Canadian Stock Assessment
Proceedings Series 97/21

Évaluation des stocks canadien
Séries des comptes rendus 97/21

# Report of the PSARC Salmon Subcommittee Meeting April 29-May 2, 1997 and the Steering Committee Meeting June 5, 1997

J. Rice and D. Peacock (Editors)
Pacific Stock Assessment Review Committee (PSARC)
Pacific Biological Station
Nanaimo, British Columbia V9R 5K6

June 1997

Fisheries and Oceans Canada
Science

Pêches et Océans Canada
Sciences

Canada

# Report of the PSARC Salmon Subcommittee Meeting April 29-May 2, 1997 and the Steering Committee Meeting June 5, 1997

J. Rice and D. Peacock[1] (Editors)
Pacific Stock Assessment Review Committee (PSARC)
Pacific Biological Station
Nanaimo, British Columbia V9R 5K6

June 1997

[1] Fisheries and Oceans Canada
Stock Assessment Division
202-417 2nd Avenue West
Prince Rupert, B.C. V8J 1G8

**PACIFIC STOCK ASSESSMENT REVIEW COMMITTEE**

**PSARC ADVISORY DOCUMENT 97-1**
**JUNE 1997**

# PACIFIC SALMON

## I. STEERING COMMITTEE REPORT

The PSARC Steering Committee met June 5, 1997 in the Seminar Room at PBS, Nanaimo to review the Salmon Subcommittee Report. Steering Committee provided the following comments pertaining to individual Working Papers summarized in the Subcommittee Report. The Steering Committee also reviewed a report generated from the Adhoc Subcommittee Meeting on Marine Environment and Habitat Issues which was held March 10-12, 1997.

Major Steering Committee Concerns:

1. Working papers S97-5 and S97-6 highlight the serious state of coho in southern British Columbia. The Steering Committee has grave concerns with the current state and recent trajectory of Strait of Georgia and Fraser River coho. Those concerns are heightened by the absence of any indication that the situation will ameliorate in the next cycle (three to four years).

2. The Steering Committee concurs with the Subcommittee's dissatisfaction with the current state of coho assessment in the region and emphasizes the Subcommittee's concern that the credibility of PSARC is compromised by the continuing failure of the coho assessment unit to produce critical assessment documents for PSARC review. The Steering Committee notes that two Working Papers are urgently needed and recommends that their preparation be given the highest priority:

   a) A comprehensive coho assessment strategy, which would include:
      i) explicit statement of objectives and in particular conservation objectives;
      ii) a critical assessment of the current strategy;
      iii) development of a risk-averse framework for fisheries management;
      iv) development of criteria for determining acceptable levels of risk for coho populations;
      v) an examination of whether conservation objectives can be achieved through a harvest strategy;
      vi) a review of the characteristics and utility of current indicator streams;
      vii) development of a method for rationalizing resource expenditures within the proposed assessment framework, that explicitly deals with perceived need for additional indicator streams and continued juvenile density size estimates; and;
      viii) a discussion of alternative strategies,

   b) Assessment of Skeena River coho to include status and trajectory of interior stocks and recommendations for total exploitation rate with the context of a risk-averse approach.

3. The Steering Committee highlights the need to develop assessment strategies and operational definitions of conservation objectives for all managed species, although these are most urgently needed for coho. Without explicit conservation objectives defined within a formal assessment strategy, PSARC will be unable to provide advice on the adequacy of current assessments, nor will PSARC be able to provide the best advice for achieving conservation or production objectives. The Steering Committee therefore recommends that assessment strategies and conservation objectives be developed for all managed species.

4. The Steering Committee notes the increasing profile of recreational fisheries throughout the region and further notes that increases in the level of Departmental accountability in the monitoring of these fisheries should be anticipated. The Steering Committee therefore recommends that a regional strategy for the monitoring of recreational fisheries be developed.

5. The Steering Committee suggests that all high profile or large studies should be preceded by an independent review of the study design, including a sensitivity analysis to insure that the study design is statistically sound and that biases which may affect most seriously the eventual assessment advice are adequately determined. As a general principle of good science the methods section of all Working Papers should include explicit treatments of the appropriateness and sensitivity to bias of the study design employed. The Steering Committee notes that in some instances this issue could be dealt through Working Papers dealing with general methodologies.

