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Proceedings of the PSARC Salmon Subcommittee Meeting March 5 – 7, 2002

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Salmon Subcommittee Chair

Fisheries and Oceans Canada
Pacific Scientific Advice Review Committee
Pacific Biological Station
Nanaimo, British Columbia V9T 6N7

April 2002

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PACIFIC SCIENTIFIC ADVICE REVIEW COMMITTEE (PSARC)
SALMON SUBCOMMITTEE MEETING

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SUMMARY

The PSARC Salmon Subcommittee met March 5 – 7, 2002 at the Pacific Biological Station, Nanaimo, B.C. The Subcommittee reviewed six Working Papers.

Working Paper S2002-01: Pre-season 2002 stock size forecasts for Skeena River and Nass River sockeye salmon

The Subcommittee accepted the forecasts of 1.2 million (50% CI, 795,000 – 1.7 million) for the Skeena River, based on the sibling model, and 685,000 (50% CI, 592,000 – 794,000) for the Nass River, based on the 5-year average (YRA) model.

The Subcommittee recommended that work on in-season methodologies should continue considering the imprecision of present pre-season forecast methods. Because in-season run-size forecasts are useful for managing Skeena and Nass sockeye fisheries, the Subcommittee also recommended further evaluation of a Bayesian approach for integrating pre- and in-season forecasts, using pre-season forecasts as the prior probability distribution.

The Subcommittee noted that Alaskan exploitation will likely reduce the aggregate run-size of Skeena sockeye in Canada to below their aggregate escapement target.

Working Paper S2002-02: Forecast for southern British Columbia coho salmon in 2002

Forecasts of marine survival for all indicator stocks, abundance of Thompson watershed coho and distribution of Georgia Basin coho were presented. These were accepted by the Subcommittee. Marine survival is forecast to be poor (<5%) for West Coast Vancouver Island (WCVI) and Georgia Basin coho. Although abundance of Thompson coho is increasing, the forecast is 25,000 (50% CI, 15,000 – 40, 000), 29% of the mean abundance. Abundance forecasts for WCVI and Strait of Georgia coho were not made because the models performed poorly. The distribution forecast, based on February salinity, is for a moderately strong “outside” year.

The Subcommittee recommended continued caution in prosecuting fisheries which impact on Strait of Georgia coho. Additional concern was expressed for wild WCVI coho. Based on Carnation Creek, smolt abundance is low and lower survival is forecast and, because of the potential outside distribution of Strait of Georgia coho, there could be concerns related to mixed-stock fisheries. WCVI fisheries exploitation rates should not be greater than last year; fishing plans should be risk-adverse.

The Subcommittee recommended that work on biologically-based forecasting approaches continue and that new approaches consider S-R relationships which include environmental correlates. It also recommended that time series analyses be

revisited. The Subcommittee noted that more freshwater/marine survival information is required, especially for interior coho.

Working Paper S2002-03: Forecast for northern and central coast British Columbia coho salmon in 2002

The Subcommittee accepted the paper and the forecasts. Abundance forecasts vary among regions addressed in the paper. The forecasts of abundance for Skeena and Nass aggregates and the northern and western portions of the Queen Charlotte Islands are for average or better, and the forecasts for escapement are above average or better. Hecate Strait aggregates are considered to be the least productive in the region and abundance is expected to be no better than below average. Returns to Areas 4C/5, Areas 12 and 13 were forecast with limited data, however, the circumstantial evidence was sufficient to produce a cause for major concern. Lower Johnstone Strait (Area 13) coho require assessment information to determine if the depressed abundance trends are real.

The Subcommittee recommended an assessment for Area 13 coho and extreme caution with respect to fishing because evidence suggests a conservation concern. The effect of mark-selective fishery in Area 13 should also be assessed.

More detailed assessments of high interior fisheries are required. Managers should consider the implications of mixed stock fisheries for these stocks because there is the potential for a severe conservation concern for high interior coho stocks, which remain severely depressed.

Working Paper S2002-04: Forecast for central coast sockeye, pink and chum salmon in 2002

The Subcommittee accepted the working paper and forecasts. Returns for all sockeye stocks are forecasted to be very low. Chum abundance is expected to exceed aggregate escapement target in Area 8 only, to be slightly below target in Area 7 and there is no information for Area 10. Area 9 escapement is forecast to be well below escapement target. Pink abundance is forecasted to be at or above aggregate escapement target in Areas 9 and 8, slightly below escapement target in Area 10 and well below target in Area 7.

There are grave concerns about the status of all sockeye stocks in the Central Coast and concerns about pink and chum stocks in Area 10. The Subcommittee felt that assessment effort in the southern Central Coast was inadequate to determine status. There is anecdotal information that the observed declining trend for Area 10 chum also reflects trends for Areas 11 and 12 chum stocks; however, data quality is poor. The downward trend for even-year pinks in Area 7 will become a concern if it continues. A move away from the statistical area approach should be considered. Trends in aggregates of populations could be evaluated using the approach Dr. R. Peterman's research team at SFU has developed to identify spatial covariation

between stocks and environmental variables. These relationships could be incorporated into Ricker stock-recruit relationships to potentially improve forecast reliability.

The Subcommittee recommends extreme caution to limit exploitation on sockeye from Areas 9 and 10. Central Coast and CORE stock assessment personnel should develop a stock assessment framework for the Central Coast. The Subcommittee recommended increased assessment effort to include other sockeye lakes, data collection for pink and chum in the southern Central Coast, enumeration of Area 10 chum and assessments of chum in the southern Central Coast.

Working Paper S2002-05: Review of 2001 chinook returns to the west coast Vancouver Island, forecasts of the 2002 return to the Stamp River/Robertson Creek hatchery indicator stock and outlook for other WCVI chinook stocks

The Subcommittee accepted the working paper and forecasts. It is anticipated that the return of Stamp Falls/Robertson Creek Hatchery chinook to the terminal area of Barkley Sound will be double the 2001 return. The expected return of females continues to be limited by the poor returns of age 5 fish, however, egg numbers for the river and hatchery are expected to exceed the interim goal. This assumes no fishing mortality in Canadian waters. Forecasts for wild indicator streams were cautious because of poor survey conditions. Based on the forecasted return for Stamp Falls/Robertson Creek Hatchery chinook, most populations are expected to have more than 100 females. Several populations remain depressed.

The Subcommittee recommended that there be continued caution in the prosecution of fisheries in Canadian waters because of concerns about rebuilding wild WCVI chinook stocks.

Working Paper S2002-06: Review of the year 2001 return of Barkley Sound sockeye salmon and forecasts for 2002

The forecasts and paper were accepted by the Subcommittee. The Survival Stanza Model forecast for 2002 is 970,000 (50% CI, 880,000 – 1.22 million) for all ages and 840,000 (50% CI, 750,000 – 1.10 million) for adults. A similar forecast was obtained from another recently developed model, the Coho Leading Indicator, which assumes that sea conditions shared during early marine migration cause similar trends in the survival of coho and sockeye.

The Subcommittee expressed concern about the current status and management of Henderson Lake sockeye. Escapements to this population have been below target every year since 1994. The Subcommittee recommended that a Working Paper be prepared on Henderson Lake sockeye to examine current status, the escapement goal, forecasting capability (a retrospective analysis) and harvest strategies. A member of the Stock Assessment Coordinating Committee indicated that such a paper was scheduled for the May PSARC Salmon Subcommittee meeting. The

Subcommittee also recommended that consideration be given to managing fisheries in 2002 to avoid Henderson Lake sockeye, perhaps by modifying the timing and location of fisheries in Barkley Sound.

SOMMAIRE

Document de travail S2002-01 : Prévisions de la taille des stocks de saumon rouge des rivières Skeena et Nass avant la saison de pêche 2002

Le Sous-comité accepte la prévision de 1,2 million (IC à 50% : 795 000 – 1,7 million), fondée sur le modèle des espèces jumelles, pour la rivière Skeena et la prévision de 685,000 (IC à 50 % : 592 000 – 794 000), fondée sur le modèle de la moyenne quinquennale, pour la rivière Nass.

Le Sous-comité recommande de poursuivre les travaux sur les méthodes d'évaluation des stocks pendant la saison de pêche étant donné l'imprécision des méthodes actuelles de prévisions avant la saison de pêche. Comme les prévisions de la remonte effectuées durant la saison sont utiles pour gérer les pêches du saumon rouge des rivières Skeena et Nass, le Sous-comité recommande aussi d'évaluer davantage une méthode bayesienne d'intégration des prévisions faites avant et pendant la saison de pêche (les prévisions d'avant-saison servant de distribution de probabilité a priori).

Le Sous-comité remarque que la pêche en Alaska réduira sans doute la taille de la remonte combinée du saumon rouge de la Skeena et de la Nass à un niveau inférieur à la cible d'échappée combinée.

Document de travail S2002-02 : Prévisions concernant le saumon coho du sud de la Colombie-Britannique en 2002

Les prévisions de la survie en mer de tous les stocks indicateurs, de l'abondance du saumon coho dans le bassin de la rivière Thompson et de la répartition du saumon coho du bassin de Georgia sont présentées, et le Sous-comité les accepte. On prévoit une faible survie en mer (< 5 %) pour le saumon coho de la côte ouest de l'île de Vancouver (COIV) et du bassin de Georgia. Bien que l'abondance du coho de la Thompson augmente, la prévision se chiffre à 25 000 (IC à 50 % : 15 000 – 40 000), soit 29 % de l'abondance moyenne. Aucune prévision des l'abondance n'a été faite pour le coho de la COIV et du détroit de Georgia parce que les modèles ont mal fonctionné. En se fondant sur la salinité en février, on prévoit que la répartition du coho sera modérément forte à l'extérieur du détroit cette année.

Le Sous-comité recommande de continuer d'user de prudence dans la gestion des pêches qui ont un impact sur le coho du sud du détroit de Georgia. On s'inquiète aussi du coho sauvage de la COIV. Selon les données pour le ruisseau Carnation, l'abondance des smolts est faible, on prévoit une baisse de la survie et, compte tenu de la possible répartition du coho à l'extérieur du détroit de Georgia, la pêche de

stocks mélangés pourrait être une source de préoccupation. Les taux d'exploitation des pêches de la COIV ne devraient pas dépasser ceux de l'an dernier; les plans de pêche devraient être prudents.

Le Sous-comité recommande que le travail sur des méthodes de prévisions axés sur la biologie se poursuive et que les nouvelles méthodes tiennent compte des relations stock-recrutement qui comprennent des corrélats environnementaux. Il recommande aussi de revoir les analyses de séries chronologiques et remarque qu'il faut obtenir davantage de données sur la survie en eau douce et en mer, surtout pour le saumon coho de l'intérieur.

Document de travail S2002-03 : Prévisions concernant le saumon coho de la côte nord et centrale de la Colombie-Britannique en 2002

Le Sous-comité accepte le document et les prévisions. Les prévisions d'abondance varient selon les régions couvertes par le document. L'abondance prévue pour les stocks combinés des rivières Skeena et Nass et des secteurs nord et ouest des îles de la Reine-Charlotte est au moins moyenne, tandis que les échappées devraient dépasser la moyenne. Les stocks combinés du détroit d'Hécate sont considérés comme les moins productifs de la région, et on prévoit que leurs effectifs seront inférieurs à la moyenne. Les prévisions des remontes dans les zones 4C/5, 12 et 13 sont fondées sur des données limitées, mais il y a suffisamment de preuves circonstancielles pour susciter de graves inquiétudes. Il faut instamment obtenir des données d'évaluation sur le stock de coho du sud du détroit de Johnstone (zone 13) pour déterminer si les tendances à la baisse des effectifs sont réelles.

Le Sous-comité recommande de procéder rapidement à une évaluation du coho de la zone 13 et d'être extrêmement prudent en ce qui concerne la pêche parce qu'il y a des indications que la situation est très préoccupante pour la conservation. Il faudrait aussi évaluer l'effet de la pêche sélective de poissons marqués dans la zone 13.

Il faut aussi des évaluations plus détaillées des pêches dans l'intérieur. Les gestionnaires devraient tenir compte des conséquences de pêches de stocks mélangés pour les stocks de saumon coho de cette région, car ces stocks restent gravement appauvris, et leur conservation pourrait être très préoccupante.

