Fisheries and Oceans Science | Pêches et Océans Sciences

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Canadian Stock Assessment Secretariat | **Secrétariat canadien pour l'évaluation des stocks**

Proceedings Series 2000/07 | **Série des compte rendus 2000/07**

Report of the PSARC Salmon Subcommittee Meeting, May 1-5, 2000

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May 2000

Canada

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PACIFIC SCIENTIFIC ADVICE REVIEW COMMITTEE

PSARC ADVISORY DOCUMENT 2000-02
May 2000

SALMON

SUMMARY

The PSARC Salmon Subcommittee met May 1-5, 2000 at the Pacific Biological Station in Nanaimo. External participants from the Pacific Fisheries Resource Conservation Council, the Fraser River Watershed Committee, Simon Fraser University, the Sport Fishing Institute, Fraser River Aboriginal Fisheries Resource Conservation Council and Sport Fish Advisory Board attended the meeting.

Working Paper S00-02: 2000 Forecast for Johnstone Strait, Georgia Strait and Fraser River chum salmon

The Subcommittee recommended a return forecast of 1.75 million for wild Study Area chum (25% probability of exceeding 2.5 million and 75% probability of exceeding 1.3 million) and a forecast of 342,000 for enhanced Study Area chum. The recommended total forecast is 2.1 million.

Working Paper S00-08: Biological reference points for the conservation and management of steelhead, *Onchorhynchus mykiss*

Although, at this time the Subcommittee does not necessarily endorse this method for Pacific salmon, the Subcommittee encouraged the continued development of this method, noting that it is one of a number of approaches to the formulation of biological reference points.

Working Paper S00-09: Assessment of Campbell/Quinsam chinook salmon (*Onchorhynchus tshawytscha*)

To provide advice on a biologically-based escapement goal, the Subcommittee recommended a review and analysis of the impact of historic habitat change, enhancement and exploitation effects on Campbell/Quinsam River chinook.

Working Paper S00-10: An assessment of Rivers Inlet chinook stocks

In light of the apparent low 1999 Wannock chinook escapement and the uncertainties in the data, the Subcommittee recommended caution in the harvest of Wannock chinook in 2000.

The Subcommittee recommended initiation of a multi-year investigation to determine the status of River's Inlet chinook stocks.

Working Paper S00-11: In-season indicators of run-strength and survival for northern British Columbia coho

The Subcommittee recommended the use of the models presented in the working paper for run-strength predictors and as early-warning indicators of run-strength for northern B.C. coho.

Working Paper S00-12: Overview of salmon stock assessment frameworks in the Pacific Region

The Subcommittee recommended the paper as a basis for further discussions on the development of species-specific assessment frameworks in the Pacific Region.

Working Paper S00-13: Status in 1999 of coho stocks adjacent to the Strait of Georgia

The Subcommittee endorsed the recommendation for two additional coho indicator facilities, one on the Sunshine Coast and the other in the lower Fraser River.

Working Paper S00-14: Evaluation of utility of aerial over-flight based estimates versus mark-recapture estimates of chinook salmon escapement to the Nicola River, B.C.

The Subcommittee recommended additional studies to further characterize aerial escapement assessment methods to broaden tests of their applicability to other salmon stocks and river systems.

Working Paper S00-15: A preliminary review of a new model based on test fishing data analysis to measure abundance of returning chum stocks to the Fraser River

The Subcommittee accepted the paper as a preliminary review of a new model based on test fishing data analysis to measure abundance of returning chum stocks to the Fraser River.

Working Paper S00-16: Stock status and genetics of Interior Fraser coho salmon

The Subcommittee recommended development of limit and target reference points for Interior and Fraser coho to provide management advice.

The Subcommittee recommended more extensive baseline coverage of interior Fraser coho for genetic sampling (e.g. Nahatlatch) as this will aid in the delineation of populations, and provide more precise estimates of the distribution and numbers of interior Fraser coho in catches.

Working Paper S00-17: A biologically-based escapement goal for Cowichan River Fall chinook salmon (*Oncorhynchus tshawytscha*)

The Subcommittee recommended the biologically-based escapement goal of 7400 (95% CI = 4200, 19000) based on stock-recruitment analysis.

The Subcommittee recommended development of an escapement policy that allows escapements in excess of the goal to further evaluate production potential of this stock.

The Subcommittee recommended continuance of the present programs of coded-wire tagging, intensive escapement monitoring and juvenile assessments. The Subcommittee also recommended to continue to examine the production dynamics in this stock and to monitor the effect of recent low marine survival.

The Subcommittee recommended investigation of the effect of enhancement on wild stock productivity and the estimated "biologically-based" goal.

The Subcommittee recommended exploitation rates on this stock should not be increased until productivity rates are known to be increasing.

Working Paper S00-18: Stock description and biologically-based escapement goals for the Harrison River Fall chinook

The Subcommittee recommended acceptance of the biologically based escapement goal of 75,000 (90% C.I. =42,000 – 149,000) based on a stock-recruitment analysis.

The Subcommittee recommended development of an escapement policy that allows escapements in excess of the goal to further evaluate production potential of this stock.

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 12 Working Papers. Working Paper titles and authors are listed in Appendix 2. A list of meeting participants, observers and reviewers is included as Appendix 3.

WORKING PAPER SUMMARIES, REVIEWS AND DISCUSSION

S00-02 2000 forecasts for Johnstone Strait, Georgia Strait and Fraser River Chum salmon

V. Palermo, C. Murray, D. Bailey, and A. Thompson **Accepted subject to revisions**

Summary

The stock forecasted in this paper is known as the Study Area chum stock. These stocks originate from the East Coast of Vancouver Island, Mainland Inlets and the Fraser River.

The 2000 Study Area chum forecast return is comprised of two separate components: wild and enhanced. The interim target escapement goal for wild Study Area chum is 2.0 million (including 800,000 Fraser River chum). Existing major enhancement facilities throughout the Study Area have the capacity to produce 1.3 million chum at favourable marine survival rates. The major facilities on Vancouver Island include Big Qualicum Hatchery, Little Qualicum spawning channel and the Puntledge Hatchery. They have a production potential of about 650,000 adults. Major facilities on the Fraser River include the Chehalis, Chilliwack and Inch hatcheries; these have a production potential of about 250,000 (not including habitat restoration). An additional 400,000 production occurs from various minor facilities and habitat restoration projects within the Study Area.

The long-term average stock size model was used to forecast wild Study Area chum salmon stock sizes because it has been recommended in previous working papers for forecasting chum salmon stocks.

The 2000 return forecast is presented in Table 1. The total Study Area wild chum return is expected to be 1.75 million (50% probability level) using the long-term average return by calendar year (AVGCY) model. Based on this estimate, there would be no harvestable surplus of wild chum (escapement goal for wild chum is 2.0 million) in 2000. Both 3 and 5 year enhanced component forecasts are similar. The 2000 forecast for Study Area chum, wild and enhanced, is 2.1 million using the AVGCY model for the wild and the recent 3 year or 5 year average survival for the enhanced component. Expectations for wild and enhanced returns in 2000 to the Study Area would be low regardless of the forecasting method used because of low wild escapement levels in 1996-97 and highly variable ocean survival rates.

Subcommittee Discussion

The Subcommittee recognized that the forecast is for the aggregate for all wild and enhanced Johnstone Strait, Georgia Strait and Fraser River Chum. The Subcommittee is concerned that the forecasts of individual stocks are not possible because of a lack of stock specific data.

A number of elements reduce the ability to reliably predict returns: the large variability in age-at-return, recent highly variable marine survival, and concern about the accuracy of escapement estimates. Given the large imprecision of forecasts for the stock complex, the discussion initially centred on the utility and application of the forecast for fisheries management. The forecasts are used as a means for initial preseason fishery planning. The Clockwork management regime is based mainly on in-season run size estimates, which replace these pre-season forecasts. The Subcommittee seeks direction as to the utility and application of this forecast in fisheries management.

Subcommittee Recommendations

1. The Subcommittee recommended a return forecast of 1.75 million for wild Study Area chum (25% probability of exceeding 2.5 million and 75% probability of exceeding 1.3 million) and a forecast of 342,000 for enhanced Study Area chum.

S00-08 Biological reference points for the conservation and management of steelhead, *Oncorhynchus mykiss*

N.T. Johnston, E.A. Parkinson, A.F. Tautz, B.R. Ward **Accepted subject to revisions**

Summary

The authors' derive two simple biological reference points from a Beverton-Holt stock-recruitment relationship. N_{CCT}[1] is a simple approximation to N_{MSY}[2], the spawner abundance at Maximum Sustainable Yield (MSY), over a wide range stock productivity. The authors' define N_{LRP}[3] in terms of the rate of recovery of a depressed population to N_{MSY} by considering the resilience of the population to increases in density-independent mortality. The authors' then compare the performance of N_{LRP}, simple approximations to it, and other common biological reference points as limit reference points[4] (LRPs) in single threshold and dual

[1] N_{CCT} is an abundance threshold (the "conservation concern threshold") below which a population is regarded as overfished. N_{CCT} is defined to be 0.25 of the asymptotic maximum recruitment for a population with a Beverton-Holt stock-recruitment relationship, and approximates N_{MSY}.
[2] N_{MSY} is the spawner abundance that produces the maximum sustainable yield.
[3] N_{LRP} is the minimum abundance threshold from which a population can rebuild within a defined time period (one generation) to an abundance level (N_{CCT}) potentially capable of producing maximum sustainable yield.
[4] Limit Reference Points are defined in the paper as population levels that would allow rebuilding of the population to an intermediate reference point within a pre-specified time period (e.g. one generation).

threshold harvesting policies, using an age-structured population model based on Keogh River steelhead that incorporates realistic levels of uncertainty and observation error. A dual threshold harvesting policy with LRPs and TRPs (target reference point[5]) greatly reduces the risk of extinction for small populations, but maintains acceptable catch, escapement, and recovery times. Using N_{LRP} and N_{CCT} as the reference points in a conservation policy allows stock status to be determined from smolt abundance without estimates of stock productivity.

Reviewers' Comments

The reviews of this paper were generally positive. Both reviewers noted that alternative stock-recruit models may be more appropriate for the steelhead data presented, and would like to have seen a sensitivity analysis with different production relationships.

Reviewer #1

The first reviewer commended the authors for a well-written working paper that offers methodology for defining stock-specific TRPs and LRPs for steelhead. The conceptual framework that links the stock dynamics model and harvest policy simulations is described in extensive detail. Further analysis to test parameter sensitivity on the outcome could be done but generally the reviewer felt that uncertainty was properly considered. The reviewer noted that the choice of recruitment function could have a large effect on parameter uncertainty. The reviewer suspected that a Beverton-Holt model is realistic. Inputs to the simulations to evaluate effects of different harvest policies are clearly identified and the sensitivity of the model outcomes to variations in a nicely allows the search for policies that are independent of productivity at least within the range identified in the paper. The autocorrelative structure in ocean survival patterns is acknowledged in the paper. A non-parameteric approach to modelling the ocean survival pattern that uses the observed residual pattern rather than parametric resampling might be more revealing. This approach, however, may be limited by the relatively short time series of data.

The equation describing the relationship between harvest on surplus fish in relation to escapement and the LRP results in a harvest rate trajectory that declines asymptotically as the run declines to zero at the LRP. It declines at varying rates depending on the LRP and harvest rate applied to the surplus. It wasn't clear to this reviewer how the single threshold policy differs conceptually from the dual threshold policy that also declines as recruitment declines from a TRP. Other policy performance measures could be used that measure the catch variance to capture long-term stability of the fishery or sum of the log of catch that discounts high catch and penalizes closures. Another point the authors may

[5] A target reference (TRP) is an abundance goal that defines a desirable state for the population, consistent with population-specific management objectives. N_{CCT} is a minimum TRP.

want to consider in future work is to determine the harvest policy that optimizes a particular objective function.

Reviewer #2

The reviewer felt that the thresholds defined in the paper (TRP and LRP) make good conceptual sense. The challenge is in setting these values. The approach taken in the paper has strong practical appeal because most of data required for setting the thresholds is available or can conceivably be obtained. However, the paper could more clearly point out where the method is likely to fail or be inappropriate. The crux of the method involves setting thresholds as a fraction of “b”, habitat capacity, in the Beverton-Holt stock recruitment function. The model explicitly does not deal with many of the problems that are faced by small populations (notably environmental stochasticity, depensation and genetic processes). The suggested approach is probably appropriate if one is dealing with pristine habitats. Unfortunately, this is seldom the case. If the habitat capacity is degraded, the reviewer suggests that it may be necessary to evaluate viable thresholds based on small population paradigms that are not tied to the assumption that habitat capacity is adequate.

In summary, the reviewer felt that the paper provided a reasonable approach for setting threshold for relatively healthy and large populations with abundant habitat capacity. For small populations, with limited habitat capacity and declining trends (e.g., those of most concern regarding extinction), models that focus on issues particular to small populations and declining populations may be more appropriate.

Subcommittee Discussion

The Subcommittee expressed concern over the practical implementation of the approach proposed in this paper. A key data requirement is the estimation of the capacity of stream habitats to produce juvenile fish, and it is not clear whether accurate estimates can be obtained by remote sensing or other indirect methods.