**S97-1 Assessing the historical estimates of northern diversion of Fraser River sockeye salmon.**

The Steering Committee supported both Subcommittee recommendations, and notes the importance of documenting historical methods of estimating the diversion rate.

**S97-2 Catch and effort surveys conducted on the first nations sockeye fisheries in the Fraser River between sawmill Creek and Kelly Creek, 1995 and 1996.**

1. The Steering Committee concurs with the Subcommittee that the survey design and analyses contained in WP S97-2 be accepted as appropriate for estimating catch and effort in the First Nations' sockeye fisheries on the Fraser River.

2. Following the receipt of the revised Working Paper, The Subcommittee Chair and the PSARC Chair will decide whether the revision is acceptable, should be re-reviewed by the original reviewers, or should be subject to a new review.

3. The Steering Committee acknowledges the progress that has been made in assessment of this fishery.

4. Because of the high profile of this fishery and the possibility that the nature of the fishery might change with time, the Steering Committee recommends that there be a regular review of the survey design and analyses employed in the assessment of this fishery or, at the very least, that there be a regular review of the general nature of the fishery.

5. The Steering Committee recommends that a WP be prepared updating the assessment with the results of the 1997 fishery.

**S97-3 Evaluation of 1995 Fraser River Pink Mark Recovery Escapement Estimates.**

1. The Steering Committee accepted the abundance estimate and confidence limits generated from the Strawberry Island live recovery site for 1995.

2. The Steering Committee recommends a review of the escapement program to elucidate the potential effects of biases in the mark-recapture estimates and to determine if corrections for bias are operationally feasible.

3. The Steering Committee supports the recommendation to drop the lower Fraser River mainstem pink spawning ground survey from the pink escapement estimation program.

4. The Steering Committee acknowledges the Subcommittee's concern over the importance of communicating changes in escapement programs to other agencies and clients that might be affected.

**S97-4 Angler effort and catch in the 1996 lower Fraser River sport fishery.**

The Steering Committee addresses the Salmon Subcommittee advice on the need for a regional strategy for the assessment of recreational fisheries under major Steering Subcommittee concerns.

1. The Steering Committee supported acceptance of the survey methods used in the program and the catch estimates generated in 1996.

2. The Steering Committee did not concur with the second recommendation of the Subcommittee in that both the objectives and use of the data generated were clear. However, the basis of the recommendation appeared to be a lack of communication between Stock Assessment and Fisheries Management. For that reason the Steering Committee urges closer communication between Stock Assessment and Fisheries Management in the design and conduct of creel surveys in the recreational fishery to insure that the data are appropriate and are of useable quality.

**S97-5 A 1996 Update of Assessment Information for Strait of Georgia Coho Salmon Stocks (Including the Fraser River).**

The Steering Committee suggested that the inclusion of some graphs to illustrate trends in abundance, survival and distribution, which were mentioned in the WP summary would have been informative and should be added to Subcommittee Report.

In recognition of the serious state of southern B. C. coho, the Steering Committee advanced recommendations on several of the issues raised in this WP to Major Steering Committee Concerns.

1. The Steering Committee notes that the Subcommittee recommendation is phrased in terms of the risk of coho stocks failing to reach conservation goals. The Steering Committee supports this approach and recommends that a formal risk assessment framework be developed and reviewed by PSARC.

2. The Steering Committee supports both the Subcommittee recommendation to reduce fishing mortality on coho stocks in southern BC through conservation measures in all intercepting fisheries and the Subcommittee's comments that even with no fishing there is a high likelihood that many stocks will not achieve conservation goals.

**S97-6 1997 forecasts of survival and distribution for Strait of Georgia coho salmon stocks.**

1. The Steering Committee supports the Subcommittee's acceptance of the point estimates for returns and survival of southern BC coho for 1997.

2. Because of the uncertainties in the point estimates of survival, the current downward trend in survivals, and the tendency to overestimate survivals and returns during downward trends in survival, the Steering Committee concurs with the Subcommittee that survival and abundance levels could be below the point estimates of those quantities contained in the Working Paper. In consequence, the Steering Committee urges caution be exercised in designing the fisheries exploiting southern B.C. coho during 1997.

