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Report of the PSARC Salmon Subcommittee Meeting, March 7-9, 2000

M. Stocker and A. Macdonald (Editors)
Pacific Scientific Advice Review Committee
Pacific Biological Station
Nanaimo, British Columbia V9R 5K6

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M. Stocker and A. Macdonald[1] (Editors)
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[1] Fisheries and Oceans Canada
100 Annacis Parkway, Unit 3
Delta, British Columbia V3M 6A2

Salmon

SUMMARY

The Pacific Scientific Advice Review Committee (PSARC) Salmon Subcommittee met March 7-9, 2000 at the Pacific Biological Station in Nanaimo. The Subcommittee reviewed six Working Papers.

General Subcommittee Discussion and Concerns

The Subcommittee noted a concern about the current schedule for the review of working papers that present forecasts of current year returns.

Working Paper S00-1: Trends in Abundance and Pre-Season 2000 Stock Size Forecasts for Major Sockeye, Pink, and Chum Salmon Stocks in the Central Coast and Selected Salmon Stocks in Northern British Columbia

The Subcommittee accepted the northern B.C. sockeye, pink, and chum forecast probability distributions but cannot discount that the returns of Owikeno and Long Lake sockeye may be as low as predictions based on the "Like 1996 sea-entry" model, which is the recommended forecast for management decisions under the precautionary approach.

Working Paper S00-2: 2000 Forecast for Johnstone Strait, Georgia Strait and Lower Fraser River Chum Salmon

This paper was not presented at the meeting.

Working Paper S00-3: Forecast for Southern British Columbia Coho Salmon in 2000

The Subcommittee accepted the marine survival forecasts.

The Subcommittee accepted the abundance and distribution forecasts. For the Strait of Georgia/Fraser River stock aggregate in 2000 there is a 75% probability of a run size greater than 180,000, a 50% probability of a run greater than 250,000, and a 25% probability of a run greater than 340,000. For West Coast Vancouver Island (WCVI) coho in 2000, the 75, 50 and 25 percentiles respectively are 240,000, 330,000, and 460,000. For the Interior-Fraser stock aggregate (coho originating above Hells Gate, including the Thompson River), the 75, 50 and 25 percentiles respectively are 15,000, 24,000 and 38,000.

Working Paper S00-4: Forecast for Northern British Columbia Coho Salmon in 2000

The Subcommittee accepted the Lachmach, Toboggan Creek and Fort Babine Hatchery coho marine survival forecasts.

The Subcommittee accepted the abundance forecasts for each of several stock aggregates.

Working Paper S00-5: Run Size Forecasts for Fraser River Sockeye in 2000

The Subcommittee recommended adopting the Fraser sockeye salmon forecast probability distributions. The Fraser sockeye run size forecast for 2000 based on the 19 stocks considered in this report is 4.3 million sockeye at the 50% probability level (50% chance the run will exceed this forecast), and 2.4 million at the 75% probability level (75% chance the run will exceed this forecast). Forecasts by management group are 291,000 (50%) and 157,000 (75%) for Early Stuart, 547,000 (50%) and 289,000 (75%) for Early Summer stocks, 2.9 million (50%) and 1.7 million (75%) for Mid Summer run stocks and 577,000 (50%) and 286,000 (75%) for Late Summer run stocks.

The Subcommittee recommended that the large uncertainties in the Fraser sockeye forecasts be acknowledged and consideration be given that the returns in 2000 may be well below the median (50% probability level) of the forecasts.

Working Paper S00-6: Review of the 1999 Return of Barkley Sound Sockeye Salmon and Forecasts for 2000

The Subcommittee accepted the forecast return for 2000. The 2000 Barkley Sound sockeye forecast return is 532,000 at the 50% probability level (50% chance the run will exceed this forecast), and 485,000 at the 75% probability level (75% chance the run will exceed this forecast).

Working Paper S00-7: Review of 1999 Terminal Run of Somass (Stamp) River Chinook Salmon and 1999 Escapement to WCVI Extensively Surveyed Indicators, and Forecast for 2000

The Subcommittee accepted the forecast return of 10,000 Stamp/Somass chinook salmon to the terminal area of Barkley Sound, determined in the absence of any Canadian fishing mortality.

The Subcommittee recommended that fishing mortality on WCVI chinook be minimized in 2000. Low escapements forecast to Statistical Area 24 represent a potentially serious conservation concern. These populations should be assessed to determine mechanisms limiting their production.

The Subcommittee noted that these concerns are likely to persist beyond 2000.

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 six Working Papers. Working Paper titles, authors and reviewers are listed in Appendix 2. The Subcommittee noted the attendance of external participants: Tom Bird, Sport Fishing Institute, Barry MacPhee, Heiltsuk Tribal Council; Dave Narver, B.C Fish and Wildlife Federation; Mike Staley, Fraser River Watershed Committee, Mary-Sue Atkinson, Pacific Fisheries Resource Conservation Council (PFRCC); Murray Chatwin, PFRCC and Ocean Fisheries Ltd.; Ken Wilson, Fraser River Aboriginal Fisheries Resource Conservation Council and Rick Routledge, PFRCC. A number of observers also attended the meeting: Kathy Scarfo, Area G Troll Association; Kit Rawson, Tulalip Tribes; Dave Blackbourn, Consultant, and Dr. Randall Peterman with two students from Simon Fraser University. A list of meeting participants is included as Appendix 3.

General Subcommittee Discussion and Concerns

The Subcommittee is concerned about the schedule for release of forecasts and review of the forecast working papers. Under the new annex arrangements of the Pacific Salmon Treaty, Canada is obligated to provide return forecasts of Fraser River sockeye and pink salmon, and coho and chinook to the Pacific Salmon Commission no later than the annual meeting of the Pacific Salmon Commission in late February. Current constraints in the timely acquisition of appropriate and accurate data hampers development of forecasts and a PSARC review prior to early March.

WORKING PAPER SUMMARIES, REVIEWS AND DISCUSSION

S00-1 Trends in Abundance and Pre-season 2000 Stock Size Forecasts for Major Sockeye, Pink, and Chum Salmon Stocks in the Central Coast and Selected Salmon Stocks in Northern British Columbia

D. Rutherford and C. Wood **Accepted subject to revisions**

Summary

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

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

Subcommittee Discussion

The Subcommittee accepted the working paper with minor revisions and noted the improved condition of Skeena River sockeye forecasted for 2000, but also that a serious conservation concern exists for Owikeno and Long Lake sockeye populations. Returns to these sockeye populations in 1999 were the lowest on record as a consequence of exceptionally poor marine survival in sea-entry years 1996 and 1997. Five-year average forecast methods applied in the past for these stocks could not predict this return since such poor survivals had not been observed in the recent record. Consequently, for the 2000 forecasts, the authors recommended application of sibling and smolt regression models. Sibling models for the age-five returns in 2000 will account for the poor marine survival but a smolt-based forecast for age-four sockeye still requires an assumption of the marine survival for smolts that entered the sea during 1998. Such models typically describe the “average” marine survival rate and would be liable to the same limitation as the five-year models that failed to forecast the 1999 return. While the authors and Subcommittee accepted that the “sibling/smolt” model presented in the working paper was the best statistical model for the 2000 forecast, they were very concerned about the risk of over-estimating the 2000 forecast given the severity of the poor return in 1999. The most conservative 2000 forecast would be the author’s “Like 1996 sea-entry” model, that assumes a marine survival for the age-four sockeye in 2000 similar to the age-four return observed in 1999. The Subcommittee can not advise statistically which of these models is likely to be the most accurate but notes the asymmetrical consequence of error in these two models. Returns in 1999 clearly demonstrate the need for extreme caution during 2000.

A concern for the accuracy of the Age-3 “Jack” sockeye counts in the Skeena

River (Babine fence count) was also discussed. Recent counts of Jack sockeye at the sockeye enhancement facilities on Babine Lake have exceeded the Babine fence counts. The authors will review this concern and, if necessary, account for it in next year's report. However, the Jack measurement issue is not significant for the 2000 forecast since all three models presented provided similar forecasted returns.

Subcommittee Recommendations

1. The Subcommittee accepted the northern B.C. sockeye, pink, and chum forecast probability distributions (Table 1), but cannot discount that the returns of Owikeno and Long Lake sockeye may be as low as predictions based on the "Like 1996 sea-entry" model, which is the recommended forecast for management decisions under the precautionary approach.

S00-2 2000 Forecast for Johnstone Strait, Georgia Strait and Lower Fraser River Chum Salmon

V. Palermo, C. Murray, D. Bailey and A. Thompson

This paper was not presented at the meeting.

