 1985 | 717602 | 485190 | 468966 | 2.065 | 6.009 | 0.570 |
| 1986 | 330805 | 202013 | 286915 | 2.101 | 6.004 | 0.572 |
| 1987 | 717945 | 383684 | 413102 | 2.145 | 6.086 | 0.566 |
| 1988 | 307013 | 228777 | 310815 | 2.199 | 6.166 | 0.561 |
| 1989 | 102148 | 186905 | 274088 | 2.224 | 6.160 | 0.561 |
| 1990 | 98147 | 57545 | 127630 | 2.175 | 5.596 | 0.605 |
| 1991 | | | | | | |

Appendix A 2. Area 9 (Owikeno Lake) sockeye salmon.

Table A2.6 Summary of retrospective forecasts of total stock size by calendar year.

| Year | Actual Stock | Non-Biological Models | | | | Biological Models | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | *AVGCY* | *5YAVGCY* | *AVGBY* | *5YAVGBY* | *LSRESC* | *NLSRESC* | *LSIB* | *NLSIB* |
| 1948 | 557000 | | | | | | | | |
| 1949 | 840000 | | | | | | | | |
| 1950 | 1994000 | | | | | | | | |
| 1951 | 1320995 | 684018 | | | | | | | |
| 1952 | 1521222 | 977132 | | | | | | | |
| 1953 | 1962285 | 1053635 | | | | | | | |
| 1954 | 679464 | 1133942 | 1133942 | | | | | | |
| 1955 | 717145 | 1242470 | 1458720 | | | | | | |
| 1956 | 1295832 | 1139831 | 1398136 | | | | | | |
| 1957 | 586876 | 1075687 | 1139530 | | | | | | |
| 1958 | 1314295 | 1098173 | 1135156 | | | | | | |
| 1959 | 819919 | 1031474 | 938266 | | | | | | |
| 1960 | 645303 | 1054448 | 865989 | | | | | | |
| 1961 | 1004803 | 1032573 | 899152 | | | | | | |
| 1962 | 1449417 | 995901 | 880369 | | | | | | |
| 1963 | 1369959 | 996534 | 836702 | | | | | 1667822 | 473960 |
| 1964 | 1627491 | 1021737 | 1002537 | 763481 | | | | 1188646 | 1127593 |
| 1965 | 785124 | 1040638 | 1010889 | 1034418 | | | | 856832 | 1042562 |
| 1966 | 728212 | 1068376 | 1159452 | 1208336 | | | | 1123598 | 1096476 |
| 1967 | 1538088 | 1050248 | 1205835 | 1000252 | 1000252 | | | 828727 | 906571 |
| 1968 | 3282552 | 1030200 | 1130637 | 992533 | 1042508 | 1217859 | 1640926 | 1752063 | 1305375 |
| 1969 | 953330 | 1051053 | 1144144 | 952736 | 1040979 | 1426552 | 1890605 | | |
| 1970 | 121269 | 1109625 | 1362641 | 1120573 | 1175673 | 581815 | 668469 | | |
| 1971 | 618438 | 1101994 | 1224409 | 1120573 | | 1083399 | 1188792 | 622536 | 653927 |
| 1972 | 603006 | 1001171 | 842731 | 1120573 | | 1688840 | 1853131 | 1175398 | 1129698 |
| 1973 | 2745156 | 981276 | 815636 | 919282 | | 1217781 | 1293891 | 963852 | 967591 |
| 1974 | 675599 | 962349 | 676339 | 890379 | | 475906 | 516799 | 732514 | 804527 |
| 1975 | 520633 | 1001939 | 652583 | 992630 | | 421966 | 455664 | 663764 | 752570 |
| 1976 | 913067 | 987421 | 609151 | 963194 | | 570064 | 537604 | 832445 | 870732 |
| 1977 | 852419 | 965106 | 815232 | 900077 | 633903 | 1557304 | 1504983 | | |
| 1978 | 960908 | 963263 | 881297 | 900077 | | 1991432 | 1935316 | | |
| 1979 | 325853 | 959346 | 944471 | 900077 | | 1339258 | 1301519 | 476504 | 543894 |
| 1980 | 313528 | 959396 | 765617 | 900077 | | 1007325 | 978940 | 716463 | 763466 |
| 1981 | 851781 | 927561 | 661726 | 798451 | | 576909 | 575926 | 472445 | 543476 |
| 1982 | 862180 | 897569 | 597898 | 768043 | | 580937 | 564721 | 916074 | 869861 |
| 1983 | 671663 | 896188 | 589647 | 756826 | | 633453 | 609766 | | |
| 1984 | 268180 | 895198 | 590991 | 756826 | | 563550 | 560968 | 602162 | 687205 |
| 1985 | 684973 | 888082 | 550142 | 756826 | | 984049 | 727668 | 658560 | 701010 |
| 1986 | 1163069 | 859802 | 529122 | 704345 | | 1449539 | 875801 | 663150 | 703803 |
| 1987 | 920554 | 854674 | 618636 | 703113 | | 1270134 | 791034 | 830267 | 803050 |
| 1988 | 875018 | 861452 | 658402 | 719289 | | 712040 | 562182 | 753804 | 766220 |
| 1989 | 438921 | 862883 | 667085 | 728990 | | 565769 | 538492 | 500074 | 595301 |
| 1990 | 820781 | 863176 | 703322 | 740131 | 689140 | 1008865 | 748806 | 796724 | 780499 |
| 1991 | 514726 | 849389 | 776151 | 709387 | 726801 | 1004045 | 728681 | 510484 | 595386 |
| 1992 | 851073 | 848712 | 804743 | 718537 | 776917 | 742448 | 632693 | 683989 | 713407 |
| 1993 | 393529 | 839121 | 683677 | 703120 | 644925 | 611292 | 595756 | 524584 | 606622 |
| 1994 | 131639 | 839384 | 673030 | 709997 | 638847 | 634126 | 639205 | 475863 | 563046 |
| 1995[a] | 118426 | 825675 | 573623 | 695228 | 534524 | 599825 | 616956 | 339436 | 409522 |
| 1996 | | 794040 | 450844 | 662118 | 488838 | 429164 | 513182 | 317603 | N/A |
| All Years | | | | | | | | | |
| RMSE | | 605264 | 599560 | 657929 | 310128 | 683416 | 652878 | 526491 | 603846 |
| MAD | | 434376 | 411424 | 439970 | 268500 | 510048 | 492717 | 325428 | 387387 |
| MAPE | | 94 | 88 | 105 | 158 | 108 | 108 | 50 | 62 |
| COUP ($*10^6$) | | 1.98 | -0.39 | 0.54 | 1.20 | 4.08 | 3.10 | -2.59 | -3.15 |
| 1986-1995[b] | | | | | | | | | |
| RMSE | | 402007 | 357480 | 348239 | 310128 | 329131 | 295210 | 223162 | 248078 |
| MAD | | 306511 | 311102 | 301299 | 268500 | 293198 | 256025 | 168267 | 205458 |
| MAPE | | 158 | 119 | 132 | 158 | 118 | 113 | 64 | 83 |
| COUP | | 2294957 | 478482 | 922828 | 1199407 | 2388772 | 520296 | -130934 | 327545 |