**S97-7 Changes Associated with the 1990 Ocean Climate Shift, and Effects on British Columbia Salmon Populations.**

The Steering Committee concurs with the Subcommittee recommendation that understanding the mechanisms that affect survival is an important requirement for stock assessment. However, the Steering Committee notes that in choosing an appropriate approach to forecasting it is critically important to match the forecasting approach to the actual pattern of variation in the variable being forecast. Forecasting methods will differ depending on whether the variable of concern is varying randomly, is trending or is alternating between discrete domains. It is primarily for the purpose of discerning the

temporal patterns in production that the Steering Committee endorses the Subcommittee recommendation that a WP be prepared that assembles and analyses production time series for all species of Pacific salmon.

**Adhoc Subcommittee Report on Marine Environmental and Habitat Issues:**

Major Steering Committee Concerns:

1. The Steering Committee believes that it is important that all the implications of the draft policy document on MPAs for science and management be itemized and evaluated.

2. Steering Committee endorsed the creation of a Habitat and Ecosystem Steering Committee of PSARC. Such a forum could also review environmental impact assessments with regard to their implications for exploited stocks and their habitat. The need for this Subcommittee had previously been identified by PSARC, and the recent initiatives on MPAs makes the need for the development of such a committee even more pressing.

Marine Environmental Issues (Day I)

The Chair summarized the report on this meeting. Many of the participants at this meeting thought that DFO was already detecting changes in assessment parameters relatively well, and also doing fairly well at partitioning variability among causes, including fishing, ocean environment, and (for salmon) freshwater environment at pre-adult stages.

These participants generally viewed the weak link to be how these changes were interpreted in the context of advice to managers, as opposed to difficulties in recognizing that the changes were occurring.

The Steering Committee discussion centered on the importance of developing and maintaining time series for all relevant aquatic ecosystems. In advance of the next round of meetings, Chairs are to alert the assessment biologists to the existence of the many environmental datasets catalogued in the appendix to this report, and also through a PICES web site discussed there. Agendas of individual Subcommittee meetings should include an opportunity to discuss and identify potentially important environmental indices at the next meeting. Assessment biologists would also be encouraged to explore uses of the environmental data in assessments.

Marine Protected Areas - MPAs (Day II)

The Steering Committee noted that the recommendations contained in the draft discussion paper on MPAs for the Pacific Coast should explicitly include the goal of increasing scientific knowledge as a specific consideration during the design phase. MPAs are potentially a useful tool in understanding what limits fishery yields because

they eliminate local exploitation, but the possibility that they will improve fishery yields is as yet untested in B.C. waters.

There are now many different policy documents that use the term biodiversity, often without a clear definition. Regional staff need to be fully aware of what these policy documents imply, and how they might impact on regional issues in terms of DFO's accountability. A regional workshop to disseminate this information quickly would be valuable.

The Steering Committee also noted that the potential need for active management of MPAs may become very contentious. Getting explicit initial agreement from the various client groups at the outset of what the MPA is intended to achieve will become extremely important in such cases.

Many other items in the Subcommittee Report should be brought to the attention of the Regional Coordinator for MPAs, and revisions to the draft discussion paper should be considered. It is unclear to Steering Committee who is presently coordinating this work, however.

Steering Committee agrees that the Provincial classification proposals for marine ecosystems need to be subjected to scientific peer review with strong DFO representation prior to their acceptance as a framework for identifying representative ecosystems for inclusion as MPAs. Steering Committee agrees that PSARC would be a logical forum for that peer review.

## II. SALMON SUBCOMMITTEE REPORT

### 1. INTRODUCTION

The Salmon Subcommittee met April 29 - May 2, 1997, at the Pacific Biological Station, Nanaimo. Seven Working Papers were presented to the Subcommittee. Meeting participants and reviewers of Working Papers are listed in Appendices 1 and 2, respectively.

### 2. MAJOR SUBCOMMITTEE CONCERNS

Capacity for Coho Assessments

In spite of exceptional effort and progress in recent years, coho stock assessments are failing to keep up with the demand. The subcommittee notes there was an expectation that a paper dealing with coho conservation requirements would be available for this meeting. As this was not the case, it has been more difficult to provide specific advice on the magnitude of reductions needed in harvest rates on coho stocks in 1997 and

beyond. Models such as that expected in the coho conservation requirement paper are currently being discussed with fishery managers for implementation in 1997 yet these have not yet benefited from PSARC review. Concerns are not limited to southern areas, a PSARC paper responding to Skeena coho conservation issues has been deferred for 2 consecutive PSARC sessions and management actions are proceeding based on stock assessment advice that has not been reviewed by PSARC.