In the paper LRPs are defined as population levels that would allow rebuilding of the population to an intermediate reference point within a pre-specified time period (e.g., one generation). There was some discussion over whether this meant that LRPs would then vary with productivity, and in particular, marine survival conditions. The authors’ suggested that under the dual threshold management model, the LRP under a wide range of productivity, was not approached under average productivity conditions.

Although, at this time the Subcommittee does not necessarily endorse this method for Pacific salmon, the Subcommittee encouraged the continued development of this method, noting that it was one of a number of approaches to the formulation of LRPs. The Subcommittee encouraged the authors to submit a follow up paper that deals with some of the implementation and data issues, perhaps by taking a case history approach.

S00-09 An assessment of Campbell/Quinsam Chinook salmon (*Oncorhynchus tshawytscha*)

D. Nagtegaal, B. Riddell, S. Lehmann, D. Ewart, B. Adkins
Accepted subject to revisions

Summary

The development and assessment of effective management strategies for the rebuilding of chinook salmon stocks to historical levels requires accurate estimates of escapement as well as estimates of the relative contribution of hatchery and natural production to that escapement. In 1984, various “key streams” were chosen including the Campbell/Quinsam River system. The key stream program was designed as a means of monitoring escapement parameters in specific spawning areas and initiated in response to objectives set out in the Canada-U.S. Pacific Salmon Treaty. The goal for these selected streams was to use the escapement and exploitation information from this stock as an indicator of harvest and exploitation rates on Upper Georgia Strait/Johnstone Strait chinook.

Interim escapement goals for naturally-spawning chinook stocks were established as double the 1979-82 base period or, for key streams, double the 1984 escapement. Since the Quinsam/Campbell was designated a key stream, the interim escapement goal was set at 5,970.

The Campbell River used to be one of the most important producers of chinook in the Strait of Georgia. In summary, three over-riding key aspects were identified to have contributed to the decline of the Campbell River chinook stock. First, hydroelectric development and associated construction of dams and water diversions are suggested to have significantly contributed to the decline of salmon stocks. Major changes in river discharge and flow regimes are known to have considerable detrimental effects to both the adult and juvenile life stages. Second, the estuary has been used extensively by industry and for urban development which has also been documented to have had a considerable impact on the rearing capacity for juveniles. And finally, high exploitation of this stock in past years has obviously been detrimental to the natural stock in the Campbell River.

Reduction in exploitation by approximately 50% since the late 1970s and improved marine survival up by 400% in recent years should contribute substantially to the rebuilding process. In 1999, there was double the number of natural spawners in the Campbell River compared to the previous 5 years.

Reviewers' Comments

Reviewer # 1

The reviewer felt that the working paper was well written, required few editorial changes, and should be accepted with minor revisions. The reviewer noted that the working paper provides a preliminary review of historic habitat alterations to the Campbell/Quinsam watersheds and the subsequent impacts on the chinook stocks in these systems. The reviewer supported the authors' conclusions regarding the negative affects that hydroelectric development, estuarine development, and high exploitation rates have had on Campbell/Quinsam chinook. The reviewer suggested that additional research be conducted to evaluate the interaction between hatchery and wild juveniles more closely to determine whether there are any negative impacts of enhancement activities on the wild component. The reviewer suggested the current escapement goal of 5,970 (double the 1984 escapement) be reviewed, given that the 1984 escapement of about 3,000 included a hatchery component of more than 1,000. The reviewer also supported the authors' recommendation to explore habitat-based escapement goals.

Reviewer #2

The reviewer felt the working paper provides a useful summary of the current status of the Campbell/Quinsam chinook stock but would have preferred some additional analysis of the results, the inclusion of minimal statistical information and a strengthening of the recommendations and their rationale. The reviewer recommended acceptance of the paper subject to the above noted revisions.

The reviewer was concerned that recent and significant work of the federal/ provincial water and planning team appears to have been ignored in the summary of history of flow management in the system, and should be explored. The reviewer also suggested that the working paper describe, in more detail, the potential benefits that the estuarine efforts at habitat restoration have had. The reviewer expressed concern that the escapement trend summary needs to be clarified in terms of enhanced and wild contributions, and whether the Campbell/Quinsam chinook should be treated as one stock or two. The reviewer was also concerned with the lack of supportive statistics throughout the working paper, especially with respect to the fecundity size and age of maturation data.

Subcommittee Discussion

The Subcommittee discussed the potential for developing habitat versus biologically-based escapement goals for Campbell/Quinsam chinook. To date, stock-recruit analysis has not been attempted due to the effect of long-term habitat degradation on the available data series. The Subcommittee was concerned that factors in addition to habitat alteration, such as high exploitation rates and enhancement may also have significantly influenced stock dynamics. Those effects need to be more fully explored for the Subcommittee to provide advice on a biologically-based escapement goal. The Subcommittee noted that this investigation requires a comprehensive compilation of habitat restoration activities in addition to habitat losses.

Subcommittee Recommendations

1. To provide advice on a biologically-based escapement goal, the Subcommittee recommended a review and analysis of the impact of historic habitat change, enhancement and exploitation effects on Campbell/Quinsam River chinook.

S00-10 An assessment of Rivers Inlet Chinook stocks

R. McNicol **Accepted subject to revisions**

Summary

This paper assembles all available biological data on Rivers Inlet chinook and attempts to assess the status of these stocks. However, in light of concerns regarding the low escapement of Wannock chinook in 1999, the focus of this paper is on this stock.

There are 12 known chinook stocks in Rivers Inlet. Eight of these are situated around the Owikeno Lake basin. Basic biological information on age structure, life history, and run-timing for these lake basin stocks is largely lacking. However, the limited information available indicates that these are comprised of small, early summer runs with stream-type life histories (e.g. juveniles remain in freshwater for one year prior to outmigrating to the ocean). Escapement data for most of these stocks is incomplete. Consequently, it is difficult to determine whether there have been any long-term changes in abundance among these stocks. Nevertheless, escapement to many of these systems appears to be under 50 fish.

The Kilbella and Chuckwalla stocks are the second and third largest runs, respectively, in Rivers Inlet. These are early summer runs which enter their natal rivers in late June through July, and spawn in August through September. These stocks are predominantly stream-type which spawn primarily at 4 or 5 years of age. These stocks have been enhanced since the mid-1980s, and escapements over the past 4 years suggest that both stocks are rebuilding. While hatchery escapement to the Kilbella appears to be modest, those to the Chuckwalla have recently amounted to ~ 50% of total escapement. Alaskan fisheries are the primary harvesters of these stocks, though the central coast tidal sport fishery harvests significant numbers.

Historically, the largest stock in the inlet is the Wannock river fall run, which has a life history distinct from other Rivers Inlet stocks. This stock is comprised of ocean-type fish (e.g. juveniles go to sea the same year they hatch) which spawn primarily at 4 or 5 years of age. This stock has been enhanced since 1983. The largest harvester of this stock is the central coast tidal sport fishery, which primarily takes place in and around Rivers Inlet. While no trends in escapements are apparent from the mid-1980s to 1998, the 1999 escapement was estimated to be only 500 fish, the lowest recorded since 1950. This estimate was based on the very low numbers of carcasses observed that year (32). This carcass count was believed to accurately reflect low spawner abundance. However, the limited Rivers Inlet sport catch information available suggested that the terminal run of Wannock chinook to Rivers Inlet was normal. Unfortunately, insufficient data was available to reconcile the apparent incongruity of high Wannock chinook terminal sport catch and low spawner abundance. While higher than normal predation may have accounted for some of the apparent post-fishery losses, there is no data available to either support or refute this notion.

Incomplete information on Wannock chinook makes it difficult to provide a compete assessment of this stock. However, due to the apparent low spawner escapement in 1999, and the uncertainties in catch data that year, caution is recommended in the harvest of this stock in year 2000. Considering the high escapements to the Kilbella and Chuckwalla Rivers the past several years, current enhancement programs should be reviewed to determine whether their original goals have been met. A lack of even basic biological information on Owikeno Lake basin chinook stocks make it impossible to assess the status of these stocks. Consequently, it is recommended that efforts be made to collect age and DNA samples from each stock, and undertake to gather better information on abundance of these stocks.

Reviewers' Comments

Reviewer #1

The reviewer agreed that the author achieved the goal of reviewing the information and recent patterns of abundance of Rivers Inlet chinook and the paper will be a valuable reference document for the future. The reviewer did not believe that the author achieved the goal of making recommendations regarding the management of the Rivers Inlet sport fishery. However, the reviewer felt the author did do a good job of providing supporting evidence that the low abundance of Wannock chinook escapement in 1999 is real. This reviewer indicated that the contradictory evidence of abundance in the sport fishery might be due to a depensatory sport fishery effect. The reviewer also indicated that any advice on restrictions of the sport fishery needs to be evaluated and are predicated on some sort of management plan. Any resumption of marking would require careful evaluation of the sampling rates and expansion factors derived from the terminal sports fishery.

Reviewer #2

The reviewer indicated that the purpose of the paper was clearly stated and in most cases the data and methods were adequate to support the conclusions but not all the recommendations. The reviewer suggested that recommendation #1 should be revised to give a clearer statement of the Wannock chinook stock risk for 2000, and the risk-adverse approach that should be applied. Other recommendations should be considered in the text before the conclusions.

The reviewer noted that there is substantial biological sampling data on the terminal sport fishery, which could be analyzed. The reviewer would like to have more detail on the estimation of percent enhanced in the Wannock chinook. The reviewer suggested using the Wannock mark-recapture versus patrolman escapement ratio estimate of 2.5 to adjust all the Sampson escapement estimates. The reviewer was also concerned with the quality of the coded-wire tag (CWT) estimates in the sport fishery because of the awareness factors used to estimate the contribution. If it is assumed that the awareness factors are accurate, the CWT rate in the escapement and the number of estimated CWTs in the sport fishery could be used to provide an estimate of the proportion of Wannock chinook in the sport fishery. The reviewer is not convinced the data supports the conclusions regarding the proportion of Wannock chinook in the terminal sport catch. The reviewer agreed there is no evidence of high post fishery mortality and also indicated that Rivers Inlet chum and pink stocks which went to sea in the same year as the Wannock chinook had good or average returns in 1999. The reviewer finds it hard to believe that the severe marine survival problem with Rivers Inlet sockeye would not have affected other species. Assuming the poor Wannock chinook escapement index in 1999 is real, the chinook may be following the Owikeno sockeye trend delayed one year. If so, the prognosis for Wannock chinook in 2000 would be very poor.

Subcommittee Discussion

The Subcommittee had substantial discussion on the inability to estimate the proportion of the terminal sport fishery catch attributed to Rivers Inlet stocks (Wannock, Chuckwalla/Kilbella, Owikeno Lake). Data on catch by stock from the sport fishery is limited because there is no creel survey; there is a paucity of CWTs, and undetermined awareness factors. The available data depends on the cooperation of the fishing lodges and does not include the non-lodge catch. Difference in life history traits (e.g., size, scale characteristics) may be useful to assess the proportion of all Rivers Inlet stocks.

The Subcommittee was also faced with the common problem of the uncertain quality of escapement estimates due to limited documentation on how they were derived. Nevertheless, the reported low carcass numbers in 1999 (along with supportive data that factors likely to reduce carcass recovery were not present in 1999) would indicate a severely depressed stock in 1999. The Subcommittee also discussed the contradictory evidence from the sport fishery that returns in

1999 were similar to previous years but some members were not convinced that the proportion of the catch of Wannock origin could be adequately estimated. A number of mechanisms were proposed to account for this discrepancy. However, on the basis of the information provided, the Subcommittee could not distinguish between the possibility of a depensatory fishing effect, and/or an unaccounted for post-fishery loss. Although there is conflicting evidence of the stock status of other chinook stocks and species, the very poor status of Owikeno sockeye and the poor return of Wannock chinook in 1999 would suggest a precautionary approach to harvest in 2000.

The Subcommittee noted the requirement for an evaluation of the success and impacts of enhancement on Rivers Inlet chinook stocks.

Subcommittee Recommendation

1. In light of the apparent low 1999 Wannock chinook escapement and the uncertainties in the data, the Subcommittee recommended caution in the harvest of Wannock chinook in 2000.
2. The Subcommittee recommended initiation of a multi-year investigation to determine the status of Rivers Inlet chinook stocks.

S00-11 In-season indicators of run-strength and survival for Northern British Columbian coho

B. Holtby **Accepted subject to revisions.**

Summary

In providing forecasts of run-strength and survival for the coho of northern British Columbia for 2000, Holtby et al. (2000) concluded that there potentially were some limited fishing opportunities available on coho from the upper Skeena that would pose limited risk of irreversible damage. They emphasized that forecasts for the area had not proven sufficiently reliable to proceed with modest incremental fishing without an early in-season indicator that would warn of unforeseen survival disasters such as the one that occurred in 1996 sea-entry. The purpose of the working paper was to make a preliminary examination of the utility of four possible in-season indicators of run-strength and survival for northern B.C. coho.