S00-3 Forecast for Southern British Columbia Coho Salmon in 2000

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

Summary

This Working Paper documents forecasts of marine survival, abundance and distribution for the coho salmon of southern British Columbia [Fraser River including the Thompson River, lower Fraser, Strait of Georgia, and West Vancouver Island (WCVI)] for return year 2000.

Marine survival: Forecasts of marine survival for the five hatchery indicators and one wild coho indicator are given in the following Table. Survivals are forecast to be either unchanged or higher in 2000 compared to those observed in 1999 (following Table, Fig. 2) but survival will remain poor to below average throughout southern B.C. Survival is forecast to improve at Black Creek only because survivals were particularly poor there in 1999. In 1999, the sibling models generally performed better than the statistical models so we also have tabulated the sibling forecasts in the following Table. The two forecasts are similar only for the Big Qualicum hatchery population. There doesn't appear to be a geographic pattern to the forecast survivals. The forecast survival for WCVI coho is similar to those seen over the past two years.

indicator	best model	$\hat{S}_{2000}$	(50% CI)	change relative to observed in 1999	$\hat{S}_{2000}$ (sibling)	(50% CI)
Big Qualicum	LLY*	0.015	(0.006–0.04)	same	0.012	(0.007–0.021)
Quinsam	LLY	0.01	(0.006–0.016)	same	0.026	(0.013–0.066)
Chilliwack	RAT3*	0.014	(0.008–0.025)	same	0.008	(0.005–0.013)
Inch Creek	LLY	0.019	(0.009–0.040)	same	0.040	(0.024–0.066)
Black Creek	3YRA*	0.033	(0.024–0.046)	higher		–
Robertson Creek	sibling regression	0.030	(0.013–0.066)	same		–

*LLY – Like Last Year

*RAT3 – Average 3-year trend

* 3YRA – 3-year average

Abundance forecast: Without fisheries information, forecasting abundance is highly problematic, and because the authors use time-series models the forecast is dependent on the highly uncertain estimate of abundance in 1998 and 1999. Although the observed abundance of the Strait of Georgia-Fraser River (StG-Fr) aggregate in 1999 (3.3×10^5) was well above the forecast (2.0×10^5; 50% CI: 1.5×10^5–2.8×10^5), the RAT3 model continues to be the best performing model. The RAT3 model forecast of the StG-Fr aggregate is 2.5×10^5 (50% CI: 1.8×10^5–3.4×10^5) or 15% of the long term average abundance of 1.6×10^6 (Fig. 3).

The estimated abundance of the WCVI aggregate in 1999 (4.7×10^5) was close to the forecast (4.5×10^5; 50% CI: 3.1×10^5–6.5×10^5) and was slightly larger than the estimated abundance in 1998 (4.5×10^5). However, escapement records indicate that there were declines in abundance in 1999 compared to 1998 (-29% for South West Vancouver Island streams and –49% for North West Vancouver Island streams relative to 1998). This discrepancy is perhaps an indication of the severe data limitations for WCVI where there is only hatchery stock on which to base estimates of abundance in the absence of fisheries. The 3YRA forecast for WCVI abundance in 2000 is 3.3×10^5 (50% CI: 2.4×10^5 – 4.6×10^5) or 56% of the overall average abundance of 6.0×10^5 (Fig. 3).

The abundance forecast for interior-Fraser (coho originating above Hell's Gate, including the Thompson River) coho is for continued depression with no change from the last three years (Fig. 4). Brood year escapements in the Lower and South Thompson were respectively the lowest and second lowest on record since records began. Since there is no indication of improved marine survival, poor escapement is again likely in those areas and it is unlikely that total stock size will increase in 2000.

Distribution forecast: In the hypothetical circumstance of historical patterns of fishing, the predicted proportion of catch inside the Strait of Georgia (p_{inside}) would be 0.37 (50%CI 0.26–0.50), which can be characterized as a moderately strong outside distribution. The confidence interval suggests that an extreme

outside year (p_{inside} < 0.2) is less likely than a return to a "normal" distribution (p_{inside}>0.4). This forecast of distribution is based on incomplete salinity data.

Subcommittee Discussion

The Subcommittee accepted the authors' forecast of marine survival rates; these rates are likely to be similar to those observed in 1999 and continue to be low. The Subcommittee endorsed the use of the models recommended by the authors to predict marine survival and noted that the statistical and biologically based models support the continuation of low marine survival.

The Subcommittee discussed the use of additional data sources to support the relation between hatchery marine survival and wild coho survival; in particular the use of the Salmon River (Lower Fraser River) data. The authors noted in discussion that these data were not available in time for inclusion in the report; there were issues about timeliness of other data relative to the production of the forecasts.

The Subcommittee supported the continued development of a biologically-based model that relates Euphausiid abundance to WCVI coho marine survival.

The Subcommittee adopted the forecasts made for the WCVI and Strait of Georgia/Fraser River total coho abundance. The Subcommittee noted that the 2000 abundance forecast of WCVI coho is 56% of the mean abundance for the period of record (1984-1999), and Strait of Georgia/Fraser River aggregate forecast abundance is 15% of the mean abundance for the same period. The Subcommittee also noted that the forecast abundance for the Interior-Fraser River stock aggregate (coho originating above Hell's Gate, including the Thompson River) continues to be low, and that there is little prospect for improvement based on the marine survival forecast. The Interior-Fraser forecast of abundance is 20% of the mean abundance for the period of record (1975-1999).

The Subcommittee noted that the historical relationship between salinity and distribution of coho catches (inside/Strait of Georgia vs. outside/WCVI) indicates that the year 2000 would be a moderate 'outside' year. The authors noted that this index may be revised as the environmental data through February is currently incomplete.

Subcommittee Recommendations

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

2. The Subcommittee recommended acceptance of the abundance forecasts. For the Strait of Georgia/Fraser River stock aggregate in 2000 there is a 75%

probability of a run size greater than 180,000, a 50% probability for a run greater than 250,000, and a 25% probability for a run greater than 340,000. For WCVI coho in 2000, the 75, 50 and 25 percentiles respectively are 240,000, 330,000, and 460,000. For the Interior-Fraser stock aggregate (coho originating above Hells Gate, including the Thompson River), the 75, 50 and 25 percentiles respectively are 15,000, 24,000 and 38,000.

S00-4 Forecast for Northern British Columbia Coho Salmon in 2000

B. Holtby, B. Finnegan and B. Spilsted **Paper 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 shown in the following table is expected to be above average for 2000 (Fig. 5).

Indicator	model	$\hat{s}_{2000}$	(50% CI)
Lachmach	sibling regression	0.14	(0.11–0.17)
Toboggan Creek hatchery	from Lachmach	0.05	(0.03–0.08)
Fort Babine hatchery	from Lachmach	0.03	(0.02–0.06)

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

Abundance forecast:
The forecast total return of Lachmach coho is 2.3×10^3, which is below the mean of the short data series (2.8×10^3). Abundance is forecast to be below the mean despite strong marine survival because smolt production in 1999 was relatively poor. In contrast, smolt production from Toboggan Creek in 1999 was estimated to have been 44×10^3, indicating high fresh water survival and the potential for a strong return of wild coho to Toboggan in 2000.

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

	forecast as percentile of cumulative probability distribution[†]		rank of forecast in observation time series[‡]		
Aggregate	Abundance	escapement	abundance	Escapement	characterization of forecast abundance
Area 6	7%	16%	48	48	well below average
Babine	9%	22%	51	39	well below average
Area 4-U	10%	23%	44	38	well below average
Area 2E	16%	75%	44	13	below average
Area 7	22%	43%	37	24	below average
Area2W	23%	54%	39	18	below average
Area 4-L	23%	63%	47	23	below average
Area 5	31%	65%	33	17	below average
Area 3	33%	77%	30	13	below average
Area 8	33%	76%	33	13	below average
Area 1	51%	>99%	24	1	average

[†] The distribution was the Log_e N(0,1) of observed abundance and escapement.
[‡] All of the time series had 50 observations except Babine, which had 54.

In the context of a simple approach to determining the status of coho within large geographic aggregates relative to two reference points, the aggregates of Area 2W and Area 6 appear unable to support incremental fishery mortality. Limited incremental fishing mortality on upper Skeena stocks, including the Babine Lake aggregate would have a low risk of causing irreversible damage but would slow rebuilding. However, forecasts for this area have not proven sufficiently reliable to proceed with incremental fishing, even if modest, without an early in-season indicator that would warn of unforeseen survival disasters such as the one that occurred in 1997 (1996 sea-entry). Such a system is under development for the 2000 fishing season.

Reviewer #1

The reviewer acknowledged that the forecasts were based on previous PSARC-approved methods. The reviewer suggested that sources of uncertainty in the stock-recruit data and the potential direction of bias should be acknowledged, and raised a concern about the statistical basis for ranking the characterisation of forecast abundance (ie. below average, average, and above average). The primary focus of the reviewer's comments was on the development and interpretation of a set of provisional reference points. The reviewer expressed the view that considerably more analyses are required before a scheme identifying reference points, such as 'limit reference points', is employed operationally. Until such a scheme is developed, fisheries management advice should be based on an analysis of trends, or relative abundance over the available data series.