[a] Preliminary stock size used for 1995

[b] except *5YAVGBY* method, 1990-1995

Appendix A3. Area 4 (Skeena River) sockeye salmon.

Table A3.1. Spawning escapment, total stock and age composition data by calendar year.

| Calendar | | Total | Age Composition | | |
|---|---|---|---|---|---|
| Year | Escapement | Stock | % age 4 | % age 5 | % other |
| 1970 | 678652 | 1486243 | 62.26 | 30.54 | 7.19 |
| 1971 | 821850 | 1983222 | 56.94 | 38.25 | 4.81 |
| 1972 | 697237 | 1735617 | 24.24 | 70.97 | 4.79 |
| 1973 | 820196 | 2448390 | 47.09 | 43.19 | 9.71 |
| 1974 | 723898 | 2552057 | 32.59 | 63.80 | 3.61 |
| 1975 | 822633 | 1518749 | 74.21 | 23.98 | 1.81 |
| 1976 | 582652 | 1504761 | 36.46 | 61.46 | 2.08 |
| 1977 | 951805 | 2496644 | 45.32 | 51.82 | 2.85 |
| 1978 | 424075 | 1184299 | 22.27 | 73.03 | 4.70 |
| 1979 | 1166236 | 2924595 | 85.43 | 10.72 | 3.85 |
| 1980 | 541964 | 1473109 | 19.55 | 74.18 | 6.26 |
| 1981 | 1424209 | 3679645 | 86.35 | 11.17 | 2.48 |
| 1982 | 1140246 | 3785048 | 16.42 | 80.29 | 3.29 |
| 1983 | 893724 | 2149794 | 35.14 | 60.95 | 3.90 |
| 1984 | 1055215 | 2392288 | 60.68 | 32.98 | 6.34 |
| 1985 | 2174806 | 5132530 | 33.77 | 64.75 | 1.48 |
| 1986 | 714307 | 1785674 | 34.23 | 62.53 | 3.24 |
| 1987 | 1324128 | 2329397 | 41.97 | 54.81 | 3.22 |
| 1988 | 1417593 | 3855686 | 68.14 | 27.76 | 4.10 |
| 1989 | 1137994 | 2609613 | 33.41 | 62.47 | 4.13 |
| 1990 | 989482 | 2628803 | 31.10 | 61.91 | 6.99 |
| 1991 | 1232578 | 3668724 | 24.20 | 67.60 | 8.20 |
| 1992 | 1236158 | 4423945 | 37.79 | 45.67 | 16.54 |
| 1993 | 1629426 | 4894865 | 32.66 | 59.15 | 8.19 |
| 1994 | 1026806 | 2719696 | 23.76 | 68.89 | 7.35 |

Appendix A3. Area 4 (Skeena River) sockeye salmon.

Table A3.2 Escapement and brood year returns by age class for age 1.* sockeye.

| Brood Year | Escapement | Adult Returns Age 3 | Age 4 | Age 5 | Total |
|---|---|---|---|---|---|
| 1970 | 678652 | 208350 | 831757 | 364197 | 1404304 |
| 1971 | 821850 | 256772 | 1127097 | 924801 | 2308670 |
| 1972 | 697237 | 137396 | 548679 | 1293885 | 1979959 |
| 1973 | 820196 | 255458 | 1131537 | 864870 | 2251865 |
| 1974 | 723898 | 47697 | 263777 | 313432 | 624906 |
| 1975 | 822633 | 296274 | 2498508 | 1092804 | 3887586 |
| 1976 | 582652 | 90509 | 288034 | 411161 | 789704 |
| 1977 | 951805 | 233886 | 3177365 | 3039052 | 6450304 |
| 1978 | 424075 | 155395 | 621563 | 1310373 | 2087331 |
| 1979 | 1166236 | 60223 | 755494 | 788985 | 1604702 |
| 1980 | 541964 | 353135 | 1451716 | 3323273 | 5128123 |
| 1981 | 1424209 | 120752 | 1733185 | 1116550 | 2970487 |
| 1982 | 1140246 | 66714 | 611270 | 1276820 | 1954804 |
| 1983 | 893724 | 88125 | 977637 | 1070368 | 2136130 |
| 1984 | 1055215 | 638641 | 2627321 | 1630157 | 4896120 |
| 1985 | 2174806 | 77631 | 871807 | 1627596 | 2577034 |
| 1986 | 714307 | 122711 | 817553 | 2480221 | 3420485 |
| 1987 | 1324128 | 89631 | 887664 | 2020415 | 2997710 |
| 1988 | 1417593 | 416049 | 1671873 | 2895397 | 4983319 |
| 1989 | 1137994 | 258240 | 1598624 | 1873677 | 3730540 |
| 1990 | 989482 | 90580 | 646101 | 2099914 | 2836594 |
| 1991 | 1232578 | 320804 | 2286244 | 2740730 | 5347777 |
| 1992 | 1236158 | 542895 | 3701513 | | |
| 1993 | 1629426 | 43000 | | | |
| 1994 | 1026806 | | | | |

Appendix A3. Area 4 (Skeena River) sockeye salmon.

