Canadian Stock Assessment
Proceedings Series 99/04

Évaluation des stocks canadien
Séries des comptes rendus 99/04

Report of the PSARC Salmon Subcommittee Meeting March 9-11, 1999

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Pacific Scientific Advice Review Committee (PSARC)
Pacific Biological Station
Nanaimo, British Columbia V9R 5K6

March, 1999

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Salmon

SUMMARY

The PSARC Salmon Subcommittee met March 9-11, 1999 at the Pacific Biological Station in Nanaimo. The Subcommittee reviewed eight Working Papers. External participants from the Pacific Fisheries Resource Conservation Council and the Fraser Aboriginal Fisheries Secretariat attended the meeting.

General Subcommittee Discussion and Concerns

The Subcommittee noted that stated probability distributions used for PSARC forecasts likely underestimate the uncertainty in the forecasts under the current highly variable environmental conditions. Given this increased uncertainty the forecasts should be used conservatively.

The Subcommittee noted that stock size forecasts are provided for only a subset of Pacific salmon populations in British Columbia, those for which sufficient, reliable data exist. These populations are typically the largest or most productive ones, and thus, most resilient to environmental and human impacts.

The Subcommittee requests clarification of the need to formally review all PSARC forecasts each year.

Working Papers S99-1: Run size forecasts for the Fraser River sockeye and pink salmon in 1999

The total 1999 Fraser sockeye run size forecast based on the 18 stocks at the 50% probability level is 8.2 million sockeye (50% chance the run will exceed this forecast), with a range of 4.8-14.6 (75-25% probability levels).

The Subcommittee recommended cautious use of the 1999 Fraser sockeye forecast given the potential for well below normal marine survival as a result of the extreme ocean conditions for juvenile Fraser sockeye ocean entry in 1997.

The Fraser pink salmon forecast for 1999 is 8.1 million at the 50% probability level with a range of 6.4-10.3 million (75-25% probability levels).

Working Paper S99-2: Forecast for southern British Columbia coho salmon in 1999

The Subcommittee recommended adoption of the marine survival forecasts. Marine survival for southern British Columbia coho salmon are expected to be well below average.

The Subcommittee recommended accepting the abundance forecasts. For Strait of Georgia coho in 1999 there is a 50% probability of a run larger than 72,000 with a range of 54,000-97,000 (75-25% probability levels). For west coast Vancouver Island coho in 1999 there is a 50% probability of a run larger than

434,000 with a range of 300,000-626,000 (75-25% probability levels). The abundance forecast for Thompson coho is for continued severe depression.

The Subcommittee recommended that during periods of low abundance and marine survival such as we are experiencing, a conservative approach be exercised in fishery management applications of these forecasts. All forecasts of coho survival, distribution and abundance have high statistical uncertainty

Working Paper S99-3: Trends in abundance and pre-season 1999 stock size forecasts for major sockeye, pink and chum salmon stocks in northern British Columbia

The Subcommittee recommended acceptance of the northern British Columbia sockeye, pink and chum salmon forecast probability distributions. The Subcommittee noted that Skeena River, Owikeno Lake and Long Lake sockeye forecasts are well below escapement targets.

Working Paper S99-4: Population status and sustainable production of British Columbia's salmon populations in the 1990's

The Subcommittee recommended that this paper not be accepted. Members did support the need to complete this paper, and the importance of finding a way to effectively incorporate marine uncertainty in our forecasts.

Working Paper S99-5: 1999 Forecasts for Johnston Strait, Georgia Strait and Lower Fraser River Chum Salmon

The Subcommittee recommended that the forecast of wild Inside chum based on the five year average brood year model of 2.0 million (50% C.I. of 1.3 to 2.7 million) be adopted.

For enhanced stocks, given the low survival measured for the two most recent brood years, the forecast of 0.45 million based on the 1990-92 brood years should be adopted.

The combined forecast for wild plus hatchery chum is 2.47 million. Confidence limits around this combined forecast are not provided but fishery managers should be aware that both the wild and hatchery forecasts are highly uncertain.

Working Paper S99-6: Review of 1998 Terminal Run of Somass River Chinook Salmon, 1998 WCVI Extensive Escapement Indicators, and Somass Terminal Run Forecast for 1999

The recommended forecast for the total terminal run of Robertson Creek

Hatchery and Stamp River chinook (age 3, 4, and 5) to Barkley Sound in 1999 is 35,000±20%. The estimate of the terminal run in the absence of any Canadian fisheries is 40,000. The age structure of the return is projected to be 15% Age 3, 11% Age 4, and 74% Age 5; with an expected sex ratio of 62% females.

Working Paper S99-7: Forecast for northern British Columbia coho salmon in 1999

The Subcommittee recommended acceptance of the Lachmach, Toboggan Creek and Fort Babine Hatchery coho marine survival forecasts. Marine survival for the coho of northern British Columbia is expected to be above average for 1999.

The Subcommittee recommended acceptance of the abundance indicators:

Aggregate	1999 Abundance Forecast	Confidence in Forecast
Babine Lake upper Skeena	well below average	high
lower and middle Skeena	below average	moderate
Area 3	below average	high
Area 6	well below average	low
Areas 7 & 8	below average	low

Working Paper S99-8: An update on 1998 stock status and 1999 forecasts of Barkley Sound sockeye

The Subcommittee recommended acceptance of the paper and the 1999 forecast. The 1999 Barkley Sound sockeye run size forecast at the 50% probability level is 332,000 (50% chance the run will exceed this forecast), 302,000 at the 75% probability, and 433,000 at the 25% probability level.

INTRODUCTION

The Subcommittee Chair opened the meeting welcoming the participants. During the introductory remarks the objectives of the meeting were reviewed, and the Subcommittee accepted the meeting agenda (Appendix 1).

The Subcommittee reviewed eight Working Papers. Working Paper titles, authors and reviewers are listed in Appendix 2. The Subcommittee noted that the first external participants to attend the Salmon Subcommittee were present at the meeting. Carl Walters, Paul LeBlond, Rick Routledge and Marie-Sue Atkinson attended on behalf of the Pacific Fisheries Resource Conservation Council. Ken Wilson attended on behalf of the Fraser River Aboriginal Fisheries Secretariat. A list of meeting participants is included as Appendix 3.

General Subcommittee Discussion and Concerns

1) The Subcommittee wants to stress that stated probability distributions used for PSARC forecasts likely underestimate the uncertainty in the forecasts under the current highly variable environmental conditions. Given this increased uncertainty the forecasts should be used conservatively.

2) The Subcommittee noted that stock size forecasts are provided for only a subset of Pacific salmon populations in British Columbia, those for which sufficient, reliable data exist. These populations are typically the largest or most productive ones, and thus, most resilient to environmental and human impacts. To conserve biodiversity, the status of other (non-forecasted) populations should also be considered when developing harvest management plans. The Subcommittee noted it was difficult to isolate forecast from stock status papers, particularly if there had been no previous stock status review. A number of participants expressed concern about the current separation of stock status and forecast assessments from technical assessments of the management approach. The Subcommittee expanded further on this concern by reiterating the need to continue progress on the management/assessment frameworks for each species, as these are an essential component of meaningful stock status assessments.

3) The Subcommittee requests clarification of the need to formally review all PSARC forecasts each year. Based on the review of the 1999 forecast papers the coho methodologies changed enough to warrant a formal committee review, but all other forecast papers were standard approaches and were approved without difficulty.

WORKING PAPER SUMMARIES, REVIEWS AND DISCUSSION

S99-1 Run size forecasts for the Fraser River sockeye and pink salmon in 1999

A. Cass **Accepted subject to revisions**

Summary

Run size forecasts for 1999 Fraser River sockeye and pink returns presented here are based on methods previously approved by PSARC. Forecasts are made for 18 individual sockeye stocks and four migratory timing / management groups. Forecasts of pink salmon are made for all Fraser pink populations combined.

Forecasts are based on a variety of explanatory variables. For most stocks, forecasts are based on regression models that use spawning escapement to predict adult abundance. Additional explanatory variables are available for some stocks and include fry and smolt abundance estimates. Environmental indices are also used to help explain variation in ocean survival of Chilko sockeye and pink salmon. Methods that incorporate attributes of escapement-based and juvenile-based models are explored and pool results from individual sockeye forecast models (i.e. Bayesian approach) where time series of different life stages are available. Sibling models were not considered suitable candidate models for forecasting 1999 returns for two reasons. First, because estimates of age-3 jack returns in 1998 are considered to be particularly unreliable and secondly, because of the poor performance of sibling models in recent years compared to other forecast models.

The total 1999 Fraser sockeye run size forecast is 8.2 million sockeye at the 50% probability level (the chance the run will exceed the forecast) and 4.8 million at the 75% probability level. Forecasts by management group are 318,000 (50%) and 197,000 (75%) for Early Stuart, 477,000 (50%) and 244,000 (75%) for Early summer stocks, 5.3 million (50%) and 3.3 million (75%) for summer run stocks and 2.1 million (50%) and 1.1 million (75%) for late run stocks. The 1999 forecast of Fraser pink is 8.1 million at the 50% probability level and 6.4 million at the 75% level (Table 1).

A note of caution regarding 1999 sockeye returns. Sockeye smolts that return as adults in 1999 entered the ocean during the intense 1997 El Nino. Sockeye returns in 1995 that went to sea during the less intense 1993 El had very low survival rates for all major stocks. If the intense El Nino in 1997 resulted in low sockeye survival then forecasts presented here significantly over-estimate returns of Fraser sockeye in 1999.

Subcommittee Discussion

The Fraser forecast paper represents a thorough and complete review of the forecasts for 1999 for both sockeye and pink salmon using well established methods and the Subcommittee recommended acceptance of this paper.

The Subcommittee noted that the forecasts for sockeye cover about 96% of the biomass of production and a majority of the stocks represented by approximately 150 spawning locations in the Fraser River watershed. The remainder (~4%) of the biomass production is represented by a number of very small stocks with limited data reliability. Forecasts were not made for these stocks because of these data concerns, but their status with respect to conservation should be included in future status documents on Fraser sockeye.

The Subcommittee discussed whether it would be possible to clarify the

precautionary view of the author concerning the possible impact of the intense El Nino in 1997, on the 1995 brood sockeye smolt survival. The author explained that the sibling models were not suitable models for forecasting 1999 returns because estimates of age-3 jack returns in 1998 are considered to be particularly unreliable and because of the poor performance of sibling models in recent years compared to other forecast models. After considerable discussion the Subcommittee accepted that a cautious approach is warranted, however the data does not exist to quantify the possible effects on returns.

The Subcommittee accepted the pink salmon forecast, but noted the poor relationship between forecasted and observed returns of the Fraser River pink salmon.