Four fishery-performance measures were examined: the Skeena test-fishery index, which is essentially a catch per unit effort (*CPUE)* of a river-mouth gill-net fishery, the wild coho *CPUE* in the SE Alaskan Tree Point gill-net fishery, the coho *CPUE* in the Alaskan boundary area troll fishery, and the upper Skeena CWT catch as a proportion of coded wire tags (CWTs) released in the SE Alaskan troll fishery. To ensure that these measures would serve as 'early-warnings', analysis was confined to data available by week 31 or roughly Aug.

1st. Forecast models for Babine and Toboggan hatchery coho and Lachmach wild coho, total stock size of the Babine Lake coho aggregate and the total stock size of the 'average-streams' of Areas 3, 4L, 4U and 6 were developed where there was a useful statistical relationship.

It is important that the early-warning schemes detect a sea-entry year like 1996 (return year 1997), which saw record low survival and escapement over much of northern B.C. For upper Skeena coho marine survivals in 1992 and 1995 and 1998 were also very low and given the precarious state of upper Skeena coho returning off the 1997 brood, should also be detectable by any early-warning scheme. There are as yet no limit reference points (*LRP*s) for northern B.C. coho. However, abundance values equal to 20% of carrying capacities from stock-recruitment analyses (Holtby et al. 2000) exceed levels seen in the upper Skeena in the years of poor survival. Values of 20% of the observed mean marine survivals also seem to exceed survival realized in most of the years noted above. Consequently, the models were evaluated using 'trigger' points set 20% of the long-term mean survival or 20% of the estimated carrying capacity of the stock. Where data-series are too short to establish these levels then the models were evaluated using trigger points set to approximately twice the values observed for the 1996 sea-entry year.

Of the four fishery-performance variables evaluated as early-warning forecast tools, the CPUE in the Alaskan boundary area troll appears to be the most promising. Models based on this CPUE were predictive for most of the variables of concern and were able to reliably detect trigger situations while not giving more than one false trigger. The second best predictor was the proportion of CWTs recovered to week 29 in the Alaskan troll. Models based on this performance measure were able to detect trigger situations for upper and lower Skeena coho but failed outside of the Skeena and notably in Area 6. Furthermore, the models signaled spurious false triggers. The remaining two performance measures, the Skeena test-fishery index and CPUE in the Alaskan Tree Point gill-net fishery seem unsuitable as early-warning indicators. Although one scheme appears to hold the most promise the author recommended using two or three models where they are available.

Reviewers' Comments

Both reviewers agreed with the analysis and recommended that the paper be accepted with minor revisions.

<u>Reviewer #1</u>

This reviewer questioned whether the same conclusions regarding model utility (e.g., dismissal of the Skeena test fishery as an in-season indicator) would have been reached had different levels of, or confidence limits about, the performance criteria been used in the assessment. The reviewer also suggested that a retrospective analysis be conducted that would use only that data which would have been available at the time for any particular year being forecasted. He agreed with the author that using two or three models where they are available is a good idea and suggested that statistical methods (e.g., Bayesian analysis) that combine the different indicators be used to produce a composite forecast.

Reviewer #2

The reviewer concluded that the analysis was good and did not have any major criticisms about the methods and conclusions. The reviewer also suggested that the best estimator would be a variance-weighted combination of the data rather than a point estimate based on the single best predictor available. The reviewer however, cautioned that unless the data types are truly independent, there is a risk that the answers they provide could give levels of confidence that are not actually warranted. He suggested checking cross-correlations of patterns of prediction residuals for the individual predictor equations, to ensure that they are not correlated.

Subcommittee Discussion

The Subcommittee agreed with the reviewers' comments regarding the utilization and application of the method. Concerns were expressed that the SE Alaska fisheries may not continue to operate in the future as they have in the past, in part due to new provisions within the Pacific Salmon Treaty. This would compromise the long term utility of the results presented in this paper. This is a concern because there currently is no reliable indicator within Canadian waters to evaluate early run strength of species such as coho. It was recommended that the relationships be regularly investigated.

The Subcommittee concluded that the boundary area CPUE is an adequate predictor of run-strength and an early-warning indicator and should be used. The Subcommittee supports the development of statistical methods that combine available indicators to produce one composite forecast.

Subcommittee Recommendations

1. The Subcommittee recommended the use of the models presented in the working paper for run-strength predictors and as early-warning indicators of run-strength for northern B.C. coho.

S00-12 Overview of salmon stock assessment frameworks in the Pacific Region

B. Holtby **Accepted subject to revisions.**

Summary

The enterprise of assessing and managing Pacific salmon has become a large, complex and expensive one. It is necessarily so because of the diversity and magnitude of the resource itself and the multiplicity of interactions between the salmon resource and other resources and their users. These factors would be present even if there were not significant changes underway in public policy and resource management. Among the most significant of these changes are the shift in emphasis from production objectives to a more varied set of conservation and ecosystem objectives, the adoption of the precautionary approach, the Wild Salmon Policy proposal, the requirements of the recent Pacific Salmon Treaty and the growing acceptance of public and private partnerships in the provision of data and analysis for assessment. Because Pacific salmon are a public resource, the resources for assessment and management are, for the most part, public resources. Therefore, there are increasing pressures to maximize benefits while minimizing costs. The global experience in fisheries over the past half-century would suggest that our collective ability to learn from past mistakes has been extremely limited. Consequently, any approach to tackling our problems should be structured to maximize the potential to learn and adapt.

The Stock Assessment Division retains its status as the lead agency in bringing together the varied resources directed at assessment to address the conflicting aspirations of resource users and because this is a public resource, the resource owners, and their increasingly contradictory objectives of conservation and sustained development. One possible approach to the tackling these problems is to adopt a structured approach that embraces the following principles:

1. objectives: It is necessary to have a clear and explicit statement of what assessment and management are trying to do
2. precaution: The Department must accept the fact that it is easier and cheaper to maintain a natural system than it is to fix it once something goes wrong, and act accordingly
3. approach: The Department must carefully and deliberately choose what they do to gather the information, analyze it and make decisions from it. If the Department can't explain what it is they do or how decisions were made, then how can we learn from mistakes or successes?
4. performance metrics: Without objective measures of progress towards objectives how will we know whether objectives are being achieved or not?
5. learning: The Department must accept the fact that they have been slow to learn from past mistakes so there must be a deliberate attempt to accelerate learning and incorporation of new knowledge into practice
6. efficiency: There must be a continuous appraisal of whether information

could be acquired and applied more quickly, and with greater efficiency.

Incorporation of these principles into the Assessment Framework approach described in this document was done with the hope that the approach will go some way toward focusing our energies on the challenges ahead.

Reviewers' Comments

Reviewer #1

The reviewer pointed out that all the issues raised by the author were relevant to stock assessment, but the structure of the document and the way in which issues were described and discussed did not lead to any clear definition of the framework. The reviewer saw this paper as a work in progress that will be revised and refined over time into something that should be helpful in guiding stock assessment for salmon. Further, the reviewer stated that development of the framework is a complex and difficult task and one that is likely to be highly contentious. If this document starts the process of debate and negotiation that will lead to a more explicit framework, then its wide ranging approach may be an asset.

Reviewer #2

The reviewer thought that the author's paper will prove to be a very useful starting place for the development of assessment frameworks and was a very timely development given the discussion of a new 'Wild Salmon Policy'. The reviewer expressed a concern about the apparent separation of institutional roles between Stock Assessment and Fishery Management and pointed to a number of good examples of integrated fisheries models (e.g., Chinook coastwide model, Skeena River model, Fraser sockeye model marine and in-river, in-season run size models, etc.) within the Department.

The reviewer found the paper to be a good examination of the roles of stock assessment, fish management and other staff, data requirements in order to fulfil their mandates and possible guiding principals for the development of assessment frameworks. The reviewer also pointed out that while the paper did not state any explicit recommendations, he assumed that the author was implying that initiation of the use and development of assessment frameworks is needed as a useful way to focus our talents and energies. The reviewer concluded that he would fully support the author's paper and look forward to the development of the assessment frameworks.

Subcommittee Discussion

The Subcommittee noted that both reviewers agreed that the paper should be of use in guiding stock assessments.

The author noted and the Subcommittee recognized that this paper addressed a request by the Subcommittee in May 1999 to develop a conceptual framework for the management and assessment of each salmon species. The assessment framework was deemed necessary to evaluate and compare prospective assessment programs within the context of the "New Direction for Canada's Pacific Salmon Fisheries" policy. The paper proposed a generic technical framework for future assessments that were supported by the Subcommittee as presented. A preliminary 'Table of Contents for an Assessment Framework' from the paper is shown in Table 2. The Subcommittee discussed and agreed that it was not in a position to endorse opinions on non-technical topics addressed in the paper (e.g. institutional arrangements).

It was noted that the paper, once accepted and finalised by the Subcommittee, becomes a public document. Solicitation of advice from appropriate parties may improve the framework. The Subcommittee requested that RMEC consider whether consultation on the proposed framework should be pursued with groups within and outside the department. The Subcommittee also discussed and agreed that the next step after the generic framework is established is to develop species-specific frameworks.

Subcommittee Recommendations

1. The Subcommittee recommended the paper as a basis for further discussions on the development of species-specific assessment frameworks in the Pacific Region.

S00-13 Status in 1999 of coho stocks adjacent to the Strait of Georgia

K. Simpson, R. Semple, A. Dobson, J.R. Irvine, S. Lehmann, S. Baillie
Accepted subject to revisions

Summary

Escapements of 1996 brood coho were poor relative to 10-year averages and 1998 in areas of the Georgia Basin other than the lower Fraser. Compared to ten year averages, one lower Fraser wild indicator, Salmon River, was very poor and another, Upper Pitt, quite good. 1999 escapements were better than 1998 escapements in this area with the notable exception of the Salmon River indicator stock. In terms of the provisional limit reference point of 3 females/km, virtually all enumerated stocks in the Basin were above the limit. Escapements were the result of poor escapements in 1996 and poor marine survival. Exploitations due to release mortalities based on DNA stock compositions were 12.6% and 10% for East Coast Vancouver Island and lower Fraser coho, respectively. If accurate, and our confidence in the escapement estimates is low, these values approximate the exploitation of wild coho. Exploitations due to catch of marked hatchery stocks, when added to the DNA derived estimates,

provide estimates of their total exploitation ranging from 15% to about 28%. Extremely low marine survival is the driving short-term cause of poor abundances. A slight increase in 1999 everywhere except in the northern Strait provides some hope that the decline has stopped.

Based on smolt estimates at Black Creek and Salmon River and using fry densities and sizes, the 1997 brood smolt runs were probably below average in 1999 and possibly well below average on the Sunshine Coast. With marine survivals forecast to remain poor, the authors' expect escapements in 2000 to be well below 1990s averages, similar to 1999 except in the Fraser Valley where escapements were not as depressed in 1999. Nevertheless, assuming continued near-abatement of exploitation, most monitored stocks will probably exceed the provisional limit reference point of three females per kilometre of stream as they did in 1999.

Considering the currently low productivity of Georgia Basin coho, the authors' recommend that fishing mortality remain similar to existing minimal levels in order to ensure that there is a sufficient proportion of escapements that exceed the provisional limit reference point.

The abundance of 1998 brood smolts this spring will probably be better than the 10-year average everywhere except possibly on the Sunshine Coast. Excluding this part of the Basin, fry densities were above average in 1999 in response to average, to better than average, escapements. Their sizes were probably sufficient to provide average winter survival with some regional variation. With inadequate data coverage, the authors' think fry abundances were probably poor on the Sunshine Coast and winter survival, as inferred from fry size, was likely average despite lower densities. Smolt runs may be poor in this area but sample sizes were too small to conclude this with any confidence.

Fry densities at both the individual stream level and summarised over the Basin are correlated with parental escapements throughout the 1990s, which is the period of the fry survey. Fry surveys are an economical and effective way to determine trends (at least) in escapements when escapements are low to moderate. Continuing in a tactical vein, a 'full' indicator facility is needed on the Sunshine Coast where juveniles are enumerated and tagged and adults are accurately counted and sampled. Another is required in the Fraser Valley. The existing indicator of Salmon River and the escapement indicator of Upper Pitt have different escapement trends and the area requires another full indicator facility.

Reviewers' Comments

Reviewer #1

The first reviewer found that the paper adequately met the requirements for acceptance. The reviewer agreed with the authors' conclusions, particularly with respect to the need for better guidelines for collection and analysis of escapement data and the need for more index streams. The authors' cautionary note regarding the use of these data in relation to LRPs was emphasized.

The reviewer suggested there was room for more work on the use of fry density as an index of spawner abundance, particularly soon after emergence. The use of mid-water marine trawl catches and conducting hatchery mark coho fisheries were mentioned as being promising indices of marine abundance. An issue regarding depensatory mortality and predation by harbour seals at Black Creek was raised particularly when coho abundance was low.

Reviewer #2

The second reviewer also found the purpose to be clearly stated and that the data generally support the conclusions. Although weak in detailed analyses the reviewer felt that the biological interpretation and conclusions presented in the paper were logically derived from the data. The recommendations were felt to be useful for fisheries managers, in particular that fishing mortalities remain at the current low levels to ensure escapement above the reference point. The reviewer felt that the uncertainties in the data could have been explained in more detail and that recommendations to improve the acquisition of the needed data be provided. It was suggested that methods to better quantify marine survival should be considered for future research.