Table A3.3. Retrospective forecasts of total stock by calendar year from non-biological models. Parameter estimates are means of log-transformed tota stock data.

| Year | Total [a] Stock | Forecasts | | Parameter Est. (a) | | Standard Deviation | |
|---|---|---|---|---|---|---|---|
| | | *AVGCY* | *5YAVGCY* | *AVGCY* | *5YAVGCY* | *AVGCY* | *5YAVGCY* |
| 1970 | 1466278 | | | | | | |
| 1971 | 1969532 | 1466278 | | 14.198 | | | |
| 1972 | 1729740 | 1699377 | | 14.346 | | 0.209 | |
| 1973 | 2439682 | 1709438 | | 14.352 | | 0.148 | |
| 1974 | 2550392 | 1868415 | | 14.441 | | 0.215 | |
| 1975 | 1512451 | 1988383 | 1988383 | 14.503 | 14.503 | 0.232 | 0.232 |
| 1976 | 1502102 | 1899752 | 2000751 | 14.457 | 14.509 | 0.236 | 0.222 |
| 1977 | 2488293 | 1837071 | 1895223 | 14.424 | 14.455 | 0.233 | 0.257 |
| 1978 | 1180465 | 1908085 | 2038189 | 14.462 | 14.528 | 0.241 | 0.276 |
| 1979 | 2921826 | 1808948 | 1762741 | 14.408 | 14.382 | 0.276 | 0.341 |
| 1980 | 1474694 | 1897794 | 1811332 | 14.456 | 14.410 | 0.302 | 0.381 |
| 1981 | 3686199 | 1854771 | 1802196 | 14.433 | 14.405 | 0.296 | 0.384 |
| 1982 | 3795223 | 1964027 | 2156641 | 14.491 | 14.584 | 0.345 | 0.476 |
| 1983 | 2150767 | 2066115 | 2346633 | 14.541 | 14.668 | 0.377 | 0.541 |
| 1984 | 2394505 | 2072049 | 2645776 | 14.544 | 14.788 | 0.363 | 0.398 |
| 1985 | 5137073 | 2092126 | 2542526 | 14.554 | 14.749 | 0.352 | 0.396 |
| 1986 | 1786952 | 2212946 | 3263384 | 14.610 | 14.998 | 0.407 | 0.358 |
| 1987 | 2331914 | 2185287 | 2823417 | 14.597 | 14.853 | 0.398 | 0.435 |
| 1988 | 3858728 | 2193186 | 2561357 | 14.601 | 14.756 | 0.386 | 0.406 |
| 1989 | 2609950 | 2259382 | 2878990 | 14.631 | 14.873 | 0.397 | 0.426 |
| 1990 | 2632867 | 2275735 | 2929028 | 14.638 | 14.890 | 0.388 | 0.419 |
| 1991 | 3648927 | 2291587 | 2562513 | 14.645 | 14.756 | 0.379 | 0.277 |
| 1992 | 4774692 | 2340558 | 2955811 | 14.666 | 14.899 | 0.383 | 0.224 |
| 1993 | 4880351 | 2414246 | 3411326 | 14.697 | 15.043 | 0.403 | 0.261 |
| 1994 | 2692425 | 2486095 | 3575399 | 14.726 | 15.090 | 0.419 | 0.306 |
| 1995 | 5000000[b] | 2494036 | 3597716 | 14.729 | 15.096 | 0.411 | 0.298 |
| 1996 | | 2561656 | 4090111 | 14.756 | 15.224 | 0.425 | 0.266 |

[a] Data has been revised see Appendix B.

[b] Preliminary data was used for 1995

Appendix A3. Area 4 (Skeena River) sockeye salmon.

Table A3.4. Retrospective forecasts of total returns by brood year for age 1.* sockeye.