Recommendations

1. The Subcommittee recommended adopting the Fraser sockeye salmon forecast probability distributions (Table 1). The total 1999 Fraser sockeye run size forecast based on the 18 stocks considered in this report at the 50% probability level is 8.2 million sockeye (50% chance the run will exceed this forecast), and 4.8 million at the 75% probability level (75% chance the run will exceed this forecast). Forecasts by management group are 318,000 (50%) and 197,000 (75%) for Early Stuart, 477,000 (50%) and 244,000 (75%) for Early summer stocks, 5.3 million (50%) and 3.3 million (75%) for summer run stocks and 2.1 million (50%) and 1.1 million (75%) for late run stocks.

2. The Subcommittee recommended adopting the Fraser pink salmon forecast for 1999 of 8.1 million at the 50% probability level with a range of 6.4-10.3 million (75-25% probability levels) (Table 1).

3. The Subcommittee recommended cautious use of the 1999 Fraser sockeye forecast given the potential for well below normal marine survival as a result of the extreme ocean conditions for juvenile Fraser sockeye ocean entry in 1997.

S99-2: Forecast for Southern British Columbia coho salmon in 1999

B. Holtby, J. Irvine, R. Tanasichuk, K. Simpson **Accepted subject to revisions**

Summary

This Working Paper documents forecasts of marine survival, abundance and distribution for the coho salmon of southern British Columbia (Thompson River, lower Fraser, Strait of Georgia, and west Vancouver Island).

Marine survival: Our recommendations for the marine survival forecast for the five hatchery indicators and one wild coho indicator are given in the following Table. Survivals are expected to remain poor for all Strait of Georgia wild and

hatchery stocks and are forecast to be either unchanged or lower in 1999 compared to 1998 (Figure 1). We note with some concern that survivals in 1998 in the mid-Strait (Big Qualicum) and the lower Fraser (Chilliwack) were lower than predicted, and there is no indication that an already bleak situation will improve in 1999. Survival of Black Creek coho, the single wild indicator on the Strait of Georgia for which there is a forecast, is one of the survivals expected to be lower in 1999 compared to 1998. Nevertheless, survival rates appear to be substantially greater toward the north end of Georgia Strait compared to the lower mainland and the Fraser. CWT escapement data are not yet available for Thompson coho and consequently there is no forecast of marine survival for this aggregate. There are no indications in the magnitude of the escapement that survivals improved in 1998 and the forecast of abundance remains dismal (Figure 3). The forecast survival for wVI coho is slightly lower than in 1997 and 1998.

indicator	model	$\hat{s}_{1999}$	(50% CI)	change relative to 1998
Big Qualicum	LLY	0.003	(0.0013–0.008)	same
Quinsam	LLY	0.021	(0.013–0.034)	same
Chilliwack	RAT3	0.009	(0.006–0.015)	lower
Inch Creek	LLY	0.005	(0.003–0.010)	same
Black Creek	3YRA	0.042	(0.031–0.056)	lower
Robertson Creek	sibling regression	0.029	(0.020–0.041)	lower

Abundance forecast: Without fisheries information, forecasting abundance is highly problematic, and because we are using time-series models the forecast is dependent on the highly uncertain estimate of abundance in 1998. With those caveats the RAT3 forecast of the Strait of Georgia + Fraser aggregate is 72,178 (50% CI: 53,855–96,736). This forecast portends a substantial and very worrisome further deterioration in the status of Strait of Georgia wild coho (Figure 2).

The LLY forecast for the West Coast Vancouver Island aggregate is 433,624 (50% CI: 300,267–626,210). This forecast is 74% of the overall average abundance of 588,403.

The abundance forecast for Thompson coho is for continued severe depression. Brood year escapements in the Thompson were very low (perhaps much less than 10% of an eventual target). That fact, and the prospect for no improvement in marine survival, lead us to conclude that it is unlikely that stock size will increase appreciably for either the North or South Thompson aggregate in 1999.

Distribution forecast: The predicted proportion of catch inside the Strait of Georgia (p_{inside}) should there be no fishing restrictions is 0.329 (50%CI 0.246–

0.424), which can be characterized as a moderately strong outside distribution. The confidence interval suggests that an extreme outside year (p_{inside} < 0.2) is about as likely as a return to a “normal” distribution (p_{inside}>0.4).

Subcommittee Discussion

Subcommittee discussion dealt with Strait of Georgia, Thompson River and WCVI stocks separately. The Subcommittee accepted the marine survival, abundance and distribution forecasts as presented.

Most of the discussion concerning the Strait of Georgia stock dealt with data quality and statistical issues. The Subcommittee was unanimous in its conclusion that the trend in low survival rates for Strait of Georgia coho is unlikely to be reversed in 1999. The potential for negatively biased survival estimates resulting from including stocks in the analysis with ventral fin-clipped coho was discussed. The authors responded that to their knowledge the survival estimates are based on CWT groups that were not ventrally marked. Concern was expressed that the uncertainty in forecasts expressed in the paper was under-estimated. Furthermore, the performance measures used to pick the most appropriate forecast model were influenced by the time series of data used in the retrospective analysis. Even the best performing current models overestimate marine survival under the circumstances of a persistent declining trend. The authors acknowledged that uncertainties are likely under-estimated and performance ratings change depending on the time series used in the evaluation procedure. The authors will give some additional thought (for next year) about new approaches to use in circumstances where consistent declining trends are present. It was noted that perhaps the Chilliwack hatchery data should not be included in the analysis because of poor accounting of in-river catches. The authors acknowledged that the contribution of hatchery and wild components in the forecast of the Strait of Georgia stock needs to be examined as do the estimates of exploitation rates used in the analysis. The authors noted the exploitation rate estimate used in the analysis (3% for Canadian fisheries) is preliminary, but that the final results that include U.S. harvests would not be expected to substantively affect the present forecasts.

The Subcommittee noted that the time series of Thompson River coho escapement and return estimates showed a pronounced two-year periodicity that was suggestive of high exploitation during high odd-year pink fisheries. The high catches of pinks in 1991 and the potential for high mortality on co-migrating coho was identified as a potential cause of the very low abundance of coho in 1994 (1991 brood year). Further analysis on impacts of pink fisheries on coho is warranted. Habitat related causes of Thompson River coho declines was discussed with particular reference to over escapement to the Eagle River hatchery. The authors noted that this was a forecasting working paper not a report on stock status. The authors agreed that there are habitat problems that make forecasting difficult.

Unlike survival trends for Strait of Georgia and Thompson River coho, there is no downward trend for WCVI coho. The Subcommittee noted that US coho populations in Puget Sound and particularly along the outer coast of Washington are also severely depressed. The geographic break-point between depressed outer US stocks and WCVI Canadian stocks was not clearly defined. The authors noted that coho survival increases in a northward gradient off Canada's south-west coast. Considerable discussion focussed on the inclusion of a new model that correlates Euphausiid abundance with WCVI coho. The Subcommittee agreed that the method was untested but because Euphausiids are believed to be a dominant prey species of young coho and because the model results in a precautionary forecast its utility is worth consideration. The Subcommittee noted that the pattern of variability in marine survival was perhaps disconcerting because short-term (~3-yr) reversals in survival have occurred throughout the time series. The Subcommittee discussed whether the high Barkley Sound sockeye jack return in 1998 means that survival of coho might be higher than anticipated in 1999. It was pointed out that this relationship between Barkley Sound sockeye and WCVI coho has been weak in the past.

The Subcommittee agreed with the authors summary points that the forecast portends a substantial and very worrisome further deterioration in the status of the Strait of Georgia coho, and that the abundance forecast for Thompson coho is for continued severe depression.

Subcommittee Recommendations

1. The Subcommittee recommended adoption of the marine survival forecasts.

2. The Subcommittee recommended accepting the abundance forecasts. For the Strait of Georgia (including Fraser River) coho in 1999, 75% probability of a run larger than 54,000, 50% probability of a run larger than 72,000, and a 25% probability of a run larger than 97,000; for west coast Vancouver Island coho in 1999, 75% probability of a run larger than 300,000, 50% probability of a run larger than 434,000, and a 25% probability of a run larger than 626,000.

3. The Subcommittee recommended that during periods of low abundance and marine survival such as we are experiencing, a conservative approach be exercised in fishery management applications of these forecasts. All forecasts of coho survival, distribution and abundance have high statistical uncertainty.

S99-3: Trends in abundance and pre-season 1999 stock size forecasts for major sockeye, pink and chum salmon stocks in northern British Columbia

C. Wood, D. Rutherford, L. Jantz **Accepted subject to revisions**

Summary

This working paper includes pre-season 1999 stock size forecasts for nine sockeye, five pink, and five chum salmon stocks or stock groupings in northern British Columbia, statistical areas 1-10 (Figure 4). The recommended forecasts (Table 2) are based on simple models that have been evaluated in a previous working paper (S95-12).

The recent 5-yr mean model is a simple time-series approach that effectively accommodates gradual changes (autocorrelated anomalies) in productivity. For northern populations of sockeye salmon, this model has performed as well, or better than other models because variations in the independent variables used by other models have been small, and their effects have been obscured by other factors. However, for Skeena River sockeye, the 5-yr mean model should be rejected in favour of the “smolt” or “sibling age-class” models that include the effect of measured, record low smolt production in two consecutive years. Although the sibling model has not performed especially well in retrospective analyses under typical conditions (Wood et al. 1995), it’s use is recommended for 1999 to capture the combined effects of poor freshwater production for the 1994 and 1995 brood years as well as apparent poor marine survival for the 1994 brood year. This recommendation is also consistent with the precautionary approach to fisheries management because the sibling model predicts the lowest stock size in 1999.

Subcommittee Discussion

The paper represents a thorough review of the 1999 forecasts for selected northern British Columbia sockeye, pink and chum stocks using well established methods and the Subcommittee recommended acceptance of this paper. Much of the discussion focused upon the utility of producing forecasts for some of the pink and chum salmon stocks given the quality of the catch and escapement data used in the development of the forecasts. The utility of producing forecasts for the off-cycle year pink stocks in QCI was questioned and the author pointed out that although the odd-year pink stocks have been very small in recent times, the stock in the 1950’s and 1960’s was somewhat larger (50,000 to 150,000). Concerns were raised about using only terminal area catch plus escapement to represent total production for some of the pink and chum stocks. The interceptions of pink and chum stocks in fisheries outside the terminal statistical areas is very poorly understood, but does occur, and would result in underestimates of the catch and total stock estimates.