The reviewer pointed out that the paper indicated that data on recreational fisheries in Fraser River tributaries was not available in 1998 and 1999 when in fact creel surveys were conducted and the data was available through the CWT mark data group.

The reviewer felt that the paper presented the strong message well regarding the continued state of coho population decline and their corresponding vulnerability to over exploitation. As such, the reviewer recommended the acceptance of this paper in the present format.

Subcommittee Discussion

The Subcommittee discussed the accuracy of the Area-Under-the-Curve (AUC) escapement estimation technique because this method is used extensively and suggested that the uncertainty of AUC estimates should be provided.

The Subcommittee raised a concern regarding the current exploitation rates on wild Chilliwack coho as a result of increased recreational fisheries on the enhanced Chilliwack coho returns. The Subcommittee noted that there is currently little assessment of the wild Chilliwack coho.

The Subcommittee discussed the continued low marine survival and concluded that there was no additional information provided in the paper which would change the Subcommittee's recommendation based on the forecast that fishing mortalities need to be maintained at recent (1998 and 1999) low levels.

It was noted that there is a need to evaluate whether predation by seals is a significant source of depensatory mortality for stocks of salmon.

Subcommittee Recommendations

1. The Subcommittee endorsed the recommendation for two additional coho indicator facilities, one on the Sunshine Coast and the other in the lower Fraser River.

S00-14 Evaluation of utility of aerial over-flight based estimates versus mark-recapture estimates of chinook salmon escapement to the Nicola River, B.C.

R. Bailey, C.K. Parken, J. R. Irvine, B. Rosenberger, M.K. Farwell
Accepted subject to revisions

Summary

Helicopter overflight counts of adult chinook salmon escapement to the Nicola River were examined to determine their statistical properties. Replicated counts were compared and variances estimated for reach counts using regression and quartile approaches. Reach counts were highly repeatable. Expansions of peak counts indexed abundance well among years, however, when using the standard expansion factor (π=1.54), estimates were biased low for three of four years when compared to Petersen mark-recovery estimates. AUC (area-under-the curve) estimates of spawner-days described the spawner abundance in a more robust manner than peak counts. Apparent redd residence times were stable among years (mean = 5.81 d, range 5.34 - 6.37 d). Retrospective AUC estimates, calculated using observed spawner data, and the mean apparent redd residence time, adequately estimated spawner abundances for all four years. While at this time, the authors are unsure of the minimum number of overflights required to produce scientifically defensible AUC escapement estimates, it is likely that four or more flights may be required on many systems.

The authors recommend similar studies be conducted in other watersheds in order to examine: 1) The repeatability of aerial counts; 2) spatial and temporal variability in survey life; and 3) degree of bias associated with aerial overflight-based estimates.

Reviewers' Comments

Reviewer #1

Reviewer 1 cautioned that the aerial counts and AUC estimates provided in this study conducted by two crews of highly experienced field personnel may underestimate the variance associated with execution of the same types of surveys conducted by a wider range of personnel (e.g. different pilots, crews exhibiting more variable enumeration experience).

This reviewer was also concerned that the conclusion that expanded peak counts were typically biased low relative to mark recapture estimates should not be prematurely accepted as a generalization nor as evidence for the superiority of the mark recapture estimates given: (i) the limited sample size (n = 4) involved in the comparison and (ii) the possibility that mark recapture estimates may also be inaccurate.

Reviewer 1 noted that the apparent consistency of spawner residence time among the four estimates obtained in this study should be interpreted very cautiously as evidence of long-term consistency for this stock of chinook (or others) as more extreme values would be expected within a longer time series of observations. AUC estimates are highly sensitive to variations in estimates of spawner residence time and the reviewer cautioned that use of average AUC residence times based on a wider range of observations not perform as well as suggested in the current paper.

Reviewer #2

This reviewer commended the authors on their work as their paper provides valuable insights into parameters which are critical to the effective use of AUC and Peak Count escapement estimation methods. However, the reviewer noted that results from this paper should be viewed as an initial rather than a definitive "evaluation of the utility of aerial overflight based estimates versus mark-recapture estimates" as implied by the paper's title. Additional work suggested for future evaluations included better definition of the objective of various escapement assessments, specification of the associated levels of precision and accuracy that are required to meet the objective(s) and analysis of the cost-benefit given application of different methods.

In common with reviewer 1, this reviewer expressed concerns that: (i) the application of a mean residence time rather than a year specific value would reduce the reliability of the AUC estimates provided here and (ii) that estimates developed during the current study have not been calibrated against those derived from the longer series of historic data.

This reviewer expressed a desire to see a broader workplan with the objective of enhancing the application of standardized AUC and Peak Count methods throughout the Pacific region.

Subcommittee Discussion

The Subcommittee noted that results from this study were obtained under nearly ideal conditions (low fish density, clear water, total channel exposure etc.) for application of the AUC spawner estimation technique. Consequently, the performance of the AUC technique in this study may overestimate its utility in other situations exhibiting less ideal conditions (e.g. dense aggregations of fish, deep water, variable flow, channel concealment by forest canopy etc.). Subcommittee members agreed with reviewers that it would be desirable to discuss how results from this study fit within a broader context of how the AUC methodology might be expected to perform in assessments of escapement of chinook or other species of salmon throughout the region.

Subcommittee members agreed with the authors' appraisal that the AUC procedure applied in the current study provides escapement estimates that are superior (e.g. known precision, higher accuracy) to those based on peak count expansions. However, they also noted that this outcome appears to be a function of the use of either year specific residence times or the existence of low variance in the mean residence time used in the AUC application. AUC estimates employing average residence times exhibiting either high or unknown variance would not be invariably superior to escapement estimates based on peak counts.

Subcommittee members questioned the authors about the relative roles of pilot and field personnel experience in generating differences in escapement estimates executed within the same day. The authors noted that field personnel were all well experienced and that most of the between "trial" differences in escapement estimates appeared to originate with pilot experience in providing a flight path that is optimal for visual enumeration (e.g. low altitude, aspect selected to minimize water surface glare etc).

Some concern was expressed that calculated variances associated with both reach counts and residence times on redds might be artificially low due to an assumption that observations from both follow the normal distribution rather than some other distribution.

A request was also made for the authors to adopt a consistent set of definitions and nomenclature for terms used in equations throughout the paper to improve its clarity for readers.

Subcommittee Recommendations

1. The Subcommittee recommended additional studies to further characterize aerial escapement assessment methods to broaden tests of their applicability to other salmon stocks and river systems.

S00-15 A preliminary review of a new model based on test fishing data analysis to measure abundance of returning chum stocks to the Fraser River

W.J. Gazey and V. Palermo **Accepted subject to major revisions**

Summary

The test-fishery has operated at Albion on the Fraser River since 1978 to provide the means for an index of chum salmon abundance (escapement) within a season. Recent degradation of the accuracy and consistency of escapement estimates has seriously undermined the potential to evaluate clockwork management for the Fraser River chum salmon (PSARC paper S99-20, Ryall et al.). To address this problem the cumulative catch-per-unit-effort (CPUE) was calculated to account for saturation, depletion in the second set and interpolation for missing sampling days. In addition, the test-fishery data were cast into a Bayesian framework that incorporated preseason knowledge of run size and migration timing, within season information on migration timing and a predictive regression to calibrate run size to the historical record. Based on a retrospective analysis of 1979-1998 data, the Bayesian procedure was judged to be superior to the classical test fisheries approach of using a simple predictive regression of cumulative CPUE on run size. However, the predictive ability of the either model was seriously compromised by the reliability of escapement enumeration (end of season minimal residual standard deviation of prediction was 256 thousand fish).

Reviewers' Comments

Reviewer #1

This reviewer agreed with the authors that the new model is better than the simple regression model used currently to estimate abundance using data from the Albion test fishery. The reviewer recommended the Subcommittee accept the paper after the completion of a sensitivity analysis for the prior distribution for the pre-season abundance and inclusion of a posterior distribution plot with the simple regression as a comparison (e.g. by using the data to 1998 and forecasting the escapement for 1999 by both models).

Reviewer #2

This reviewer noted that the new model has the advantage of incorporating prior migratory timing into the predictive framework and should explain a higher proportion of the variability in run size than previous models. The reviewer was unable to comment on the retrospective analysis missing from the first draft of the working paper. The reviewer pointed out that the report was well written and organized. The advice from the new model incorporated the variability in the data and the manuscript emphasized the need to examine the reliability of the escapement estimates. The paper sufficiently indicated the influence of the uncertainty in the data on management strategies. The paper did not fully discuss the limitations and uncertainty of predicting chum run size from test fishery CPUE at Albion. The reviewer indicated that the paper documented a depletion effect from the test fishery but no discussion was presented about the influence of downstream net fisheries on the ability of the test fishery to accurately estimate the daily abundance of migrating chum. The reviewer believed the paper would have benefited by clarifying the extent of downstream net fisheries and their potential influence on CPUE measured at the test fishery. Model use for fisheries management may benefit from a sensitivity analysis or simulation modelling of the effects of errors in CPUE or escapement on the long term management of Fraser River chum. An area of future investigation offered by the reviewer was the influence of variable in-season catchability (coefficient), downstream net fisheries, river discharge, relative abundance of seals, picking time, and other potential factors on test fishery CPUE estimations.

Subcommittee Discussion

This paper presents preliminary results of a new method to estimate the terminal run of Fraser River chum salmon from Albion test fishery and chum spawning escapement data. The Subcommittee acknowledged the technical contribution of the work and agreed that the new Bayesian analysis is superior to the current regression method. The Subcommittee also noted that the uncertainty in the estimate is large (± 500,000 fish relative to the escapement goal of 800,000) and the analysis is limited by poor data quality.

The Subcommittee encouraged the authors to continue the development of the method recognizing that further assessment is required to define the quality of the input data which is essential to the performance of the model.

Subcommittee Recommendations

1) The Subcommittee accepted the paper as a preliminary review of a new model based on test fishing data analysis to measure abundance of returning chum stocks to the Fraser River.

S00-16 Stock status and genetics of Interior Fraser coho salmon

J.R. Irvine, R. E. Withler, M.J. Bradford, R.E. Bailey, S. Lehmann, K. Wilson, J. Candy, W.S. Shaw

Summary

The authors evaluated the impacts of continued restrictions in salmon harvest on the status of coho salmon of the interior Fraser River, including the Thompson drainage in 1999. Total exploitation rate on the aggregate in 1999 was estimated to be ~8% (~3% Canadian, ~5% US), which is similar to 1998, and much lower than in previous years. Various indices of escapement suggest the total spawning population in 1999 was about the same as in 1998, but higher than the 1996 parental escapement. Total abundance in 1999 was about 10% of that observed in the mid-1980s, and spawning populations in many streams are small or non-existent. The authors conclude that the status of the aggregate is largely unchanged from 1998, and remains poor. It is premature to draw any conclusion about whether the better survival of the 1996 brood (1999 return) represents a trend towards improved survival in the future. The authors have no basis to alter the conclusion reached in this year's forecast document (Holtby et al. 2000) that it is unlikely that stock size will increase in 2000.

The potential for traditional ecological knowledge to assist in stock assessment was discussed, as were recent enhancement activities in the interior region. Analysis of genetic information on interior Fraser coho supported the idea that non-Thompson coho can be grouped with Thompson coho as a single management or conservation unit that is distinct from lower Fraser.

The major recommendations from this paper are:

1. Target and limit reference points for Interior Fraser coho are needed to provide management advice relative to current abundance levels and forecast trajectories.

2. Policies on the role and evaluation of strategic enhancement to restore declining populations such as the Thompson need to be formulated.

3. More extensive baseline coverage of interior Fraser coho for genetic sampling (e.g. Nahatlatch) will aid in the delineation of populations, and provide more precise estimates of the distribution and numbers of interior Fraser coho in catches.

Reviewers' Comments

Reviewer #1

Reviewer 1 noted the diversity of topics covered in the paper and commented on the inclusion of data from other published papers. The reviewer made specific suggestions in the sections on genetics, enhancement, spawning escapements and Traditional Ecological Knowledge (TEK).

Reviewer 1 considered the genetics section a valuable contribution, but the presentation was difficult to follow for readers unfamiliar with genetic theory. Additional analysis was considered desirable and the importance of non Thompson stocks needed further clarification, both in relation to the definition of conservation units and for the purposes of stock identification. This reviewer felt the section on enhancement was too brief and lacked an appropriate amount of analysis.

This reviewer considered the Spawning escapements to be good estimates, but some differences in the stock composition represented in the Yale fish wheel and the actual escapement calculations were noted.

A major concern by the reviewer centered around the inclusion of a discussion on Traditional Ecological Knowledge (TEK) in the paper. The use of TEK was recognized as a valid source of information but the integration of TEK with traditional science was considered to be a difficult area and one which should be considered as a topic in its own right.