Reviewer #2

The reviewer complimented the authors on the overall quality of the working paper. The reviewer raised a concern about the recommendation to fisheries managers that some limited incremental fishing mortality on Skeena coho would exert a limited risk of irreversible damage. Since the upper Skeena forecast is not sufficiently reliable to permit the identification of fishing opportunities, fisheries managers would need to rely on inseason assessment of abundance, which is currently under development. The reviewer was concerned that the inseason assessment has not been reviewed but needs to be, and that expectation of a harvest opportunity may be generated prior to such a review.

Subcommittee Discussion

Subcommittee members agreed with the two reviewers that the paper represented a sound analytical approach to forecasting northern coho returns given the highly variable nature of both the quantity and quality of data that are generally available for application to this subject.

The Subcommittee accepted the marine survival forecasts for the northern indicator stocks. The Subcommittee noted that although marine survival was expected to be above average for the year 2000, the majority of abundance forecasts remain below average due to low brood year escapements.

Development and interpretation of a set of provisional reference points for several northern coho aggregates by the authors prompted considerable discussion among Subcommittee members. The senior author noted that the reference point component of the paper was developed to respond to ongoing concerns by fisheries management that stringent protection of Upper Skeena coho has severely restricted fisheries for other species in outside or lower river areas. The provision of reference points was intended to identify conservation concerns that apply to a given geographic area and coho aggregate in the year 2000. Subcommittee members complimented the authors on the development of an informative and potentially useful approach to identifying a set of reference points that could focus discussion on stock conservation needs. Further clarification of issues surrounding the development and implementation of reference points is expected to be achieved during a PSARC meeting scheduled for early May so detailed consideration of them here was premature. Following additional discussion, Subcommittee members concluded that the analysis and graphical presentations pertaining to reference point development and interpretation should be characterised as generic reference points.

Subcommittee members considered the issue of what advice, if any, should be provided to fisheries managers by the Subcommittee on the basis of the current paper. The authors concluded that the status of several geographic aggregates

of coho outside of the Skeena appear unable to support incremental fishery mortalities, but small incremental mortalities for Upper Skeena coho would impose a limited risk of inflicting irreversible damage on these stocks. After considerable discussion, the Subcommittee determined that it could not endorse the management recommendations without detailed documentation of a harvest management strategy that included formally defined Limit Reference Points and Target Reference Points for the subject stocks.

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 forecasts for each of several stock aggregates.

S00-5 Run Size Forecasts for Fraser River Sockeye in 2000

A. Cass **Accepted subject to revisions.**

Summary

Adult returns of sockeye to the Fraser River on the 2000 cycle line are the lowest of the four cycle lines averaging 4.5 million sockeye compared to an all-year mean of 9.4 million during 1970-99. The major stocks expected in 2000 based on brood year escapement estimates for 1996 are Chilko, Stellako, Early Stuart, Late Stuart, Birkenhead, and Weaver Creek sockeye. Forecasts are made for each of four migratory timing groups and 19 individual stocks. Forecasting methods are unchanged from previous PSARC reviews and are based on a variety of explanatory variables and forecast models.

The 2000 forecast of all stocks combined (Table 2), at the 50% probability level, is 4.3 million sockeye or near the long-term mean (1970-1996). At the 75% probability level the forecast is 2.4 million fish. The summer run group accounts for 67% of the forecast. Within that timing group, Chilko and Stellako sockeye respectively account for 33% and 21% of the forecast at the 50% probability level.

A cautionary prognosis for 2000 returns is warranted. Estimates of jack returns in 1999 (2000 age-4 returns) to several of the major stocks on the cycle line were very low compared to brood year escapements and compared to jack returns on the previous year in this cycle. Temperatures in the north Pacific Ocean in the spring of 1998 were above average during the transition from intense El Nino conditions in 1997 to cooler La Nina conditions in the latter half of 1998. Ocean survival of sockeye that went to sea in 1997 was very low. The carry-over effect of above average temperatures in the spring of 1998 on juvenile sockeye survival for the 1996 brood (2000 age-4 returns) is unknown. Survival of south coast

stocks of pink and coho in ocean-entry-year 1998 for which ocean survival rates are estimated were very low. There is no evidence for correlated ocean survival trends among Fraser sockeye and other south coast salmon species. However, the trend in salmon production seen so far from ocean-entry-year 1998 in south coast regions is consistent with the hypothesis of generally unfavourable ocean conditions in 1998. An offshore index of ocean productivity measured by nitrate concentrations was also low in 1998. The latter can only be viewed as qualitative since the nitrate data is not of sufficient quality to link directly to sockeye survival. It is difficult to quantify the effects of low sibling jack returns, low survival trends for other south coast salmon species, and low nitrate levels. They do, however, argue for precautionary management in 2000. If these indexes signal low sockeye survival then returns will likely be lower than the 50% probability level.

Subcommittee Discussion

The working paper represented a thorough and complete review of forecasts for Fraser River sockeye salmon in 2000 using previous PSARC-approved methods and the Subcommittee recommended acceptance of this paper subject to minor revisions.

The Subcommittee noted that the forecasts were made for four sockeye timing groups (19 individual stocks) that cover about 96% of the brood-year escapement in the Fraser River watershed. The remaining escapement is represented by a number of very small stocks with limited data reliability.

The Subcommittee discussed whether it would be possible to clarify the precautionary view of the author concerning the possible impact on smolt survival of oceanographic conditions at the time of smolt entry to the sea in 1998. Although returns of jacks to the spawning grounds of the Fraser in 1999 were low, it was noted that record high river flows may have disproportionately affected their survival in-river and no estimate is possible at river entry sites such as at Mission. The Subcommittee agreed that many signals pointed to the need to be cautious including carry-over effects from the intense El Nino in 1997, low survival for 1998 ocean-entry year south coast pink and coho and low indices of ocean productivity. Data does not exist however, to quantify the possible effects of these factors on returns and the Subcommittee suggested that linkage to oceanographic variables be further investigated.

Subcommittee Recommendations

1. The Subcommittee recommended adopting the Fraser sockeye salmon forecast probability distributions (Table 2). The Fraser sockeye run size forecast for 2000 based on the 19 stocks considered in this report is 4.3 million sockeye at the 50% probability level (50% chance the run will exceed this forecast), and 2.4 million at the 75% probability level (75% chance the run will exceed this forecast). Forecasts by management group are 291,000

(50%) and 157,000 (75%) for Early Stuart, 547,000 (50%) and 289,000 (75%) for Early Summer stocks, 2.9 million (50%) and 1.7 million (75%) for Mid Summer run stocks and 577,000 (50%) and 286,000 (75%) for Late Summer run stocks.

2. The Subcommittee recommended that the large uncertainties in the Fraser sockeye forecasts be acknowledged and consideration be given that the returns in 2000 may be well below the median (50% probability level) of the forecasts.

S00-6 Review of the 1999 Return of Barkley Sound Sockeye Salmon and Forecasts for 2000

K. Hyatt, W. Luedke, J. Till, P. Rankin, and D. Lewis **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 (Fig. 6). 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 small commercial fisheries were correctly anticipated in 1997, 1998, and 1999. 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 1997, and (ii) management to protect escapement as a basis for increases in future year returns.

Over the past 12 years, four independent techniques have been tested 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 1999 are as follows:

(1) The SStM forecast exhibits the best overall performance with a Mean Absolute Percent Error (MAPE) value of approximately 28 % over the most recent 12 years of forecasting. 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 = 0.78, P<0.01).

(2) The SSM forecast exhibits the next best performance with a MAPE value of 35 % over the most recent 12 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 (54 %) than that displayed by both SSM and SStM forecasts (28-34 %). 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.

Different models provide highly divergent forecast alternatives for returns of Barkley Sound sockeye in the year 2000. Midpoint forecast estimates range from a low of 532,000 to a high of 1,900,000 sockeye. Comparative performance of the various forecast options, along with Fisheries and Ocean Canada's recent pursuit of a more risk averse approach to management recommends initial adoption of the SStM forecast range of 485,000 (75% probability) to 714,000 (25% probability) sockeye as the preferred, pre-season forecast for the year 2000 (Table 3). However, supplementary information suggests that returns are likely to be closer to the upper end than the lower end of this range.