The Subcommittee discussed the potential to include forecasts for the Skeena and Nass pink stocks as the largest pink producers in northern British Columbia. The problem in these areas is the allocation of catch among stocks, including the sometimes large catch of U.S. origin pink stocks. There is a reconstruction model of the boundary area pink stocks using the international tagging data from 1982,

1984 and 1985 but the stock compositions are so variable among years that reconstruction estimates are very uncertain which supports the authors view that the data are insufficient to evaluate forecast methods. There are manager forecasts of the pink returns to these areas based on brood year escapements times an assumed return rate. It was noted that the Area 8 chum forecasts include wild and enhanced chum salmon.

The Subcommittee agreed that the best prediction for Skeena River sockeye for 1999 is 0.6 million based upon the sibling model (Figure 5). While this sibling model has not performed well in the long term retrospective analysis, it is recommended because it captures the effects of poor fresh water production from two consecutive brood years (1994 and 1995) and poor marine survival for the 1994 brood year.

Subcommittee Recommendations

The Subcommittee recommended acceptance of the northern British Columbia sockeye, pink and chum salmon forecast probability distributions (Table 2).

S99-4 Population status and sustainable production of British Columbia's salmon populations in the 1990's

D. W. Welch, J.P. Eveson, F. Whitney, J.F.T. Morris **Paper Not Accepted**

Summary

Assessment of the population trends of Canadian and Alaskan salmon indicates that there has been a very large drop in the overall productivity of British Columbia salmon populations during the 1990s. This follows a prolonged period of population increase for all species (except coho) from 1977-89, a previous regime. The declines in productivity appear to be identical to those previously identified for coho. These changes have substantial temporal and geographic coherence. They appear to be the result of large-scale changes in ocean climate that have sharply reduced ocean survival starting in 1990. Once lagged back to the year of ocean entry, adult returns (both catch and escapement components) all begin to drop sharply in 1990.

The patterns of change indicate that the reduced ocean survival of young salmon likely occurred in the coastal ocean off British Columbia during the first few months after ocean entry from 1990 to 1995. After 1995, suddenly reduced marine survival of Alaskan salmon populations indicates that the region of poor ocean survival increased to include much of Alaskan coastal waters. This change is likely to further reduce the ocean survival of all species of British Columbian salmon.

Both recruitment and adult escapement has been sharply reduced in British Columbia as a result of reduced ocean survival. For each species of salmon the rates of decline in catch and escapement are almost identical. This indicates that the declines in catch are a reflection of overall population trends and that the sharp declines in catch occurring in the 1990s are not the result of reduced harvest rates, as previously had been suggested. On the contrary, harvest rates appear to have remained roughly stable through much of the 1990s. A similar management response is also evident in Bristol Bay, where we show that although very large declines in recruitment were evident in 1997, only a very small change in harvest rate occurred, and escapement consequently fell by one third.

The measured rates of population decline during the 1990s are much greater than during any previous period since 1952. The rates of population decrease in the 1990s are three to six times greater than the rates of population increase observed in the 1977-89 period. As a result of the rapidity of the population declines, both escapement and total population size have dropped very rapidly in the most recent years from the record levels seen in the late 1980s. Escapement levels for British Columbia salmon in the most recent year of available data (1996) are now the lowest (chum, coho, chinook) or near lowest (sockeye) seen in the last 40 years.

The precipitous declines in population size and spawning escapements now occurring are the result of changes in ocean conditions; they are not initially the result of overfishing. However, the only direct control that can be exercised over rates of population increase or decrease is to change harvest rates to ensure adequate spawning escapements. The reductions in escapement that occurred following 1990 are already large enough to substantially reduce future recruitment levels for all species of salmon. As ocean conditions appear to be deteriorating further for all species of Pacific salmon, the combined effect of reduced numbers of smolts entering the ocean and elevated ocean mortality on future productivity is extremely serious.

The cause of the precipitous declines in British Columbia salmon abundance and productivity during the 1990s are not yet well understood. However, they are clearly the result of oceanographic changes in the structure of the ocean that may be operating to reduce biological productivity at the base of the food chain over a vast region of the coastal ocean stretching from Vancouver Island north to the Aleutian Islands in the 1990s. Juvenile British Columbia salmon travel through this region in their migration to the offshore North Pacific. The observed oceanographic changes may also be partly attributable to the early stages of global warming. Further oceanographic changes in this region are likely, and may determine whether salmon survival improves or deteriorates further. However, the magnitude of these natural changes in survival are so large that, at least for some species, it may not be possible to reduce harvest rates sufficiently to compensate for the reduced ocean survival that is now apparently occurring.

There is an immediate need to recognise and react to these ocean changes much more rapidly than has occurred to date. This will require identifying what factors are reducing the marine survival of pacific salmon, and understanding how these changes are linked to physical changes in the ocean and atmosphere. Such an understanding would allow more pro-active management steps to be taken than was the case in the early 1990s in either British Columbia or Alaska.

Reviewer #1

The first reviewer stated that this paper was a resubmission of a 1997 paper and felt the basic concerns identified by the Subcommittee were not addressed. The reviewer indicated the need for systematic geographic clustering of the data, to differentiate between local and ocean effects. Concerns are expressed over the treatment of Fraser sockeye data. The reviewer does not accept the paper.

Reviewer #2

The second reviewer noted that the paper summarises a great deal of evidence that marine survival rates have changed dramatically, but goes on to be critical of the paper in a number of areas. The reviewer questioned whether the data supports that decreases in ocean productivity have been responsible for the sudden declines since 1990, questioning the consistency of the response among stocks, whether the timing was coincident among stocks, and whether the calculated changes to the Ricker parameters are as expected. The reviewer went on to question the merits of PSARC reviewing studies of mechanisms rather than keeping to reviews of short term forecasts, long term production relationships and analysis of in-season procedures for meeting exploitation rate goals.

Reviewer #3

The third reviewer indicated the conclusions stated by the authors could not be supported by the analysis. The reviewer repeated the concern of the previous PSARC review that the paper failed to test the hypothesis posed in the paper with sufficient rigour to support the conclusions. Other concerns were expressed regarding the effect of the uncertainty in the catch and escapement data would affect the stock recruit and harvest rate analysis, the incomplete treatment of the available information, and the testing of alternate hypotheses. The reviewer recommended that the paper not be accepted unless major revisions were undertaken to correct the concerns identified.

Subcommittee Discussion

The authors responded to some of the reviewers concerns, including details of the need to line up ocean entry years among species to evaluate whether trends were coincident. The Subcommittee indicated concerns regarding the nature of

some of the analysis and interpretation of the data, particularly Fraser and Skeena/Nass sockeye. This expanded into a lengthy discussion of various aspects of the escapement and catch data used in the analysis and whether the data supports a breakpoint in 1990, that matches climate change.

The Subcommittee discussed concerns regarding the stock recruit analysis, particularly the impact of using the biased (underestimated) escapement database that would overestimate the stock productivities. Concern was expressed over the use of catch or escapement trends in isolation rather than in the context of a stock-recruit relationship. The Subcommittee discussed the theory of whether density dependent processes occur only in freshwater and noted there were arguments in the literature for both freshwater and ocean density dependence.

Strong concern was expressed regarding the aggregation of the data for all of British Columbia. The general consensus was the paper needed to deal with a detailed analysis for each species, similar to the treatment for steelhead in the previous paper. An example was provided detailing that information was available for individual chinook indicator stocks, and that the aggregations for chinook were misleading because of the high proportions of Canadian hatchery and US chinook in the BC catch which do not reflect Canadian wild chinook abundance. There were further comments for other species indicating the Subcommittee's views that stock specific treatments would be the most informative and the best match for current management.

The Subcommittee did not accept the paper. Some members suggested acceptance with major revisions was an option, however further discussion indicated the data availability and the level of revision precluded this option.

Subcommittee members did support the need to complete this paper, and the importance of finding a way to effectively incorporate marine uncertainty in our forecasts. Some questioned whether the quality of the data is sufficient to resolve the issue. Concerns were raised over the availability of the data.

The Subcommittee stressed that if further work was initiated on the paper it should be done with a clear understanding and acceptance of the approach by the Subcommittee.

Subcommittee Recommendations

The subcommittee recommended that this paper not be accepted.

S99-5 1999 Forecasts for Johnston Strait, Georgia Strait and Lower Fraser River Chum Salmon

P. Ryall. D. Bailey, V. Palermo **Accepted subject to revisions.**

Summary

The stock forecasted in this paper is known as the Study Area chum stock. These stocks originate from the east coat of Vancouver Island, Mainland Inlets and the Fraser River. In this working paper, the authors conduct retrospective analyses in order to assess the forecast accuracy of some alternative forecasting models.

The 1999 forecast return is comprised of two separate components: wild and enhanced. Existing major facilities throughout the inside waters have the capacity to produce 1.3 million chum at favourable marine survival rates. The major facilities on Vancouver Island include Big Qualicum, Little Qualicum spawning channel and the Puntledge Hatchery. They have a production potential of about 650,000 adults. Major facilities on the Fraser River include the Chehalis, Chilliwack and Inch hatcheries; these have a production potential of about 250,000 (not including habitat restoration). An additional 400,000 production occurs from various minor facilities and habitat restoration projects within the Study Area.

Nine models were examined with retrospective analyses for the wild component of the Study Area stock. The retrospective analysis found little difference in predictive ability among the nine models tested. The two best models though were 5YAVGBY (non-biological model) and 5YLSRESC (biological model).

The 1999 forecast return is shown in Table 3. The total Study Area wild chum return is expected to be 2,016,000 (50% probability level) using the 5YAVGBY forecast, whereas the 5YLSRESC model forecasts a wild return of 3,312,000. For the 5YAVGBY model there is a small harvestable surplus of 16,000 wild chum at the forecasted level (escapement goal for wild chum is 2,000,000), but 1,300,000 if the 5YLSRESC model is adopted. The enhanced forecast is 425,000 using recent year survival (1990-92) or 936,000 if a long term (1979-88) average survival is used. As the recent year trend has been to lower survival rates for enhanced chum salmon it would be prudent to forecast using the recent year average brood survival (1990-92)(Figure 6). The 1999 forecast for Study Area chum, wild and enhanced, is 2,469,000 or 3,765,000, respectively using the 5YAVGBY or 5YLSRESC models for the wild and recent year (1990-92) average survival for the enhanced component.

Subcommittee Discussion

Discussion initially centred around the utility of the forecast for fisheries management. The author noted that the forecasts that performed very poorly were not used once the season started, and had minimal value in pre-season planning. Once in-season, test fisheries and actual fishery results drove fisheries management.

Approaches to improving the forecasts were discussed briefly with the need to investigate the predictive capability of the Mission chum fry index as the only specific suggestion. This idea had also been expressed in previous PSARC reviews of this forecast. A suggestion was also made to consider stock recruit models, particularly for Fraser chum.