Reviewer #2

Reviewer 2 also suggested treating TEK as a separate subject in a different publication or policy discussion, and also commented on the difficulties associated with an amalgamation of separate papers and components in a single paper. The difficulty of checking information without direct access to the information contained in the other documents was also noted.

Reviewer 2 also commented on the confusion arising from the loose definitions of reference points (e.g. LRPs and TRPs), maximum estimated escapements etc., and indicated that stock status must be measured relative to a standard, and these standards are not currently defined in the paper.

The lack of analysis of current management actions was noted and the reviewer felt that a section dealing with regulatory change, marine survival trends and stock and recruitment effects would be of benefit.

The role of habitat degradation in the decline was noted as an important possible contributing factor as was the interaction between wild and enhanced stocks.

Reviewer #3

Reviewer 3 recommended acceptance of the paper subject to a number of minor revisions. Like the previous reviews, reviewer 3 identified the problems associated with the inconsistent writing and the lack of clarity on the reference point definitions.

This reviewer also noted that TEK was not considered to be appropriate for this particular paper, but its value was recognized as a potential additional tool for stock assessment.

The section on enhancement was considered by reviewer 3 to be too short and lacked sufficient detail on the specific studies related to stream carrying capacity conducted prior to enhancement. Lack of juvenile population information was noted, and cryopreservation of sperm was discussed relative to the overall problem of storing genetic material for threatened stocks.

The reviewer considered the habitat section to be a useful addition to the paper but the lack of correlation between logging impacts and declining recruits per spawner was questioned. The interpretation of the meaning of the intercept of regression of impacts versus annual change in recruitment was questioned by the reviewer.

Subcommittee Discussion

The Subcommittee agreed with the reviewers and authors that the use of Traditional Ecological Knowledge (TEK) in scientific assessments needs careful review.

The Subcommittee reaffirmed the need for the continued development of the concepts of limit reference points and target reference points under the Wild Salmon Policy. The Subcommittee identified a need to evaluate the effectiveness of enhancement as part of a conservation strategy for the Thompson River coho populations.

The Subcommittee commented that the DNA based approach is being used with increased frequency to estimate stock specific exploitation rates in mixed stock fisheries. The Subcommittee encouraged the collection of additional base-line genetic samples to refine this approach.

Subcommittee Recommendations

1. The Subcommittee recommended development of limit and target reference points for Interior and Fraser coho to provide management advice.
2. The Subcommittee recommended more extensive baseline coverage of interior Fraser coho for genetic sampling (e.g. Nahatlatch) as this will aid in the delineation of populations, and provide more precise estimates of the distribution and numbers of interior Fraser coho in catches.

S00-17 A biologically-based escapement goal for Cowichan River fall chinook salmon (*Oncorhynchus tshawytscha*)

B. Riddell, D. Nagtegaal, D.Chen **Accepted subject to revisions.**

Summary

In 1985, a program to increase chinook production was initiated coastwide through the Pacific Salmon Treaty between the United States and Canada. The program required both countries to stop the decline in escapements to naturally-spawning chinook stocks and attain escapement goals in selected indicator stocks by 1998. To implement this program, however, escapement goals were needed for Canadian chinook stocks. These were generally not available during

the early 1980s and the status of chinook stocks was uncertain (Healey 1982). Chinook production was considered to be depressed but the status of individual populations had not been determined. In order to proceed with the Treaty, the recommendation of a Regional workshop in 1982 was to set interim goals by doubling the spawning escapements observed during a recent period (1979-1982) and to monitor escapements during the rebuilding period in order to allow determination of biologically-based goals.

The Cowichan River fall chinook was selected as an indicator stock for chinook salmon produced naturally in the lower Strait of Georgia. However, by the Fall of 1987, spawning escapement to the Cowichan River had decreased to only 15% of its interim goal (11,625 Age-3+ chinook). In response to the continued decline in escapement, further conservation measures were taken to reduce harvest rates, enhancement guidelines were implemented to assist recovery, and an intensive program of escapement enumeration and assessment was established (Nagtegaal et al 1994).

A community economic development program hatchery (CEDP) has been established on the Cowichan River since 1979. In most years, a proportion of the chinook produced are nose-tagged with a small coded-wire tag (CWT) for assessment of hatchery production. Recovery information from these tags provides the basis for assessing exploitation rates, distribution, and marine survival for these stocks. Since no naturally spawning chinooks are tagged, information compiled from the hatchery facility is used to assess both hatchery and naturally-spawning chinook.

In recent years, enhanced production has contributed up to 50% of the naturally-spawning population, based on the incidence of CWT chinook recovered in the escapement. However, based on otolith microstructure (Zhang et al. 1995) the proportion of hatchery chinook in the Cowichan River has been estimated to be as high as 60%. In either case, it is clear that enhancement contributed to recent annual escapements (Figure 1).

The objective of this working paper was to provide our first quantitative assessment of a biologically-based escapement goal for chinook salmon that spawn naturally in the Cowichan River. The report provides:

(a) a review of the escapement monitoring programs and recommends escapement values for use in assessments;
(b) the results of a cohort analysis for Cowichan fall chinook reared and released from the Cowichan Hatchery, and
(c) a stock-recruitment analysis of this data and a revised escapement goal for this stock.

To estimate the Age 3+ adult production of Cowichan chinook, parameters from the cohort analysis are applied to the age-structured terminal run data for the Cowichan River fall chinook.

The working paper summarized age-structured terminal runs since 1981, cohort parameters, and estimated total adult production by brood years since 1981. Notable results from the cohort analysis include the recent trends to low marine survival rates (Figure 2) and recent reductions in fishery exploitation rates. Exploitation rates on the Cowichan fall chinook has been substantially reduced in recent years. Current total exploitation rates are between 30 to 40%, and have contributed to maintaining the spawning population given the reduced marine survivals indicated above. It is notable, however, that for brood years during the 1990s incidental mortality have accounted for 33% of the total Adult Equivalent Factor (AEQ) fishing mortality.

A notable result from this analysis is the inverse relationship between the proportion of chinook spawning naturally that were of Cowichan Hatchery origin (pHat) and the returns per spawner in this data set (Figure 3). At present, these data suggest a limiting interaction between hatchery and natural production in this system. A Ricker stock-recruitment model, that included 'pHat' as a co-variate, provided a significant fit to this data set (Figure 4). The analysis resulted in the following parameters for fishery management.

Point estimates from the fitted Ricker model and statistics from the bootstrap simulations to estimate standard errors and 90% confidence intervals.

MSY	Model Estimate	Bootstrap Mean	Bootstrap SntDev	95% Bootstrap CI
S_{msy}[6]	6573	7405	3522	(4185, 18915)
u_{msy}[7]	0.705	0.659	0.117	(0.361 , 0.794)

To quantify the uncertainty in the parameters estimated from the Ricker function with pHat as the co-variate, bootstrapping of the data set was conducted (Figure 5).

Based on the Ricker model, excluding the 1986 and 1987 brood years, with the proportion of hatchery fish in the naturally spawning population as a co-variate; the biologically-based escapement goal for adult fall chinook in the Cowichan River was estimated to be 7400 (90% CI = 4185, 18915). The associated maximum sustainable exploitation rate at S_{MSY} was estimated to be 0.659 (90% CI = 0.361, 0.794).

The authors discussed the limitations and interpretation of this analysis but recommend the above values as the first biologically-based escapement goal for Cowichan River fall chinook. Further, they noted the potential for future concern in this stock if current levels of marine survival continue. At present survival rates (e.g., less than 1% survival to Age 2 recruitment), Cowichan fall chinook salmon

[6] the estimated number of spawners that will, on average, provide maximum sustainable yield or maximum surplus production available for harvest
[7] the estimated exploitation rate at Smsy (i.e., the maximum portion of the production that can be harvested and still provide the Smsy)

will not be able to sustain recent spawning population sizes. Presently, the rate of decline has been minimized by the reductions in ocean fishery exploitation rates. The escapement trend and fishery exploitation on this population must be closely monitored in the next few years to minimize risks of a more serious conservation issue developing.

Reviewers' Comments

Reviewer #1

The first reviewer of this paper acknowledged that the purpose was clearly stated. Several concerns were presented regarding the quality of the data and the clarity of the methods used (e.g. the derivation of the expansion factors used to estimate spawner counts, the accuracy of the native catch and the absence of the number of samples from which age determinations). It was stated that enough special conditions and variations existed within the escapement data sources that a case could be built that recent year escapement increases are due more to methodological biases than to biology. The reviewer recommended presentation of CWT return expansions from which fishing mortality estimates were derived. Concern was expressed over the influence of several uncertain but extreme data points on the subsequent calculations of the escapement goal.

It was this reviewer's opinion that the authors' first recommendation did not reflect the full level of uncertainty in the data sources and analyses. He agreed that both Limit Reference Points and Target Reference Points needed further development but stated that the adoption of the "biologically-based" escapement goal as presented was premature. The authors' suggestions to maintain CWT and escapement assessment programs for this stock were supported. Improvements in quality control of the data were advocated. The recommendation that exploitation rates not be increased until productivity rates are known to be increasing was supported.

Reviewer #2

The reviewer stated that the paper provided a first evaluation of a biologically-based escapement goal and that the title of the paper should clearly reflect that it is a first evaluation. It was this reviewer's opinion that the data and methods were explained in sufficient detail to properly evaluate the conclusions and sufficiently specified the uncertainty of the data.

The reviewer indicated that the main recommendation of the paper should be presented in a form that would note its limitations and that would provide a full understanding to fisheries managers. This would include, in addition to the first assessment of a biologically-based escapement goal of 7,400, that the 95% CI points of 4,185 to 18,915 includes the interim goal of 11,600. The reviewer noted that the authors' suggestion as to an appropriate use of this first assessment be included. Recognizing that further research may be required, the reviewer recommended clarification of the relationship and importance of enhanced/wild survivals, the goal for naturally spawning escapement and the present poor marine survivals.

Subcommittee Discussion

The Subcommittee noted that the escapement goal was empirically based and derived from a 20 year data set, 11 years of which were collected as part of the Pacific Salmon Treaty key stream program. The Subcommittee also noted that this was the first empirically defined escapement goal for Cowichan River fall chinook.

The appropriate presentation of the escapement goal was discussed. References to Target Reference Points and Maximum Sustainable Yield may not be the best characterization of the revised goal as presented in the paper. It was noted that the confidence intervals of the biologically-based escapement goal encompassed the interim escapement goal of 11,625. The suggestion was made that, since there is no statistical difference between the interim goal and the revised biologically-based goal, that a better description of the revised goal would be as an update rather than a reduction.

The lack of a recommendation regarding the natural versus hatchery interaction was questioned. This suggested that there was a significant effect of the portion of hatchery fish and the naturally-spawning population, however, the possibility exists that this was a statistical artifact resulting from declining marine survival. It was agreed that close monitoring of the hatchery component in the naturally-spawning population was needed, and that a report on the return from the very small release from the 1997 brood year could be informative.

Due to three common problems in stock recruitment analysis (e.g. short time series of data, aggregation of escapement ranges, and trends in marine survival), the Subcommittee noted that the parameters of the stock recruitment function are likely to be poorly defined. As a result, the Subcommittee advises that managers should continue to test escapements in excess of this goal in order to continue evaluation of the production potential of Cowichan River chinook. Further, the Subcommittee requested more detail on the availability and utility of juvenile data to help determine freshwater capacity.

Subcommittee Recommendations

1. The Subcommittee recommended the biologically-based escapement goal of 7400 (95% CI = 4200, 19000).

2. The Subcommittee recommended development of an escapement policy that allows escapements in excess of the goal to further evaluate production potential of this stock.

3. The Subcommittee recommended continuance of the present programs of coded-wire tagging, intensive escapement monitoring and juvenile assessments. The Subcommittee also recommended to continue to examine the production dynamics in this stock and to monitor the effect of recent low marine survival.

4. The Subcommittee recommended investigation of the effect of enhancement on wild stock productivity and the estimated “biologically-based” goal.

5. The Subcommittee recommended exploitation rates on this stock should not be increased until productivity rates are known to be increasing.

S00-18: Stock description and biologically-based escapement goals for the Harrison River fall chinook

B. Riddell, D. Chen, G. Brown **Accepted subject to revisions**

Summary

The Harrison River fall chinook (*Oncorhynchus tshawytscha)*, also known as the Fraser River Late stock, is the largest naturally spawning population of chinook salmon in British Columbia.

The Harrison River originates from Harrison Lake situated in the lower Fraser valley in an area of coastal rainforest in southern British Columbia. The river flows southwest for approximately 16.5 km and joins the main Fraser River 116 km upstream from the sea. Spawning takes place in the stable main channel areas that are normally protected by Harrison Lake from flow fluctuations. Adults return to the Harrison River in September and October with peak spawning occurring in late October and November. Harrison River chinook are a white-fleshed population whose fry emigrate from freshwater almost immediately after emergence (Starr and Schubert 1990).

For Harrison River fall chinook, an interim escapement goal was set at 241,700 fish, which was double the 1984 mark-recapture estimate since the Harrison River was a designated key-stream indicator (Staley 1990, Starr and Schubert 1990).