Such concerns are highlighted by the fact that the PSARC process will become more public in the coming year and public perception of PSARC's utility would be diminished if important scientific and technical discussions were bypassing the PSARC process.

## 3. WORKING PAPER SUMMARIES, REVIEWS AND DISCUSSION

### S97-1: Assessing the historical estimates of northern diversion of Fraser River sockeye salmon. Skip McKinnell

Working Paper Summary

The northern diversion estimate is an annual measure of the proportion of Fraser River sockeye returning via Johnstone Strait. Although these estimates were produced by the International Pacific Salmon Fisheries Commission for the years up to 1985, and during the past decade by the Pacific Salmon Commission, the methods have not been published. DFO produces annual forecasts of northern diversion, developed from a model that uses a strong historical relationship between sea surface temperatures at Kains Island (Quatsino Sound) in spring and the northern diversion.

The forecasts of northern diversion constitute one element of the planning process for Fraser River sockeye fisheries. Because the historical record of estimates of northern diversion is such a critical part of the forecasting, an assessment of the historical record was warranted. This work is one component of the research program on northern diversion requested by the Fraser River Public Sockeye Review Board.

Fraser River sockeye caught in Washington State, on the west coast of Vancouver Island, in Johnstone Strait, or in the Strait of Juan de Fuca are caught in fisheries approaching the Fraser River where the route taken by the sockeye around Vancouver Island is known with relatively little error. Those fish escaping from these approach route fisheries are not observed until they appear as catch at the river mouth (Statistical Area 29), as catch in upriver fisheries, or as spawning ground escapements. These terminal area catch and escapements provide no direct information on whether the sockeye arrived by a northerly or southerly approach.

The total catch of Fraser River sockeye returning via the southern approach route was computed by summing the catches in DFO Statistical Areas 20, 21 and 24-27, plus the U.S. (Washington State) catch of Fraser sockeye. The total catch of Fraser River

sockeye in the northern route was computed by summing catches in DFO Statistical Areas 11-16. The sum of these northern plus southern catches is defined as the *approach route catch*. In the 44 years between 1953 and 1995, the percentage of the total run observed in the approach route fisheries varied from 28.1% (1995) to 71.6% (1985) with a mean of 56.6%. That portion of the approach route catch taken annually in the northern route can be considered a *naive estimate* of northern diversion If one assumes the proportion of the escapement from the northern route is equal to the naive estimate. No direct measures of harvest rate have ever been made so this assumption remains untested. The northern diversion estimates produced by the commissions were compared with naive diversion estimates. The naive diversion estimate accounts for 92.6% to 93.7% (depending on whether the data from the 2 commissions is combined or not) of the variation in the northern diversion estimates (Fig. 1).

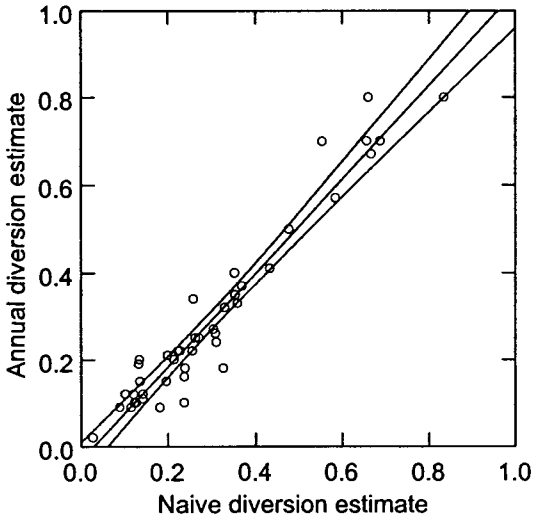


Fig. 1

This raises the question 'How wrong could the northern diversion estimates be if harvest rate assumptions are not met?' The most extreme potential error would occur if the harvest rate in an approach route was 100% i.e. all of the escapement arrived at the river mouth via one route. This line of reasoning led to the development of a simple simulation to examine the question posed above. The simulation results suggest that when the fishery in Johnstone Strait is catching approximately 80% of the fish that are available, then the naive diversion estimates are slightly biased, but not unreasonable approximations of the true diversion. However, when the fishery takes less than this, the bias in the naive diversion estimate increases. The bias is slightly greater for interior values (e.g. 50%) than the extremes (10%, 90%).