| | | Forecasts | | | | | | Parameter Estimates | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Brood Yr. [a] | Non-Biological Models | | Biological Models | | | | Non-Biological Models | | Biological Models | | | | | | Standard Deviation | |
| Year | Return | AVGBY | 5YAVGBY | LSRESC | LSRJUV | NLSRESC | NLSRJUV | AVGBY | 5YAVGBY | LSRESC | LSRJUV | NLSRESC | | NLSRJUV | | AVGBY | 5YAVGBY |
| | | | | | | | | a | a | a | a | a | b | a | b | | |
| 1970 | 1401768 | | | | | | | | | | | | | | | | |
| 1971 | 2301822 | | | | | | | | | | | | | | | | |
| 1972 | 1972939 | | | | | | | | | | | | | | | | |
| 1973 | 2239611 | 1796279 | | | | | | 14.153 | | | | | | | | | |
| 1974 | 622482 | 1853334 | | | | | | 14.401 | | | | | | | | 0.351 | |
| 1975 | 3884020 | 1943160 | | 1838701 | 1117740 | | | 14.432 | | 2.540 | 0.026 | | | | | 0.254 | |
| 1976 | 790212 | 1547505 | 1547505 | 2127329 | 1952000 | 2012520 | 2118851 | 14.480 | | 2.586 | 0.032 | 0.072 | 1.00E-06 | -2.445 | -1.50E-08 | 0.228 | |
| 1977 | 6460139 | 1804016 | 1897375 | 1209003 | 2128000 | 1028181 | 1851014 | 14.252 | 14.252 | 2.075 | 0.028 | -1.180 | 3.00E-06 | -3.183 | -7.00E-09 | 0.546 | 0.546 |
| 1978 | 2088740 | 1603343 | 1532102 | 2261488 | 3462400 | 4033936 | 2376387 | 14.406 | 14.456 | 2.380 | 0.032 | -2.355 | 4.00E-06 | -3.061 | -7.00E-09 | 0.562 | 0.675 |
| 1979 | 1605973 | 1908440 | 1942286 | 931269 | 1490400 | 345575 | 1634869 | 14.288 | 14.242 | 2.196 | 0.027 | -1.901 | 4.00E-06 | -2.857 | -1.20E-08 | 0.544 | 0.762 |
| 1980 | 5132614 | 1927679 | 1915383 | 2949411 | 5936400 | 11220309 | 5723960 | 14.462 | 14.479 | 2.529 | 0.030 | -2.401 | 4.00E-06 | -3.543 | 0.00E+00 | 0.611 | 1.006 |
| 1981 | 2970437 | 1892801 | 2315143 | 1473570 | 4051700 | 1206284 | 4050760 | 14.472 | 14.465 | 2.724 | 0.031 | 0.261 | 1.00E-06 | -3.474 | 0.00E+00 | 0.539 | 1.004 |
| 1982 | 1955603 | 2072478 | 2447876 | 3622424 | 4085100 | 4230863 | 2272464 | 14.454 | 14.655 | 2.544 | 0.027 | 1.089 | 0.00E+00 | -2.988 | -8.00E-09 | 0.484 | 0.809 |
| 1983 | 2137749 | 2135588 | 3190103 | 3269085 | 2367120 | 1952280 | 2398839 | 14.544 | 14.711 | 2.867 | 0.028 | 1.678 | -1.00E-06 | -3.055 | -6.00E-09 | 0.483 | 0.862 |
| 1984 | 4894422 | 2121173 | 2511959 | 2495277 | 1400760 | 1726192 | 1776515 | 14.574 | 14.976 | 2.792 | 0.027 | 1.552 | -1.00E-06 | -3.063 | -6.00E-09 | 0.446 | 0.587 |
| 1985 | 2574672 | 2122353 | 2523637 | 2838528 | 4287060 | 1828561 | 2811841 | 14.567 | 14.737 | 2.690 | 0.027 | 1.605 | -1.00E-06 | -3.081 | -6.00E-09 | 0.410 | 0.457 |
| 1986 | 3403212 | 2243933 | 3153694 | 5800208 | 3316410 | 1227689 | 2800565 | 14.568 | 14.741 | 2.667 | 0.027 | 1.603 | -1.00E-06 | -3.044 | -6.00E-09 | 0.380 | 0.455 |
| 1987 | 3007528 | 2263299 | 2747237 | 1976487 | 2142000 | 1605204 | 2318199 | 14.624 | 14.964 | 2.767 | 0.028 | 1.524 | -1.00E-06 | -3.114 | -5.00E-09 | 0.375 | 0.451 |
| 1988 | 4982814 | 2318261 | 2822994 | 3473987 | | 1653138 | | 14.632 | 14.826 | 2.624 | 0.027 | 1.546 | -1.00E-06 | -3.111 | -5.00E-09 | 0.351 | 0.361 |
| 1989 | 3706397 | 2352029 | 3076775 | 3852882 | 1660680 | 1711520 | 2046698 | 14.656 | 14.853 | 2.718 | 0.028 | 1.606 | -1.00E-06 | -3.070 | -5.00E-09 | 0.334 | 0.374 |
| 1990 | | 2446821 | 3644176 | 3054269 | 1230880 | 1806937 | 1638007 | 14.671 | 14.939 | 2.691 | 0.028 | 1.600 | -1.00E-06 | -3.070 | -5.00E-09 | 0.317 | 0.312 |
| 1991 | | 2906658 | 3534925 | 2700296 | 2629800 | 1729694 | 2727828 | 14.710 | 15.109 | 2.729 | 0.030 | 1.548 | -1.00E-06 | -2.944 | -6.00E-09 | 0.312 | 0.295 |
| 1992 | | 2906658 | 3534925 | 3394244 | 1699110 | 1689696 | 2214890 | | | 2.754 | 0.031 | 1.548 | -1.00E-06 | -2.825 | -7.00E-09 | | |

[a] Data have been revised (see Appendix B)

Appendix A3. Area 4 (Skeena River) sockeye salmon.

Table A3.5. Retrospective forecasts of age 1.2 and age 1.3 returns by brood year using sibling models.