Document de travail S2002-04 : Prévisions concernant les saumons rouge, rose et kéta de la côte centrale en 2002

Le Sous-comité accepte le document de travail et les prévisions. On prévoit que les remontes de tous les stocks de saumon rouge seront très faibles. On s'attend à ce que l'abondance du saumon kéta dépasse la cible d'échappée combinée dans la zone 8 seulement et qu'elle soit légèrement sous la cible dans la zone 7; il n'y a pas d'information pour la zone 10. Dans la zone 9, on prévoit une échappée bien en dessous de la cible d'échappée. On s'attend à ce que l'abondance du saumon rose

atteigne ou dépasse la cible d'échappée combinée dans les zones 8 et 9, qu'elle soit légèrement sous la cible dans la zone 10 et bien en dessous de la cible dans la zone 7.

Il y a des inquiétudes sérieuses concernant le statut de tous les stocks de saumons sockeyes de la Côte Centrale et des inquiétudes au sujet des saumons roses et kétas dans l'Aire 10. Le Sous-Comité pense que les efforts d'évaluation des stocks dans la partie sud de la Côte Centrale était inadéquate pour déterminer le statut des stocks. Il y a des informations tirées d'anecdotes qui suggèrent que le déclin des saumons kétas observé dans l'Aire 10 reflète également la tendance des stocks de saumons kétas dans l'Aire 11 et 12. Cependant, la qualité de ces données est pauvre. La tendance à la baisse des saumons roses d'années pairs de l'Aire 7 deviendra inquiétante si elle continue. Une alternative à l'approche statistique basée sur l'aire devrait être considérée. Des tendances au niveau des regroupements de populations pourraient être évaluées en utilisant l'approche développée par le Dr. R. Peterman à USF pour identifier la covariation spatiale entre les stocks et les variables environnementales. Ces relations pourraient être incorporées dans les modèles de recrutements de Ricker, ce qui pourrait améliorer la fiabilité des prévisions.

Le Sous-Comité recommande une prudence extrême pour limiter l'exploitation des saumons sockeyes des Aires 9 et 10. Le personnel de l'évaluation des stocks de la Côte Centrale et de CORE devrait développer un modèle d'évaluation des stocks pour la Côte Centrale. Le Sous-Comité recommande d'augmenter les efforts d'évaluations pour inclure d'autres lacs à saumons sockeyes, la collection de données pour les saumons roses et kétas dans la partie sud de la Côte Centrale, une énumération des saumons kétas dans l'Aire 10 et une évaluation des stocks de saumons kétas dans la partie sud de la Côte Centrale.

Document de travail S2002-05 : Remontes du saumon quinnat sur la côte ouest de l'île de Vancouver en 2001, prévision de la remonte de 2002 du stock indicateur de la rivière Stamp/l'écloserie du ruisseau Robertson et perspectives pour les autres stocks de saumon quinnat de la côte ouest de l'île de Vancouver

Le sous-comité accepte le document de travail et les prévisions. On s'attend à ce que la remonte au fond de la baie Barkley du stock de saumon quinnat des chutes Stamp/de l'écloserie du ruisseau Robertson soit deux fois plus forte que celle de 2001. La remonte prévue des femelles continue d'être limitée par les faibles remontes des poissons de cinq ans, mais, en supposant qu'il n'y aura aucune mortalité par pêche dans les eaux canadiennes, on prévoit que le nombre d'œufs pour la rivière et l'écloserie dépassera l'objectif intérimaire. Les prévisions pour les stocks sauvages des cours d'eau indicateurs sont prudentes en raison des mauvaises conditions dans lesquelles le relevé a été effectué. En se fondant sur la remonte prévue du saumon quinnat des chutes Stamp/de l'écloserie du ruisseau

Robertson, on s'attend à ce que la plupart des populations comptent plus de 100 femelles. Plusieurs populations sont toujours appauvries.

Le Sous-comité recommande de continuer d'user de prudence dans la gestion des pêches en eaux canadiennes en raison des préoccupations liées à la reconstitution des stocks de saumon quinnat sauvages de la côte ouest de l'île de Vancouver.

Document de travail S2002-06 : Remonte du saumon rouge de la baie Barkley en 2001 et prévisions pour 2002

Le Sous-comité accepte le document de travail et les prévisions. Pour 2002, le modèle des périodes de survie a donné une prévision 970 000 poissons de tous âges (IC à 50 % : 880 000 – 1,22 million) et de 840 000 poissons adultes (IC à 50 % : 750,000 – 1,10 million). Des prévisions semblables ont été obtenues à l'aide d'un autre modèle récemment mis au point, le *Coho Leading Indicator*, qui postule que des saumons quinnat et rouge exposés aux mêmes conditions océaniques au début de leur migration en mer présenteront des tendances semblables en ce qui concerne leur survie.

Le Sous-comité s'inquiète de l'état actuel et de la gestion du stock de saumon rouge du lac Henderson. Les échappées de cette population sont inférieures à la cible chaque année depuis 1994. Le Sous-comité recommande de rédiger un document de travail sur ce stock afin d'examiner l'état actuel du stock, la cible d'échappée, la capacité de prévision (analyse rétrospective) et les stratégies de pêche. Selon un membre du comité de coordination de l'évaluation des stocks, on prévoit présenter un tel document à la réunion de mai du Sous-comité du CEESP sur le saumon. Le Sous-comité recommande aussi d'envisager de gérer les pêches en 2002 de façon à éviter de tuer du saumon rouge du lac Henderson, peut-être en modifiant les lieux et les périodes de pêche dans la baie Barkley.

INTRODUCTION

The PSARC Salmon Subcommittee met March 5 - 7, 2002, at the Pacific Biological Station in Nanaimo, British Columbia. External participants from the Pacific Fisheries Resource Conservation Council, Fishing Vessel Owners Association and the Sierra Club of BC attended the meeting. Observers included member of the public and representatives of the Area G Troll Association and the Nuu-chah-nulth Tribal Council. The Subcommittee Chair, R. Tanasichuk, opened the meeting by welcoming the participants. During the introductory remarks the objectives of the meeting were reviewed, and the Subcommittee accepted the meeting agenda.

The Subcommittee reviewed six Working Papers. Summaries of the Working Papers are in Appendix 1. The meeting agenda appears as Appendix 2. A list of meeting participants, observers and reviewers is included as Appendix 3.

DETAILED COMMENTS FROM THE REVIEW

S2002-01: Pre-season 2002 stock size forecasts for Skeena River and Nass River sockeye salmon

S. Cox-Rogers **Accepted with revisions**

Rapporteur: Cindy Yockey

Data, forecasting models and forecast performance

This working paper used data series and forecasting methods which have been used in previous PSARC assessments. Retrospective analyses were presented for 2001 only. For the Skeena, total returns were 4.6 million and the smolt model predicted 2.8 million (error=-39%). Return to the Nass River was about 580,000 which was below the forecast made using the 5-yr mean model (741,000; error=+29%). Forecasts for both rivers were within the 50% confidence interval of the forecast.

There was some Subcommittee discussion regarding the reliability of total return data for age 3_2 ("jacks") of Skeena River stocks. The jack escapement is estimated reliably at the Babine fence, but no catch is reported from fisheries, although jacks are known to be captured by the seine fishery (but not the gillnet fishery). Changes in exploitation rate by seines could therefore affect the accuracy of the sibling model forecasts.

Discussion regarding the sibling model continued. The Subcommittee expressed concern that the uncertainty of the sibling model forecast may have been under-estimated by not considering the variance contribution from both brood years expected to return in 2002. The author will incorporate this suggestion into the revision.
The Reviewer noted the author's comment that the forecasting models are not useful because of their inaccuracy. He questioned the utility of pre-season forecasting and suggested that the author consider developing models which would reflect the biological basis for survival variations and hence be better forecasters. He also recommended that it may be more appropriate to conduct a bootstrapping of the forecasting model to derive empirical estimates of the error distribution for the forecast stock size, rather than assuming that it is normally distributed. Finally, the reviewer encouraged the author to conduct retrospective analysis of the performance of a simple average forecast from the three models presented for Skeena sockeye.

The author recommended more work on in-season methodology. He felt that the pre-season forecasts, in practice, serve only as a guide. Managers use the forecasts only as an indication of likely return strength. He found that an in-season composite estimator performed better.

Stock status

Average sockeye returns to the Skeena River have increased steadily (with occasional poor years) since enhancement began in the early 1970's. Returns over the 1990's have ranged between 0.8 million in 1998 and 6.9 million in 1996. Escapements over that period have met or exceeded the target (1.1 million) in all years except 1998 and 1999.

Nass River total returns have been relatively stable over time, ranging between 500,000 and 1.0 million since the mid-1990's. Mean returns over the 1990's were slightly less than 1.0 million. Target escapement was met in most years in the 1990's.

Recommended forecast

Returns to the Skeena River in 2001 suggest poor adult production from 1997 and 1998 brood years (incoming 5_2 and 4_2 sockeye respectively). The recommended forecast for the Skeena River, based on the sibling model, is 1.2 million (50% CI, 795,000 – 1.7 million). An average return is expected for the Nass River. The forecast, based on the 5-yr mean model, is 685,000 (50% CI, 592,000 – 794,000).

Conclusions

The Subcommittee accepted the forecasts for Nass and Skeena River sockeye. The working paper should be revised to address the reviewer's comments.

The Subcommittee decided that further work on in-season estimation should be pursued. The pre-season forecast could provide a prior probability distribution for Bayesian in-season management models that are used for fine-tuning fishing plans. Discussion ensued on composite forecasts. The Subcommittee requested integration of pre- and in-season forecasts.
Finally, the Subcommittee noted that forecast and status data were not available for individual (lake-specific) sockeye stocks in the Skeena River.

Recommendations

The Subcommittee recommended that the sibling model forecast be used for Skeena sockeye because the sibling model has performed well for this stock in the past and because it is the most conservative forecast for 2002. The 5-yr mean forecast should be accepted for the Nass River. It should be noted that Alaskan exploitation will likely reduce the aggregate run-size of Skeena sockeye in Canada to below their aggregate escapement target.

In addition, the Subcommittee recommended a peer review of recent efforts to revise the basis for stock reconstruction. This review should be followed by a stock status report that would include smaller sockeye populations.

Finally, the Subcommittee noted that pre-season forecasts could be used as prior probability distributions for in-season Bayesian assessment of run-size and recommended doing more work on in-season estimates and the integration of pre- and in-season forecasts into a single assessment model.

S2002-02: Forecast for southern British Columbia coho salmon in 2002

K. Simpson, D. Dobson, S. Lemke, R. Sweeting, R. Tanasichuk and S. Baillie
Accepted with revisions

Rapporteur: Chuck Parken

Data, forecasting methods and forecast performance

The authors presented forecasts of marine survival rates for southern B.C. coho, abundance forecasts for interior Fraser coho and a distribution forecast for fish either along the WCVI or in the Strait of Georgia during their second marine year. Marine survival rates were forecast using methods approved in previous working papers. In addition, two new forecasting methods were introduced. The euphausiid forecasting method for West Coast Vancouver Island (WCVI) coho was updated to a multiple regression model which forecasts marine survival based on smolt production and euphausiid (9-12 mm *Thysanoessa spinifera*) abundance over June–August of sea-entry year. Marine survival for Strait of Georgia coho was also forecast using the CPUE from June-July mid-water trawl surveys. The Subcommittee encouraged the use of biologically-based forecasts and new approaches; this included a re-examination of proper time series models and S-R models which include environmental correlates.

Reviewer 1's comments focussed on forecasting methodology. The reviewer felt that the paper does a good job of applying traditionally used methods, with some valuable innovations. This reviewer was particularly encouraged to see the success in using estimates of euphausiid abundance to reduce uncertainty. Reviewer 1 generally found the models "refreshingly straightforward and parsimonious". This reviewer had two major concerns about the methods: 1) the methods should evaluate the brood-year effects; and 2) the methodology does not adequately handle the potential for temporal trends. The authors responded that they have tested for a brood-year effect and found no evidence for one. Trends cannot be evaluated as yet because the time series was too short.