If the harvest rates are known in each route, the catches can be accurately expanded. With simulated errors of up to 20% in Johnstone Strait and 10% in the Strait of Juan de Fuca, an error of approximately equivalent magnitude is introduced into the northern diversion estimate, particularly if the harvest rate in Johnstone Strait is about 50%. The

estimates appear unbiased. The range of errors appears to decrease with increasing diversion rate and with increasing harvest rate.

**Reviewers' Comments**

The first reviewer indicated approval of the paper and found the paper to be an interesting analysis as diversion estimates are an important input into the calculation for many fisheries that harvest Fraser River sockeye. He also found the result that raw catch between the two approach routes may be indicative of diversion somewhat surprising. This reviewer also agreed with the author that the methods used by the two commissions be published, to enable a comprehensive review, and that current diversion estimates should be used for forecasting purposes until the methods are further reviewed.

The second reviewer was also supportive of the working paper and agreed with the authors recommendations regarding publishing methods and using historical time series for forecasting purposes. The appropriateness of including U.S. Area 7-A catch in the southern approach catch was questioned, and some suggestions were provided regarding the approach for choosing the harvest rates for the simulations.

**Subcommittee Discussion**

The Subcommittee accepted the Working Paper subject to minor revision. The Subcommittee noted this simple method using catch alone, recreated values similar to the historic estimates generated by the commissions, and accounted for 93% of the variation in the northern diversion estimates. However, the simulation results indicate that although the naive diversion rate estimates are unbiased for high (80%) harvest rates they progressively underestimate for lower harvest rates. The simulated naive diversion rate for 50% harvest rates underestimates the true diversion rate by 20% to 30% for mid-range (40%-60%) diversion rates. Errors in calculating harvest rates also resulted in biased diversion rate estimates in the simulations.

Given the recent changes to Canadian fisheries (e.g. reduction in fleet size, purse seine boundary changes in Johnstone Strait) that harvest Fraser River sockeye the Subcommittee is concerned these altered fisheries will affect the range and estimation of daily harvest rates and potentially affect the estimation of northern diversion using catch. Determination of the northern diversion parameter also affects estimates of harvest rates for many Fraser River sockeye fisheries.

**Subcommittee Recommendations**

The Subcommittee endorsed the continued use of historical northern diversion estimates as the basis for stock assessment advice.

The Subcommittee encourages documentation of the methodology used to determine historic diversion estimates to provide support for their continued use should future

harvest rates fall below the current averages, or if the accuracy in estimating harvest rates becomes more variable.

**S97-2 Catch and effort surveys conducted on the first nations sockeye fisheries in the Fraser River between sawmill Creek and Kelly Creek, 1995 and 1996. Vic Palermo and B. Ennevor**

Working Paper Summary

Catch estimation programs for First Nation fisheries on the lower Fraser River between Sawmill Creek and Kelly Creek were conducted in 1995 and 1996. The programs were designed as randomised sample surveys where representative portions of the fishery were sampled and this data expanded to represent the total harvest in the study area. The 1995 program was reviewed by PSARC and recommendations were made to improve major deficiencies in the program, including reanalyses to provide defensible daytime catch numbers with corrections for fishing effort bias along with available information for night catches, documentation of changes for the 1996 field program that address the potential 1995 fishing effort bias and night sampling deficiencies, and documentation of data archival and data validation procedures.

The 1995 program was reanalysed using three methods. The first used the 1995 algorithm with CPUE's calculated from complete trip information only. This method resulted in a 4% increase in the original 1995 estimate of 90,336, but this method does not account for the effort bias in the 1995 algorithm and therefore underestimates. The second analysis used 1995 effort counts and CPUE information expanded with the effort profiles generate from the 1995 interview data and resulted in a catch estimate 29.5% greater than the initial 1995 estimate. The key assumption is that the 1995 effort profile information generated from the interview data is unbiased. The last method used effort profile data from the 1996 survey with the 1995 interview and effort count data analysed using the 1996 algorithm to produce an estimate 34.8% higher than the original 1995 number. The key assumption is that the 1996 empirical effort profile data was representative of the effort profile in 1995.

The 1996 program incorporated changes to accommodate the PSARC recommendations. The major program adjustment in 1996 was the introduction of 24 hour access point surveys to collect effort profile and night CPUE data. The observed effort was expanded using the effort profile information. Helicopter overflights were conducted at peak hours to minimise the required expansion factor. Only complete trip surveys were used for CPUE calculations. The only major problem in the execution of the 1996 survey was the 24 hour surveys were not conducted during the first two weeks of the program.