Subcommittee Discussion

The Subcommittee agreed with the recommendation of the author to accept the forecast return for 2000 based on the SStM model. This forecast model has performed as well as or better than other models examined in retrospective comparisons. An alternate SSM model has performed about equally well in retrospective comparisons but it predicts an extremely high level for the return in 2000. Given that the two forecasts are equally credible, the lower forecast return (SStM model) was recommended for pre-season management planning as it is consistent with a precautionary approach. The Subcommittee recognised however, that the SStM forecast may underestimate sockeye returns in 2000 and noted that fishery managers should be prepared to respond to inseason indications of abundance. Fisheries managers of the Subcommittee agreed that inseason assessment procedures would be adequate to identify fishing opportunities if estimated abundance inseason was greater than the forecast return.

Subcommittee Recommendations

1. The Subcommittee recommended acceptance of the forecast return for 2000. The 2000 Barkley Sound sockeye forecast return is 532,000 at the 50%

probability level (50% chance the run will exceed this forecast), and 485,000 at the 75% probability level (75% chance the run will exceed this forecast) (Table 3).

S00-7 Review of 1999 Terminal Run of Somass (Stamp) River Chinook Salmon and 1999 Escapement to WCVI Extensively Surveyed Indicators, and Forecast for 2000

B. Riddell, W. Luedke, J. Till, and R. Ferguson **Accepted subject to revisions**

Summary

The detailed assessments and abundance forecasts of the Robertson Creek Hatchery (RCH) and Stamp River 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). Forecasts presented in this working paper indicate a conservation concern developing for naturally spawning chinook populations along the WCVI during the next few years. The minimum escapement goal established for the Stamp/RCH chinook stock will not be met in 2000 and total terminal return for this stock is projected to decline by 66% relative to 1999. If this decline is assumed for the naturally spawning stocks along the WCVI, the numbers of females expected to spawn naturally in 2000 will vary from as low as 30 females to over a couple of hundred females in each river system.

1999 Terminal return of the WCVI chinook:
The 1999 terminal return of chinook to the Stamp River/RCH indicator stock was estimated to be 30,500 (a 57% decline from the 1998 return) (Table 4). Age-5 chinook comprised the majority (69%) of the spawning stock and returns of age-3 and age-4 chinook were much lower than average. The age 3 return is production from the 1996 brood, which was the lowest escapement on record.

Returns to another 22 WCVI streams that were monitored for chinook spawning escapements did not indicate a proportional reduction as large as the indicator stock but the age compositions were generally very similar. In all extensively surveyed systems along the WCVI (excluding the two rivers, Nitinat and Conuma, with major hatcheries), the 1999 total escapement declined 28% from 1998 levels. Escapements to the Nitinat and Conuma rivers each declined by about 40% from 1998. However, there was significant variation between systems with two rivers (San Juan River and Sarita River in southwest Vancouver Island) indicating greater declines than for the Stamp River/RCH indicator stock. On average, the age-5 chinook comprised 64% of the spawning populations along the WCVI, and age-3 and age-4 components were weak. The overall age composition was very similar to that in the Stamp River/RCH terminal run.

Forecast for the 2000 terminal return of the WCVI chinook:

The forecasting methods applied have been reviewed and accepted previously by PSARC. However, for the first time, the method could not be applied to one age-class since no coded-wire tags were recovered from age-2 chinook. Consequently, the forecast of age-3 chinook in 2000 is based on the lowest cohort size for age-3 chinook observed from past brood years (cohort sizes for 1983 and 1996 broods were about 4000 chinook).

For 2000, the forecasted total return of Stamp River/RCH chinook to the terminal area of Barkley Sound and Alberni Inlet is estimated to be 10,000 based on averaging the Prod2[1] forecast of 12,000 and the Prod3[2] forecast of 7,800. The mean absolute percent error in the average forecast (1985-1999 returns) is 10%. The age structure of the 2000 return is projected to be: 13% Age 3, 52% Age 4, and 35% Age 5; with an expected sex ratio of 50% females (note that the forecast of Age 3 is very uncertain). At this time, the forecast only assumes fishing mortality in South East Alaska (SEAK). Harvest rate factors in SEAK were based on the Pacific Salmon Treaty agreements and we initially used a harvest rate scalar of 0.5 in SEAK troll fishery. The remaining cohort is identified as the expected terminal run assuming no fishing mortality on this stock in Canada.

At this level of terminal run to the Stamp River/RCH, the indicator stock will not achieve the minimum target escapement goal established by PSARC in 1995. The forecast represents a further two-third (66%) reduction in terminal abundance relative to 1999 returns and would be the smallest return since 1985 (Fig. 7), when the indicator stock program began. However, given the expected sex ratio, the expected number of eggs available will be the fourth worst since 1985 (Table 5).

A slightly more conservative terminal run is predicted if the forecast is expressed as a cumulative probability distribution as previously requested by PSARC. Based on the annual deviations from forecasts observed between 1988 and 1999, the 50% value of the cumulative distribution is 9000 chinook in the terminal run and the 50% confidence interval is 8200 to 9800 chinook (Fig. 8). However, given that this distribution is based on only 12 years of observations, the authors recommend continuing with past methods and applying the average forecast model that predicts 10036 chinook returning to the terminal area of Barkley Sound.

[1] Regression model uses total terminal return at a younger age class (independent variable) to predict total production (the surviving cohort in the ocean) of a subsequent age or ages from the same brood year.

[2] Regression model uses estimated total production (total fishing mortality plus escapement) of an age class(es) to predict total production of subsequent ages (i.e., the surviving cohort) from the same brood year.

The more serious concern for conservation is the expected run size to the naturally spawning chinook populations along the WCVI. While the relative decline from 1998 to 1999 was not as large in many of these populations, relative to the Stamp River/RCH stock, we are unable to make specific forecasts for these natural populations. Applying the expected decline for the Stamp River/RCH indicator stock to these naturally spawning populations provides a conservative expectation of their returns in 2000 (Table 6).

Returns to most of these streams in 2000 are not likely to constitute a serious conservation concern with the possible exception of returns to the Area 24 streams. However, these are returns projected for 2000 only and do not indicate the declines expected in future years. Marine survival rates for the 1995 through 1997 brood years from RCH indicate that production from WCVI populations is expected to be poor for a few years (likely through 2002).

Subcommittee Discussion

The Subcommittee accepted the working paper subject to minor revisions. The Subcommittee noted that the total chinook forecast return (if realized) to the Stamp/Somass river system, expressed in terms of eggs potentially available for incubation, would be the fourth worst on record.

The Subcommittee noted that the working paper indicated poor marine survival for the 1995 to 1997 brood years will generate a multiple year concern for chinook populations along the west coast of Vancouver Island (WCVI).

The Subcommittee emphasized the reduction in abundance of naturally spawning WCVI chinook. Applying the relative change predicted for the Stamp/Somass indicator population to the natural WCVI populations projected escapements for a majority of the rivers that are below mean escapements (Table 6). The Subcommittee was particularly concerned with the low number of female chinook forecast to return to un-enhanced streams in Area 24.

Subcommittee Recommendations

1. The Subcommittee recommended acceptance of the forecast return of 10,000 Stamp/Somass chinook salmon to the terminal area of Barkley Sound, determined in the absence of any Canadian fishing mortality.

2. The Subcommittee recommended that fishing mortality on WCVI chinook be minimized in 2000. Low escapements forecast to Statistical Area 24 represent a potentially serious conservation concern and these populations should be assessed to determine mechanisms limiting their production. The Subcommittee noted that these concerns are likely to persist beyond 2000.

APPENDIX 1: PSARC SALMON SUBCOMMITTEE MEETING AGENDA MARCH 7-9, 2000

PSARC Salmon Subcommittee Meeting
Re: Forecasts of Returns in 2000
March 7-9, 2000
Seminar Room, PBS, Nanaimo

Tuesday March 7, 13:00

Introductions and procedures
Fraser River Sockeye (A. Cass)
Northern B.C. Sockeye, Pink, and Chum (D. Rutherford and C. Wood)

Wednesday March 8, 08:30
Southern B.C. Coho (B. Holtby et al.)
Northern B.C. Coho (B. Holtby et al.)
Barkley Sound Sockeye (K. Hyatt et al.)
West Coast Vancouver Island Fall Chinook (B. Riddell et al.)