A broader discussion ensued on the need to scientifically review in-season management systems generally and the Inside Chum Clockwork specifically. The review of the Clockwork should include:

- A clear statement of the stock and fisheries objectives,
- The conservation basis for the management approach,
- A review of escapement data quality and the escapement goal,
- An evaluation of the effectiveness of in-season run-size estimation tools.

The Subcommittee felt that a stock status evaluation should accompany the clockwork review. A suggestion was made to use a boxcar model using catch and run timing to estimate spawning escapement, however, others felt that this would not be possible for Inside chum stocks because of the lack of appropriate data. A working paper reviewing the chum Clockwork Management Plan is scheduled for the April, 1999 Subcommittee meeting.

Subcommittee Recommendations

1. The Subcommittee recommended that the forecast of wild Inside chum based on the 5 year average brood year model of 2.0 million (50% C.I. of 1.3 to 2.7 million) be adopted.

2. For enhanced stocks, given the low survival measured for the two most recent brood years, the forecast of 0.45 million based on the 1990-92 brood years should be adopted.

3. The combined forecast for wild plus hatchery chum is 2.45 million. Confidence limits around this combined forecast are not provided but fishery managers should be aware that both the wild and hatchery forecasts are highly uncertain.

S99-6 Review of 1998 Terminal Run of Somass River Chinook Salmon, 1998 WCVI Extensive Escapement Indicators, and Somass Terminal Run Forecast for 1999

B. Riddell, W. Leudke, J. Till, B. Patten **Accepted subject to revisions**

Summary

The detailed assessments and forecasts of the Robertson Creek Hatchery/Stamp River (Somass) chinook are undertaken annually for management of ocean and terminal fisheries, and as an indicator of the expected returns to the naturally spawning chinook populations along the west coast of Vancouver Island (WCVI). Based on returns through 1998, assumptions of ocean fishing mortality, and using methods previously approved by PSARC, the recommended forecast for the total terminal run of Robertson Creek Hatchery and Stamp River chinook (age 3, 4, and 5) to Barkley Sound in 1999 is 35,000±20% (based on averaging the Prod2 and Prod3 forecasts). The age structure of the return is projected to be 15% Age 3, 11% Age 4, and 74% Age 5; with an expected sex ratio of 62% females. The number of chinook required to meet the minimum escapement goal on the Stamp River is 26,700. With poor age 4 returns, the age 5 spawners should be sufficient in 1999 to meet minimum egg deposition levels under conservative fishery management.

"Extensive" surveys of natural spawners in systems along the WCVI indicated improved chinook escapements in 1998, mainly due to strong returns from the 1994 brood. However, as with the Somass return, there was a seriously low number of age 3 chinook (1995 brood year) throughout the WCVI. This will result in low numbers of age 4 returns in 1999, which are usually the main age class in the run and the main age class in egg deposition.

In addition, indications of low jack returns in 1998 suggest a very low survival rate for the 1996 brood year (although note there can be large error in this estimate). However, two consecutive broods with poor survival could result in extreme conservation concerns in 2000. As a result, there is a continued need for conservative management plans in fisheries impacting these stocks during 1999.

Subcommittee Discussion

Forecast returns for age 4 (1995 brood) are very poor, and forecast returns for age 3 chinook are poor although there is more uncertainty in this estimate. A high proportion of the 1999 return will be 5 year old chinook that are mostly females. Hence the 1999 total return relies heavily on only one brood year (1994) for egg deposition. Returns of age 2 chinook to the Somass River suggest poor recruitment for the 3 year olds from the 1996 brood, but the relationship is poor. This raises the potential concern that in 2000 returns of both age 4 and age 5 female spawners will be poor. The subcommittee also noted in the discussion that the ocean harvests in 1999 affect both the 1999 and the year 2000 returns.

The Subcommittee asked if the nature of the forecast could be changed from a terminal forecast requiring assumptions regarding Alaskan and non-terminal Canadian harvests, to an estimate of total returning stock. The authors pointed out the need to assume a maturity schedule for each age and the additional

complexity in dealing with chinook. The final agreement was for the authors to provide an estimate of the run to the terminal area in the absence of a Canadian fishery, in addition to the current estimate that assumes a Canadian ocean exploitation. [The authors provided this estimate which is 40,000 (average of the Prod2 and Prod3 models].

The Subcommittee noted that adult escapements based on extensive stream surveys of escapement indicator stocks for WCVI show an encouraging upward trend (Figure 7).

Subcommittee Recommendations

The Subcommittee recommended the paper and the forecasts be accepted. The recommended forecast for the total terminal run of Robertson Creek Hatchery and Stamp River chinook (age 3, 4, and 5) to Barkley Sound in 1999 is 35,000±20%. The estimate of the terminal run in the absence of any Canadian fisheries is 40,000. The age structure of the return is projected to be 15% Age 3, 11% Age 4, and 74% Age 5; with an expected sex ratio of 62% females.

S99-7 Forecast for northern British Columbia Coho salmon in 1999

B. Holtby, B. Finnegan, B. Spilsted **Accepted subject to revisions**

Summary

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

Marine survival: Marine survival at the three northern indicators is expected to be above average for 1999.

Indicator	Model	$\hat{s}_{1999}$	(50% CI)
Lachmach	sibling regression	0.175	(0.143–0.215)
Toboggan Creek hatchery	from Lachmach	0.046	(0.028–0.075)
Fort Babine hatchery	from Lachmach	0.033	(0.014–0.076)

The forecast for Fort Babine is poorly defined. Based on three years observations the survival rate of wild Toboggan Creek coho should be 0.176, which is the same as the forecast for the Lachmach. The authors note that survival rate forecasts for the Skeena were optimistic in 1998.

Abundance forecast: After the application of stock-recruitment and time-series models to reconstructions of abundance in six aggregates in northern B.C. the authors conclude the following about abundance in 1999:

Aggregate	1999 Abundance Forecast	Confidence in Forecast
Babine Lake upper Skeena	well below average	high
lower and middle Skeena	below average	moderate
Area 3	below average	high
Area 6	well below average	low
Areas 7 & 8	below average	low

Average abundance is over the period 1950 to 1998 for the Statistical Area aggregates and over the period 1946 to 1998 for Babine Lake. Abundance forecasts relative to this period are not necessarily indicative of aggregate status.

Abundance was not forecast for Area 5 (Grenville and Principe) because of inadequate escapement data between 1995 and 1998. Prior to that period the trends in escapement and abundance were intermediate to those in Areas 4L and 6. Abundance was not forecast for Areas 9 (Rivers Inlet) and 10 (Smith Inlet). The escapement data for those areas in the 1990's are insufficient to make a forecast. Escapement data in 1998 suggest that both areas are similar to Area 8. Abundance was not forecast for the Queen Charlotte Islands because of a lack of exploitation rate time series.

The authors note that these forecasts were derived from the most conservative of the approaches considered. Given that survival is forecast to be above average at least in the northern area (Figure 8), it is possible that our forecasts are in fact very conservative. It is probable however, that even with above average survival, that the Babine Lake and upper Skeena aggregates will remain sufficiently depressed to warrant considerable caution in managing fisheries in 1999. It would be prudent to extend that caution to Areas 5 and 6.

Subcommittee Discussion

The North Coast forecast for 1999 represented an expansion of work undertaken last year (Statistical Areas 6 - 10). The desirability of grouping the coho systems in ways other than those presented in the paper were considered by the Subcommittee. Among the alternatives were groupings by biological criteria such as mainland rivers verses offshore islands.

The Subcommittee noted that data from Areas 1, 2E and 2W (Queen Charlotte Islands) and Area 5 were not included in the analysis. This led to a more general discussion regarding the limitation of the escapement data set and the

considerable difficulties in making forecasts in some situations. The QCI data set was a case in point where the limitations of the data set were considered by the author, to be severe enough that forecasts should not be made. However, although the Subcommittee agreed with the author's conclusions, they recommended that the data set be included in the paper, along with an explanation of the limitations.

The concerns regarding the escapement data were further discussed in the context of how to improve the reliability of the information for the future. One suggestion was that a subset of the streams within a statistical area could be selected as higher quality data and expanded in some manner to generate total estimates for the area. This could be compared with the "average stream" approach used in the paper.

The paper indicated that despite using statistical techniques which specifically incorporated trends in survival, forecasts still tended to be overestimates A discussion about the impacts of a consistent overestimate occurred and it was suggested that there was a possibility that other statistical techniques may provide marginally better results.

Abundance estimates made in the paper used both a time series and stock recruit approach in order to generate abundance estimates. Concerns were expressed by the Subcommittee regarding the stock recruit approach, particularly when stocks are at low levels of abundance. The time series approach produced a more conservative estimate of abundance and was generally felt to be a better approach.

The Subcommittee also noted with concern, the declining trends in escapement for Area 6 and recommended that further monitoring of stock status be conducted in this Area. In terms of overall priorities for stock status and monitoring, the Subcommittee recommended the following rankings:

1. Upper Skeena
2. Areas 5, 6 and 7 as a group
3. QCI
4. Lower and middle Skeena
5. Area 3 and 4 coastal
5. Areas 8, 9 and 10 as a group

Subcommittee Recommendations

1. The Subcommittee recommended acceptance of the Lachmach, Toboggan Creek and Fort Babine Hatchery coho marine survival forecasts.

2. The Subcommittee recommended acceptance of the abundance indicators.

S99-8 An update on 1998 stock status and 1999 forecasts of Barkley Sound sockeye

K.D. Hyatt, W. Luedke **Accepted subject to revisions**

Summary

Recent year returns of Barkley Sound sockeye have been gradually increasing from a low of only 200,000 fish in 1995 to 380,000 in 1996, 465,000 in 1997 and 660,000 in 1998 (Figure 9). Although moderate, recent increases were anticipated by two independent forecasting procedures first developed in 1987 and applied annually since 1988 to predict return variations of Barkley Sound and West Coast Vancouver Island (WCVI) sockeye. Given the gradual recovery of the stock in recent years, aboriginal, recreational and commercial fisheries were correctly anticipated in both 1997 and 1998. Recent year stock increases represent a continuation of a pattern of predictable variations in ocean climate states that have lead to repeated "crashes" (1978, 1985-86, 1989-90, 1994-95) followed within 1-3 years by recoveries (1979-81, 1987-88, 1991-93, 1996-98) of WCVI sockeye returns. The surplus for commercial catch in recent years is directly attributable to the combined effects of: (i) a shift of conditions in the marine environment that supported near average survival of sockeye smolts migrating seaward between 1994 and 1996 and (ii) management to protect escapement as a basis for increases in future year returns.