**Reviewers' Comments**

Both reviewers accepted the survey design and analyses used to generate the 1996 catch estimates. The main concerns with survey design and analyses identified in the PSARC review of the 1995 program were addressed in 1996. These include the schedule of helicopter overflights during the peak effort period, and the generation of effort estimates by expansion of instantaneous overflight counts using effort profiles obtained from a 24 hour access point survey. Two problems were identified by Reviewer #2 : 1) it is unknown whether fishers interviewed were representative of all fishers, although this may be an unresolvable issue; and 2) since effort data was not collected for statistical weeks 31 and 32 in 1996, the first two weeks of the survey, the authors applied 1995 effort data to generate 1996 catch estimates; the reviewer did not accept this solution given the errors in the 1995 survey design and algorithms. Also noted in the review was an unsubstantiated comment that a strong negative bias exited between soak time and CPUE, although data from complete trip interviews would capture this effect in the catch estimates.

Both reviewers recommended the deletion of the 1995 catch estimates (total of 125,000 sockeye) determined from 1995 algorithms because the PSARC review of the 1995 survey determined the effort estimate was incorrect and caused a negative bias in the catch estimate. To assist the Subcommittee and authors to generate 1995 catch estimates, Reviewer #2 provided the Subcommittee with the results of a gaming exercise which used six hypothetical effort levels and selected interview types from 1996 to determine a potential range of sockeye catch in 1995. The validity of the various assumptions was subsequently discussed by the Subcommittee. The reviewer also commented that the 1995 survey should be looked upon as an experimental year where important parameters of the fishery were observed and used to improve survey design.

**Subcommittee Discussion**

The paper was accepted subject to major revisions. The 1996 catch estimates for statistical weeks 33 to 38 were accepted since the survey design and algorithms were approved and the program was successfully executed. To calculate catch estimates for statistical weeks 31 and 32, the Subcommittee concluded that the most appropriate method was to use the average weekly effort profiles of statistical weeks 33 to 38. The Subcommittee also requested evaluation of the variation in the weekly effort profiles as a measure of the appropriateness in applying average effort profiles to weeks 31 and 32. The Subcommittee also noted the authors' concern about the existence of only one 24 hour fixed access point where 24 hour effort data could be collected. The authors were requested to provide the proportion of catch taken during the night time period. It was also noted that collection of this data was very difficult logistically because of safety concerns. To demonstrate the relationship between soak time and CPUE, the authors were advised to provide a sample of scatter plots to support their observation.

The Subcommittee examined the 1995 estimates, even though the design and

analyses contained bias that could not be resolved solely with the use of 1995 data. For generation of estimates for 1995, the Subcommittee concluded that the most appropriate method was to apply the 1996 diel effort pattern and the 1996 algorithms to the 1995 CPUE data in a manner applicable to the time and area openings of 1995. The Subcommittee concluded that calculations of standard error were not appropriate for the 1995 estimates because of the unique adjustments to the 1995 data and the teething difficulties encountered in this 'learning year'. The level of uncertainty was probably larger however, than calculated in 1996.

**Subcommittee Recommendations**

The 1996 survey design and analyses be accepted as the appropriate methodology for his program. The 1996 catch estimates and estimates of standard error be accepted (to be provided as part of the revisions requested).

The best estimate of 1995 catch will be provided (as part of the revised paper) using the approach recommended by the Subcommittee.

**S97-3 Evaluation of 1995 Fraser River Pink Mark Recovery Escapement Estimates. Neil Schubert, Timber Whitehouse and Al Cass**

Working Paper Summary

This report documents the study design, field methods, analytic techniques and results of the 1995 Fraser pink salmon escapement estimation study. PSARC reviewed the 1993 Fraser pink salmon escapement estimation program and supported the basic structure of the program while recommending improvements to evaluate: non-random mixing of tagged and untagged fish between the capture and live recapture sites, acute handling mortality, and differential vulnerability of disk tagged fish. The 1995 program was modified to accommodate those recommendations and had the specific objective of providing a system wide Fraser pink escapement estimate with a confidence interval of +-25%.