The objective of this working paper was to provide our first quantitative assessment of a biologically-based escapement goal for chinook salmon that spawn naturally in the Harrison River. The report provides:
(a) a review of the escapement monitoring programs conducted in the Harrison River,
(b) the results of a preliminary habitat assessment of spawning area,
(c) results of a cohort analysis for Harrison River fall chinook stock reared and

released at the Chilliwack Hatchery, and

(d) a stock-recruitment analysis of this data and a new escapement goal for this stock.

To estimate the Age 3+ adult production of Harrison chinook, parameters from the cohort analysis are applied to the age-structured terminal run data for the Harrison River fall chinook. The data used in the stock-recruit analyses for Harrison fall chinook are presented in tables 6 and 7 of the working paper.

A Ricker stock-recruitment model, that included the cohort estimates of brood year marine survival, provided a significant fit to this data (Figure 6), and the following parameters for fishery management (see table below). Measures of confidence about these management parameters were assessed using bootstrap simulations of residuals to the Ricker model (Figure 7).

Point estimates from the fitted Ricker model and statistics from the bootstrap simulations to estimate standard errors and 90% confidence intervals:

MSY	Model Estimate	Bootstrap Mean	Bootstrap STD	Bootstrap 90% CI
S_{msy}	72,497	75,481	27,450	(42,349, 149,485)
u_{msy}	0.739	0.749	0.082	(0.547 , 0.865)

The biologically-based escapement goal derived from this stock-recruit analysis is much smaller than the interim goal of 241,700 chinook and values based on more recent habitat assessments (Figure 8). The stock-recruit analysis, however, and the resulting escapement goal should not be dismissed. The number of brood years submitted to the analysis was adequate though minimal. The contrast in range of spawner population size was within the acceptable range for proceeding with the analysis and there was considerable range in brood year productivity. The model, including a term for marine survival (representing certain kinds of environmental variation), was highly significant as were each of the estimated parameters, and the model explained a substantial amount of variation in the stock-recruit data. Finally, the bootstrap analysis agreed closely with the point estimates from the stock-recruit model. This analysis provides an empirical assessment of a biologically-based goal that can form the basis for current management and a basis for future comparisons and/or re-assessment.

Typically, such models often overestimate the productivity of a stock and the exploitation rate it can sustain. That may also be the case with the model developed here, but given the above comments, the authors recommend a revised escapement goal of 75,500 chinook (based on the bootstrap simulation). The authors further suggest, however, that it should be reviewed as more information is acquired concerning the capacity of spawning habitat in the Harrison River. Further, the indication the authors' have from this analysis is that environmental variation (e.g., marine survival) has a very significant effect on production from this stock.

Reviewers' Comments

Reviewer #1

The reviewer raised serious concerns with respect to the validity of the paper's recommendation that the escapement goal should be reduced from 241,700 to 75,500 natural spawners. The reviewer felt the basis of the goal reduction is dependent on the reliability of the cohort analysis and the accuracy of its input data. There are deficiencies in the cohort analysis that are sufficiently serious to question the validity of the exploitation rate estimates and, consequently, the proposed goal. Reviewer #1 felt that part of the problem may be that the authors do not provide adequate detail in support of their input data and the basic assumptions underlying their analysis. Specifically, this reviewer is concerned that: the escapement data are prone to a level of bias and random error that is inconsistent with the standard expected of an exploitation rate indicator stock; all components of the escapement are not included in the analysis; and the assumption of transferability of output to the naturally spawning stock may be invalid. The reviewer felt the working paper needs extensive revision to establish the basis for the cohort analysis and for the application of the results to the naturally spawning stock. Specifically, the source data should be presented in detail and better described, and simulations are required to demonstrate that input error (within reasonable bounds) in both the cohort and stock-recruitment analyses will not introduce substantial error in the results. The reviewer felt that if the authors can establish the validity of the cohort analysis, then the stock-recruitment inputs also require modification to address other concerns regarding data quality and variable spawning success. If the cohort analysis is invalid, then the goal should be withdrawn. Regardless, this reviewer felt that the habitat-based goal should be better described and thoroughly evaluated. The paper demonstrates the need for exploitation rate and survival estimates for this important and unique stock. The authors should explore options for either increasing the number of coded-wire tags (CWT's) in the Harrison population or improving escapement estimation in the Chilliwack.

The reviewer concluded that the data and methods as presented are not adequate to support the conclusion that the escapement goal should be reduced to 75,500 naturally spawning chinook, and he recommended the rejection of the paper pending the extensive revisions necessary to support the use of these analyses.

Reviewer #2

The reviewer stated that the purpose of the paper is not clear since the title suggested a comprehensive treatment of escapement goals while the paper deals in depth with only one approach to setting the goals with little attention to biological sensitivities and implications.

The reviewer expressed a concern about the use of escapement estimates for the Harrison River for 1981-83 because these data were generated using quite different methods and are suspect. Furthermore, two of the years (1981 and 1982) produced the largest recruitment from moderate escapement estimates. The effect of these years on the results is possibly significant and the analysis should be redone with data starting with brood year 1984.

The reviewer indicated that the number and nature of the assumptions used to calculate recruitment were large and complex. The assumptions include the use of the Chilliwack hatchery “Harrison stocks” as a surrogate, escapement estimation issues in the Chilliwack, sampling and other statistical issues of the tag recovery process and potential structural problems with the cohort reconstruction (for example, the assumption of stationary natural mortalities past age 2). There is no analysis in the paper of sensitivity of the results to these assumptions.

The reviewer concluded that the large number of assumptions and the implications of the results for management are significant. There should be a comprehensive itemization of these assumptions and issues with an assessment of their implications for understanding the biology and on stock and fisheries management.

The reviewer suggested that the results are not particularly useful for management since there is no treatment of the implication for management. For example, the stock recruitment relationship in Figure 3 of the paper is flat. The yield appears to be insensitive to spawning escapement level. If this is true, managers need this pointed out. The reviewer also suggested that the analysis needs a more thorough treatment of the uncertainties, which in estimates of recruitment and escapement are large and complex. Neither of these issues were addressed adequately in the paper.

Subcommittee Discussion

This paper proposes a biologically based escapement goal for the largest chinook population in Canada. However, the data collated since commencing the indicator stock program (in 1984) has high variability and the authors utilize a new procedure for estimating adult production from a brood year. While the method was also applied to the Cowichan River chinook assessment (WP S00-17), this assessment involves two significant differences: the cohort analysis is estimated for the Harrison stock reared at a different site (Chilliwack Hatchery), and magnitude of change from the interim goal (241,700) is very substantial.

Considerable discussion focused on the uncertainties with the data used and the impact of these on the estimate of the biologically based escapement goal. Both reviewers expressed concerns about potential errors in the recruitment of

Harrison River stock based on the application of a cohort analysis and escapement program conducted in the Chilliwack River and hatchery (Harrison fall white chinook stock transferred to this hatchery in 1981). The authors acknowledged that there are no direct tests possible concerning the accuracy of the Chilliwack escapement estimates but that they had compared the cohort results with rates from other indicator stocks with known escapement values. Exploitation rates, maturity rates by age, and trend in marine survival were all comparable to these other indicators (Cowichan River, Big Qualicum River chinook stocks). Further, the distribution of these Chilliwack releases was the same as for coded-wire tagged groups released from the Chehalis Hatchery in the Harrison River.

One reviewer was concerned that assumptions in the actual cohort analysis method would affect estimates of production when applied in this manner and that these uncertainties had not been accounted for. Again, the authors acknowledged the potential for such impacts (e.g., variation in natural mortality rates by age assumed in the chinook cohort models) but noted that there are currently no reasonable alternatives. The reviewers suggested that possible errors in Chilliwack chinook escapement estimates may produce serious biases from application of the cohort analysis. The Subcommittee requested the use of simulation analysis to explore the sensitivity to possible errors and to capture the full range of uncertainty in the results of this analysis. The conduct of a defensible escapement program and/or documentation and review of the historic Chilliwack escapement estimation procedures will assist in clarifying this concern.

The Subcommittee also noted that there are well known errors associated with conducting stock-recruitment analysis on such data sets (e.g., short time series of observations from stocks that have had a long history of over-fishing, and subject to changing patterns in marine survivals). Frequently, such analyses result in over-estimating the productivity of the stock while under-estimating the optimal spawning population size. The authors were certainly aware of these concerns and had included corrections for these biases in the analysis and paper, but these are the only data available. Both reviewers, for example, were concerned about inclusion of the 1981-1983 spawning years since these were the last escapements determined by visual inspection by fishery officers and they had the largest production values in the data presented. The authors noted that omitting those years would greatly reduce the contrast in the data, but will provide results with and without inclusion of these data.

The Subcommittee recognized that the existing interim goal of 241,700 had no statistical or biological basis. After considerable discussion, the Subcommittee accepted the 75,000 (90% CI 42,000 – 149,000) escapement goal based on a stock-recruitment analysis presented in this working paper. The Subcommittee discussed the potential for applying a buffer to hedge against uncertainty in this result. For example, choosing a percentile (greater than the 50% value) of the probability distribution based on the bootstrap estimate of the goal could be adopted. Another option discussed was to accept the goal as presented, and to apply a precautionary harvest policy such as stepped harvest rates. Such a policy would protect the stock at low stock sizes and allow for continued examination of the production capacity of the stock at large stock sizes.

Concern was noted that the new goal could underestimate the freshwater capacity for juvenile production given the potential spawning capacity in this system. Further, estimates of the habitat capacity are not directly comparable to estimates of the maximum yield (expected on average) that is the basis of stock-recruitment analysis. The Subcommittee noted that studies of juvenile abundance could refine estimates of freshwater capacity and allow the development of a goal based on maximizing juvenile production.

Subcommittee Recommendations

1. The Subcommittee recommended acceptance of the biologically based escapement goal of 75,000 (90% C.I. = 42,000 – 149,000) based on a stock recruitment analysis.

2. The Subcommittee recommended development of an escapement policy, that allows escapements in excess of the goal to further evaluate production potential of this stock.

APPENDIX 1: PSARC SALMON SUBCOMMITTEE MEETING AGENDA, MAY 1-5, 2000

Monday May 1, 13:00 – 16:30

Introductions and procedures
Biological reference points for conservation and management of steelhead (T. Johnston et al.)
Stock status and review of escapement goal for the Cowichan River chinook population (B. Riddell et al.)

Tuesday May 2, 08:30 – 16:30

The status of Rivers Inlet chinook stocks (R. McNicol)
Assessment of Campbell/Quinsam Chinook salmon (D. Nagtegaal et al.)
Lunch
Stock description and biologically-based escapement goal for Harrison River fall chinook (B. Riddell et al.)
Review of Rapporteur reports

Wednesday May 3, 08:30 – 16:30

Status in 1999 of coho stocks adjacent to the Strait of Georgia (K. Simpson et al)
Stock status and genetics of Interior Fraser coho salmon (Pre –Cosewic) (J. Irvine et al.)
Lunch
In-season indications of run-strength and survival for northern B.C. coho (B. Holtby)
Review of Rapporteur reports

Thursday May 4, 08:30 – 16:30

2000 forecasts for Johnstone Strait, Georgia Strait and Fraser River chum salmon (V. Palermo et al.)
A preliminary review of a new model based on test fishing data analysis to measure abundance of returning chum stock to the Fraser River (B. Gazey et al)
Lunch
Overview of salmon stock assessment frameworks in the Pacific Region (B. Holtby)
Evaluation of utility of aerial over flight based estimates versus mark-recapture estimations to the Nicola River, B.C. (R. Bailey et al.)
Review of Rapporteur reports

Friday May 5, 08:30 – 16:30

Review of Rapporteur reports and report preparation

APPENDIX 2: PSARC SALMON WORKING PAPERS FOR MAY 2000.