| Brood Year | Actual | | Forecasted Returns | | | | Parameter Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Age 1.2 Returns | Age 1.3 Returns | Age 1.2 *LSIB* | Age 1.3 *LSIB* | Age 1.2 *NLSIB* | Age 1.3 *NLSIB* | Age 1.2 *LSIB* | Age 1.3 *LSIB* | Age 1.2 *NLSIB* | | Age 1.3 *NLSIB* | |
| | | | | | | | a | a | a | b | a | b |
| 1970 | 830949 | 362469 | | | | | | | | | | |
| 1971 | 1122101 | 922948 | | | | | | | | | | |
| 1972 | 547813 | 1287730 | | | | | | | | | | |
| 1973 | 1126329 | 857825 | 564698 | 1064381 | | | 4.110 | 0.945 | -0.120 | 1.126 | | |
| 1974 | 261907 | 312878 | 1068836 | 234407 | | | 4.184 | 0.895 | -0.456 | 1.154 | 18.657 | -0.372 |
| 1975 | 2494680 | 1093066 | 210725 | 2364957 | 40975 | 1242358 | 4.418 | 0.948 | 3.167 | 0.859 | 6.691 | 0.498 |
| 1976 | 287996 | 411707 | 1457372 | 240188 | 304867 | 130181 | 4.919 | 0.834 | 1.246 | 1.029 | 7.298 | 0.452 |
| 1977 | 3181061 | 3045191 | 418333 | 2866136 | 100827 | 1479201 | 4.622 | 0.901 | 0.164 | 1.114 | 7.118 | 0.465 |
| 1978 | 622743 | 1310603 | 1237257 | 565450 | 290017 | 407278 | 5.290 | 0.908 | -1.221 | 1.240 | 4.637 | 0.654 |
| 1979 | 755577 | 790173 | 797021 | 752555 | 193465 | 466196 | 5.129 | 0.996 | -1.312 | 1.245 | 5.223 | 0.617 |
| 1980 | 1453418 | 3326061 | 337791 | 1454871 | 58479 | 896764 | 5.609 | 1.001 | 2.075 | 0.971 | 5.225 | 0.617 |
| 1981 | 1734110 | 1115575 | 1925645 | 1871105 | 324887 | 1217349 | 5.453 | 1.079 | 2.654 | 0.920 | 4.159 | 0.702 |
| 1982 | 610830 | 1278059 | 713886 | 631598 | 104454 | 410482 | 5.912 | 1.034 | 3.391 | 0.865 | 4.540 | 0.672 |
| 1983 | 978128 | 1071496 | 407889 | 1067137 | 54443 | 626007 | 6.114 | 1.091 | 4.000 | 0.816 | 5.027 | 0.640 |
| 1984 | 2629869 | 1625912 | 562238 | 2871817 | 68037 | 1683121 | 6.380 | 1.092 | 4.557 | 0.772 | 5.024 | 0.640 |
| 1985 | 869646 | 1627395 | 3957658 | 913998 | 481540 | 536577 | 6.197 | 1.051 | 4.762 | 0.754 | 5.334 | 0.617 |
| 1986 | 817618 | 2462882 | 499167 | 891204 | 55900 | 498753 | 6.430 | 1.090 | 5.200 | 0.720 | 5.464 | 0.610 |
| 1987 | 884372 | 2033525 | 790750 | 1023218 | 88357 | 522670 | 6.444 | 1.157 | 5.193 | 0.720 | 5.778 | 0.591 |
| 1988 | 1689044 | 2877721 | 591385 | 2030231 | 63106 | 988097 | 6.598 | 1.202 | 5.404 | 0.704 | 5.897 | 0.585 |
| 1989 | 1590820 | 1857337 | 2676027 | 1947163 | 284999 | 992677 | 6.432 | 1.224 | 5.615 | 0.685 | 5.390 | 0.624 |
| 1990 | 641637 | 1160348 | 1657384 | 783439 | 178708 | 404878 | 6.418 | 1.221 | 5.545 | 0.692 | 5.296 | 0.631 |
| 1991 | | | 584060 | | 63049 | | 6.448 | | 5.498 | 0.696 | | |

Appendix A3. Area 4 (Skeena River) sockeye salmon.

Table A3.6. Summary of retrospective forecasts of total stock size by calendar year.

| | Actual | Non-Biological Models | | | | Biological Models | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Stock | *AVGCY* | *5YAVGCY* | *AVGBY* | *5YAVGBY* | *LSRESC* | *LSRJUV* | *NLSRESC* | *NLSRJUV* | *LSIB* | *NLSIB* |
| 1970 | 1466278 | | | | | | | | | | |
| 1971 | 1969532 | 1466278 | | | | | | | | | |
| 1972 | 1729740 | 1699377 | | | | | | | | | |
| 1973 | 2439682 | 1709438 | | | | | | | | | |
| 1974 | 2550392 | 1868415 | | | | | | | | | |
| 1975 | 1512451 | 1988383 | 1988383 | | | | | | | | |
| 1976 | 1502102 | 1899752 | 2000751 | | | | | | | | |
| 1977 | 2488293 | 1837071 | 1895223 | | | | | | | | |
| 1978 | 1180465 | 1908085 | 2038189 | 1796279 | | | | | | 2133217 | |
| 1979 | 2921826 | 1808948 | 1762741 | 1853334 | | 1838701 | 1117740 | | | 445132 | |
| 1980 | 1474694 | 1897794 | 1811332 | 1943160 | | 2127329 | 1952000 | 2012520 | 2118851 | 3822329 | 1547225 |
| 1981 | 3686199 | 1854771 | 1802196 | 1547505 | 1547505 | 1209003 | 2128000 | 1028181 | 1851014 | 658521 | 231009 |
| 1982 | 3795223 | 1964027 | 2156641 | 1804016 | 1897375 | 2261488 | 3462400 | 4033936 | 2376387 | 4103393 | 1769218 |
| 1983 | 2150767 | 2066115 | 2346633 | 1603343 | 1532102 | 931269 | 1490400 | 345575 | 1634869 | 1362471 | 600744 |
| 1984 | 2394505 | 2072049 | 2645776 | 1908440 | 1942286 | 2949411 | 5936400 | 11220309 | 5723960 | 1090346 | 524675 |
| 1985 | 5137073 | 2092126 | 2542526 | 1927679 | 1915383 | 1473570 | 4051700 | 1206284 | 4050760 | 3380516 | 1221651 |
| 1986 | 1786952 | 2212946 | 3263384 | 1892801 | 2315143 | 3622424 | 4085100 | 4230863 | 2272464 | 2584991 | 1321803 |
| 1987 | 2331914 | 2185287 | 2823417 | 2072478 | 2447876 | 3269085 | 2367120 | 1952280 | 2398839 | 1039487 | 464925 |
| 1988 | 3858728 | 2193186 | 2561357 | 2135588 | 3190103 | 2495277 | 1400760 | 1726192 | 1776515 | 1629375 | 694044 |
| 1989 | 2609950 | 2259382 | 2878990 | 2121173 | 2511959 | 2838528 | 4287060 | 1828561 | 2811841 | 6829475 | 2164661 |
| 1990 | 2632867 | 2275735 | 2929028 | 2122353 | 2523637 | 5800208 | 3316410 | 1227689 | 2800565 | 1413166 | 592477 |
| 1991 | 3648927 | 2291587 | 2562513 | 2243933 | 3153694 | 1976487 | 2142000 | 1605204 | 2318199 | 1681954 | 587110 |
| 1992 | 4774692 | 2340558 | 2955811 | 2263299 | 2747237 | 3473987 | | 1653138 | | 1614604 | 585775 |
| 1993 | 4880351 | 2414246 | 3411326 | 2318261 | 2822994 | 3852882 | 1660680 | 1711520 | 2046698 | 4706258 | 1273096 |
| 1994 | 2692425 | 2486095 | 3575399 | 2352029 | 3076775 | 3054269 | 1230880 | 1806937 | 1638007 | 3604548 | 1171384 |
| 1995 | 5000000 | 2494036 | 3597716 | 2446821 | 3644176 | 2700296 | 2629800 | 1729694 | 2727828 | 1367499 | 467927 |
| 1996 | | 2561656 | 4090111 | 2906658 | 3534925 | 3394244 | 1699110 | 1689696 | 2214890 | | |
| All Years | | | | | | | | | | | |
| RMSE | | 1319051 | 1190125.6 | 1601088 | 1425434 | 1756651 | 2141652 | 3089366.4 | 1966037 | 1425685 | 2395260 |
| MAD | | 990586.2 | 998831.08 | 1276962 | 1077955.6 | 1492869 | 1761474 | 2351805.8 | 1506234 | 1195971 | 2222461 |
| MAPE | | 30.71588 | 33.606434 | 35.908 | 27.848953 | 47.11694 | 55.17033 | 76.258328 | 43.26705 | 41.20879 | 70.33972 |
| COUP $*10^6$ | | -19.8641 | -8.911073 | -20.6051 | -14.112329 | -9.90288 | -12.5186 | -13.53638 | -14.30847 | -10.9786 | -35.5594 |
| 1986-1995a | | | | | | | | | | | |
| RMSE | | 1529671 | 1168648.7 | 1582000 | 1064685.7 | 1647868 | 2404018 | 2206604 | 2086082 | 1620294 | 2654444 |
| MAD | | 1191574 | 1049008.6 | 1245977 | 784021.78 | 1419417 | 2048501 | 1963255 | 1526990 | 1382402 | 2503068 |
| MAPE | | 29.67785 | 31.768773 | 30.71288 | 19.934404 | 46.08584 | 59.29936 | 57.622946 | 37.72431 | 41.31309 | 73.32928 |
| COUP $*10^6$ | | -11.0637 | -3.657866 | -12.2481 | -5.7832125 | -1.13336 | -11.097 | -14.74473 | -13.42585 | -7.88252 | -25.0307 |