Over the past 10 years, four independent techniques have been tested annually for their utility in generating reliable pre-season forecasts of Barkley Sound sockeye returns for harvest managers. The four techniques are known as the Salinity Survival Method (SSM), the Survival Stanza Method (SStM), the Sibling Age Class Method (SACM), and the Salmonid Enhancement Program Biostandard Method (SEPB). Updates on the performance of three of these techniques in 1998 are as follows:

1) The SStM forecast exhibits the best overall performance with a Mean Absolute Percent Error (MAPE) value of approximately 27 % over the most recent 11 years of forecasting (Table 4). Further, SStM forecasts account for the majority of variations in returns if the extreme observation associated with the 1991 return year is omitted from the analysis (returns = 1.17 SStM forecasts - 66.35, $r^2 = 0.82$, $P<0.01$).

2) The SSM forecast exhibits the next best performance with a MAPE value of 35 % over the most recent 11 years of forecasting. SSM forecasts also exhibit a statistically significant association with returns if the 1991 return year is omitted from the analysis (returns = 0.83 SSM forecasts + 35.28, $r^2 = 0.77$, $P<0.01$).

3) SEPB forecasts have performed well over some return intervals but not others. During the 1988-1998 testing interval SEPB forecasts exhibited a substantially higher MAPE value (56 %) than that displayed by both SSM and SStM forecasts (27-35 %). Large magnitude deviations between SEPB forecasts and actual returns tend to occur in consecutive years, which seriously erodes the confidence of harvest managers as well as fishers in their utility.

All three forecast alternatives indicate that returns for Barkley Sound sockeye will remain below the 20 year average (818,000) in 1999. Comparative performance of the various forecast options, along with DFO's recent pursuit of a more risk averse approach to management recommends the SStM forecast range of 302,000 (75 % probability) to 433,000 (25 % probability) sockeye as the preferred, pre-season forecast for 1999 (Table 4).

Subcommittee Discussion

The Subcommittee discussed whether jacks should be excluded from the forecast models because they do not contribute to the fishery. The Subcommittee recommended that the forecast be restated with only 4 and 5 year old sockeye reported in the forecasts, and that the authors evaluate whether the exclusion of the jacks would require recalculation of the retrospective evaluation of the models.

The anomalously high abundance of jacks in the 1998 return was noted but it’s significance as an indicator of future returns was uncertain. The authors noted, but did not demonstrate that the relationship between age 1.1 and age 1.2 abundance of the same brood year was poor. The Subcommittee agrees with the authors’ statement that “given the divergent forecasts, we recommend careful review of the return indicators to verify their merit as data accumulates inseason”.

A very low forecast abundance for Henderson Lake sockeye returns in 1999 was identified as a potential concern for fisheries managers.

The author reviewed the Subcommittee concerns regarding the inclusion of jacks and had the following response, “I have also looked at the issue of including "jacks" in the forecast and note that they will normally contribute less than 20 % of the forecast for a given years returns to Barkley Sound. The exceptionally high proportion of jacks predicted to return in 1999 is associated only with the SSM forecast method. Thus, if we are basing the 1999 forecast on the SSM as per our advice in the paper, the values in Table 4 do not include an exceptionally high jack component and will not mislead fisheries managers. On the other hand, if the SSM forecast with its higher jack component does materialize there is a built in "buffer" re: the expectation because the overall return under the SSM is higher.”

Subcommittee Recommendations

The Subcommittee recommended acceptance of the paper and the 1999 forecast. The 1999 Barkley Sound sockeye run size forecast at the 50% probability level is 332,000 (50% chance the run will exceed this forecast), 302,000 at the 75% probability, and 433,000 at the 25% probability level (Table 4).

APPENDIX 1: PSARC SALMON SUBCOMMITTEE MEETING AGENDA MARCH 9-11, 1999

Tuesday March 9 13:00

Procedural discussion.

Fraser Sockeye

Barkley Sound Sockeye

Northern B.C. Sockeye, Pink and Chum

Wednesday March 10, 08:30

Southern B.C. Coho

Northern B.C. Coho

Southern B.C. Chum

WCVI Chinook

Subcommittee report preparation if time allows.

Thursday March 11, 08:30

Population status and sustainable production of British Columbia's salmon populations in the 1990s.
Welch et. al.

Subcommittee Report Preparation

APPENDIX 2: PSARC SALMON WORKING PAPERS FOR MARCH 9-11, 1999.

No.	Title	Authors	Reviewers
S99-1	Run size forecasts for the Fraser River sockeye and pink salmon in 1999	A. Cass	
S99-2	Forecasts for south coastal British Columbia coho salmon in 1999	B. Holtby J. Irvine R. Tanasichuk K. Simpson	
S99-3	Trends in abundance and preseason 1999 run size forecasts for major sockeye, pink and chum salmon stocks in northern British Columbia.	C. Wood D. Rutherford L. Jantz	.
S99-4	Population status and sustainable production of British Columbia's salmon populations in the 1990's	D.W. Welch J.P. Eveson F. Whitney J.F.T. Morris	A. Cass S. Cox- Rogers C. Walters
S99-5	1999 Forecasts for Johnston Strait, Georgia Strait and Lower Fraser River Chum Salmon	P. Ryall D. Bailey V. Palermo	
S99-6	Review of 1998 Terminal Run of Somass River Chinook Salmon, 1998 WCVI Extensive Escapement Indicators, and Somass Terminal Run Forecast for 1999	B, Riddell W. Leudke J. Till B. Patten	
S99-07	Forecast for northern British Columbia coho salmon in 1999	B. Holtby B. Finnegan B. Spilsted	
S99-08	An update on 1998 stock status and 1999 forecasts of Barley Sound Sockeye	K.D. Hyatt W. Luedke	

APPENDIX 3: PARTICIPANTS AT THE SALMON SUBCOMMITTEE MEETING, MARCH 9-11, 1999.

Subcommittee Chair: David Peacock
PSARC Chair: Max Stocker

DFO Participants	**Tues**	**Wed**	**Thurs**
* Subcommittee Members			
S. Baillie		✓	
D. Anderson*	✔		
S. Argue*	✓	✓	
D. Bailey*			
M. Bradford*			
A. Cass*	✓	✓	✓
R. Goruk*			
B. Hargreaves*		✓	✓
B. Holtby*	✓		
K. Hyatt*			
J. Irvine*			✓
S. Johnston*			
R. Kadowaki*	✓	✓	✓
A. Macdonald*	✓	✓	✓
S. McKinnell*	✓		✓
D. Meerburg*	✓	✓	✓
B. Riddell*			✓
P. Ryall*	✓	✓	
M. Sullivan*	✓	✓	✓
C. Wood*	✔	✓	✓
B. Payne	✔	✓	
J. King	✓	✓	✓
B. Otway		✓	
T. Gjernes		✓	
L. Hopwo		✓	
K. Simpson		✓	
D. Rutherford		✓	✓
R. Tanasichuk		✓	
B. Finnegan		✓	
External Participants:			
C. Walters	✔	✔	
D. Blackbourn	✓	✓	
P. Leblond	✓	✓	
A. Tautz*	✓	✓	✓
R. Routledge		✓	✓
M.S. Atkinson		✓	✓
K. Wilson		✓	✓

TABLES AND FIGURES

Figure 1. **Marine survivals vs. return year for seven coho indicators in southern British Columbia. Available forecasts of marine survival in 1999 are shown with associated 50% CIs. The model used to make the forecasts is listed in the preceding Table. No forecast of survival for the Thompson River coho is available.**

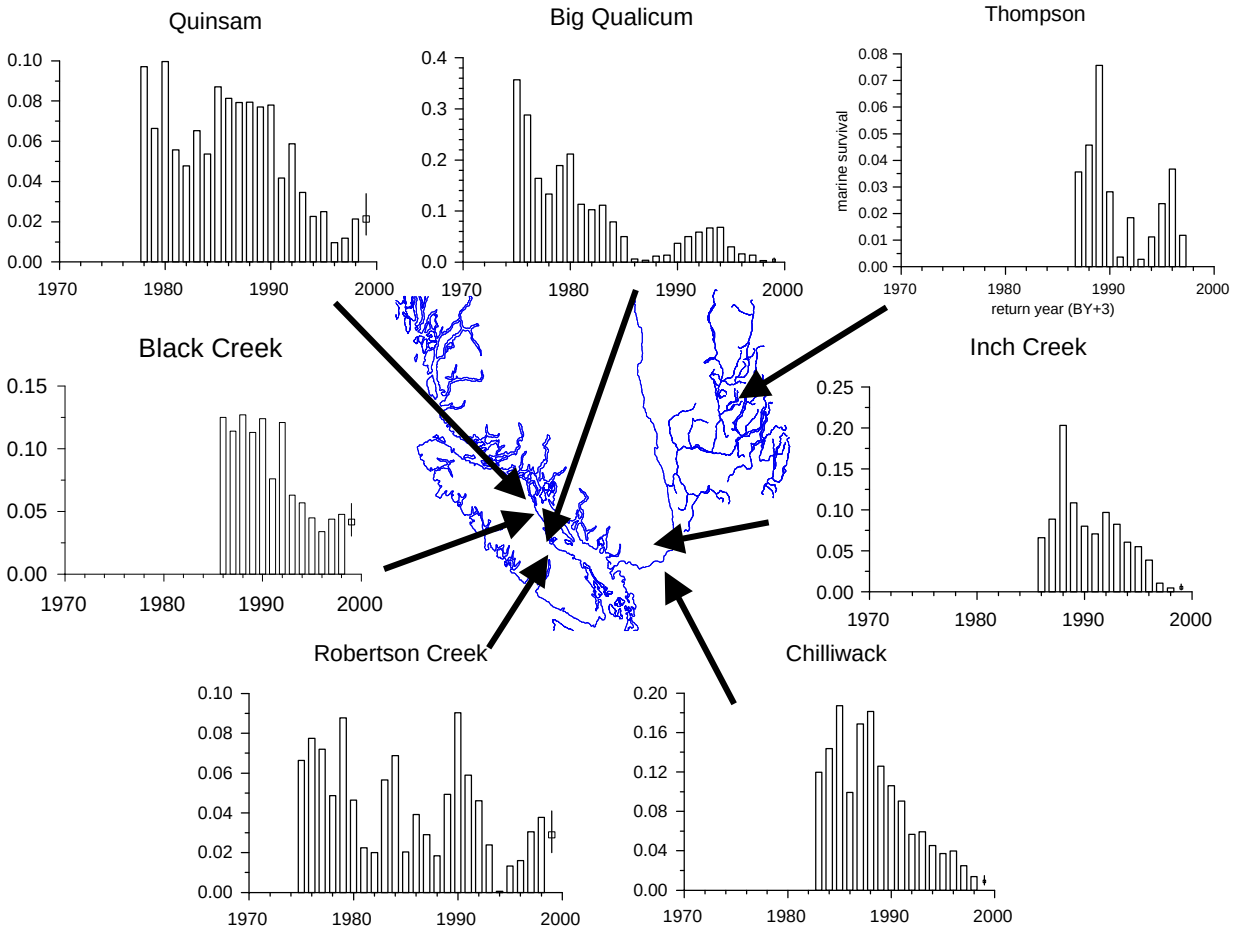


Figure 2. **Abundance estimates for the Strait of Georgia+Fraser aggregate and the West Coast Vancouver Island aggregate of southern British Columbia coho. Values shown for 1998 are for the overall p_h for the period 1990 to 1997. The forecast abundances for 1999 with associated 50% CI are shown from both aggregates.**