Data series used were, generally, those used for earlier assessments. The authors presented a method for estimating marine exploitation rates for 2001. In 1998, a coho non-retention fishery was initiated to protect this species. From 1998 to 2000, fishing mortality could be derived from genetic analyses of fish samples from catches. As of 2001, exploitation rates were estimated using an approach which relied on historic estimates of CWT recoveries and effort. The Subcommittee

requested a more detailed description of the derivation of the subjective scalars used to account for changes in commercial fleet size and efficiency. In addition, it requested a rationale for changing release mortality estimates presented in previous PSARC reports. Also, it noted that the base period (1986-97) selected from which historic estimates were derived included years when coho were more abundant outside, whereas 2001 was considered to be a year when coho were more abundant inside the Strait of Georgia. This distribution component should be considered in developing exploitation rate estimates.

Reviewer 2 concentrated on using hatchery data for stock assessment. This reviewer pointed out that the data are being used differently than intended. The reviewer recommended that a closer working relationship should be developed between data users and collectors to more clearly define the data requirements. Reviewer 2 noted that the authors recommend a review of the utility of sibling models for the next forecast. This reviewer recommended that the work "should definitely be done for next year".

The following table presents the performance of the marine survival rate forecasting models for 2001:

	Quinsam	Big Qualicum	Chilliwack	Inch	Black	Robertson	Carnation
Observed survival in 2001	0.017	0.021	0.049	0.059	0.071	0.092	0.058
Sibling forecast	0.021	0.027	0.055	0.043		0.039	
% obs of forecast	81%	78%	90%	138%		235%	
Quasi TS model	3YRA	LLY	RAT3	3YRA	3YRA	LLY	3YRA
Forecast	0.011	0.020	0.014	0.012	0.026	0.076	0.031
% obs of forecast	155%	105%	353%	495%	273%	120%	188%
Euphausiid forecast						0.040	0.102
% obs of forecast						229%	57%

Forecasts for 2001 were accurate for Big Qualicum; observed survivals of Chilliwack, Inch and Black exceeded the upper 95% confidence limit and Big Qualicum; Robertson and Carnation survival rates were within the 50% confidence interval of the forecasts. The Subcommittee noted that time series forecasts tended to be under-estimates while sibling models performed better and generally over-forecasted, except for Robertson Creek hatchery.

An abundance time series for Thompson River was derived from the historic escapement time series. Counts from intensive surveys during 1998-2000 were compared with traditional survey results which were based on visual surveys. A comparison of counts ultimately resulted in an upward scaling of the pre-1998 escapement estimates for all wild streams. The Subcommittee requested that the

"unadjusted" and "adjusted" historic escapements be compared to provide a sense of the impact of the correction.

Abundance forecasts for interior Fraser coho were made using the 3YRA models. The forecasts were 0.40, 0.32, 0.33 and 0.35 of the observed abundances for Lower Thompson, South Thompson, North Thompson and Thompson watersheds respectively.

The Subcommittee noted that a shift had occurred in coho fishery management. Fisheries Management no longer requires a forecast of ocean abundance; managers were more interested in survival forecasts.

Stock status

Fry density for wild WCVI coho has generally improved since the period of extremely low marine survivals during the early 1990's. Although marine survival rates are increasing from the 1994 low, wild coho marine survival since 1994 has averaged 5% which is much lower than the mean for the previous 18 years (10.4%). Exploitation rates remain low because of the absence of directed commercial fisheries. Wild spawner escapements increased between 1998 and 2000 but decreased in 2001. Hatchery escapements increased dramatically in 2000 and 2001, apparently due to low exploitation and increased marine survival. While marine survival has slowly improved, it still remains below long-term averages.

The conservation of Georgia Basin coho has been an issue since 1989, when a need to reduce exploitation was recommended. Marine survival rates began to decline soon after resulting in exploitation being reduced from between 75 and 85% to 5%. After steadily declining since 1992, marine survival of hatchery populations stabilized in 1999. Survival rates increased in 2000, and in 2001 for the lower Fraser only. Even though survivals have increased, they have not returned to rates observed over the 1980's. Present survivals are still near levels needed to sustain wild stocks under minimal exploitation.

The escapement for Thompson River coho in 2001 was the largest since 1989. It appears that survival is improving because of reduced fishing pressure. Therefore, if survival remains constant and fisheries do not expand, the outlook for Thompson and other interior Fraser coho is for slow but gradual improvement.

Recommended forecast

The forecast is for poor survival (0.025-0.032) for Georgia Basin indicators; the auto-correlated survivals in the 1990's have reversed their downward trend consequently increasing uncertainty with trend models (see Figs. 1 and 2). The Strait of Georgia CPUE method predicts a survival rate of 0.034. The euphausiid-smolt model predicts a marine survival rate of 0.04 (50% CI, 0.032-0.050) for Carnation Creek (WCVI wild) coho. A forecast of 0.031 is recommended for Robertson Creek. This

forecast is from the sibling regression model and was chosen because it is more conservative and similar to the forecast for Carnation Creek.

The salinity forecast predicts 0.40 of the coho to remain in the Strait of Georgia. This is considered to be a moderately strong "outside" year.

Abundance forecasts for coastal stocks have been discontinued because of poor forecast performance. Thompson River coho abundance is predicted to be about 25,000, (50% CI, 15,000 – 40, 000), 29% of the mean abundance.

Conclusions

Marine survival for southern B.C. coho was variable but remained generally low compared to historic levels. Southern B. C. coho survival rates are low (<5%) and high levels of harvest would be unsustainable. Thompson coho abundances have increased recently but they still remain well below historical levels; if survival remains constant and fisheries do not expand there will be slow and gradual rebuilding of populations. As pointed out in the paper, the abundance forecasts were not included because of the authors response to PSARC concerns about limited abilities to estimate ocean abundance of coho for coastal coho.

Recommendations

The Subcommittee accepted the paper, subject to minor revisions, and the forecasts presented. Continued caution was recommended in prosecution of fisheries which impact on southern inside coho. The Subcommittee expressed concern for wild WCVI coho because, based on Carnation Creek, smolt abundance is low and lower survival is forecast; additional concern was expressed because of the potential outside distribution of Strait of Georgia coho and therefore mixed-stock fisheries.

WCVI fisheries exploitation rates should not be greater than last year; fishing plans should be risk-adverse. A subsequent analysis, which was a scenario of returns based on a 5% exploitation rate, supported maintaining low exploitation, similar to recent years.

The Subcommittee recommended an assessment of the marine exploitation estimation approach in the context of CWT and DNA-based approaches.

The Subcommittee recommended continued work on biologically-based forecasting approaches, considering S-R relationships which include environmental correlates, and re-visiting time series analyses. The Subcommittee noted that more freshwater/marine survival information is required, especially for interior coho.

S2002-03: Forecast for the coho of the north coast and central coast areas of British Columbia in 2002

L. B. Holtby, B. Finnegan and J. Gordon **Accepted with revisions**

Rapporteur: Jennifer Gordon

Data, forecasting methods and forecast performance

Input data and methodologies used for this paper were PSARC-approved and have been used in previous forecasts. For this year's forecasts, coho streams from Area 5 and coastal streams in Area 4 were grouped (Area 4C/5). In addition, forecasts were made for streams from Areas 9 through 12, as an aggregate. Observed marine survival for Lachmach (wild indicator) was about one-half that forecasted. Marine survival forecasts were made for the two hatchery indicators (Toboggan Creek, Fort Babine). Toboggan Creek hatchery survival was predicted well (0.09 forecasted, 0.083 observed). However the forecast for Fort Babine (0.08) was much greater than the observed (0.018). Performance of 2001 abundance forecasts was determined for Babine aggregate, Lachmach River and average-stream indices for Area 6 only. Forecasts for the Babine aggregate were low; total return was at the 97th percentile for the (S-R) model and the 90th percentile for the 3YRA model. The return for Lachmach was low, possibly due to an overestimation of jack abundance, but it was within the confidence interval of the sibling regression. Total stock size was under-forecast for Area 6.

Stock status

Nass and Skeena aggregates, including the Babine and Upper Skeena and the northern and western portions of the Queen Charlotte Islands are the most productive in the North and Central Coast areas. They appear to have responded well to reduced fishing pressure and several years of above-average freshwater and marine survival. However, this group includes "high interior" populations which may still be severely depressed, as illustrated by the Sustut River escapement indicator. Hecate Strait stocks (Areas 2E, 4C/5 and 6 –12) are depressed somewhat apparently because of low productivity. Both the authors and Subcommittee were concerned about consistently poor escapements in Area 13.

Recommended forecast

The following tables summarise the marine survival rate forecasts for the indicator stocks and abundance forecasts for Northern and Central B. C. coho.

	Forecasting		Marine survival rate		Period for
Indicator	model	Forecast	50% CI	Mean	mean
Lachmach	Sibling	0.075	0.06-0.09	0.10	1987-2000
Toboggan	From Lachman	0.025	0.016-0.04	0.039	1987-2000
Fort Babine	From Lachman	0.011	0.007-0.02	0.025	1993-2000

		Return		Escapement	
Aggregate	Model	P (%)	Type	P (%)	Type
Area 2W	3YRA	35	Avg	56	Avg
Area 1	3YRA	38	Avg	70	Above avg
Area 3	S-R	71	Above avg	90	Well above avg
Area 4L	S-R	54	Avg	90	Well above avg
Area 4U	S-R	73	Above avg	85	Well above avg
Babine	S-R	63	Above avg	75	Above avg
Area 2E	3YRA	11	Well below avg	46	Avg
Area 4C/5	LLY	5	Well below avg	25	Below avg
Area 6	3YRA	23	Below avg	55	Avg
Area 7	3YRA	29	Below avg	62	Avg
Area 8	3YRA	11	Well below avg	43	Avg
Area 9-12	3YRA	38	Avg	78	Above avg
Area 13	3YRA	4	Well below avg	28	Below avg

Abundance forecasts for total return and escapement. P is equal to the proportion of observed abundance or escapement smaller than the forecasted value; calculations assume a log-normal cumulative probability distribution with the mean and standard deviation calculated over the 1950 – 2001 return years. Probability values for forecasts - values between 35 and 75% are average, probabilities less than 15 or greater than 85% are well below or well above average.

The forecasts of abundance for Skeena and Nass aggregates and the northern and western portions of the Queen Charlotte Islands are for average or better, and the forecasts for escapement are above average or better. Hecate Strait aggregates are considered to be the least productive in the region and abundance is expected to be no better than below average. With continued restrictions to fisheries, escapement should be average, except for Area 4C/5 but information for that area is particularly limited.

Conclusions

Babine/Skeena stocks are recovering but there is major concern for high interior stocks. The high interior indicator (Sustut River) fence counts remain severely depressed. This has implications for mixed-stock fisheries and could become a major conservation concern. Stocks around Hecate Strait remain depressed, apparently because of low productivity. The Subcommittee felt that the information on some stocks of concern (Area 4C/5, Areas 12 and 13) was poor but that the circumstantial evidence was sufficient to produce a cause for major concern. Lower Johnstone Strait (Area 13) coho require urgent assessment information to determine if the depressed abundance trends are real.

Recommendations

The Subcommittee recommended that the working paper be accepted with revisions and that the forecasts be accepted. It recommended an assessment of Area 13 coho and extreme caution with respect to fishing because evidence suggests a conservation concern. The effect of mark-selective fishery in Area 13 should also be

assessed. More detailed assessments of high interior stocks are required. Managers should consider the implications of mixed stock fisheries for these stocks because there is the potential for a severe conservation concern for high interior coho stocks, which remain severely depressed.

S2002-04: Forecast for central coast sockeye, pink and chum salmon in 2002

L. B. Holtby and J. Sturhahn **Accepted with revisions**

Rapporteur: Richard Bailey

Data, forecasting methodology and forecasting performance

The data and forecasting methods used for the 2002 forecasts were identical or similar to those which have been approved by PSARC for previous assessments. Because there was no significant change in methodology, this assessment was reviewed by the PSARC Salmon Subcommittee only. There were data deficiencies. No data were available for Kimsquit sockeye (Area 8) or Area 10 chum and pink.

The forecasting models used were the 5YRA (5-year average) (similar to the previously used 5-yr mean model but assumes variability constant over long term) for sockeye, the nYRA (identical to the long-term mean model) for chum and the Ricker stock-recruitment model for pink. The forecast for Atnarko sockeye was within 6% of the estimated total stock size. Forecasts for Owikeno and Long Lakes were made using the 5YRA method and assumptions that marine survival conditions were poor (like 1996 sea-entry) or average. Although returns to both lakes were improved, the magnitude of the runs suggests that ocean conditions remain poor. Chum forecasts were within about 10% for Areas 7 and 8 but overestimated by 150% for Area 9. Pink forecasts were under-estimated by between 50 and 80%. Table 1 presents the forecast performance for sockeye, pink and chum.