[a] except *LSJUV* and *NLSRJUV*, excluding 1992

Appendix A4. Area 8 (Bella Coola River) even-year pink salmon.

Table A4.1. Catch, spawnining escapement, and total stock by calendar

| Calendar Year | Troll Catch | Net Catch | Escapement | Total Stock |
|---|---|---|---|---|
| 1950 | | | 260607 | |
| 1952 | 653 | 639036 | 545285 | 1184974 |
| 1954 | 1133 | 851259 | 351377 | 1203769 |
| 1956 | 4254 | 1029154 | 781075 | 1814483 |
| 1958 | 2403 | 801626 | 283409 | 1087438 |
| 1960 | 8396 | 1480795 | 1571265 | 3060456 |
| 1962 | 47553 | 12144040 | 3910088 | 16101681 |
| 1964 | 21183 | 2830894 | 763125 | 3615202 |
| 1966 | 29830 | 2120002 | 939850 | 3089682 |
| 1968 | 101552 | 5350618 | 2095000 | 7547170 |
| 1970 | 39921 | 2012361 | 731100 | 2783382 |
| 1972 | 19984 | 1084772 | 1356100 | 2460856 |
| 1974 | 108575 | 2765920 | 1469400 | 4343895 |
| 1976 | 38085 | 1907231 | 1382200 | 3327516 |
| 1978 | 20697 | 1760476 | 2293475 | 4074648 |
| 1980 | 26058 | 883350 | 1127725 | 2037133 |
| 1982 | 1525 | 38937 | 195600 | 236062 |
| 1984 | 3541 | 171063 | 967210 | 1141814 |
| 1986 | 11210 | 3420738 | 3285535 | 6717483 |
| 1988 | 6328 | 8707244 | 5204570 | 13918142 |
| 1990 | 17482 | 3635064 | 2759835 | 6412381 |
| 1992 | 2564 | 2708363 | 4614400 | 7325327 |
| 1994 | 962 | 571402 | 367790 | 940154 |

Appendix A4. Area 8 (Bella Coola River) even-year pink salmon.

Table A4.2. Escapements, juvenile indices and adult returns by brood year.

| Brood Year | Escapement | Juvenile Index [a] | Adult Returns |
|---|---|---|---|
| 1950 | 260607 | | 1184974 |
| 1952 | 545285 | | 1203769 |
| 1954 | 351377 | | 1814483 |
| 1956 | 781075 | | 1087438 |
| 1958 | 283409 | | 3060456 |
| 1960 | 1571265 | | 16101681 |
| 1962 | 3910088 | | 3615202 |
| 1964 | 763125 | | 3089682 |
| 1966 | 939850 | | 7547170 |
| 1968 | 2095000 | | 2783382 |
| 1970 | 731100 | | 2460856 |
| 1972 | 1356100 | | 4343895 |
| 1974 | 1469400 | | 3327516 |
| 1976 | 1382200 | | 4074648 |
| 1978 | 2293475 | | 2037133 |
| 1980 | 1127725 | 3.4 | 236062 |
| 1982 | 195600 | 4.33 | 1141814 |
| 1984 | 967210 | 5.58 | 6717483 |
| 1986 | 3285535 | 10.59 | 13918142 |
| 1988 | 5204570 | 21.11 | 6412381 |
| 1990 | 2759835 | 35.05 | 7325327 |
| 1992 | 4614400 | 9.95 | 940154 |
| 1994 | 367790 | 19.28 | |

[a] Average number of live eggs or alevins per square foot of spawning gravel.

Appendix A4. Area 8 (Bella Coola River) even-year pink salmon.