Paper #	Title	Authorship
S00-08	Biological reference points for the conservation and management of steelhead, *Oncorhynchus mykiss*	N.T. Johnston E.A. Parkinson A.F. Tautz B.R. Ward
S00-09	Assessment of Campbell/Quinsam chinook salmon (*Oncorhynchus tshawytscha)*	D. Nagtegaal B. Riddell S. Lehmann D. Ewart B. Adkins
S00-10	An assessment of Rivers Inlet chinook stocks	R. McNicol
S00-11	In-season indicators of run-strength and survival for Northern British Columbian Coho	B. Holtby
S00-12	Overview of salmon stock assessment frameworks in the Pacific Region	B. Holtby
S00-13	Status in 1999 of coho stocks adjacent to the Strait of Georgia	K. Simpson R. Semple A. Dobson J. Irvine S. Lehmann S. Baillie
S00-14	Evaluation of utility of aerial over - flight based estimates versus mark-recapture estimates of chinook salmon escapement to the Nicola River, B.C.	R. Bailey C.K. Parkin J.R. Irvine B. Rosenberger M.K. Farwell
S00-15	A preliminary review of a new model based on test fishing data analysis to measure abundance of returning chum stocks to the Fraser River	W.J. Gazey R.V. Palermo
S00-16	Stock Status and genetics of Interior Fraser coho salmon	J. Irvine R.E. Withler M.J. Bradford R.E. Bailey S. Lehmann K. Wilson J. Candy W.S. Shaw
S00-17	A biologically-based escapement goal for Cowichan River Fall chinook salmon (*Oncorhynchus tshawytscha*)	B. Riddell D. Nagtegaal D. Chen
S00-18	Stock status and review of escapement goal for Harrison River chinook population	B. Riddell D. Chen G. Brown

APPENDIX 3: PARTICIPANTS AT SALMON SUBCOMMITTEE MEETING, MAY 1-5, 2000

Subcommittee Chair: Allan Macdonald
PSARC Chair: Max Stocker

DFO Participants	Mon	Tues	Wed	Thurs	Fri
* Subcommittee Members					
Anderson, D.*	✓	✓	✓	✓	✓
Bailey, D.*	✓	✓	✓	✓	✓
Beecham, T.			✓		
Bradford, M.*	✓	✓	✓		
Brown, G.	✓	✓	✓	✓	
Carter, T.	✓	✓			
Candy, J.			✓		
Cass, A. *	✓	✓	✓	✓	✓
Chen, D.	✓	✓	✓	✓	
Cox-Rogers, S.		✓	✓	✓	✓
Finnegan, B.		✓			
Godbout, L.	✓				
Hargraves, B.*	✓		✓		
Holtby, B.*	✓	✓	✓	✓	
Hyatt, K.*		✓	✓	✓	✓
Irvine, J.*	✓	✓	✓	✓	✓
Jantz, L.*	✓	✓	✓	✓	✓
McNicol, R.	✓				
Meerburg, D.*	✓	✓	✓	✓	
Nagtegaal, D.	✓	✓			
Parken, C.	✓	✓			
Riddell, B.*	✓	✓	✓	✓	
Rutherford, D.	✓	✓			
Semple, R.	✓	✓			
Shaw, B.	✓		✓		
Sullivan, M.*	✓	✓	✓	✓	✓
External Participants:					
Atkinson, M.	✓	✓	✓	✓	
Gazey, B.				✓	
Harling, W.	✓	✓	✓		
Johnston, T.	✓				
Kritistianson, G.		✓	✓		
LeBlond, P.				✓	
Otway, B.	✓	✓	✓		
Rezansoff, B.		✓	✓	✓	
Routledge, R.	✓	✓			

Staley, M.	✓	✓	✓	✓	
Tautz, A.*	✓	✓	✓	✓	
Wilson, K.	✓	✓	✓	✓	
Observers:					
Blackbourn, D.	✓	✓	✓	✓	

List of Reviewers

Anderson, D.	DFO, Stock Assessment Division
Amiro, P.	DFO, Science Branch, Maritimes Region
Bradford, M.	DFO, Marine Environment and Habitat Science Division
Brown, G.	DFO, Stock Assessment Division
Cass, A.	DFO, Stock Assessment Division
Chen, D.	DFO, Stock Assessment Division
Cox-Rogers, S.	DFO, Stock Assessment Division
Gjernes, T.	DFO, Recreational Fisheries
Healy, M.	University of British Columbia
Houtman, R.	DFO, Stock Assessment Division
Hyatt, K.	DFO, Stock Assessment Division
Jantz, L.	DFO, Fisheries Management
Luedke, W.	DFO, Stock Assessment Division
McElhany, P.	National Marine Fisheries Service
Meerburg, D.	DFO, Science Branch, National Capital Region
Palermo, V.	DFO, Science Branch
Parken, C.	DFO, Stock Assessment Division
Peacock, D.	DFO, Stock Assessment Division
Ryall, P.	DFO, Fisheries Management
Schubert, N.	DFO, Habitat and Enhancement Branch
Staley, M.	Fraser River Watershed Committee
Tautz, A.	B.C. Ministry of Fisheries
Walters, C.	University of British Columbia

TABLES AND FIGURES

Table 1. Total expected return of Johnstone Strait, Georgia Strait and Fraser River wild chum salmon for 2000.

WILD STOCK (FRASER AND NON-FRASER)		
Long-term average return by calendar year (AVGCY)		1,750,528
Probability of achieving specified run size or larger:	90%	864,879
	80%	1,104,287
	75%	1,226,693
	25%	2,531,069
ENHANCED STOCK (FRASER AND NON-FRASER)		
3 year average brood year survival (1992-94)		348,573
5 year average brood year survival (1989-94)		341,555
TOTAL WILD + ENHANCED		
3 year average brood year survival (1992-94)		2,099,101
5 year average brood year survival (1989-94)		2,092,083

Table 2. Table of Contents for an Assessment Framework

This is a very rough idea of what should be in an Assessment Framework.

1. Introduction
2. History of assessment for species in region
    2.1. Development of management and assessment
    2.2. Current assessment objectives and assessment framework
    2.3. Current management objectives and management framework
3. Knowledge base for species (akin to Phase 0 of New &Developing Fisheries)
    3.1. Relevant aspects of natural history
    3.2. Habitat dependencies and status
    3.3. Ecosystem dependencies and interactions
    3.4. Current fisheries and constraints on fisheries management
4. Definition of conservation units
    4.1. Post-glacial history
    4.2. Population genetics structure
    4.3. Phenotypic variation
    4.4. Other factors
5. Measures of status- what is available, how much does it cost and what does it give you per unit cost
    5.1. Definition of risk in species context
    5.2. Benchmarks–derivation of *LRP*s and *TRP*s
6. Alternative assessment frameworks
    6.1. Measures of status
    6.2. Measures of productivity
    6.3. Measures of fishing mortality
    6.4. Population models
    6.5. Fishery models
    6.6. Alternative frameworks and activity components
7. Data systems, ownership and responsibilities
    7.1. Data requirements for assessment
    7.2. Data ownership: responsibilities and accountabilities
    7.3. State of required assessment data
8. Risk management
    8.1. Risk-management models
    8.2. Costing of alternative frameworks
9. Development and communication of advice
    9.1. Clients and advice requested
    9.2. Communication of advice including risk assessments
10. Summary and recommendations
    10.1. Assessment framework
    10.2. Relationships between cost, fishing intensity and risk
    10.3. Recommendations for further development

Figure 1. Estimate spawning escapements of the Cowichan River fall chinook and comparison with the interim escapement goal established in 1984. Bar height determined by the sum of the number of natural spawners plus the brood stock removed for use in the hatchery.

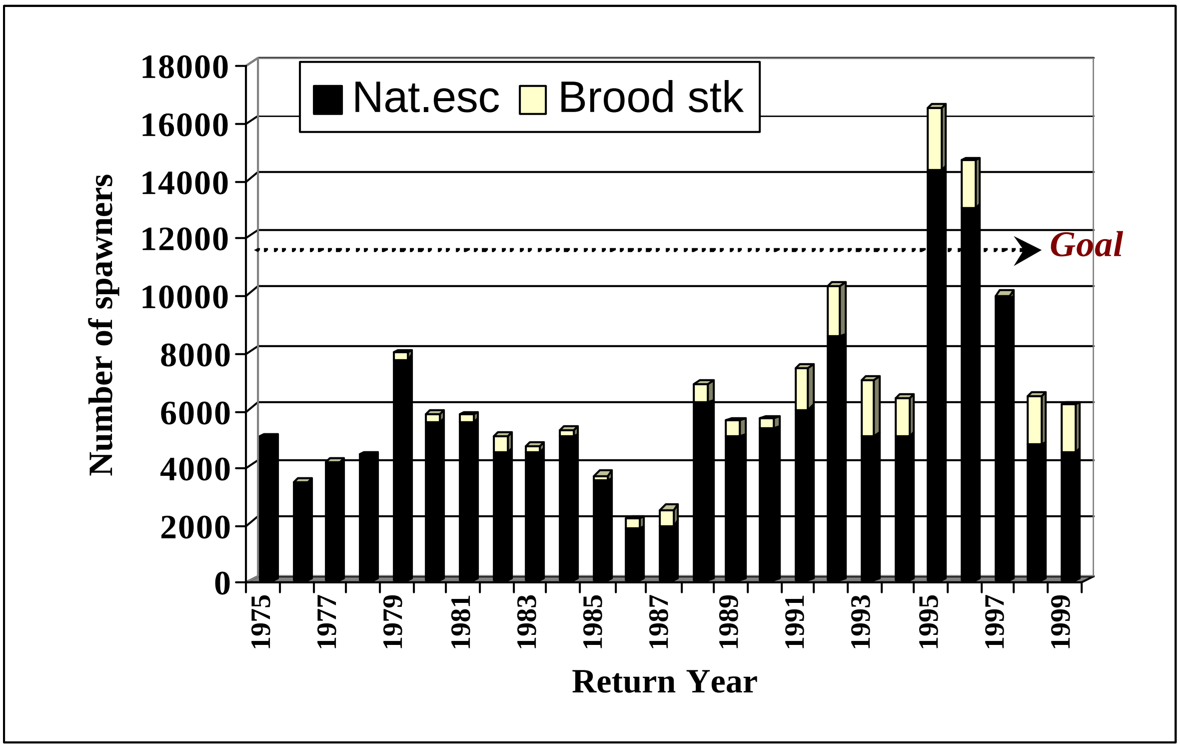


Figure 2. Estimated marine survival rates for Cowichan fall chinook released from the Cowichan hatchery, brood years 1985 – 1996 (recoveries in the latter brood are incomplete but are extrapolated using the average maturation rate for Age 3 chinook observed in 1999).

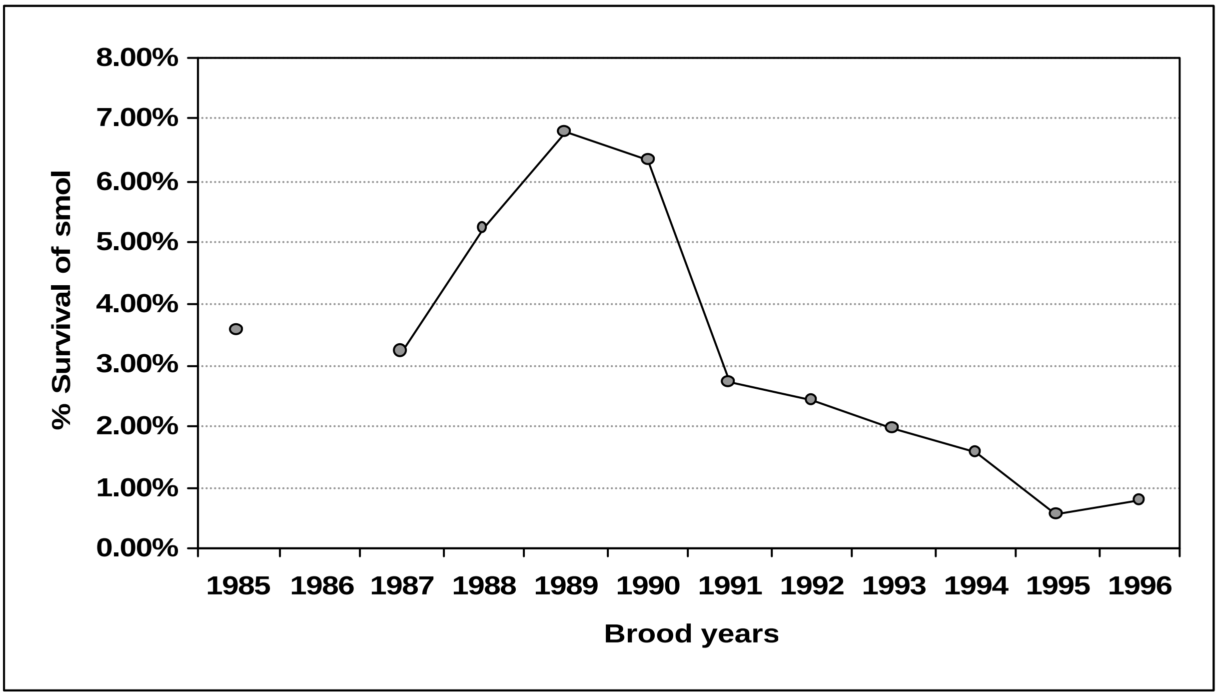


Figure 3 . Linear regression of Log (Recruits/Spawner) versus pHat in Cowichan River. The linear regression was highly significant (p = 0.0002, r-square = 0.69), and each co-efficient in the regression was significant. The regression equations was: Log (R/S) = 1.8696 – 3.5827 pHat

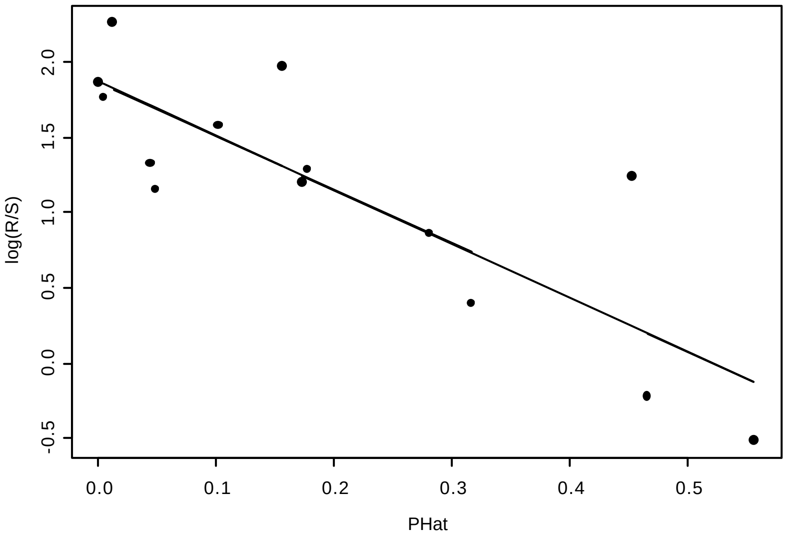


Figure 4. Ricker stock/recruitment plots for Ricker model (Stock only) and the S/R model with Stock and pHat as the covariate. The solid is Ricker model only and the dashed is Ricker model with pHat included for the Cowichan fall chinook stock.