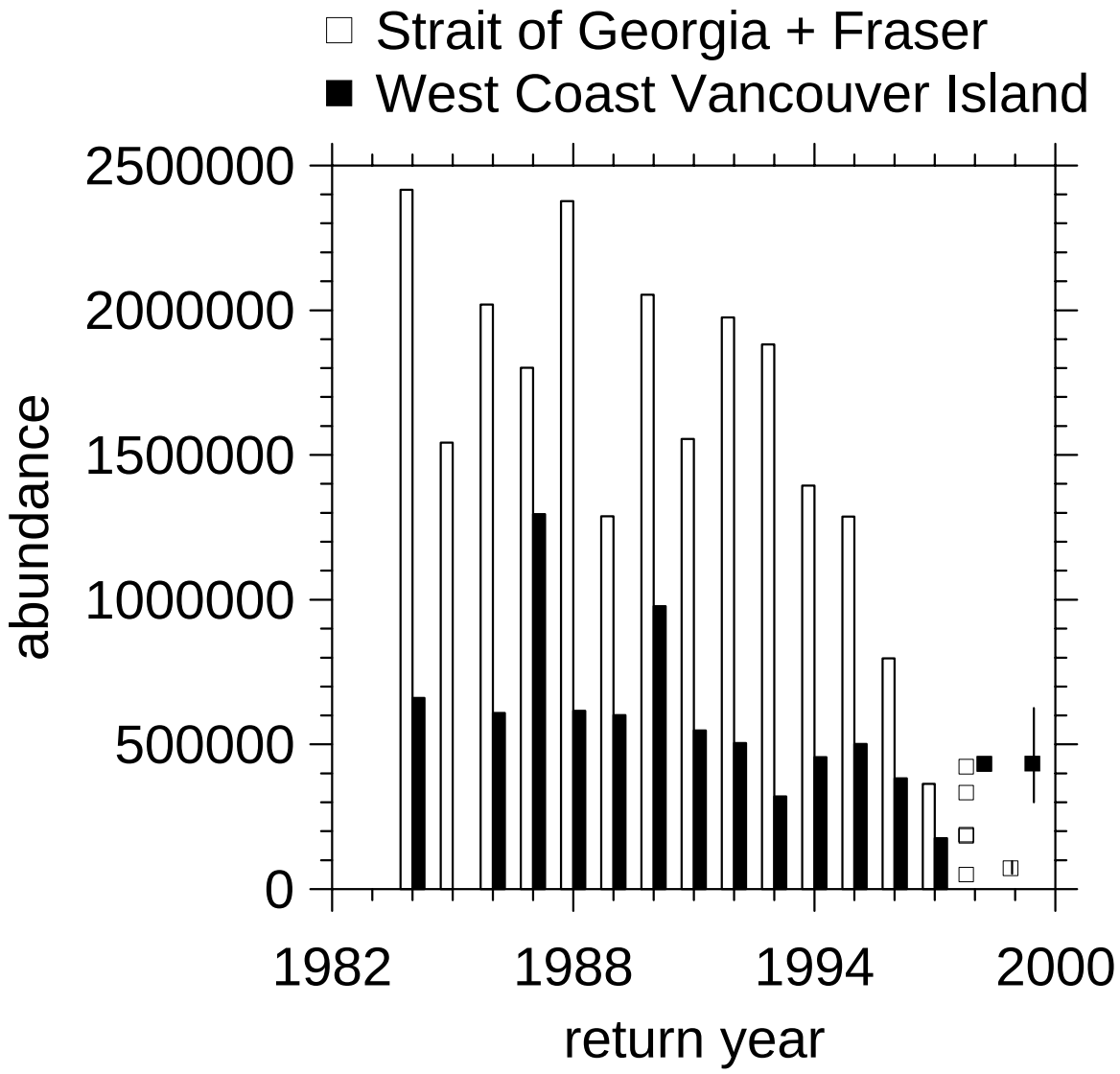


Figure 3.Total returns to North and South Thompson aggregates from 1975 to 1998. The forecasts for 1999 with their 50% CI are shown.

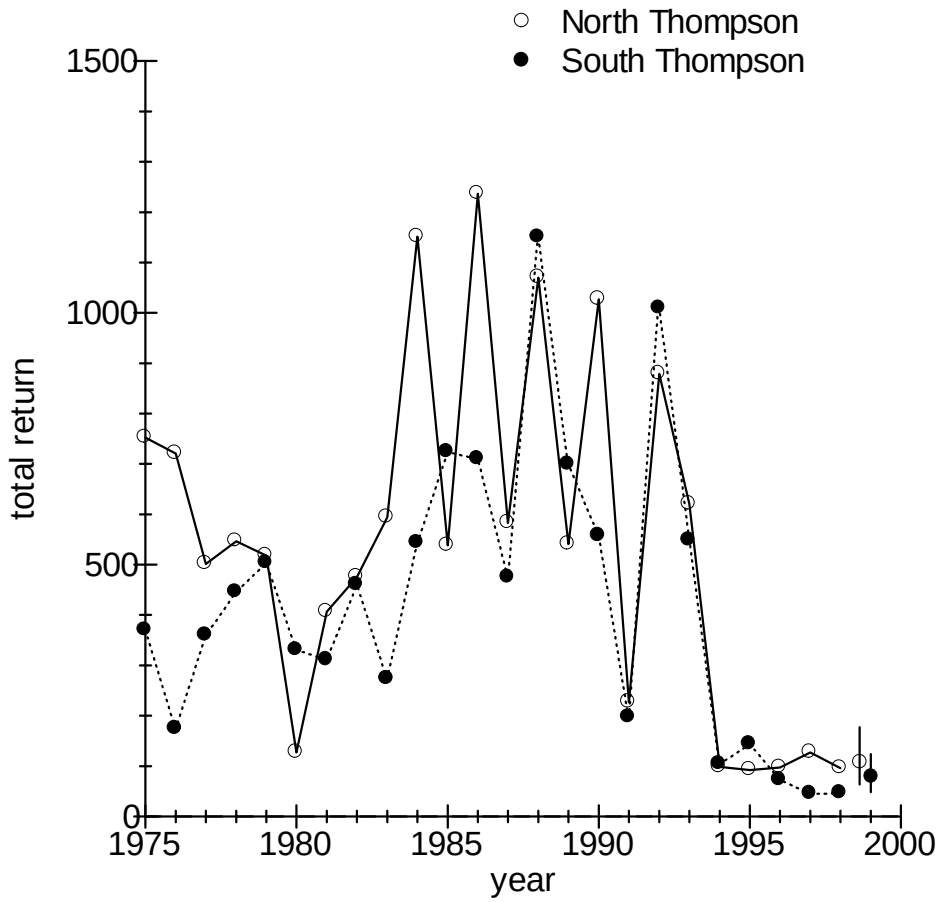


Figure 4. Map of northern British Columbia showing locations of salmon stocks and statistical areas

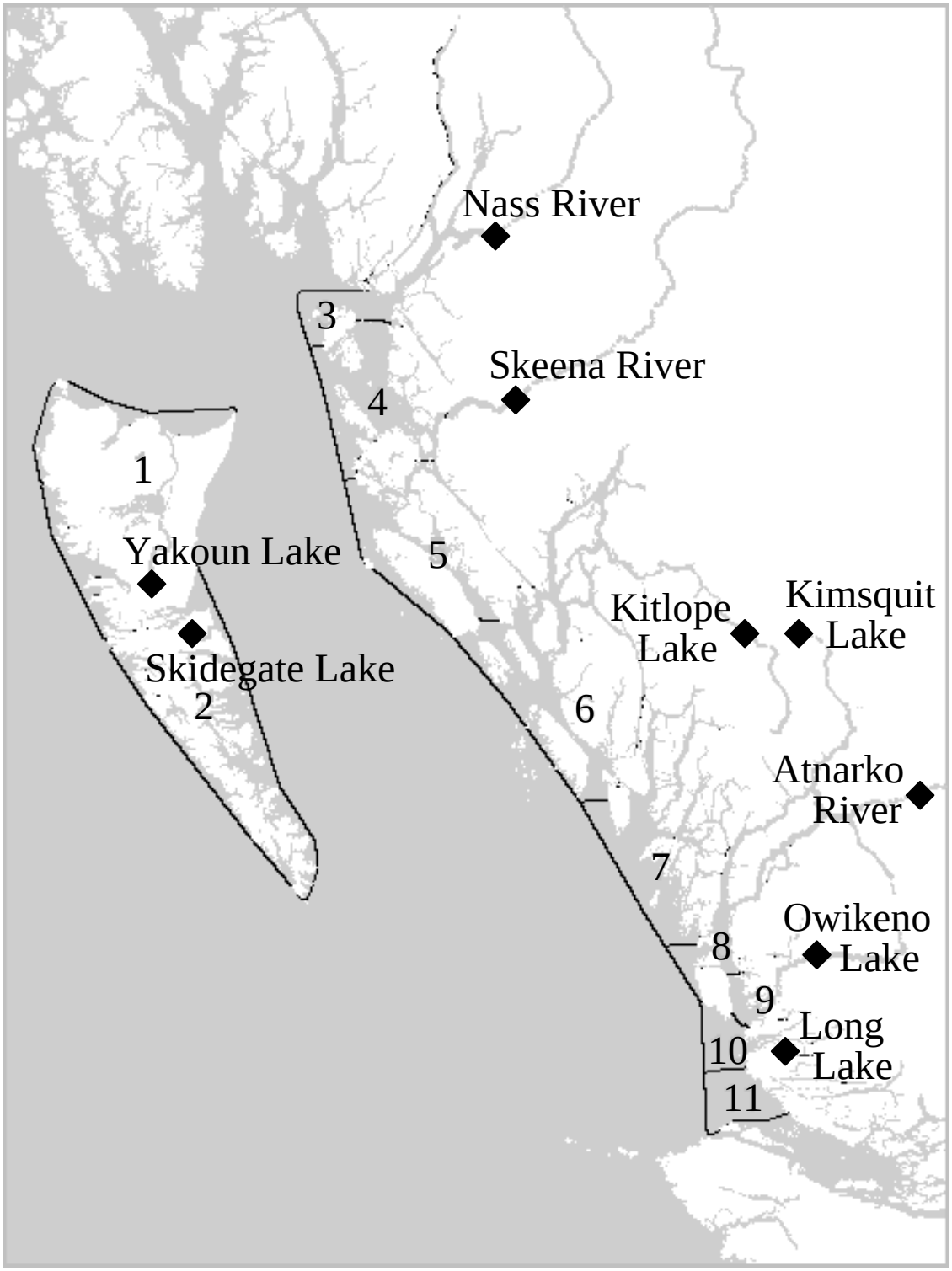


Figure 5. Sibling model for forecasting total returns of age 5_2 Skeena sockeye from age 4_2 returns from the same brood year. Dashed lines indicate very low age 5_2 returns expected given poor age 4_2 returns from brood year 1994; all labels refer to brood years.