Thursday March 9, 08:30
Subcommittee review of rapporteur reports, general concerns

APPENDIX 2: PSARC SALMON WORKING PAPERS FOR MARCH 7-9, 2000

Paper #	Title	Authorship
S00-01	Trends in Abundance and Pre-season 2000 Stock Size Forecasts for Major Sockeye, Pink, and Chum Salmon Stocks in the Central Coast and Selected Salmon Stocks in Northern British Columbia	D. Rutherford C. Wood
S00-03	Forecast for Southern British Columbia Coho Salmon in 2000	B. Holtby K. Simpson R. Tanasichuk J.R. Irvine
S00-04	Forecast for Northern British Columbia Coho Salmon in 2000	B. Holtby B Finnegan B. Spilsted
S00-05	Run Size Forecasts for Fraser River Sockeye in 2000	A. Cass
S00-06	Review of the 1999 Return of Barkley Sound Sockeye Salmon and Forecasts for 2000	K. Hyatt W. Luedke J. Till P. Rankin D. Lewis
S00-07	Review of 1999 Terminal Run of Somass (Stamp) River Chinook Salmon and 1999 Escapement to WCVI Extensively Surveyed Indicators, and Forecast for 2000	B. Riddell W. Luedke J. Till R. Ferguson

List of Reviewers

M. Bradford	DFO, Simon Fraser University, MEHS
N. Schubert	DFO, Annacis Island, Stock Assessment

APPENDIX 3: PARTICIPANTS AT THE SALMON SUBCOMMITTEE MEETING, MARCH 7-9, 2000.

Subcommittee Chair: Allan Macdonald
PSARC Chair: Max Stocker

DFO Participants	**Tues**	**Wed**	**Thurs**
* Subcommittee Members			
Anderson, D.*	✓	✓	✓
Bradford, M.*	✓	✓	
Cass, A. *	✓	✓	✓
Jantz, L.*	✓	✓	
Hargraves, B.*	✓	✓	✓
Holtby, B.*	✓	✓	✓
Hyatt, K.*	✓	✓	✓
Irvine, J.*	✓	✓	✓
Kadowaki, R.*	✓		
Meerburg, D.*	✓	✓	✓
Riddell, B.*	✓	✓	✓
Sullivan, M.*	✓	✓	
Wood, C.*	✓	✓	✓
Brown, G.	✓	✓	✓
Joe, J.	✓		
Tanasichuk, R.	✓		
Chen, D.	✓		
Parkin, C.	✓	✓	
Spencer, K.	✓	✓	✓
Otway, B.	✓		
External Participants:			
Atkinson, M.	✓	✓	
Bird, T.	✓	✓	
Narver, D.		✓	
Staley, M.	✓		
MacPhee, B.	✓	✓	
Chatwin, M.		✓	
Wilson, K.	✓	✓	✓
Routledge, R.	✓		
Observers:			
Rawson, K.	✓	✓	
Scarfo, K.	✓	✓	✓
Peterman, Dr. R. with 2 students	✓		
Blackbourn, D.	✓	✓	

FIGURES AND TABLES

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

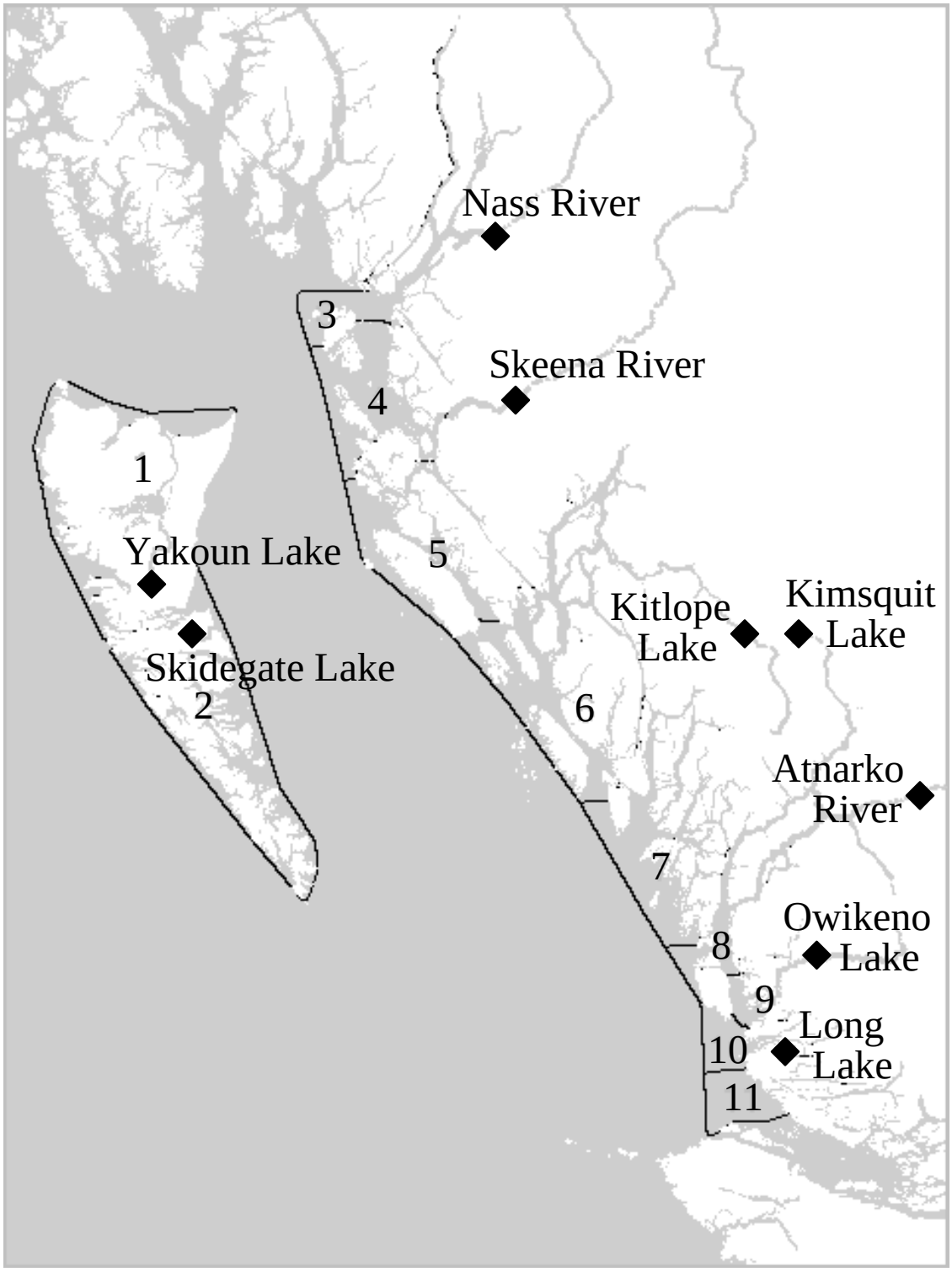

Figure 2. **Marine survivals vs. return year for seven coho indicators in southern British Columbia. The forecast survivals for 1999 and 2000 are shown with associated 50% Confidence Intervals (CIs). The Thompson values are a composite of all available smolt release data. Survival forecasts are not available for the Thompson.**