Stock status

The author expressed grave concerns about the status of Owikeno and Long Lake sockeye. These stocks remain far below the provisional Limit Reference Points of 30,000 (Fig. 3). In addition, the abundance of Atnarko sockeye has been declining since the early 1970's and there is no information for Kimsquit sockeye, a stock of concern. Chum stocks in Areas 7 though 9 appear stable but the abundance of Area 10 chum is well below historic levels (Fig. 4). In general, pink stock abundance has increased since the mid-1990's (Fig. 5). Stocks in Areas 7 through 9 are at or near historic highs. However, Area 10 pinks have appeared to collapse in 1999. The downward trend in even-year abundance in Area 7 pinks will become a concern if it continues in 2002.

Recommended forecast

The table below summarises the forecasts for Central Coast sockeye, pink and chum. Extreme caution is advised for managing all sockeye stocks in the forecast. Chum abundance is expected to exceed aggregate escapement target in Area 8 only, Area 7 is slightly below target and there is no information for Area 10. Area 9 escapement is forecast to be well below escapement target. Pink abundance is forecast to be at or above aggregate escapement target in Area 9 and 8 respectively; abundance of Area 10 pinks is forecast to be slightly below escapement target but well below the target in Area 7.

			No. fish x 1000		
Area	Stock	Escapement Target	2002 forecast	50% CI	Forecast category
			Sockeye		
8	Atnarko	75	27	17-41	Depressed
9	Owikeno	200	30	17-54	Critically depressed
10	Long	200	11	6-22	Critically depressed
			Chum		
7	All	520	300	210-440	Below-target
8	All	270	440	290-640	Abundant
9	All	150	42	24-73	Depressed
			Pink		
7	All	1500	490	290-840	Depressed
8	All	1500	3900	2000-7400	Abundant
9	All	340	340	160-730	Near-target
10	All	66	43	16-120	Near-target

Conclusions

There are grave concerns for the status of all sockeye stocks in the Central Coast and Area 10 pink and chum. The authors and Subcommittee felt that assessment effort in the southern Central Coast was inadequate. Apparently, the decline in Area 10 chum has also taken place in Areas 11 and 12. There appears to be little information for locations where it is critical. There is also a need to include other sockeye lakes such as Nimpkish. A move away from the statistical area approach should be considered. Trends in aggregates of populations could be evaluated using the approach Dr. R. Peterman's research team at SFU has developed to identify spatial covariation between stocks and environmental variables. These relationships could be incorporated into Ricker stock-recruit relationships to potentially improve forecast reliability.

Recommendations

The Subcommittee recommends extreme caution to limit exploitation on sockeye from Areas 9 and 10. Central Coast and CORE stock assessment personnel should

develop a stock assessment framework for the Central Coast. Data for pink and chum in the southern Central Coast should be collected. Concern was expressed for Kimsquit and other sockeye lakes; there should be increased assessment effort to include other sockeye lakes, most notably for those in the relatively large lakes of the Nimpkish River system, but also for those in many smaller lakes like Heydon and Phillips. In light of the order of magnitude decline in Area 10 chum since the mid 1990's, and similar declines in Areas 11 and 12, the Subcommittee recommended that Area 10 chum be enumerated and chum in the southern Central Coast be assessed.

S2002-05: Review of 2001 chinook returns to the west coast Vancouver Island, forecast of the 2002 return to the Stamp River/Robertson Creek hatchery indicator stock and outlook for other WCVI chinook stocks

B.E. Riddell, W. Luedke, J. Till, S. Taylor and A. Tompkins **Accepted with revisions**

Rapporteur: Steve Baillie

Data, forecasting methods and forecast performance

This paper used data sources and methods that have been reviewed and accepted by PSARC. There was one data issue. Confidence in the 2001 estimates of escapement to natural stock indicators, especially for northern WCVI, was relatively low because of weather-related problems; the estimates are considered to be minimum ones. The authors modified the forecast for age 3 fish. The time series of data for these fish has been affected by recent changes in fishing patterns. This resulted in an inaccurate forecast of the 2001 Stamp River/Robertson Creek indicator stock return because the large return of age 3 fish was not predicted. Prediction of the older age classes and of egg production continued to be forecasted accurately (average mean absolute per cent error ~15%).

2001 Stock status

The estimated terminal return of chinook to the Stamp River/Robertson Creek Hatchery (RCH) indicator stock was 40,445 (age 3 and older), plus 4,600 Age-2 male (jacks) chinook. The return represented a four-fold increase from the 2000 return level. However, the females accounted for only 11% of the run. Approximately 9.35 million eggs were deposited into the Stamp River. The total 2001 escapement to the Pacific Salmon Commission (PSC) seven indicator stocks was below the established goal and the base period average (Fig. 6). Total escapement to all natural stock indicators increased about 60% from 2000 to 2001. However, most decreases were for northern WCVI stocks whereas southern WCVI had some large increases. Three-year-old fish dominated in most systems. The Subcommittee noted that most wild populations will at least have 100 females, but several will not. So, there is a

need to be cautious because of the continued small population sizes and due to the uncertainty of the 2001 surveys.

The authors reported that the forecasts presented in the paper indicate a continued conservation concern for naturally-spawning West Coast Vancouver Island (WCVI) chinook. Although returns from recent brood years have been improving for some stocks, the Subcommittee decided that caution was in order for ocean fisheries. The Stamp River/Robertson Creek indicator showed good signs of recovery, but the rebuilding capacity of the smaller naturally-spawning stocks is less.

Recommended forecast

The forecasted return for Stamp River/Robertson Creek Hatchery chinook to the terminal area of Barkley Sound is expected to double the 2001 return. The prediction is 82,000 (115 million eggs) (50% CI 67,000 – 97,000 fish) chinook with an age structure of 25% age 3, 72% age 4 and 3% age 5 with an overall expected sex ratio of 40% female. The expected return of females continues to be limited by poor returns of age 5 fish, but the expected number of eggs to the river and hatchery is expected to exceed the interim goal, even after allowing 20% spawning mortality. The forecast assumes no fishing mortality in Canada but does account for fisheries expected in Southeast Alaska as determined under the 1999 Pacific Salmon Treaty.

Forecasts for indicator streams are cautious due to survey conditions. The projection is based on the forecasted return for Stamp River/Robertson Creek Hatchery chinook. Therefore, escapements are expected to double from 2001 to 2002 with a relatively greater increase in egg number. Most natural populations are expected to have more than 100 females, but several populations are likely to remain depressed. The authors recommend caution with respect to fishing wild stocks in 2002 because of these smaller populations and the uncertainty resulting from poor survey conditions during 2001.

Conclusions

The Subcommittee accepted the forecasts presented. The data presented show that Stamp Falls/Robertson Creek Hatchery chinook are recovering and that recent rebuilding and forecasts for 2002 indicate a surplus for the enhanced stock. Most natural populations are expected to have more than 100 females, but several populations are depressed. However, the wild populations will not recover as quickly as the enhanced indicator chinook is expected to.

Recommendations

The Subcommittee accepted the forecast for WCVI Chinook. In addition, the Subcommittee recommended that there be continued caution in the prosecution of fisheries in Canadian waters because of concerns about rebuilding wild WCVI chinook stocks.

S2002-06: Review of the year 2001 return of Barkley Sound sockeye salmon and forecasts for 2002

K. Hyatt, W. Luedke, J. Till, P. Rankin and D. Lewis **Accepted with revisions**

Rapporteur: Paul Rankin

Data, Forecasting methodology and forecasting performance

Forecasts in this working paper were made using the historic time-series and methodology for previous assessments. So, there was no review of it outside the Subcommittee meeting. The Subcommittee approved the data used and the methodology. The Subcommittee was concerned that the counters in the Somass system were not in place long enough to count the late-run fish. One of the authors reported that the counters performed well, were installed on time and were left in long enough to catch most of "late" run. In addition, data were returned in timely fashion. The following table, using information extracted from the Working Paper, describes the performance of the three methods (SSM –Salinity Survival Method; SStM–Survival Stanza Method; SEPB – Salmonid Enhancement Programme Biostandard Method):

	Percent error over forecasting interval	
Forecasting Method	1988-2001; MAPE – mean absolute	2001
SSM	70 percent error	-83
SStM	30	11
SEPB	65	-2

The authors noted an intent to present a paper at the May PSARC Subcommittee meeting. The topic of the paper will be forecasting methodology and in-season management procedures. The Subcommittee felt that the forecasting of Barkley Sound sockeye was one of the most accurate and questioned the need for further work. The authors indicated that forecasts have recently become highly divergent. There is a need to re-estimate forecasting relationships using more recent data and to consider age composition data. In addition, two recent biologically-based forecasting methods, the Coho Leading Indicator (CLI) and a forecast based on smolt abundance and euphausiid biomass during the smolt year, will be presented. Some members of the Subcommittee felt that the paper should be withdrawn because of the potential for forecasts to change. The Subcommittee concluded that the paper not be withdrawn, that the forecasts be accepted, acknowledging that evaluation of new methodology may lead to updated forecasts from the May meeting.

Stock status

Table 2 presents escapements for Barkley Sound sockeye for 1977-2001. The escapement into Great Central Lake and Sproat Lake has averaged 364,000 sockeye over 1977 to 2001, ranging from between 152,000 in 1978 to 782,000 in

2001. Total returns were about 1 million in 2001; this was 123% of most recent 20-year average (829,000). Henderson Lake has a target escapement of 50,000. The average escapement into Henderson Lake and Clemens Creek over 1977 to 2001 was 28,343, ranging from a low of 3,000 in 1995 to a high of 120,000 in 1993. The authors suggested that Henderson estimate might have been under-estimated for 2001 because of an early peak of spawning run but felt confident that escapement to Henderson is one of the lowest in recent years. The Subcommittee noted that Henderson Lake sockeye target escapements have not been attained since 1993.

Recommended forecast

All three forecasting methods predict that 2002 returns of Barkley Sound sockeye will be above the long-term average. The SStM forecast was recommended because of the method's superior overall performance. Although the SEPB model provided the better forecast for 2001, it's MAPE is twice (65%) that of the SStM model. The SStM forecast for 2002 is 970,000 (50% CI, 880,000 – 1.22 million) for all ages and 840,000 (50% CI, 750,000 –1.10 million) for adults; CLI suggests returns to be in the upper range of CI; returns have 90% probability of exceeding 200,000 escapement benchmark. The Coho Leading Indicator (CLI) provided ancillary information on forecasts. It is based on assumption that sea conditions in the smolt year affect marine survival. Coho smolts, sharing a given smolt year with sockeye smolts, will return one year earlier; smolt-to-adult survival for coho may predict marine survival for sockeye. The CLI forecasts that the return will be in the upper portion of the 50% CI form the SStM forecast. Based on harvest strategy adopted in 1996 (Anonymous 1996), harvest projections under SStM forecast range between 271,000 sockeye, given an SStM return of 673,000 (75% probability) to the Somass, and 565,000 with a return of 1.02 million (25% probability) to the Somass.

Conclusions

The Subcommittee accepted the SStM forecast for Barkley Sound sockeye. It is concerned about Henderson Lake not achieving its escapement target of 50,000 since 1994.

Recommendations

The Subcommittee recommended that a Working Paper on Henderson Lake sockeye status, including examining escapement goal, forecasting (retrospective) and harvest strategies be prepared. A member of the Stock Assessment Co-ordinating Committee indicated that such a paper was scheduled for the May PSARC Salmon Subcommittee meeting. The Subcommittee also recommended that fisheries management must consider avoiding Henderson Lake sockeye by modifying the timing and location of fisheries in Barkley Sound.

APPENDIX 1: Working Paper Summaries

S2002-01: Pre-season 2002 stock size forecasts for Skeena River and Nass River sockeye salmon

S. Cox-Rogers

Pre-season forecasts for Skeena River and Nass River sockeye were generated from simple methods assessed and recommended in previous working papers. The forecasting process is based on three guiding principles. First, the stocks being forecasted must be measurable. That is, forecasts should not be attempted where stock size cannot be measured with reasonable accuracy. Second, the forecasts should specify the probability of all possible run sizes, not just the point estimate. Third, the forecasts should be selected for their predictive power measured in retrospective analysis, not on how well the underlying models fit the historical data.