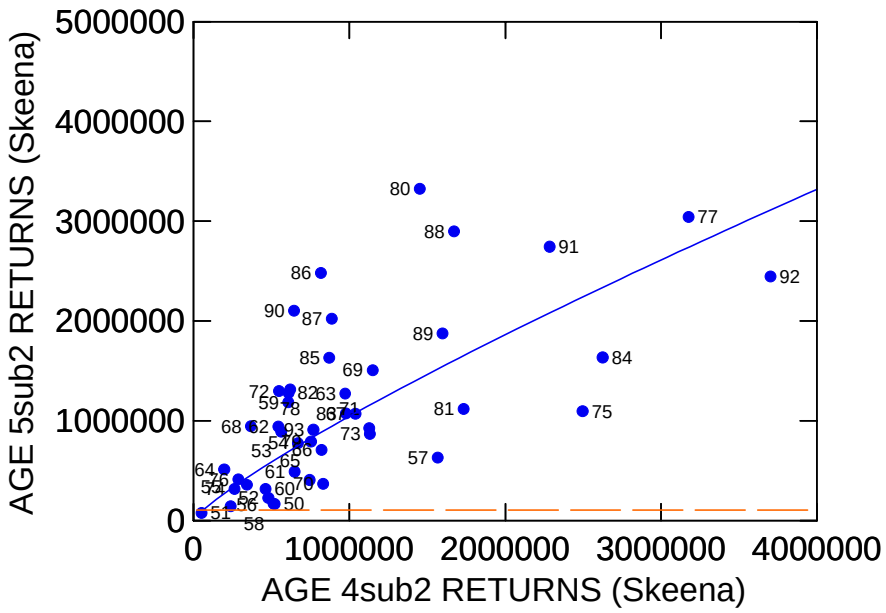
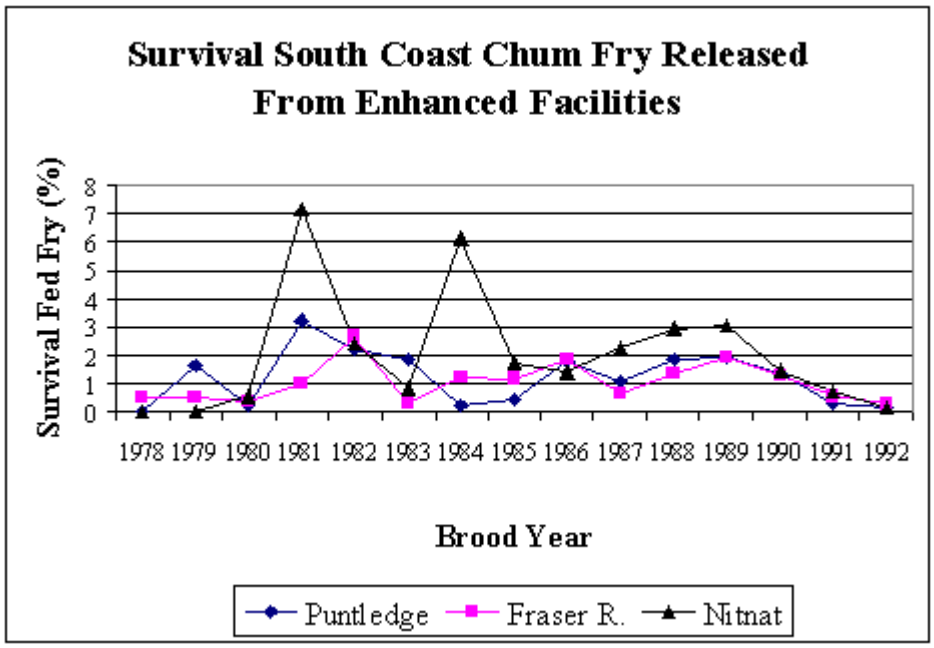


Figure 6. Marine survival estimates for fed and unfed chum fry releases.



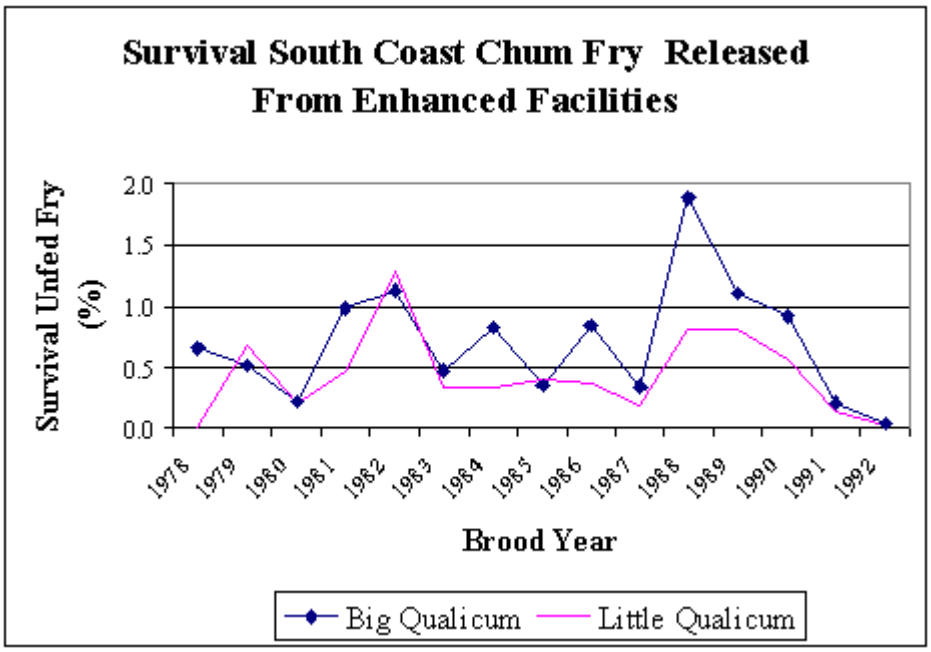


Figure 7. Trend in adult WCVI chinook escapement of PSC escapement indicator stocks, 1975 to 1998. The solid line indicates the base period (1975-1982) average escapement. The broken line indicates the PSC rebuilding goal (double the base period average).

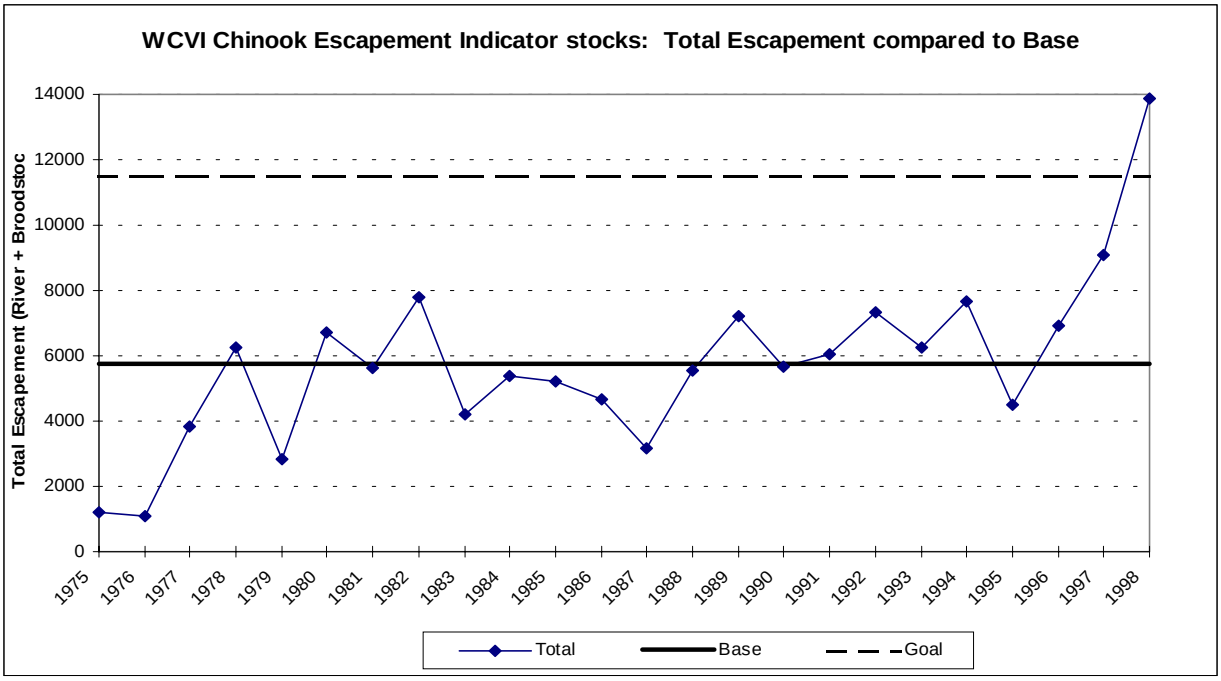


Figure 8. Time series of standardized survivals for three northern BC coho indicators. Forecast survivals for 1999 are shown with 50% confidence intervals.