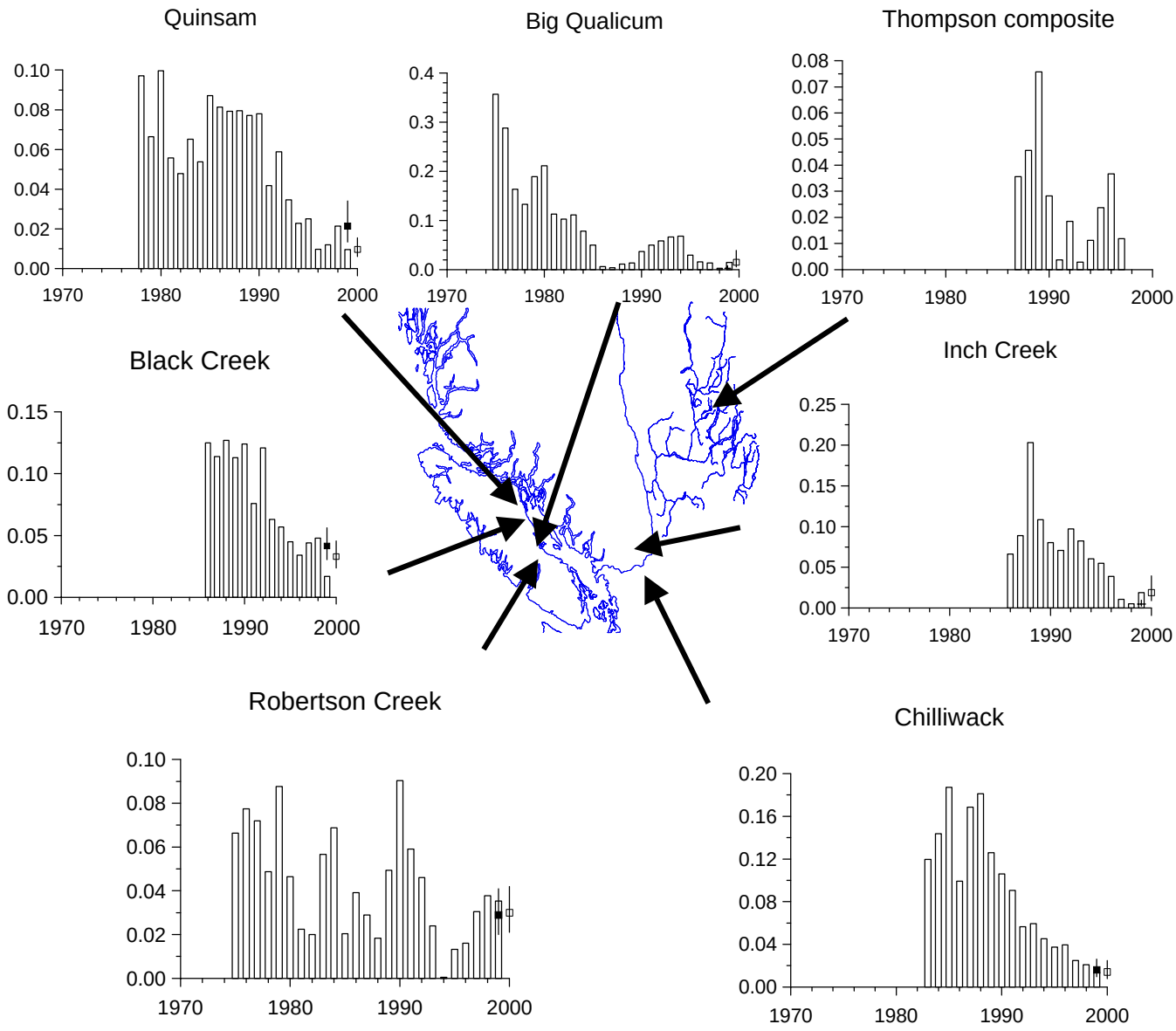

Figure 3. Abundance estimates for the Strait of Georgia+Fraser aggregate and the West Coast Vancouver Island aggregate of southern British Columbia coho. The forecast abundances for 1999 and 2000 with associated 50% CIs are shown for both aggregates.

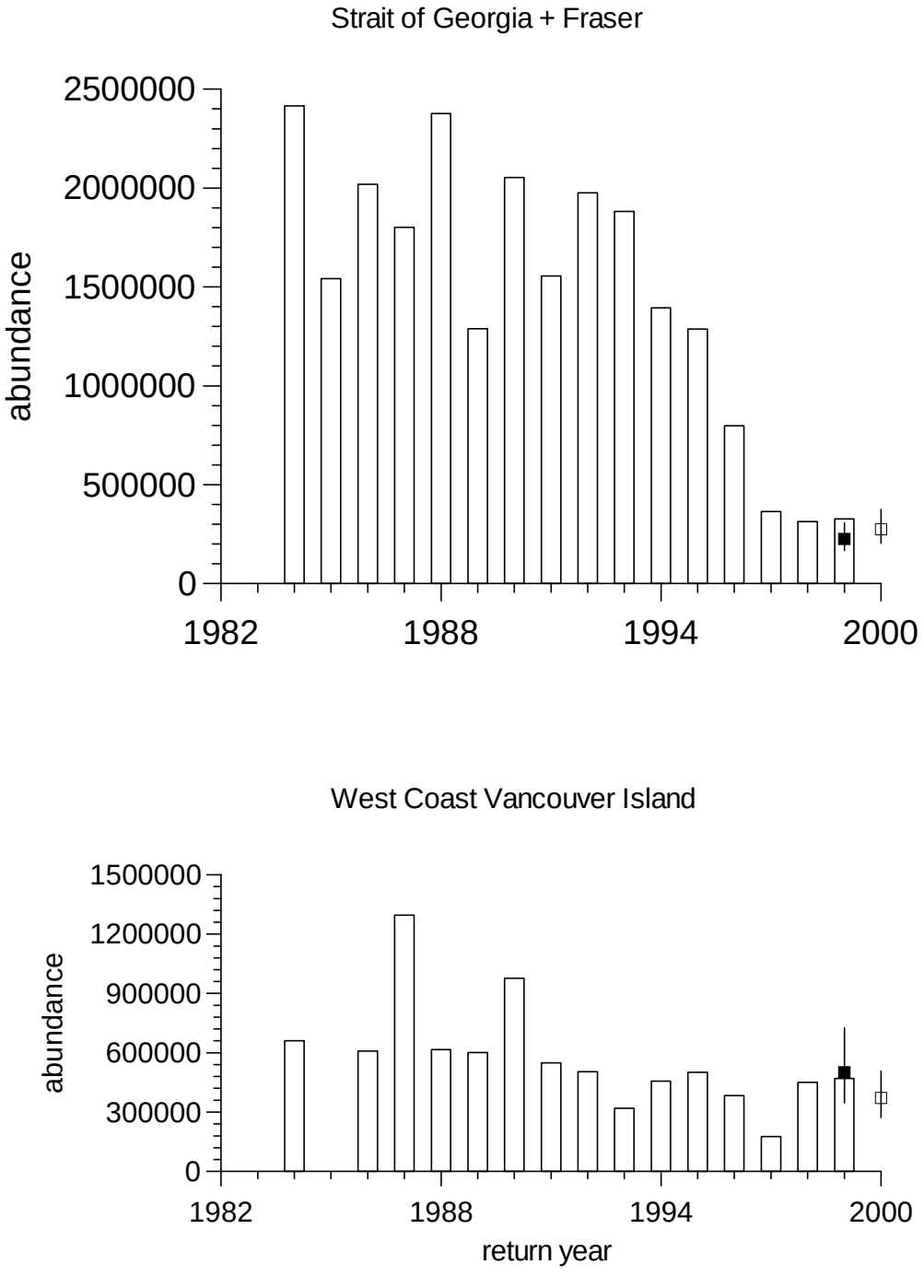

Figure 4. **Estimated total abundance of the coho aggregate above Hell's Gate from 1975 to 1999. The forecasts for 2000 with associated 50% CI are shown.**

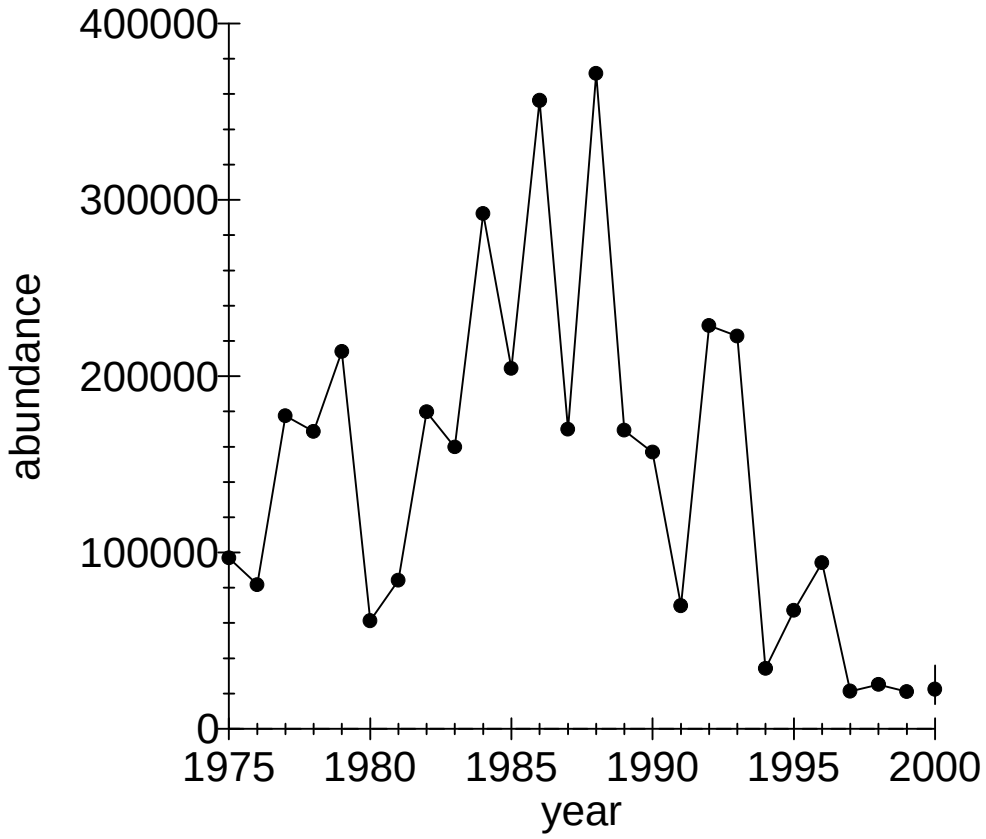

Figure 5. **Time series of standardized survivals (Z-score) for three northern BC coho indicators. Forecast survivals for 1999 are shown with 50% confidence intervals.**