This working paper presents pre-season forecasts for Skeena River and Nass River sockeye returning in 2002. The basic forecasts developed in this working paper were all based on procedures that performed best in past assessments. Three forecasting models were used to forecast Skeena sockeye returns in 2002, and one forecasting model was used to forecast Nass sockeye returns in 2002. The recommended median (50%) sibling model forecast for the 2002 Skeena River sockeye return is 1,187,453. The recommended median (50%) 5-yr average return forecast for the 2002 Nass River sockeye return is 685,513. Other probability reference points are provided to facilitate risk adverse management decisions.

S2002-02: Forecast for southern British Columbia coho salmon in 2002

K. Simpson, D. Dobson, S. Baillie, R. Sweeting, R. Tanasichuk, B. Holtby and S. Lemke

This Working Paper documents forecasts of marine survival, abundance and distribution for the coho salmon of southern British Columbia (Fraser River system, Strait of Georgia, and west Vancouver Island) for return year 2002.

Marine survival

Recommendations for the marine survival forecast for the five hatchery indicators and two wild coho indicators are:

Indicator	Recommended Model	Predicted Survival in 2002 (50% CI)	Change (2002 forecast minus 2001 observed S)
Big Qualicum	LLY	0.021 (0.014 - 0.032)	0.000
Quinsam	3YRA	0.013 (0.010 - 0.018)	-0.004
Chilliwack	RAT3	0.035 (0.025 - 0.049)	-0.014
Inch	3YRA	0.026 (0.013 - 0.050)	-0.033
Black	3YRA	0.030 (0.021 - 0.042)	-0.041
Robertson:	Sibling	0.031 (0.019 - 0.049)	-0.061
Carnation	Euphausiid	0.040 (0.032 - 0.050)	-0.018

For the 1999 brood in the Strait of Georgia, time series forecasts are for survivals to remain about the same (Vancouver Island hatcheries) or decrease (Lower Fraser hatcheries and Black Creek, the wild indicator on Vancouver Island). Trawl surveys in 2001 suggest that the four hatchery indicators will have a mean survival similar to the 2001 return. These survivals can be characterized as poor, relative to survivals experienced 10 to 20 years ago and in terms of the low exploitations that are necessary at these survivals for wild populations to sustain themselves.

Survival forecasts have been less accurate for west Vancouver Island indicator stocks. Until recently, Robertson Hatchery was the only indicator stock, where survival and exploitation measurements were taken. This year a sibling model predicted a survival of 3.1%, much less than the 9.2% last year but a time series model predicted the same survival as last year. Both have performed about the same in the past. We chose the sibling forecast because it is more conservative and because the second indicator, the wild Carnation Creek stock, has a similar forecast of 4%. The Carnation forecast is based on the abundance of an euphausiid prey species in Barkley Sound. This forecast also represents a decrease: survival in 2001 was 5.8%.

Abundance

Forecasting abundance of coastal stocks is highly problematic, particularly in the present regime of low exploitation. The forecasts have been sufficiently poor that we have chosen to discontinue them. Another method may be developed in the future. The forecast total abundance of Thompson River watershed coho uses time series analysis of measured abundances (direct estimates of catch and escapement) and it is still feasible. The forecast for 2002 is ~25,000, which is about half the observed abundance in 2001. It does represent a forecasted increase over the 1999 brood abundance of 18,700, however. The escapement in 2001 was the largest since 1989 and escapements in 2000 and 1999 were larger than brood year escapements. Greater proportions of fish that are surviving to maturity are returning to spawn

because of the significant reductions in fishing pressure. Thus, assuming marine survivals and fishing pressures remain low, the outlook for Thompson and other interior Fraser coho is for slow but gradual improvement.

Distribution

In the hypothetical circumstance of historical patterns of fishing, the predicted proportion of catch inside the Strait of Georgia would be 0.40 (50% CI: 0.31–0.50), which can be characterized as a moderate outside distribution. A strong inside year is highly unlikely.

S2002-03: Forecast for the coho of the north coast and central coast areas of British Columbia in 2002

L.B. Holtby and B. Finnegan

This Working Paper documents forecasts of marine survival and abundance for the coho of northern and central coastal British Columbia (Statistical Areas 1 to 12), including the upper Skeena conservation area.

Marine survival

In 2002, marine survival at the three northern indicators is expected to be below the means of their respective periods of observation.

Indicator	Model	S-hat (2002)	50% CI	Observed mean and period of observation (year of sea-entry)	
Lachmach	Sibling regression	0.075	(0.06-0.09)	0.10	(1987-2000)
Toboggan Creek Hatchery	From Lachmach	0.025	(0.016-0.04)	0.039	(1987-2000)
Fort Babine hatchery	From Lachmach	0.011	(0.007-0.02)	0.025	(1993-2000)

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

Abundance forecast

Estimated smolt production from Lachmach in 2001 was $3.6 \cdot 10^4$, which is slightly above the observed mean of $3.1 \cdot 10^4$ (1987 – 2000). That combined with below-mean marine survival produce a forecast return of $2.7 \cdot 10^3$ (50%CI: $2.2 \cdot 10^3$ – $3.3 \cdot 10^3$) which is the mean return observed over the period 1988 to 2001 (return years). The forecast of abundance for wild Toboggan coho is $1.4 \cdot 10^3$, which is considerably less than the mean total return of $4.7 \cdot 10^3$ (return years 1988 – 2001). Assuming an exploitation rate of 36% (i.e., same as 2001), the wild escapement to Toboggan would be $8.7 \cdot 10^2$, including terminal sport fisheries. That escapement is considerably below the mean of the available observations ($2.1 \cdot 10^3$; 1988 –2001). Abundance of

Babine Lake coho is forecast to be $2.2 \cdot 10^4$ (50%CI: $1.7 \cdot 10^4$ – $3.0 \cdot 10^4$) using the preferred S-R model. This return is above the mean of the time series ($1.2 \cdot 10^4$; 1946 to 2001). Assuming an exploitation rate of 0.55, escapement would be $9.4 \cdot 10^3$, which is approximately 78% of the provisional escapement target for the aggregate ($1.2 \cdot 10^4$; Holtby et al. 1999b).

The stock-recruit and time series forecasts of abundance for Babine coho and the average-stream indices of the 11 north and central coastal aggregates show some indication of geographic patterning but do not indicate any conservation concerns in the area, with the possible exceptions of Area 4C/5. Unfortunately, escapement data are very poor in this area so it is difficult to determine the extent to which the poor escapements are due simply to limited data. The total abundance and the escapement of coho in the northern part of the forecast region (Areas 1, 3, 4L and 4U) will average to above-average in 2002. In the areas around Hecate Strait (Areas 2E, 4C/5, 6 to 12), total abundance will be well below average to average but provided fisheries do not expand much over levels in 2001, escapements will be average in most of those areas.

S2002-04: Forecast for central coast sockeye, pink and chum salmon in 2002.

L.B. Holtby and J. Sturhahn

Considerable concern for the future of the Owikeno and Long Lake sockeye must be advised. There is only scant evidence that marine survival has improved for sockeye in this part of the coast. As the full impact of the recent reductions in escapement are felt over the next few years the total sizes of these two populations may reach very low levels. Thus extreme caution is urged in avoiding all harvest whether directed or incidental. Caution must also be urged for Kimsquit sockeye and probably for other small sockeye populations in this general area of the coast. If the poor survival has resulted even in part from the effects of the last El Niño then the recent reports that another episode is developing do not bode well for the future of Central Coast sockeye.

Chum in the northern part of the forecast area appear to be stable and there may be a harvestable surplus in Area 8. The chum of Area 9 are depressed and the stock of Area 10 may be severely depressed. Enumeration effort is required in this area and the abundance of stocks to the south in Areas 11 to 13 should be scrutinized.

Even-year pink show the opposite geographical trend in abundance than do chum. Abundance is forecast to be at or near escapement targets except in Area 7 where it is forecast to remain well below the escapement target.

A summary of the forecasts and their characterization relative to established escapement targets is presented in the following Table:

Species	Area	Stock	Escapement target	2002 forecast	50% CI	Characterization of forecast
Sockeye	Area 8	Atnarko	$7.5x10^4$	$2.7x10^4$	$1.7x10^4$-$4.1x10^4$	Depressed
	Area 9	Owikeno Lake	$2.0x10^5$	$3.0x10^4$	$1.7x10^4$-$5.4x10^4$	Critically depressed
	Area 10	Long Lake	$2.0x10^5$	$1.1x10^4$	$5.8x10^3$-$2.2x10^4$	Critically depressed
Chum	Area 7	All	$5.2x10^5$	$3.0x10^5$	$2.1x10^5$-$4.4x10^5$	Below-target
	Area 8	All	$2.7x10^5$	$4.4x10^5$	$2.9x10^5$-$6.4x10^5$	Abundant
	Area 9	All	$1.5x10^5$	$4.2x10^4$	$2.4x10^4$-$7.3x10^4$	Depressed
Pink	Area 7	All	$1.5x10^6$	$4.9x10^5$	$2.9x10^5$-$8.4x10^5$	Depressed
	Area 8	All	$1.5x10^6$	$3.9x10^6$	$2.0x10^6$-$7.4x10^6$	Abundant
	Area 9	All	$3.4x10^5$	$3.4x10^5$	$1.6x10^5$-$7.3x10^5$	Near-target
	Area 10	All	$6.6x10^4$	$4.3x10^4$	$1.6x10^4$-$1.2x10^5$	Near-target

S2002-05: Review of 2001 chinook returns to the west coast Vancouver Island, forecast of the 2002 return to the Stamp River/Robertson Creek hatchery indicator stock and outlook for other WCVI chinook stocks

B.E. Riddell, W. Luedke, J. Till, S. Taylor and A. Tompkins

The intensive assessments and resulting 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 paper indicate a continued conservation concern for naturally spawning WCVI chinook in 2002 but improving returns from recent brood years to some stocks particularly for the hatchery stocks.

Return of the WCVI chinook in 2001

The 2001, the terminal return of chinook to the Stamp River/RCH indicator stock was estimated to be 40,445 (age 3 and older) chinook, plus 4,600 Age-2 male (Jacks) chinook (Table 1). The 2001 return represented a four-fold increase from the 2000 return level and was approximately three times the forecast due to a much larger return of Age-3 chinook than forecasted.

Table 1. 2001 Terminal run of Stamp River chinook

Fishery	# Age 2	# Age 3	# Age 4	# Age 5	# Age 6	Total Adult	Total
Alberni Inlet Sport[a]	0	64	19	10	0	93	93
Somass Native	0	0	0	0	0	0	0
Barkley Sound Sport1	0	25	7	4	0	36	36
Hatchery Returns[b]	3463	30148	1720	351	5	32224	35687
River Escapement[c]	1149	5638	1642	903	39	8221	9370
Total Terminal Run	4612	35786	3362	1254	44	40574	45186

[a] Calculated at 15% of incidental catch.
[b] Includes captures from Great Central Lake Dam and Sport caught brood stock but excludes hatchery releases.
[c] Stamp River only, includes pre-spawn mortalities and hatchery releases.

Returns to another 18 WCVI streams were monitored for naturally spawning chinook. Confidence in the 2001 surveys and estimates of escapement to natural stock indicators is poorer than in recent years due to weather related problems. Estimates based on the available data indicated that the total 2001 escapement to the PSC seven indicator stocks was below the established goal and the base period average. Total escapement over all natural stock indicators increased about 60% from 2000 to 2001, but the return and information quality is variable between these populations (Table 2).

Table 2. Recent spawning escapement estimates and the 2002 outlook for total escapement and female spawners in selected WCVI indicator streams assuming a response based on the RCH/Stamp River indicator stock forecast (2x increase and expected 40% female component).