Table A4.3 Retrospective forecasts of total stock by calendar year. Parameter estimates are means of log-transformed total stock data.

| Year | Total Stock | Forecasts | | | | | | Parameter Estimates | | | | | | | | Standard Deviation | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *AVGCY* | *5YAVGCY* | *LSRESC* | *LSRJUV* | *NLSRESC* | *NLSRJUV* | *AVGCY* | *5YAVGCY* | *LSRESC* | *LSRJUV* | *NLSRESC* | | *NLSRJUV* | | *AVGCY* | *5YAVGCY* |
| | | | | | | | | a | a | a | a | a | $b*10^{-5}$ | a | b | | |
| 1950 | | | | | | | | | | | | | | | | | |
| 1952 | 1184974 | | | | | | | | | | | | | | | | |
| 1954 | 1203769 | | | | | | | | | | | | | | | | |
| 1956 | 1814483 | 1194335 | | 1108100 | | 1365578 | | 13.993 | | 3.166 | | 2.411 | -0.30 | | | 0.011 | |
| 1958 | 1087438 | 1372993 | | 2914972 | | 764442 | | 14.133 | | 3.732 | | 2.322 | -0.30 | | | 0.242 | |
| 1960 | 3060456 | 1295246 | | 826704 | | 1938683 | | 14.074 | | 2.917 | | 2.773 | -0.30 | | | 0.229 | |
| 1962 | 16101681 | 1538293 | 1538293 | 5955094 | | 4386484 | | 14.246 | 14.246 | 3.790 | | 1.341 | -0.02 | | | 0.433 | 0.433 |
| 1964 | 3615202 | 2275156 | 2592218 | 17489824 | | 4506517 | | 14.638 | 14.768 | 4.473 | | 1.706 | -0.04 | | | 1.034 | 1.099 |
| 1966 | 3089682 | 2430764 | 3229903 | 2725119 | | 3093542 | | 14.704 | 14.988 | 3.571 | | 1.705 | -0.04 | | | 0.960 | 1.014 |
| 1968 | 7547170 | 2504749 | 3592706 | 3408836 | | 3887728 | | 14.734 | 15.094 | 3.627 | | 1.796 | -0.04 | | | 0.893 | 0.965 |
| 1970 | 2783382 | 2831318 | 5292947 | 8300390 | | 4409466 | | 14.856 | 15.482 | 3.962 | | 1.792 | -0.05 | | | 0.912 | 0.724 |
| 1972 | 2460856 | 2826487 | 5193437 | 2596867 | | 3173880 | | 14.855 | 15.463 | 3.552 | | 1.761 | -0.04 | | | 0.860 | 0.743 |
| 1974 | 4343895 | 2791116 | 3566957 | 4793814 | | 4588132 | | 14.842 | 15.087 | 3.535 | | 1.761 | -0.04 | | | 0.817 | 0.442 |
| 1976 | 3327516 | 2895918 | 3700388 | 5151716 | | 4047317 | | 14.879 | 15.124 | 3.506 | | 1.748 | -0.05 | | | 0.790 | 0.451 |
| 1978 | 4074648 | 2927031 | 3755680 | 4685658 | | 3969247 | | 14.889 | 15.139 | 3.390 | | 1.746 | -0.05 | | | 0.757 | 0.445 |
| 1980 | 2037133 | 2997015 | 3320089 | 7696902 | | 4290188 | | 14.913 | 15.016 | 3.356 | | 1.773 | -0.05 | | | 0.733 | 0.242 |
| 1982 | 236062 | 2920862 | 3119170 | 3464371 | | 3089285 | | 14.887 | 14.953 | 3.072 | | 1.572 | -0.05 | | | 0.713 | 0.325 |
| 1984 | 1141814 | 2495920 | 1951763 | 507973 | | 889600 | | 14.730 | 14.484 | 2.597 | | 1.613 | -0.05 | | | 0.933 | 1.218 |
| 1986 | 6717483 | 2383703 | 1494067 | 2634680 | 760368 | 3174199 | | 14.684 | 14.217 | 2.724 | 135780 | 1.672 | -0.05 | | | 0.923 | 1.142 |
| 1988 | 13918142 | 2524932 | 1719442 | 9426200 | 2975346 | 4122730 | 8.25E+09 | 14.742 | 14.358 | 2.869 | 280693 | 1.541 | -0.04 | 6.846 | 1.286 | 0.928 | 1.298 |
| 1990 | 6412381 | 2762276 | 2198294 | 15244186 | 8710122 | 4763897 | 1.32E+09 | 14.832 | 14.603 | 2.929 | 412802 | 1.473 | -0.03 | 10.947 | 0.332 | 0.983 | 1.586 |
| 1992 | 7325327 | 2881076 | 2764940 | 7738577 | 13628488 | 5261522 | 30391758 | 14.874 | 14.833 | 2.804 | 388276 | 1.473 | -0.03 | 12.593 | 0.031 | 0.975 | 1.654 |
| 1994 | 940154 | 3011989 | 5495990 | 12906477 | 3501100 | 3571272 | 3606532 | 14.918 | 15.520 | 2.797 | 350110 | 1.590 | -0.04 | 12.884 | -0.009 | 0.972 | 0.933 |
| 1996 | | 2856729 | 5286480 | 913223 | 5600011 | 1555257 | 5458681 | 14.865 | 15.481 | 2.483 | 290156 | 1.589 | -0.04 | 12.630 | -0.004 | 0.981 | 1.015 |

Appendix A4. Area 8 (Bella Coola River) even year-pink salmon.

Table A4.4 Summary of retrospective forecasts of total stock size by calandar year.