The 1995 program resulted in an escapement estimate of 7.3 million with 95% confidence limits of 5.8 to 8.7 million. While the overall program was successful the following problems were identified. Severe temporal bias (incomplete mixing of tagged fish) in the Ridgedale bar recovery site required that this data not be used in making the 1995 estimate. The spawning ground surveys should be excluded from future studies because tag application and recovery are nonrepresentative. The 1995 Fraser River pink salmon escapement estimate should be derived from the Duncan Bar tag application and the Strawberry Island live recovery data. Total escapement should be calculated from the sum of the male and female estimates to ensure consistency if sex-specific bias are present. The live recovery recaptures were insufficient to adequately test the assumptions of equal proportions and complete mixing of tag recoveries among strata. Failure to recover live fish over a 24 hour period limited the opportunity to

evaluate some biases. Evaluations to evaluate stress indicated no difference in recovery rates associated with fish size or handling techniques. There was a difference in the spawning success of tagged and untagged females.

Improvements in the program for 1997 should include: 24 hour live recapture at both the Ridgedale and Strawberry Island sites; cancellation of mainstem spawning ground surveys; implementation of further procedures to minimise/evaluate stress impacts and use of combined spaghetti tags and opercular punches and biological sampling for sex ratios.

**Reviewers' Comments**

Reviewer #1

The reviewer noted that the working paper provides a useful summary and review of the enumeration program and that the study is clearly laid out and conclusions concerning the most appropriate escapement estimator to use are sound. The reviewer noted the major design goal which PSARC directed the authors to work on has been met. That is, a system wide escapement can now be estimated with a confidence interval of roughly +/- 25% of the point estimate. The reviewer recommended that a number of the major recommendations in the paper not be supported, prior to a clear evaluation of the goals of the Fraser River pink enumeration program. In particular the reviewer suggested there is a need to clarify the incremental benefits of implementing the recommendations relative to the costs.

Reviewer #2

The reviewer commented that the authors have presented a comprehensive and extremely detailed report that is well written and fully documented. All relevant data are clearly tabled and appended, such that the analyses could be independently reproduced. The authors are to be commended for their high standard of presentation and attention to detail. The reviewer noted that the authors have clearly implemented the PSARC recommendations for the 1995 study. That was, to evaluate the non random mixing of tagged and untagged fish between the capture and live recapture sites, handling mortality, and vulnerability of disk tagged fish to alternate sampling gear. The reviewer supported the authors recommendation that the pooled Peterson estimate using the Duncan Bar tag application and Strawberry Island live recovery data, be accepted as the most appropriate estimate for 1995.

**Subcommittee Discussion**

The Subcommittee accepted the working paper subject to minor revisions.

The Subcommittee noted that the importance of potential biases were recognised early in the tagging program (1961-91) when the program was conducted by agencies other than DFO. Study design during that period did not include experiments to elucidate the

effect of bias, particularly tagging stress, on escapement estimates. Study design changes were introduced by DFO in the 1993 and 1995 programs to reduce and/or evaluate the biases. The two particularly important assumptions to evaluate are the extent of tagging mortality, and the mixing of tagged fish at the Strawberry Island recovery site. With respect to the control of stress from tagging and the evaluation of its impact, the Subcommittee agreed that procedures to minimise stress should continue as standard operational approach. Although the Subcommittee supports continued efforts to resolve important biases in the program, it does not support programs to investigate biases whose influence on the escapement estimates would be small relative to desired confidence intervals.

The Subcommittee is concerned about consistency in the historical escapement time series and future programs. Documentation of historical programs that would allow comparison between future and historical estimates, would be beneficial.

With respect to the lower river mainstem spawning ground survey, the Subcommittee noted that this activity is unlikely to provide a representative sample of the system-wide escapement and therefore the data does not provide a useful contribution to the pink escapement estimation program. However, the mainstem spawning ground survey may be important to DFO habitat or management for other reasons and they should be consulted prior to the cancellation of this component of the program.

The Subcommittee supports a 1997 objective of estimating the pink escapement to an accuracy of +/- 25%.