AREA	RIVER	2000 Adults	2001 Adults	2002 Adults	2002 Females	2001 Reliability of Escapement Estimate
20	San Juan River	370	814	1,628	651	Medium / High
21	Gordon River	19	20	40	16	Low / Medium
23	Sarita River	301	1,536	3,072	1229	Medium
23	Nahmint River	68	225	450	180	Medium
23	Toquart River	100	168	336	134	Medium
24	Bedwell River	143	263	526	210	Medium / High
24	Megin River	160	2	4	2	Low, poor surveys
24	Moyeha River	94	115	230	92	Medium
25	Burman River	212	96	192	77	Medium
25	Gold River	500	250	500	200	Low
25	Leiner River	182	394	788	315	Medium
25	Tahsis River	1,320	389	778	311	Medium
25	Zeballos River	200	100	200	80	Low / Medium
26	Kaouk River	105	415	830	332	Low / Medium
26	Artlish River	75	139	278	111	Low / Medium
26	Tashish River	391	165	330	132	Low / Medium
27	Marble River	2,575	1,450	2,900	1160	Low
27	Colonial / Cayeghle	600	571	1,142	457	Low
	Major Hatcheries:					
22	Nitinat River	8,685	15,295	30,590	12,236	Medium / High
23	Stamp River/ RCH	6,413	40,445	82,160	32,864	High
25	Conuma River	9,970	16,468	32,936	13,174	High

Forecast for the 2002 terminal return of the Stamp River/RCH chinook

The forecasting methods applied have been reviewed and accepted previously by PSARC. For 2002, the forecasted total return of Stamp River/RCH chinook to the terminal area of Barkley Sound and Alberni Inlet is estimated to be 82,000 chinook, with an age structure of 25% Age-3, 72% Age-4, and 3% Age 5; with an expected sex ratio of 40% females (Table 3). At this time, the forecast only assumes fishing mortality in Southeast Alaska based on the Pacific Salmon Treaty agreements (harvest rate scalar of 0.55 in SEAK troll fishery). The remaining cohort is identified as the expected mature run assuming no fishing mortality on this stock in Canada.

Overall, 2002 returns are expected to double those in 2001, due to the increasing returns of Age 3 and Age 4 chinook.

Table 3. Summary of predicted mature terminal run of Stamp River chinook salmon, accounting for Alaskan fisheries but no Canadian fisheries (yet to be determined)

Brood year	2002 Age classes	Prod 2 Estimate	Prod 3 Estimate	**Recommended Forecast**	Comment
1999	Age 3	20,364	7,954	20,364	Prod2 model only, ocean fishery data for Age-2s in the Prod3 not available recently due severely reduced fisheries.
1998	Age 4	82,168	36,459	59,313	Average of models
1997	Age 5	1,020	3,994	2,482	Average of models
Total				**82,159**	Sum of recommended values; 40% female composition.

At this terminal run size, the interim escapement goal for Stamp River/RCH chinook would just be met, but this forecasts does not yet account for fisheries in Canada. The interim target goal (based on egg requirements) would require 75,000 chinook with the age structure expected in the 2002 return. However, the recommended forecast is only a 'point' estimate and error in these models has recently averaged 21%. Using past deviations from forecasts, the probability distribution about this forecast indicates that 25%, 50% and 75% of the distribution would be less than 66,700, 83,300, and 97,000 chinook respectively (Figure 1).

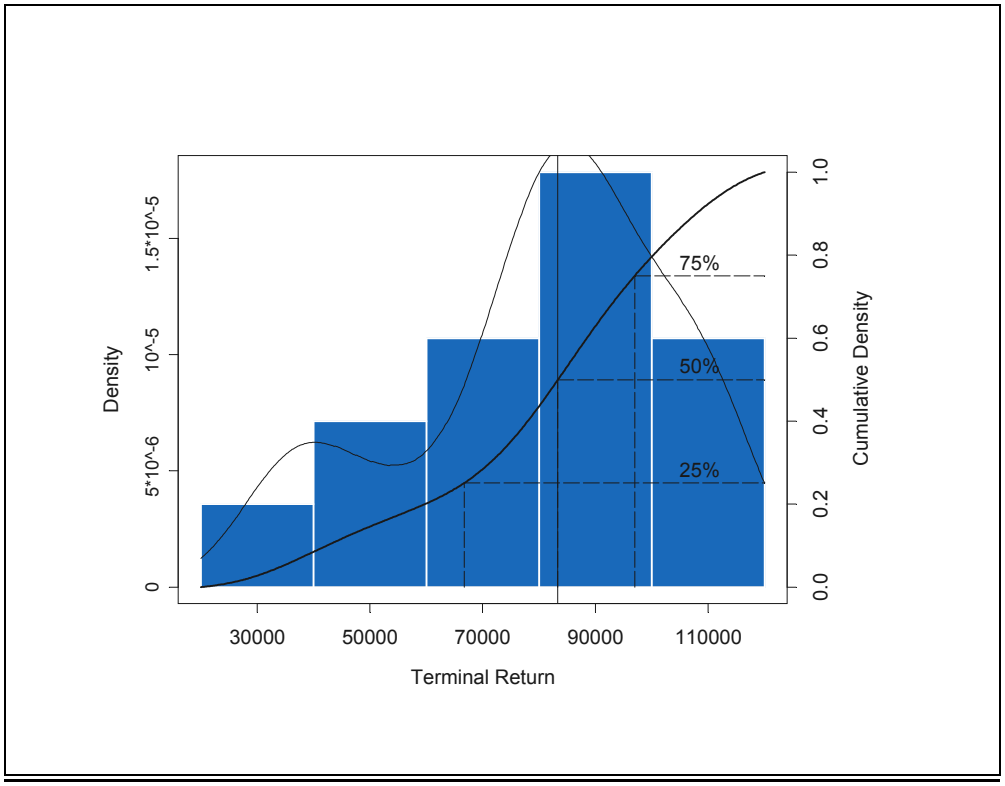

Figure 1. Cumulative probability distribution of the recommended forecast for the year 2002 terminal run to the Stamp River/RCH indicator chinook stock (WCVI). Horizontal dashed lines represent the 25%, 50%, and 75% cumulative probabilities. The vertical solid line is the recommended forecast = 82,159 chinook.

Outlook for the 2002 returns to other WCVI chinook populations

The 2002 outlook in the WCVI indicator streams is based on the forecasted changes in the RCH indicator stock (double returns from 2001 to 2002 and a 40% female). Table 2 indicates that most chinook populations along the WCVI are expected to have more than 100 females, but that a number of them remain depressed in abundance. Further, given the uncertainty in the 2001 escapement surveys, it would be appropriate to maintain caution in managing these WCVI natural populations during 2002.

Concluding comment

The RCH indicator stock for WCVI chinook production indicates that terminal return in 2002 should double compared to 2001 due to stronger returns of Age-3 and Age-4 chinook (40% female composition). The forecasted RCH terminal run will exceed the minimum escapement goal and should be slightly greater than the target goal. Changes in the WCVI natural populations assume the same production change as in the RCH indicator stock. However, the smaller size of these populations and the poorer survey conditions in many of these populations during 2001 suggests that caution is required in managing these populations during 2002. The authors recommend that ocean fisheries impacting WCVI chinook is limited by managing to the target escapement goal for the RCH indicator stock. Where appropriate, additional terminal area management could be used to conserve the natural populations or exploit the larger hatchery returns when possible.

S2002-06: Review of the year 2001 return of Barkley Sound sockeye salmon and forecasts for 2002

K. Hyatt, W. Luedke, J. Till, P. Rankin and D. Lewis

Returns of Barkley Sound sockeye remained well below the long term average return of 820,000 adults for the seven-year interval between 1994 and the year 2000 (Figure 2). This prolonged period of sub-average returns was correctly anticipated to end in 2001 as ocean climate signals suggested increased marine survival rates for Barkley Sound sockeye smolts migrating seaward during the years 1998-2000 (Hyatt et al 2001).

Over the past 14 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 the year 2001 are as follows:

(1) The SStM forecast exhibits the best overall performance by far with a mean absolute percent error (MAPE) value of 30% over the most recent 14 years of forecasting. SStM forecasts exhibit a statistically significant association with returns among all years (returns = 1.16 SStM forecasts + 47.18, r^2 = 0.46, P<0.01). They also account for the majority of variations in returns if the extreme observation associated with the 1991 return year (*when all forecasts techniques underestimated returns*) is omitted from the analysis (returns = 1.05 SStM forecasts + 31.87, r^2 = 0.76, P<0.001).

(2) The SEPB forecast performed well in predicting sockeye returns in 2001 (MAPE = 1.87%). However, to achieve a statistically significant association with returns among years, the extreme observation associated with the 1991 return year must be omitted from the analysis (returns = 1.31 SEPB forecasts – 447.57, r^2 = 0.57, P< 0.01). Further, during the 1988-2001 testing interval, SEPB forecasts exhibited a much higher MAPE value (65%) than that displayed by SStM forecasts (30%). Because large magnitude deviations between SEPB forecasts and actual returns tend to occur in consecutive years, it is viewed as having limited utility by both harvest managers and fishermen.

(3) The SSM forecast rivaled the SStM forecast in performance between the 1988-1999 testing interval (Hyatt et al. 2000). However, SSM forecasts have overestimated total returns of Barkley Sound sockeye by 490% and 83% respectively during the years 2000 and 2001 respectively. Thus, SSM forecasts now exhibit a MAPE that averages 70% and no statistically significant association with observed returns during the test interval.

Forecasts of Barkley Sound sockeye returns provided by different models vary greatly for 2002. Midpoint forecast estimates range from a low of 872,000 (SEPB model) to a high of 1,681,000 (SSM model) Barkley Sound sockeye of all ages. Comparative performance of the various forecast options, along with DFO's recent pursuit of a more risk adverse approach to management recommends initial adoption of the SStM forecast range. Thus, 754,000 (75% probability) to 1,101,000 (25% probability) “adult” sockeye (i.e. excludes “jacks”) constitute the preferred, pre-season forecast range for the year 2002. Supplementary information from coho leading indicator observations suggests that returns are likely to be closer to the upper than the lower end of this range.

APPENDIX 2: PSARC Salmon Subcommittee Meeting Agenda
MARCH 5-7, 2002

Revised Agenda
PSARC Salmon Subcommittee Meeting
Re: Return Forecasts/Assessments
March 5-7, 2002
Seminar Room, PBS, Nanaimo

Tuesday March 5 - 9:00am

9:00	–	9:30	Introduction and procedures
9:30	–	10:00	Skeena/Nass Sockeye (Cox-Rogers)
10:00	–	10:30	Break
10:30	–	11:30	Skeena/Nass Sockeye (Cox-Rogers) cont.
11:30	–	12:00	Review rapporteur report
12:00	–	13:00	Lunch
13:00	–	14:30	Southern B.C. coho (Simpson et al.)
14:30	–	15:00	Break
15:00	–	16:00	Southern B.C. coho cont.
16:00	–	16:30	Review rapporteur report

Wednesday March 6 - 8:30am

8:30	–	10:00	North/Central Coast coho (Holtby et. al)
10:00	–	10:30	Break
10:30	–	11:00	Review rapporteur report
11:00	–	12:00	WCVI chinook (Luedke et al.)
12:00	–	13:00	Lunch
13:00	–	13:30	WCVI chinook cont.
13:30	–	14:00	Review rapporteur report
14:00	–	14:30	Central Coast sockeye, pink and chum (Holtby et al.)
14:30	–	15:00	Break
15:00	–	16:00	Central Coast sockeye, pink and chum (cont.)
16:00	–	16:30	Review rapporteur report

Thursday March 7 - 9:00am

9:00	–	10:00	Somass River Sockeye (Luedke et al.)
10:00	–	10:30	Break
10:30	–	11:30	Somass River Sockeye (Luedke et al.) cont.
11:30	–	12:00	Review rapporteur report
12:00			Adjournment

APPENDIX 3: List of Attendees

Subcommittee Chair: Ron Tanasichuk
PSARC Chair: Max Stocker

DFO Participants	**Tues**	**Wed**	**Thurs**
* Subcommittee Members			
Bailey, D.*	x	x	x
Bailey, R. *	x	x	x
Beaith, B.	x		
Cox-Rogers, S. *	x	x	
Finnegan, B.		x	
Fu, C.	x		x
Gordon, J.		x	
Grout, J.			x
Hargreaves, B.*	x	x	x
Holtby, B.*	x	x	x
Hyatt, K.*		x	
Ionson, B. *	x	x	
Irvine, J.*	x	x	x
Lemke, S.	x	x	
Luedke, W.*		x	
Meerburg, D. *	x	x	x
McNicol, R.	x	x	
Parken, C. *	x	x	x
Riddell, B. *	x	x	
Schweigert, J.	x		
Sweeting, R.	x		
Tomkins, A.		x	
Wood, C. *	x	x	x
Yockey, C.	x	x	x
External Participants:			
Atkinson, M.	x	x	
Chow, S.	x		
Webb, L.	x	x	x
Observers:			
Blackbourn, D.	x	x	x
Caron, W.	x	x	x
Galesloot, M.	x	x	
Haeseker, S.	x	x	
Hall, Don		x	x
Peterman, R.	x		
Zhenming, S.	x	x	

Reviewers for the PSARC papers presented at this meeting are listed below, in alphabetical order. Their assistance is invaluable in making the PSARC process work.