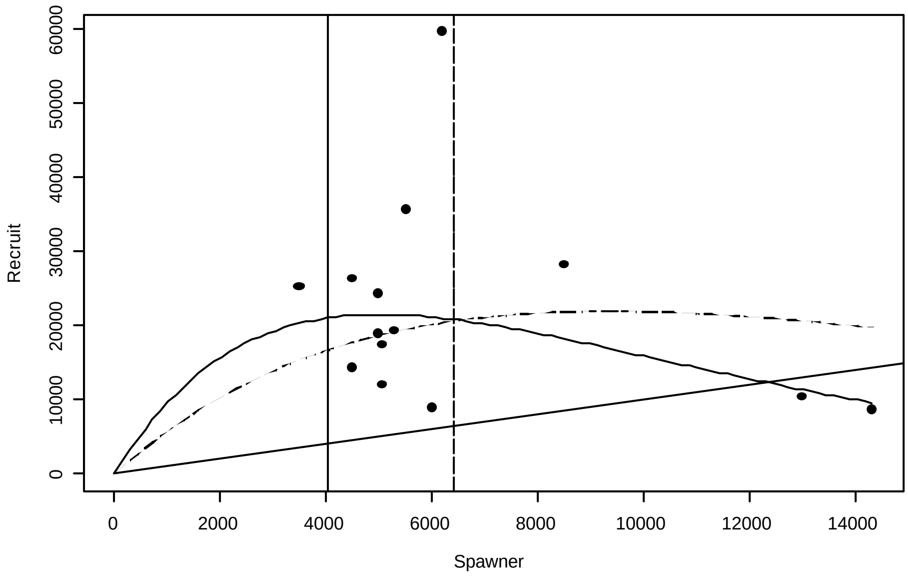


Figure 5. Bootstrap simulations about the estimates of S_{MSY} and $U_{MSY.}$ for Cowichan fall chinook salmon. The vertical solid line is the observed (parameters from the fitted model) and the dashed lines are the mean from the 990 bootstrapped samples.

Figure 5. S_{MSY} **Figure 5. U_{MSY}**

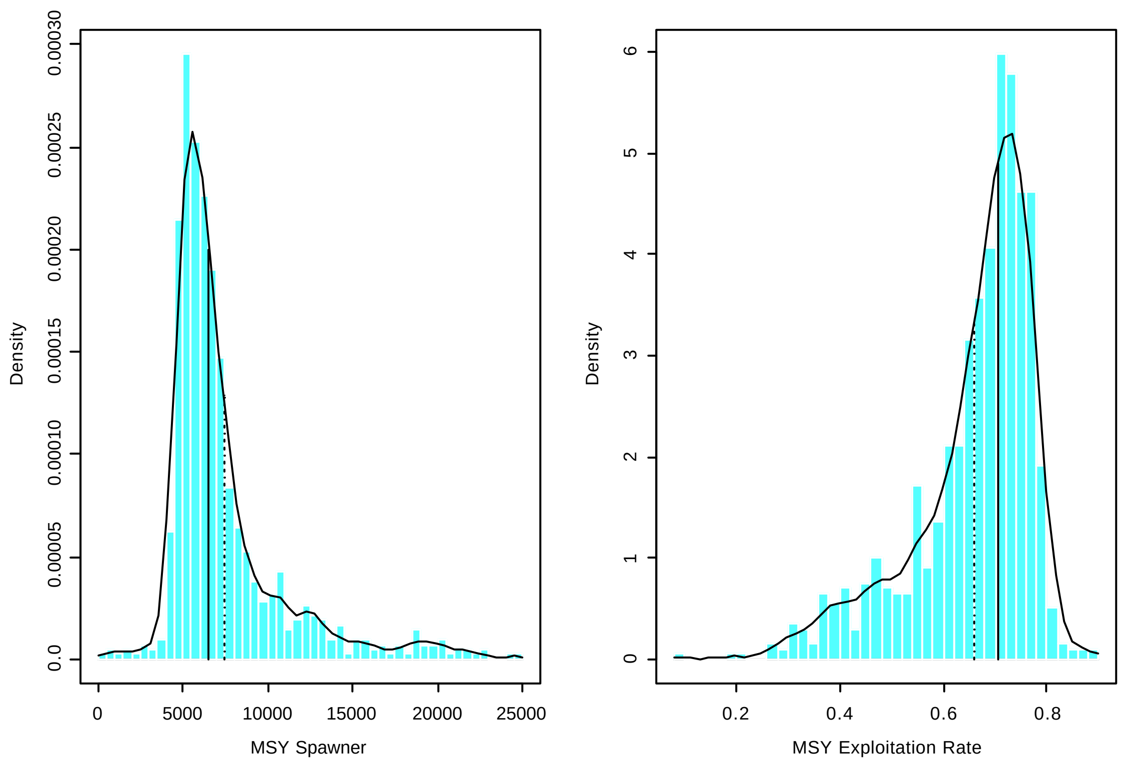


Figure 6. Data and fitted S-R model (points for actual data, line for Ricker model and associated S_{msy}, dashed line for Ricker model with survival rate and associated S_{msy}) for the Harrison River fall chinook stock.

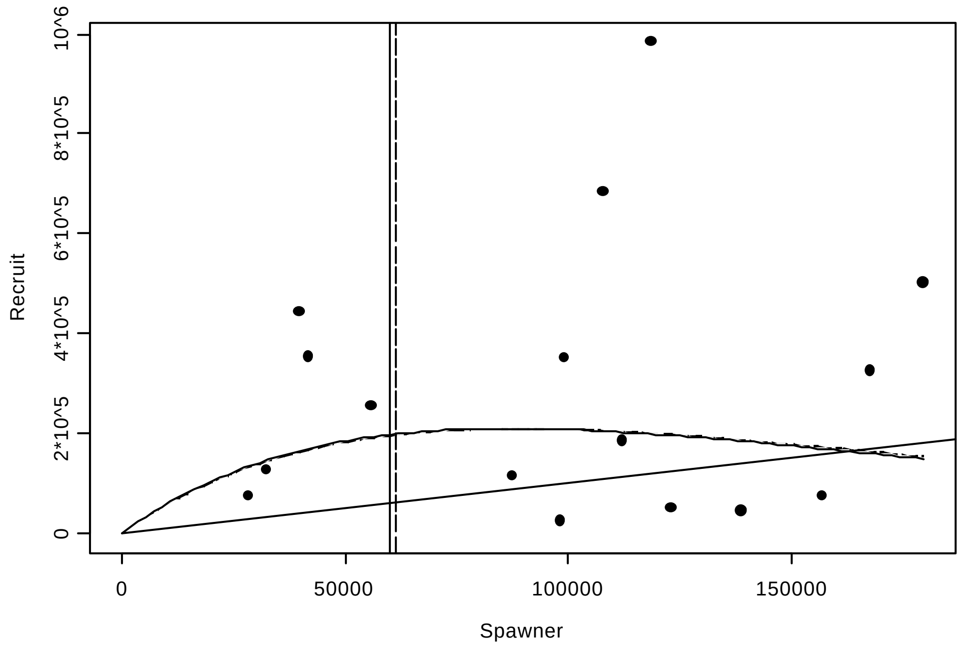


Figure 7. Distributions for optimal spawning abundance, $\hat{S}_{msy}$, and optimal exploitation rate, U_{msy}, obtained from the bootstrap simulation analysis. The vertical lines show the mean $\hat{S}_{msy}$ value (left panel) and the mean U_{msy} value (right panel) for the Harrison fall chinook stock.

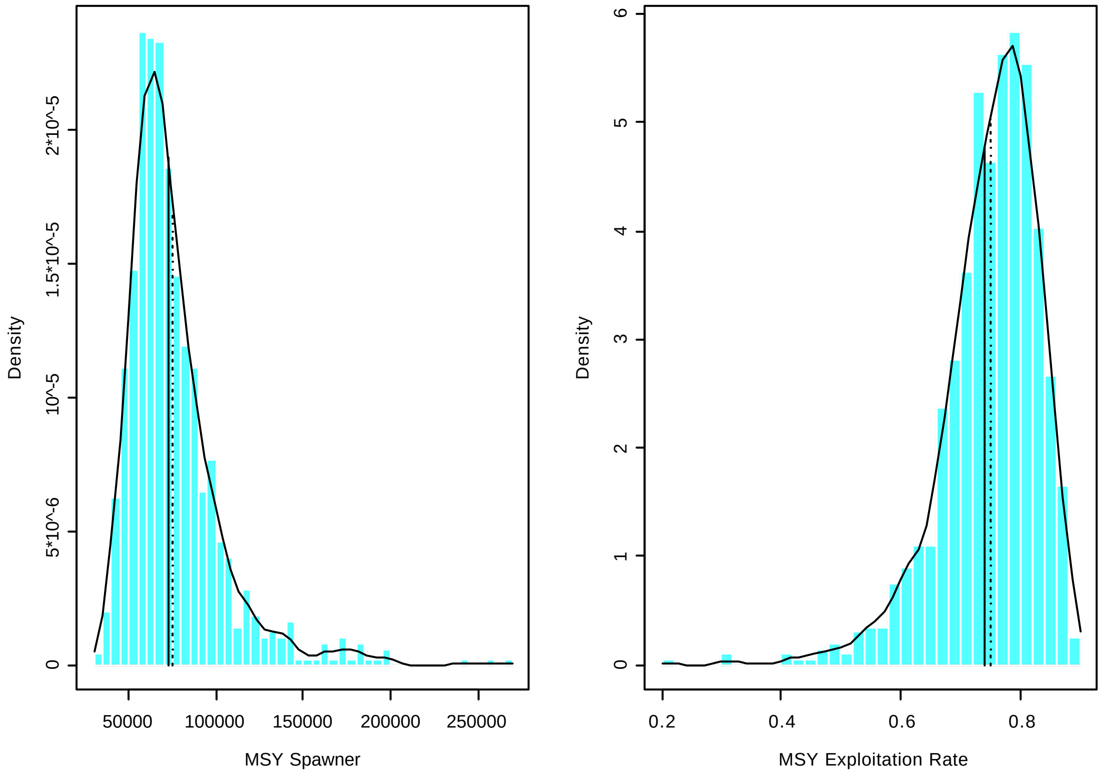
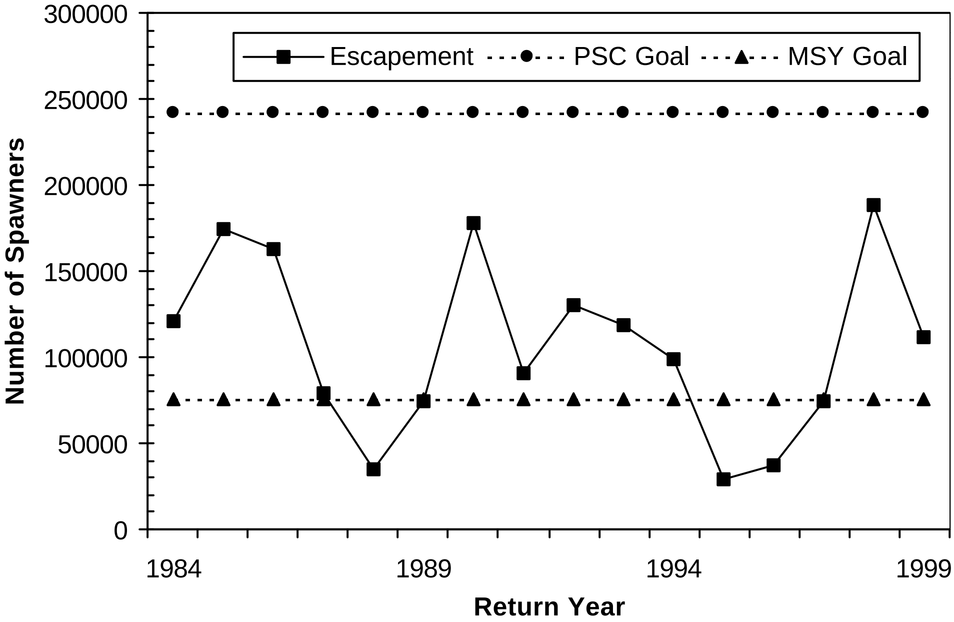


Figure 8. Estimated annual adult escapement for Harrison River fall chinook and two escapement goals: 1) the interim goal established for the Pacific Salmon Commission (PSC goal) and the biologically-based goal developed in this report (MSY goal).



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