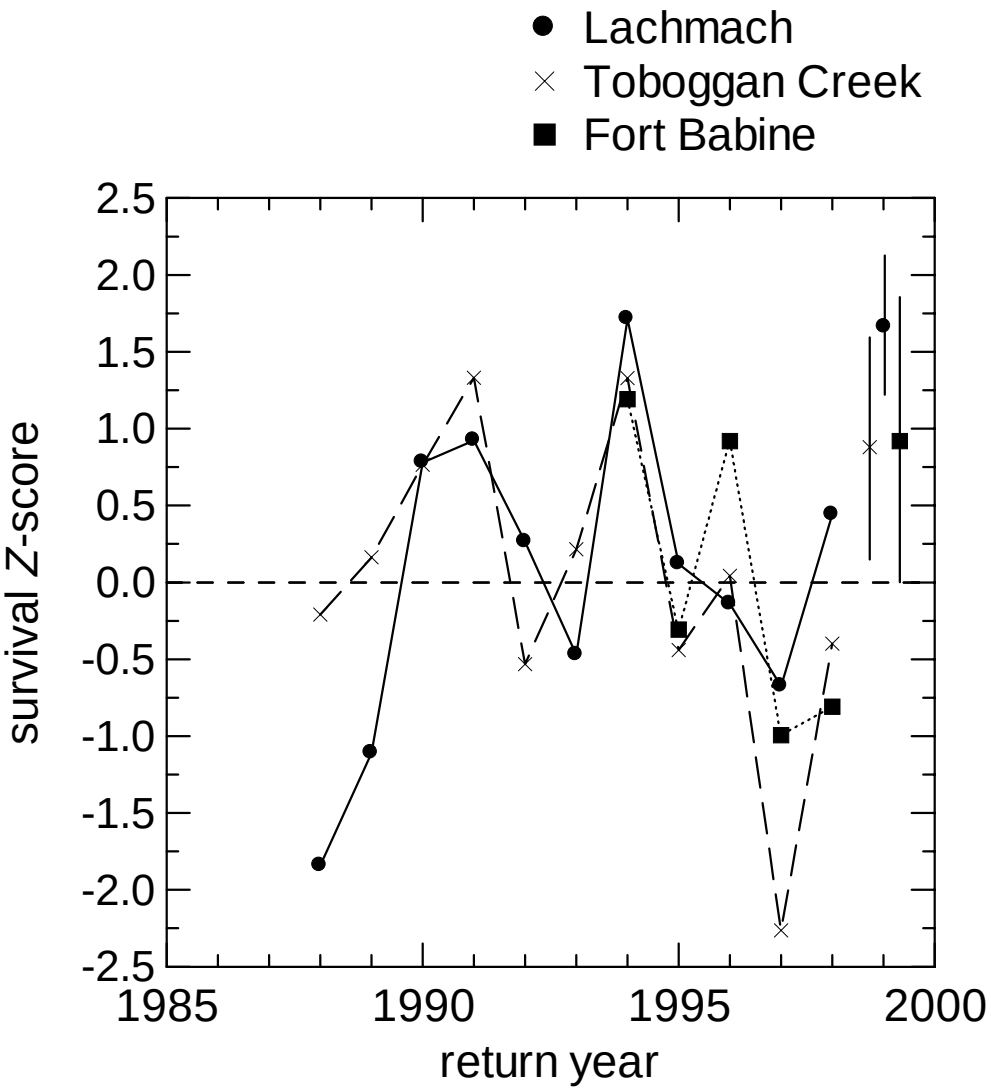


Figure 9. Sockeye Returns to Barkley Sound 1974-1998

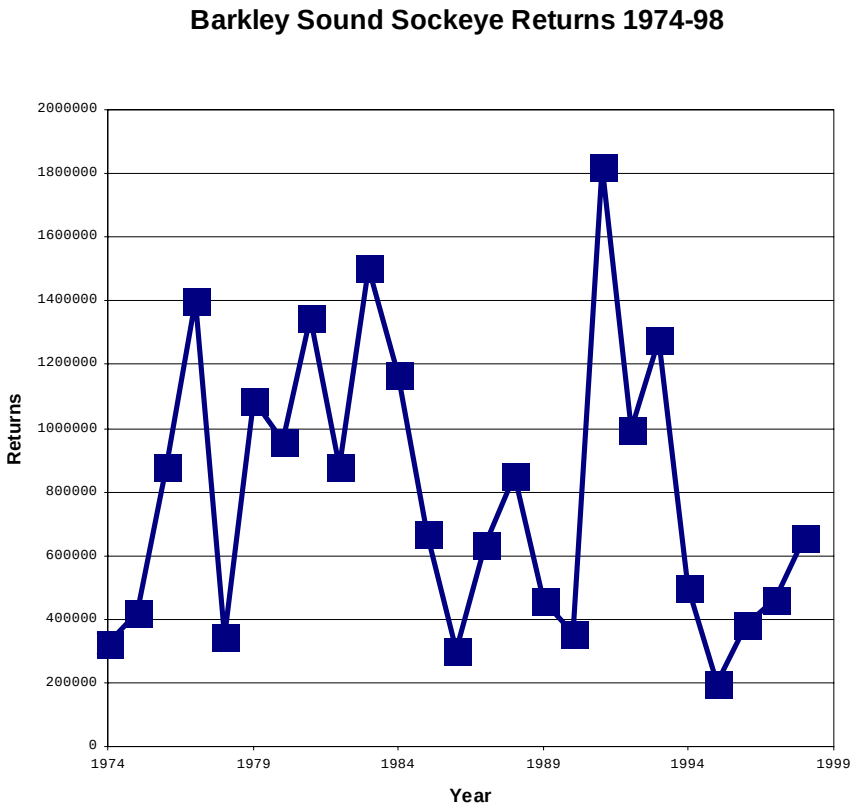


Table 1. Fraser River run size forecasts of age-4 and age-5 sockeye by stock and timing group (bold) and Fraser River pink salmon for 1999.

	Probability of Achieving Specified Run Sizes[a]				
STOCK/TIMING	**25%**	**50%**	**75%**	**80%**	**90%**
Early Stuart	**512,000**	**318,000**	**197,000**	**175,000**	**127,000**
Early Summer	**954,000**	**477,000**	**244,000**	**209,000**	**135,000**
Fennell	60,000	33,000	18,000	16,000	10,000
Bowron	122,000	69,000	39,000	34,000	24,000
Raft	11,000	6,000	3,000	3,000	2,000
Gates	85,000	47,000	26,000	23,000	15,000
Nadina	50,000	34,000	23,000	20,000	15,000
Pitt	75,000	40,000	21,000	18,000	12,000
Seymour	282,000	146,000	75,000	64,000	41,000
Scotch	269,000	102,000	39,000	31,000	16,000
Mid Summers	**9,024,000**	**5,328,000**	**3,299,000**	**2,946,000**	**2,199,000**
Chilko	4,086,000	2,949,000	2,128,000	1,962,000	1,580,000
Quesnel	3,422,000	1,593,000	741,000	611,000	361,000
Stellako	847,000	532,000	334,000	297,000	218,000
Late Stuart	669,000	254,000	96,000	76,000	40,000
Late Summer	**4,097,000**	**2,125,000**	**1,103,000**	**937,000**	**606,000**
Birkenhead	402,000	229,000	130,000	113,000	77,000
Late Shuswap	3,118,000	1,619,000	841,000	714,000	462,000
Cultus	57,000	31,000	16,000	14,000	9,000
Portage	167,000	75,000	33,000	27,000	16,000
Weaver	353,000	171,000	83,000	69,000	42,000
TOTAL	**14,587,000**	**8,248,000**	**4,843,000**	**4,267,000**	**3,067,000**
PINKS	**10,348,000**	**8,148,000**	**6,415,000**	**6,039,000**	**5,128,000**

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

Table 2. Summary of recommended pre-season stock size forecasts for 1999. Bold print is used to flag stock size forecasts that are well below escapement targets in stocks whose status has been reviewed previously by PSARC.

Species	Statistical Area	River or Lake	Escapement Target	Forecasts for reference probabilities[a] 25%	50%	75%	90%	Forecasting Model
Sockeye	1	Yakoun	[b]	12,000	9,000	7,000	5,000	*5-yr mean*
	2	Skidegate	9,525	17,000	11,000	7,000	4,000	*5-yr mean*
	3	Nass	246,000	942,000	767,000	624,000	501,000	*5-yr mean*
	4	**Skeena**	**1,159,011**	**839,000**	**578,000**	**409,000**	**299,000**	*sibling*
	6	Kitlope	20,000	52,000	42,000	35,000	28,000	*5-yr mean*
	8	Atnarko	75,000	81,000	59,000	44,000	31,000	*5-yr mean*
	8	Kimsquit	30,000	32,000	20,000	12,000	8,000	*long-term mean*
	9	**Owikeno**	**200,000[c]**	**175,000**	**108,000**	**66,000**	**39,000**	*5-yr mean*
	10	**Long**	**200,000**	**107,000**	**70,000**	**46,000**	**29,000**	*5-yr mean*
Pink	2E	all	720,909	11,000	5,000	2,000	1,000	*Ricker*[d]
	6	all	1,447,200	1,500,000	766,000	390,000	209,000	*Ricker*
	8	all	1,475,400	2,806,000	1,663,000	983,000	604,000	*Ricker*
	9	all	342,450	472,000	162,000	55,000	20,000	*Ricker*
	10	all	65,600	15,000	7,000	3,000	1,000	*Ricker*
Chum	2E	all	453,025	498,000	318,000	203,000	135,000	*long-term mean*
	6	all	518,350	429,000	269,000	169,000	110,000	*long-term mean*
	8	all	267,450	647,000	432,000	289,000	199,000	*long-term mean*
	9	all	150,700	74,000	41,000	23,000	13,000	*long-term mean*
	10	all	98,500	64,000	37,000	21,000	13,000	*long-term mean*

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

[b] 5000-10000 (under review)

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

[d] *NLSRESC* model of Wood et al. (1995).

Table 3. Total expected return of Johnstone Strait, Georgia Strait and lower Fraser River wild chum salmon for 1998.

WILD STOCK (FRASER AND NON-FRASER)	FORECAST MODEL				COMBINED
	5YAVGBY	LSRESC	3YLSRESC	5YLSRESC	5YAVGBY & 5YLSRESC
AGES					
3'S		584,950	465,824	683,699	
4'S		1,931,283	1,537,974	2,257,315	
5'S		317,562	252,890	371,171	
TOTAL	2,016,275	2,833,794	2,256,688	3,312,185	2,664,230
Probability of achieving specified run size or larger:					
90%	633,947	1,433,530	695,070	1,891,264	
80%	1,109,122	1,914,871	1,231,876	2,379,706	
75%	1,292,713	2,100,843	1,439,279	2,568,422	
25%	2,739,837	3,566,745	3,074,098	4,055,948	
ENHANCED STOCK (FRASER AND NONFRASER)					
Recent brood year survival (1990-92)	452,435	452,435	452,435	452,435	452,435
Brood year survival (1979-88)	936,391	936,391	936,391	936,391	936,391
TOTAL WILD + ENHANCED					
Recent brood year survival (1990-92)	2,468,710	3,286,229	2,709,123	3,764,620	3,116,665
Brood year survival (1979-88)	2,952,666	3,770,185	3,193,079	4,248,576	3,600,621

Table 4. Barkley Sound Sockey return forecasts for 1999

	Probability of Achieving Specified Run Sizes*			
Forecast	**25%**	**50%**	**75%**	**90%**
SStM	433000	332000	302000	226000
SSM	728000	575000	326000	171000
SEPB	750000	665000	248000	NA <0

* probability that the actual run size will exceed the specified forecast.