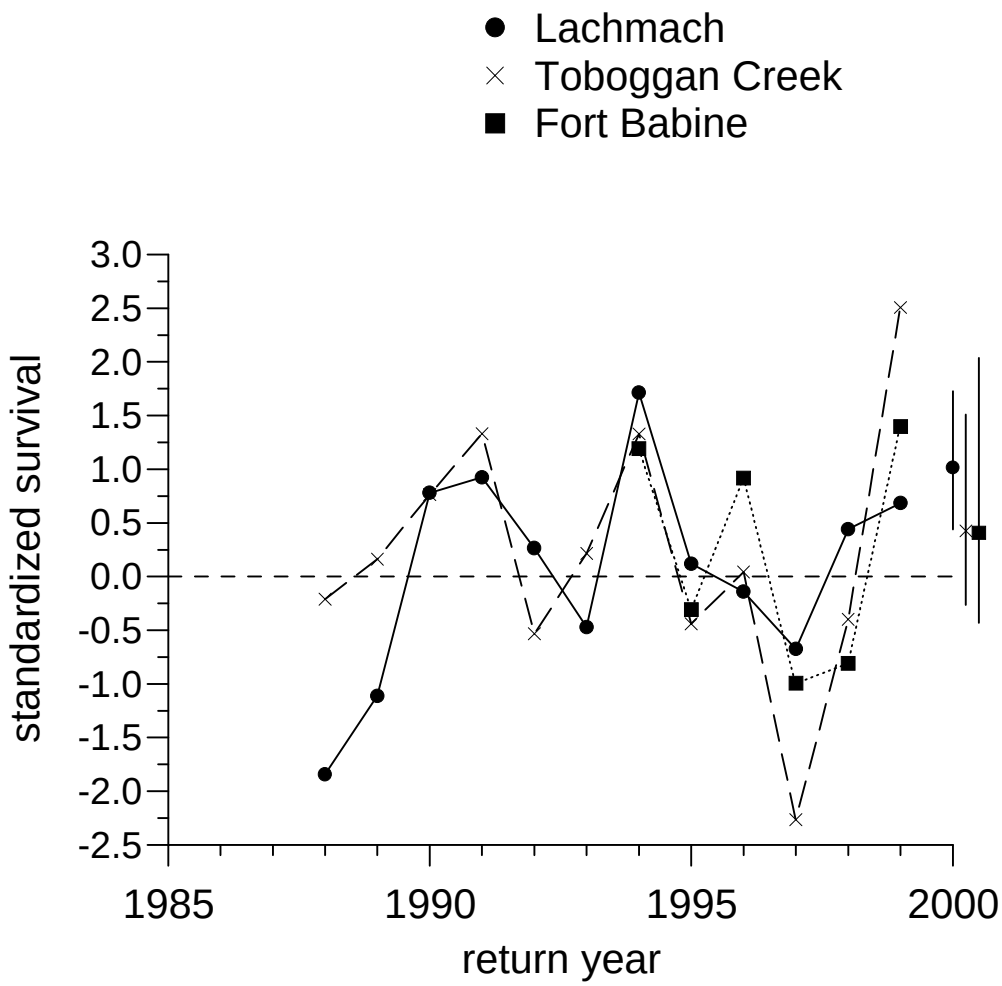

Figure 6. Sockeye Returns to Barkley Sound 1974-1999

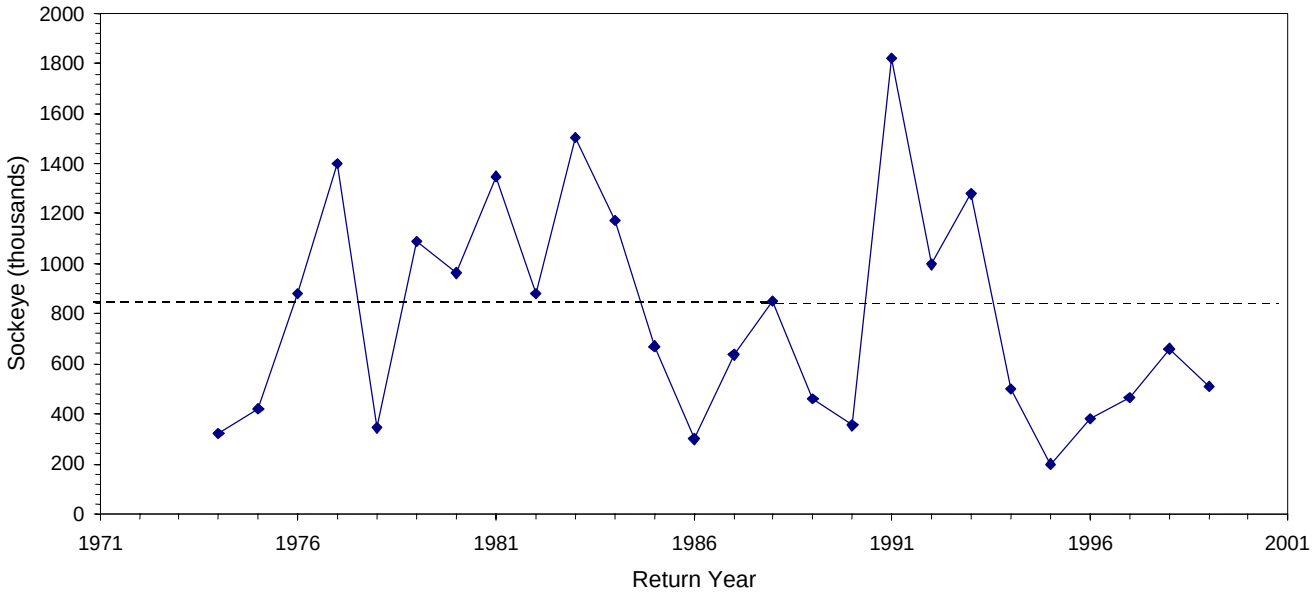

Figure 7. Terminal return of Somass/Stamp River chinook to Area 23 (Barkley Sound and Alberni Inlet), including the year 2000 recommended forecast.

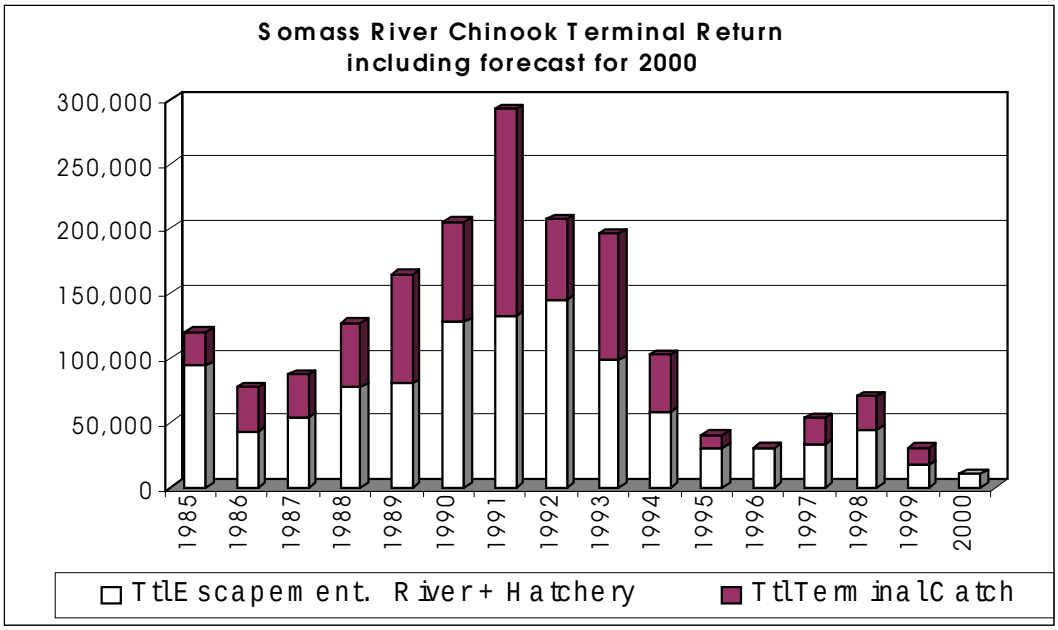

Figure 8. Probability and cumulative probability distributions of the "average" forecast (average of Prod2 and Prod3) for the year 2000 terminal run to the Stamp River/RCH indicator chinook stock (WCVI). Horizontal dashed lines represent the 25%, 50%, and 75% cumulative probabilities. The vertical solid line is the simple average value of the Prod2 and Prod3 models and equals 10036 chinook.