Lehmann, S.	Fisheries and Oceans Canada
Routledge, R.	Simon Fraser University
Schweigert, J.	Fisheries and Oceans Canada

Tables and Figures

Table 1. Comparisons of the pre-season forecast of total stock size for 2001 and preliminary observed stock sizes.

Species	Area	Stock	method	total stock size		forecast error	percent error	approx. *P*
				forecast	observed			
sockeye	8	Atnarko	5YRA	3.0×10^4	3.1×10^4	1.7×10^3	6%	0.43
	9	Owikeno	5YRA	3.9×10^4	2.6×10^4	-1.3×10^4	–49%	0.3
			optimistic	2.4×10^5	"	-2.1×10^5	–820%	
			like 1996 sea-entry	**5.6×10^3**	"	3.0×10^4	115%	
	10	Long	5YRA	1.7×10^4	8.5×10^3	-8.1×10^3	–94%	0.46
			optimistic	2.7×10^4	"	-1.8×10^4	–216%	
			like 1996 sea-entry	**1.8×10^3**	"	6.7×10^3	79%	
chum	7	all	average	3.7×10^5	3.9×10^5	1.6×10^4	4%	0.46
	8	all	average	4.3×10^5	4.9×10^5	5.4×10^4	11%	
	9	all	average	4.3×10^4	1.7×10^4	-2.6×10^4	-159%	
pink	7	all	Ricker	3.7×10^5	8.1×10^5	4.4×10^5	54%	<0.25
	8	all	Ricker	1.4×10^6	3.0×10^6	1.7×10^6	54%	<0.25
	9	all	Ricker	1.8×10^5	1.2×10^6	1.0×10^6	85%	<0.25
	10	all	Ricker	$<1\times10^3$	unknown			

Table 2: Barkley Sound sockeye escapement summary

Year	Total	Hen.	GCL	Sproat	GCL + Sproat
1977	297,800	4,800	212,200	80,800	293,000
1978	158,900	7,000	114,400	37,500	151,900
1979	360,441	20,000	263,995	76,446	340,441
1980	318,736	20,760	159,597	138,379	297,976
1981	430,191	40,354	262,287	127,550	389,837
1982	470,261	56,065	172,269	241,927	414,196
1983	644,987	44,987	350,000	250,000	600,000
1984	267,524	45,122	133,306	89,096	222,402
1985	299,719	25,000	127,758	146,961	274,719
1986	316,361	5,000	118,420	192,941	311,361
1987	435,969	29,000	255,153	151,816	406,969
1988	460,265	30,000	194,848	235,417	430,265
1989	425,401	38,000	219,414	167,987	387,401
1990	323,910	35,000	176,850	112,060	288,910
1991	698,470	50,000	437,172	211,298	648,470
1992	429,416	27,000	191,154	211,262	402,416
1993	540,809	120,000	238,094	182,715	420,809
1994	265,346	15,138	106,706	143,502	250,208
1995	169,293	3,000	63,893	102,400	166,293
1996	325,123	21,000	120,173	183,950	304,123
1997	321,036	21,000	174,063	125,973	300,036
1998	452,921	30,000	236,043	186,878	422,921
1999	392,353	4,412	215,089	172,852	387,941
2000	216,118	12,306	75,534	124,584	200,118
2001	785,740	3,633	410,589	371,518	782,107

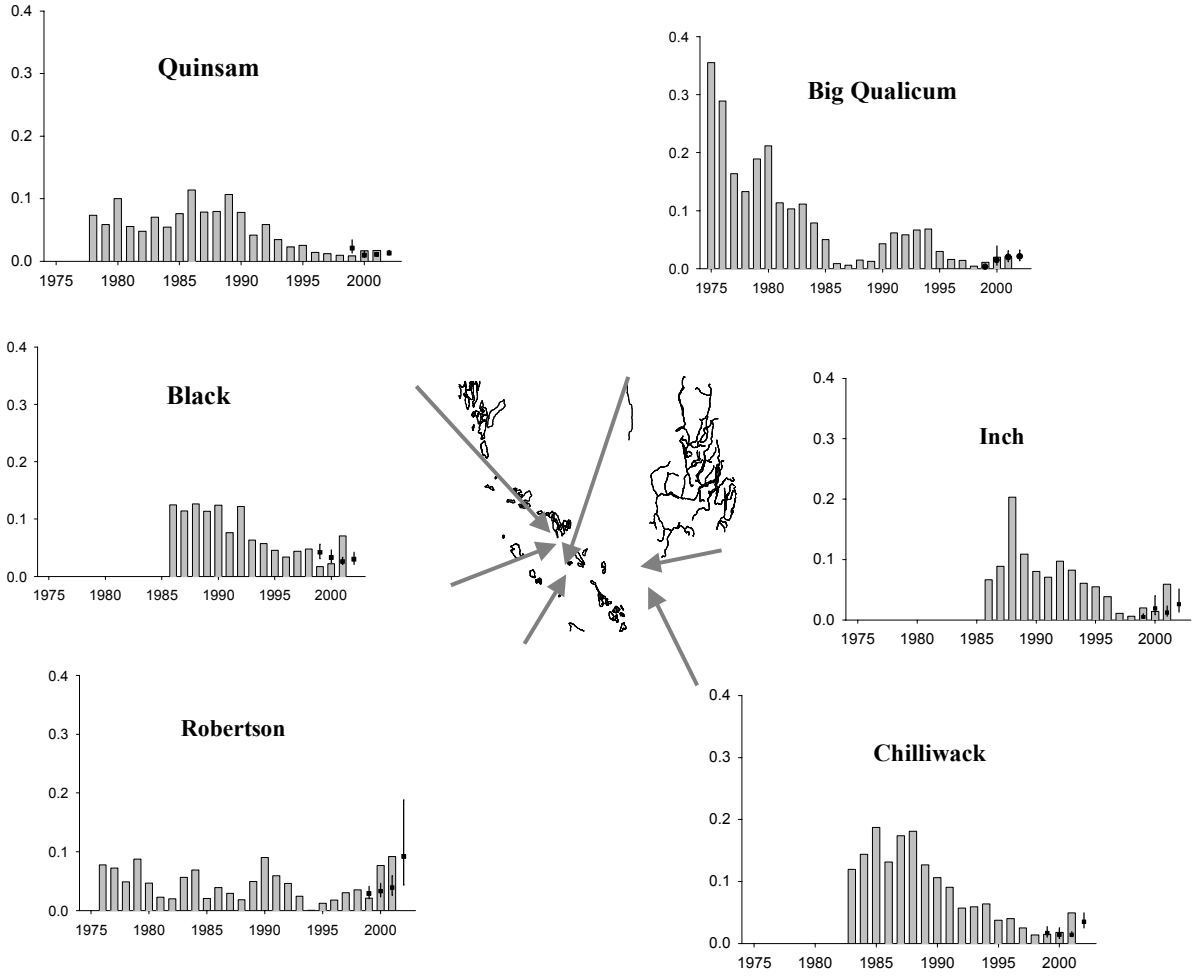

Figure 1. Marine survivals of southern BC coho. Forecasts since 1999 are shown as square symbols and bars indicate the 50% CL's. Survivals of Carnation Creek coho are shown in the next figure.

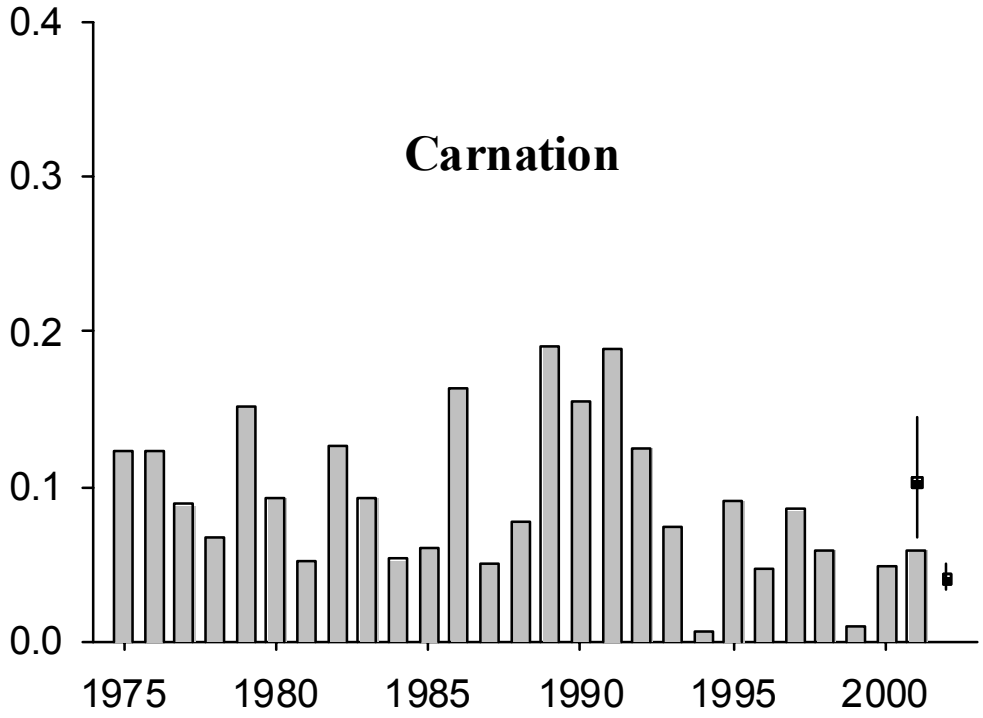

Figure 2. Marine survivals of Carnation Creek wild coho. Forecasts are shown for 2001 and 2002 (bars indicate the 50% CL's); 2000 forecast from earlier version of euphausiid-based prediction method.