| Year | Actual Stock | Non-Biological Models | | Biological Models | | | |
|---|---|---|---|---|---|---|---|
| | | *AVGCY* | *5YAVGCY* | *LSRESC* | *LSRJUV* | *NLSRESC* | *NLSRJUV* |
| 1950 | | | | | | | |
| 1952 | 1184974 | | | | | | |
| 1954 | 1203769 | | | | | | |
| 1956 | 1814483 | 1194335 | | 1108100 | | 1365578 | |
| 1958 | 1087438 | 1372993 | | 2914972 | | 764442 | |
| 1960 | 3060456 | 1295246 | | 826704 | | 1938683 | |
| 1962 | 16101681 | 1538293 | 1538293 | 5955094 | | 4386484 | |
| 1964 | 3615202 | 2275156 | 2592218 | 17489824 | | 4506517 | |
| 1966 | 3089682 | 2430764 | 3229903 | 2725119 | | 3093542 | |
| 1968 | 7547170 | 2504749 | 3592706 | 3408836 | | 3887728 | |
| 1970 | 2783382 | 2831318 | 5292947 | 8300390 | | 4409466 | |
| 1972 | 2460856 | 2826487 | 5193437 | 2596867 | | 3173880 | |
| 1974 | 4343895 | 2791116 | 3566957 | 4793814 | | 4588132 | |
| 1976 | 3327516 | 2895918 | 3700388 | 5151716 | | 4047317 | |
| 1978 | 4074648 | 2927031 | 3755680 | 4685658 | | 3969247 | |
| 1980 | 2037133 | 2997015 | 3320089 | 7696902 | | 4290188 | |
| 1982 | 236062 | 2920862 | 3119170 | 3464371 | | 3089285 | |
| 1984 | 1141814 | 2495920 | 1951763 | 507973 | | 889600 | |
| 1986 | 6717483 | 2383703 | 1494067 | 2634680 | 760368 | 3174199 | |
| 1988 | 13918142 | 2524932 | 1719442 | 9426200 | 2975346 | 4122730 | 8251151482 |
| 1990 | 6412381 | 2762276 | 2198294 | 15244186 | 8710122 | 4763897 | 1320730277 |
| 1992 | 7325327 | 2881076 | 2764940 | 7738577 | 13628488 | 5261522 | 30391758 |
| 1994 | 940154 | 3011989 | 5495990 | 12906477 | 3501100 | 3571272 | 3606532 |
| 1996 | | 2856729 | 5286480 | 913223 | 5600011 | 1555257 | 5458681 |
| ALL YEARS | | | | | | | |
| RMSE | | 4707960 | 5365596 | 5731374 | 6431173 | 3823760 | 4170730865 |
| MAD | | 2935661 | 3654142 | 4056898 | 5612352 | 2330632 | 2394321011 |
| MAPE | | 111 | 150 | 214 | 112 | 108 | 20070 |
| COUP $*10^6$ | | -43.17 | -31.55 | 27.54 | -5.74 | -22.74 | 9577 |
| 1986-1994[a] | | | | | | | |
| RMSE | | 6098426 | 6861540 | 7186254 | 6431173 | 4947818 | 4170730865 |
| MAD | | 5178636 | 6150485 | 5957225 | 5612352 | 3936421 | 2394321011 |
| MAPE | | 97 | 156 | 302 | 112 | 91 | 20070 |
| COUP | | -21749511 | -21640754 | 12636633 | -5738063 | -14419867 | 9577284044 |

[a] except for *NLSRJUV*, 1988-1994

Appendix B1. Area 3 (Nass River) sockeye salmon.
Revised from Wood et al. (1996).

Table B1.1 Escapement, total stock sizes, and age composition by calendar year. Age 3 fish and First Nation catch excluded.

| Year | Escapement | Total Stock | Age Composition % 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 |

Appendix B1. Area 3 (Nass River) sockeye salmon.
Revised from Wood et al. (1996).

Table B1.2 Escapements and brood year returns by age class.
Age 3 fish excluded.

| Brood | | Adult Returns | | | |
|---|---|---|---|---|---|
| Year | Escapement | 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 | | |
| 1993 | 440740 | 259901 | | | |
| 1994 | 179262 | | | | |
| 1995 | 237991 | | | | |
| 1996 | 219825 | | | | |

Appendix B2. Area 4 (Skeena River) sockeye salmon.
Revised from Wood et al. (1995b, 1996)

Table B2.1 Escapements, total stock sizes and age composition data by calendar year. 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 |

Appendix B2. Area 4 (Skeena River ) sockeye salmon.
Revised from Wood et al. (1995b, 1996).

Table 2.2. Escapements and total returns of age 1.* fish by brood year.
Age 3 fish are not included in escapement.

| Brood Year | Escapement | Adult Returns Age 3 | Age 4 | Age 5 | Total |
|---|---|---|---|---|---|
| 1970 | 678652 | 208350 | 831757 | 364197 | 1404304 |
| 1971 | 821850 | 256772 | 1127097 | 924801 | 2308670 |
| 1972 | 697237 | 137396 | 548679 | 1293885 | 1979959 |
| 1973 | 820196 | 255458 | 1131537 | 864870 | 2251865 |
| 1974 | 723898 | 47697 | 263777 | 313432 | 624906 |
| 1975 | 822633 | 296274 | 2498508 | 1092804 | 3887586 |
| 1976 | 575590 | 90509 | 288034 | 411161 | 789704 |
| 1977 | 951805 | 233886 | 3177365 | 3039052 | 6450304 |
| 1978 | 424075 | 155395 | 621563 | 1310373 | 2087331 |
| 1979 | 1166236 | 60223 | 755494 | 788985 | 1604702 |
| 1980 | 542164 | 353135 | 1451716 | 3323273 | 5128123 |
| 1981 | 1424509 | 120752 | 1733185 | 1116550 | 2970487 |
| 1982 | 1140737 | 66714 | 611270 | 1276820 | 1954804 |
| 1983 | 893724 | 88125 | 977637 | 1070368 | 2136130 |
| 1984 | 1055215 | 638641 | 2627321 | 1630157 | 4896120 |
| 1985 | 2174806 | 77631 | 871807 | 1627596 | 2577034 |
| 1986 | 716312 | 122711 | 817553 | 2480221 | 3420485 |
| 1987 | 1324128 | 89631 | 887664 | 2020415 | 2997710 |
| 1988 | 1417543 | 416049 | 1671873 | 2895397 | 4983319 |
| 1989 | 1137994 | 258240 | 1598624 | 1873677 | 3730540 |
| 1990 | 989566 | 90580 | 646101 | 2099914 | 2836594 |
| 1991 | 1232568 | 320804 | 2286244 | 2740730 | 5347777 |
| 1992 | 1550109 | 542895 | 3701513 | 2491059 | 6735467 |
| 1993 | 1629426 | 43480 | 782349 | | |
| 1994 | 1026816 | 6348 | | | |
| 1995 | 1720292 | | | | |
| 1996 | 1782357 | | | | |