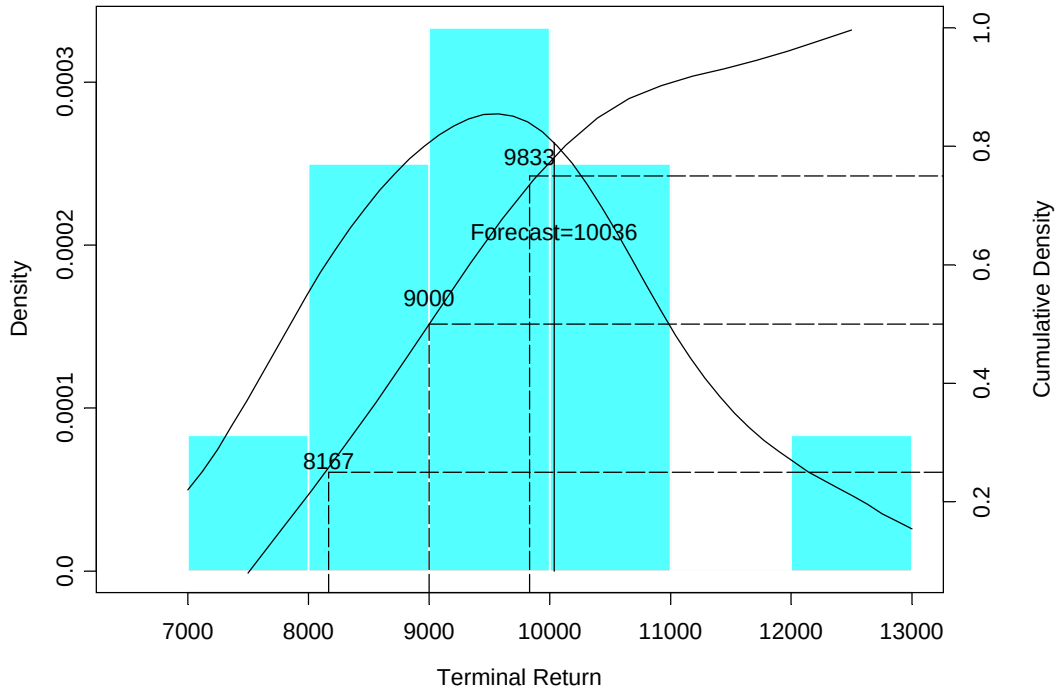

Table 1 . Summary of recommended pre-season stock size forecasts for 2000. Bold print is used to flag stock size forecasts that are well below escapement targets in stocks whose status has been reviewed previously by PSARC.

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

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

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

[c] recommended forecast for management decisions under precautionary approach

Table 2. Run size forecasts for 2000 Fraser sockeye by stock and timing group.

	Probability of Achieving Specified Run Sizes[a]				
STOCK/TIMING	**25%**	**50%**	**75%**	**80%**	**90%**
Early Stuart	**540,000**	**291,000**	**157,000**	**134,000**	**89,000**
Early Summer	**1,046,000**	**547,000**	**289,000**	**248,000**	**161,000**
Fennell	87,000	47,000	25,000	22,000	14,000
Bowron	58,000	33,000	18,000	16,000	11,000
Raft	217,000	115,000	61,000	52,000	34,000
Gates	96,000	43,000	19,000	16,000	9,000
Nadina	74,000	41,000	22,000	19,000	13,000
Pitt	63,000	29,000	14,000	11,000	7,000
Seymour	154,000	82,000	44,000	38,000	25,000
Scotch	77,000	29,000	11,000	8,000	4,000
Upper Adams[b]	220,000	128,000	75,000	66,000	44,000
Mid Summers	**4,995,000**	**2,889,000**	**1,717,000**	**1,512,000**	**1,084,000**
Chilko	2,240,000	1,444,000	931,000	834,000	623,000
Quesnel	735,000	311,000	132,000	106,000	59,000
Stellako	1,393,000	866,000	539,000	479,000	349,000
Late Stuart	627,000	268,000	115,000	93,000	53,000
Late Summer	**1,171,000**	**577,000**	**286,000**	**241,000**	**153,000**
Birkenhead	427,000	240,000	134,000	116,000	79,000
Late Shuswap	98,000	51,000	26,000	22,000	14,000
Cultus	9,000	5,000	2,000	2,000	1,000
Portage	68,000	31,000	14,000	11,000	7,000
Weaver	569,000	250,000	110,000	90,000	52,000
TOTAL	**7,752,000**	**4,304,000**	**2,449,000**	**2,135,000**	**1,487,000**

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

[b] the Upper Adams forecast is based on recruits-per-spawner data for all stocks combined.

Table 3. Barkley Sound Sockeye year 2000 return forecasts.

Table 3. Barkley Sound sockeye year 2000 return forecasts.

	Probability of Achieving Specified Run Sizes*			
Forecast	25%	50%	75%	90%
SStM	714,000	532,000	485,000	362,000
SSM	2,146,000	1,900,000	1,185,000	564,000
SEPB	982,000	946,000	437,000	NA < 0

* probability that the actual run size will exceed the specified

Table 4. Summary of 1999 terminal run of Stamp River/RCH chinook salmon.

Fishery	# Age 2	# Age 3	# Age 4	# Age 5	# Age 6	Total
Alberni Inlet Sport	115	757	1,592	4,892	0	7,355
Somass Native	0	122	898	2,571	0	3,591
Barkley Sound Sport	0	362	362	1,326	0	2,049
Hatchery Returns[1]	25	49	357	1,722	9	2,162
River Escapement[2]	63	865	3,797	10,526	124	15,375
Total Terminal Run	203	2,155	7,005	21,037	133	30,532

[1] Includes captures from Great Central Lake Dam but excludes hatchery releases.
[2] Stamp River only, includes pre-spawn mortality and hatchery releases.

Table 5. Total escapement into the Stamp River, including natural spawners, potential eggs, and hatchery removals during the period of the intensive "keystream" surveys, 1985-99.

Return Year	Total Natural Spawners	Total Adult Spawners	Potential Eggs Prior to Spawning	Total Hatchery Swimins	Total Adults in Hatchery	Total Adult Escapement
1985	74,941	74,279	167,282,000	19,076	18,875	93,154
1986	29,306	29,306	69,225,560	13,935	6,983	36,289
1987	15,454	14,491	9,744,800	38,694	36,156	50,647
1988	62,411	54,305	112,514,000	14,533	12,505	66,810
1989	50,990	44,786	67,998,400	28,929	18,258	63,044
1990	81,840	76,064	107,049,600	45,850	35,998	112,062
1991	96,907	85,843	149,254,400	35,354	30,425	116,268
1992	119,986	117,248	248,124,800	25,126	24,398	141,646
1993	77,644	76,487	176,551,600	20,415	20,043	96,530
1994	47,498	46,605	120,852,800	11,132	11,105	57,710
1995	25,460	23,313	80,042,198	4,990	4,522	27,834
1996	11,121	9,410	8,631,450	18,829	17,920	27,330
1997	13,623	12,785	14,140,245	19,415	19,309	32,095
1998	28,263	28,044	60,617,712	11,876	11,847	39,891
1999	15,375	15,312	47,199,407	2,162	2,137	17,449
2000 forecast	10,000	10,000	20,000,000	na	na	na

Table 6. Forecast of year 2000 total escapement and female spawners in WCVI indicator streams assuming a 66% reduction from 1999 levels (RCH forecast) and expected 50% female.

River	Indicator, Production Type[1]	Range in Observed Escapement[2]	Mean Escapement[2]	1999 Total Escapement	2000 Forecast Escapement	2000 Forecast Females
San Juan R (A20)	Enhanced	300-4600	900	1,620	567	284
Sarita R (A23)	Enhanced	130-2400	900	767	268	134
Nahmint R (A23)	Enhanced	200-784	300	931	326	163
Bedwell R (A24)	Wild	270-700	200	160	56	28
Megin R (A24)	Wild	160-800	200	236	83	41
Moyeha R (A24)	Wild	90-400	150	239	84	42
Leiner River (A25)	Enhanced	300-715	300	822	288	144
Tahsis R (A25)	PSC, Enhanced	380-1400	400	1,731	606	303
Gold R (A25)	PSC, Enhanced	800-3600	1500	2,000	700	350
Burman R (A25)	PSC, Enhanced	600-3200	1100	2,399	840	420
Zeballos R (A25)	Wild	150-900	200	686	240	120
Kaouk R (A26)	PSC, Wild	150-800	200	453	159	79
Artlish R (A26)	PSC, Wild	100-700	200	539	189	94
Tashish R (A26)	PSC, Wild	250-1500	600	879	308	154
Marble R (A27)	PSC, Enhanced	1000-5300	2400	4,185	1,465	732

[1] PSC (Pacific Salmon Commission) indicators of escapement as defined in Chinook Rebuilding Program. Production type “Enhanced” indicates small-scale supplementation of the wild stock by removal of natural spawners for broodstock.
[2] Based on extensive survey program initiated in 1993 to 1995, depending on river and area. Estimates are Area Under Curve estimates of total escapement.