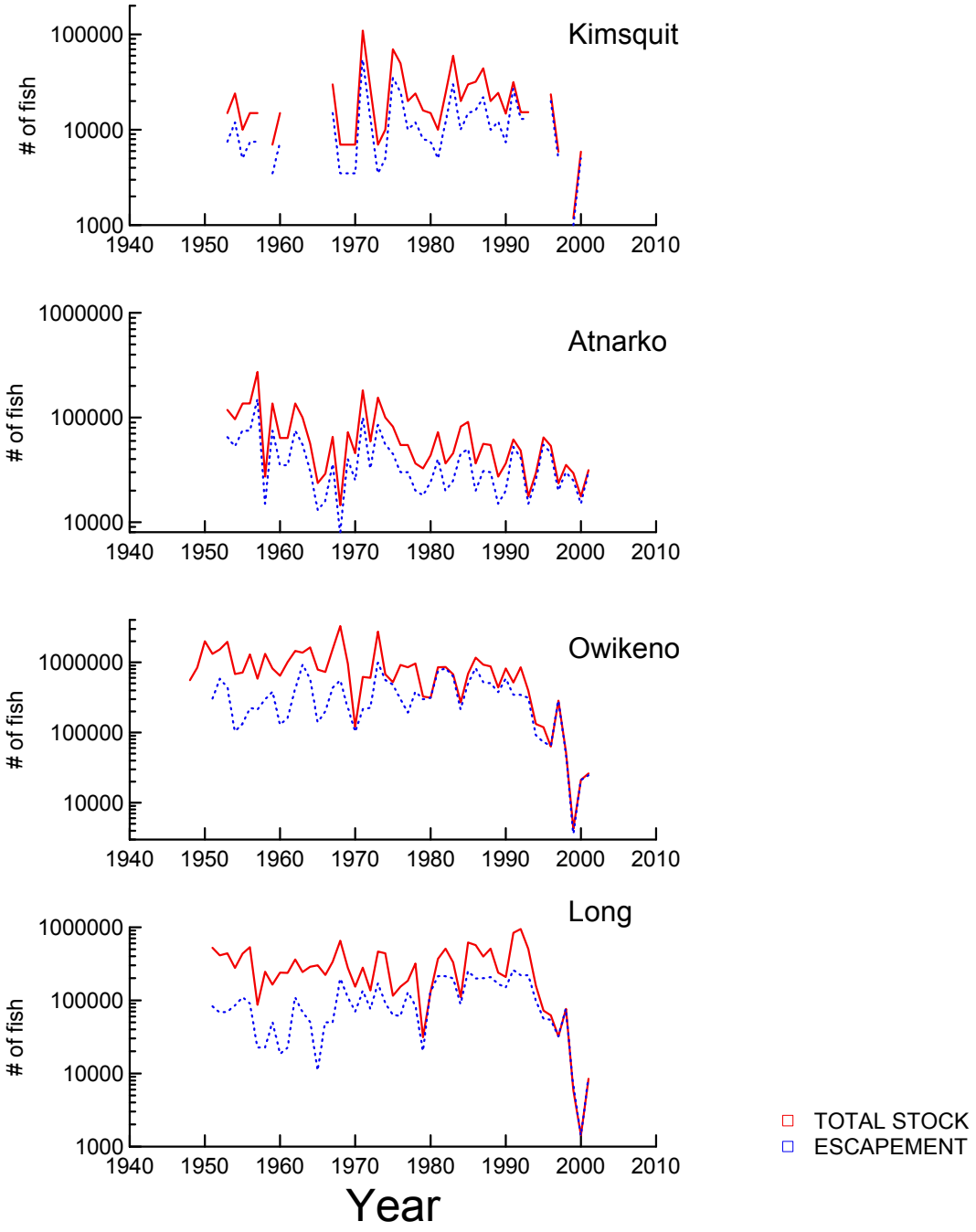

Figure 3. Time series of total stock size and escapement for the four sockeye stocks of the Central Coast considered in this paper. There is no information for 2001 returns for Kimsquit at the time of writing. Please note that abundance has been plotted on a log10 scale.

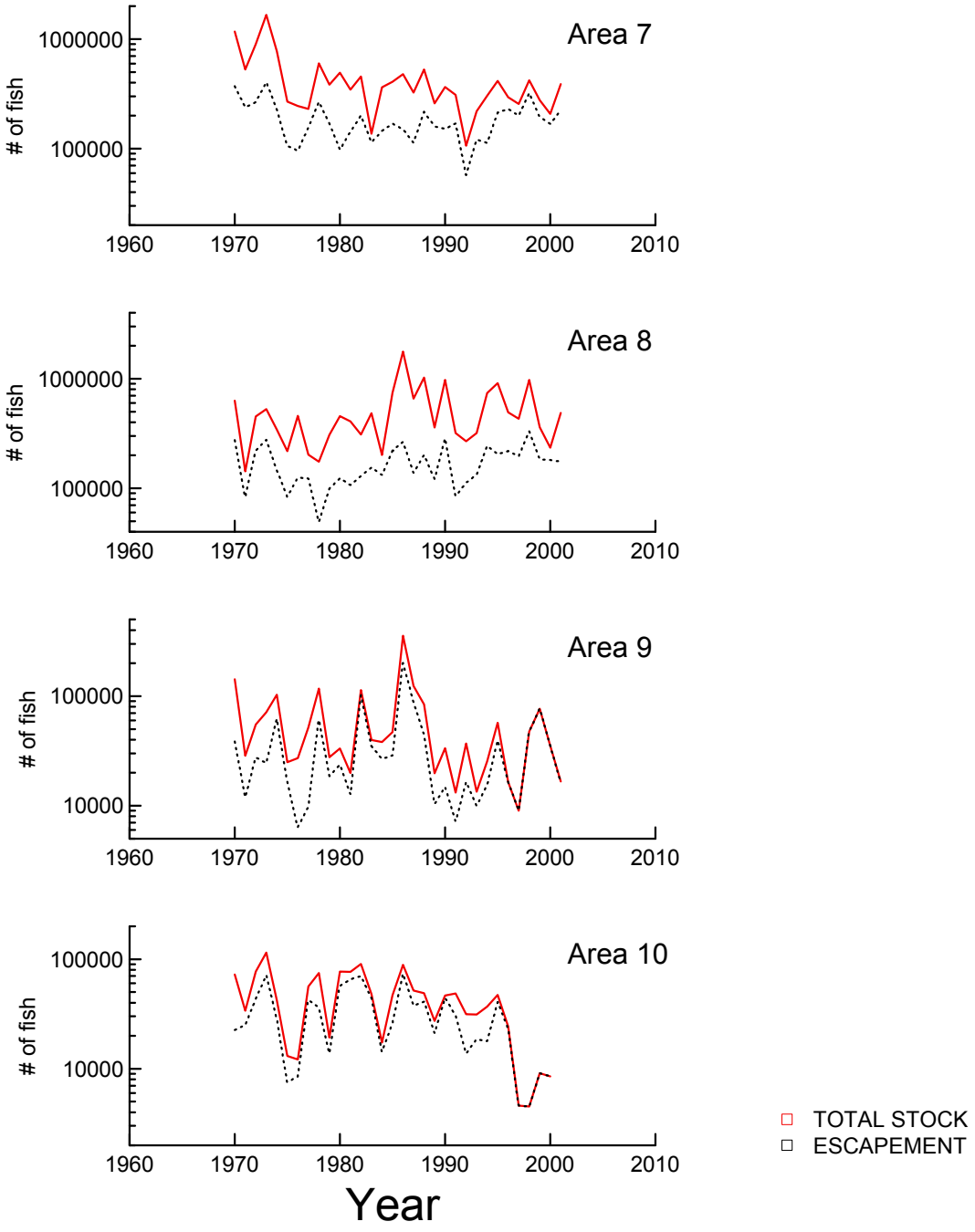

Figure 4. Time series of total stock size and escapement for the four chum stocks of the Central Coast considered in this paper. There is no information for 2001 returns Area 10 at the time of writing. Please note that abundance has been plotted on a log10 scale.

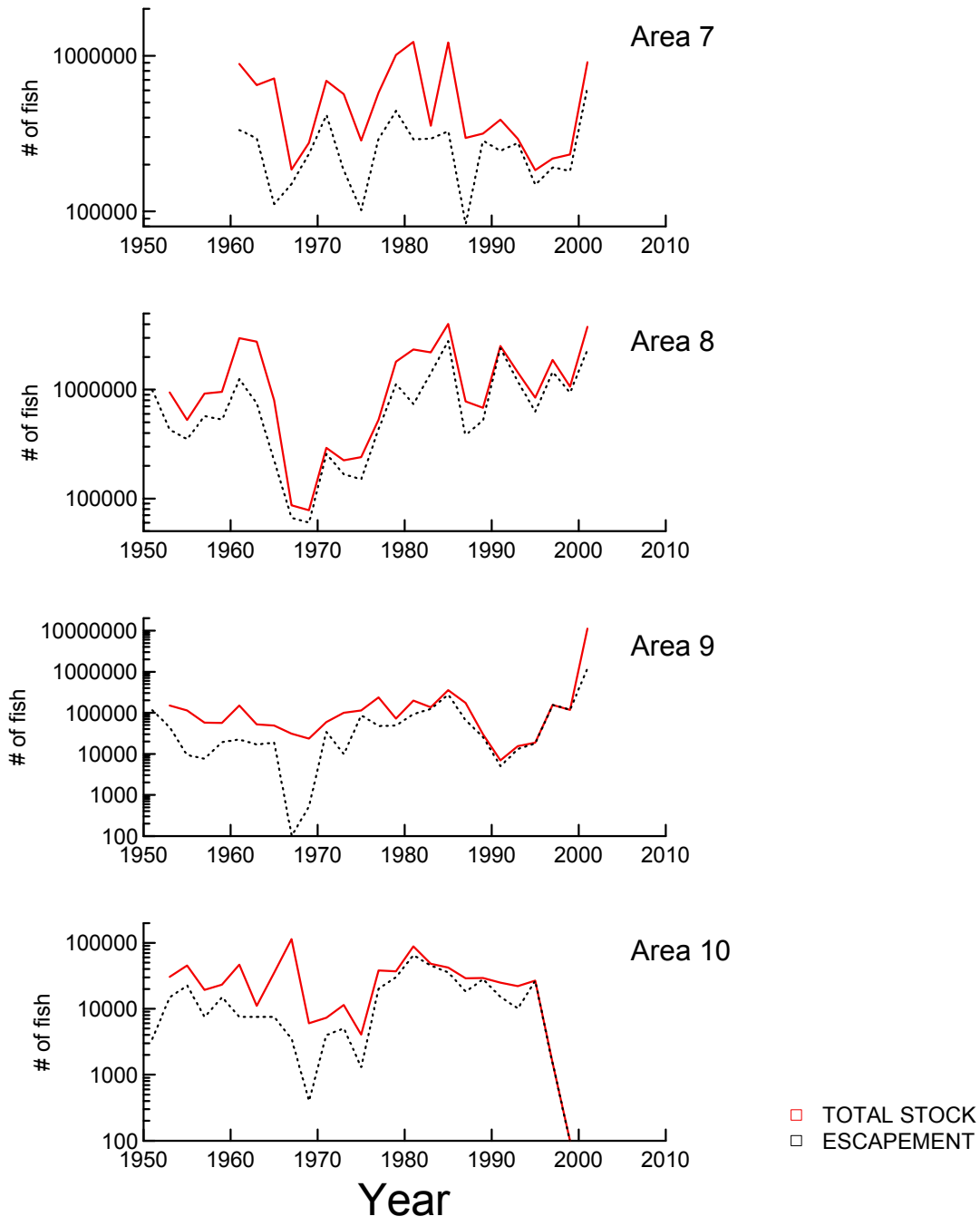

Figure 5. Time series of total stock size and escapement for the four odd-year pink stocks of the Central Coast considered in this paper. There is no information for 2001 returns Area 10 at the time of writing. Please note that abundance has been plotted on a log10 scale.

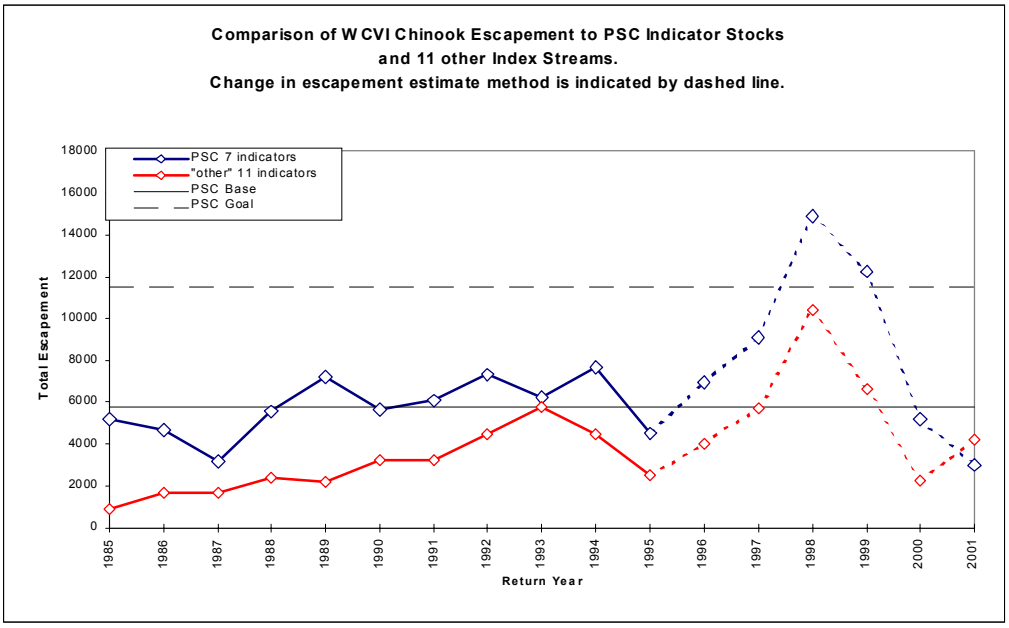

Figure 6. Trend in adult chinook escapement of PSC escapement indicator stocks, 1975 to 2001. The solid line indicates the base period (1979-1982) average escapement. The broken line indicates the PSC rebuilding goal (double the base period average).