**Subcommittee Recommendations**

The Subcommittee recommends that the pooled Petersen estimate generated from the Strawberry island live recovery site be accepted as the most appropriate estimate for 1995. The estimated escapement was 7.3 million, with 95% confidence limits of 5.8 million to 8.7 million. The escapement of males and females was 3.0 million (2.2 million to 3.9 million) and 4.2 million (3.1 million to 5.4 million), respectively,

Previous Subcommittee advice recognised that complete mixing of tagged and untagged fish was critical to the unbiased estimation of escapement. The 1995 study results demonstrated that mixing did not occur at Ridgedale Bar and that the results were equivocal at Strawberry Island. Because mixing at Strawberry Island is critical to the validation of the 1993 and 1995 escapement estimates, the Subcommittee acknowledges the uncertainty in the assumption of complete mixing and supports the authors' recommendation for further investigation.

The Subcommittee recognised in its evaluation of Working Papers S93-4 and S94-19 that stress-induced immediate mortality could bias the study results. The 1995 study results demonstrated that immediate mortality does occur but was unable to quantify its impact of the escapement estimate. The Subcommittee reiterates its concerns and supports the authors' recommendations for further investigation.

The lower Fraser River mainstem pink spawning ground survey is unlikely to provide a representative sample of the system-wide escapement and should be dropped as part of the pink escapement estimation program.

## S97-4 Angler effort and catch in the 1996 lower Fraser River sport fishery.

**A. R. Walter, Vic Palermo and K.J.Scott**

Working Paper Summary

The lower Fraser River mainstem recreational fishery was assessed from 1985-1988 and again in 1995 using an access point-overflight survey design. From June 6 to August 31, 1996, a recreational fishery survey was conducted on the lower Fraser River using the same study design, but with a new data entry and analysis program. The survey focused on angler effort, harvest and release of chinook (*Oncorhynchus tshawytscha*) and sockeye (*0. nerka*) salmon. Over the course of the survey, 25 overflights were made and 4,752 angler interviews were conducted. Angler effort was estimated at 212,205 hours. A total harvest of chinook (adult and jacks combined) and sockeye was estimated at 3,262 and 9,371, respectively. Chinook and sockeye released were estimated at 154 and 8,369, respectively.

The 1996 early season chinook catch (June and July) was down considerably from 1995, due to high water levels. Total August catch for chinook increased from 1995 to 1996 possibly due to a greater abundance of chinook in the lower Fraser River during this month. Catch rates for sockeye had increased dramatically from 1995 to 1996. Due to high water levels, angler effort in June and July was down compared to 1995. In August, as the water levels dropped and the sockeye fishery opened, angler effort increased considerably (almost double the 1995 effort).

The current survey area does not cover the complete area or the total period of the recreational fishery. If complete coverage was deemed necessary the following expansions to the program would be required: extend the survey coverage to include the area below the confluence of the Sumas River to the mouth of the Fraser; extend the survey coverage to include the months June through November in order to estimate sport catch of chinook, coho, sockeye, pink, and steelhead; and extend the survey coverage to those lower Fraser River tributary fisheries such as the Chilliwack/Vedder sport fishery that target coho salmon.

**Reviewers' Comments**

Both reviewers complimented the authors on a clear and thorough presentation of the methods, analysis and results of this sport catch estimation program. The main concerns of both reviewers were the daily start time of the survey and the duration and area covered by the program. The 0700 start time noted in the paper would likely miss about 10% of the angler effort according to one reviewer. The steelhead and coho

catch were not surveyed because the program terminated at the end of August rather than the end of October and the area covered was less than in previous years. One reviewer also noted that the increase in sockeye catch success in 1996 over 1995 could be due to the higher sockeye run in the Fraser River in 1996.

**Subcommittee Discussion**

The Subcommittee recommended that this paper be accepted with minor revisions. The Subcommittee concluded that the methodology used to estimate the catch in this portion of the lower Fraser River was sound. In response to both reviewers' concerns about the apparent lack of interview data prior to 0700 hours, the author noted that 0700 was when the interviewers came on duty and that catch prior to 0700 was in fact assessed by the interview format. Furthermore, at 0700 all anglers were canvassed as to the number of anglers that had left the fishing location prior to 0700. The number of anglers that had left was generally small. The author was asked to clarify descriptions in the paper of the survey methodology pertaining to this time period and to modify the daily effort profile figures in the working paper.

The Subcommittee discussed the need to collect adipose-clip mark incidence information in this program. This information was collected but the author felt that it was not sufficiently reliable to include it in this paper. The Subcommittee recommended that this data be included in the paper with appropriate qualifications.

With respect to future reviews of catch estimates generated by this program, the Subcommittee was of the view that unless there were significant changes to the methodology that future reviews were not necessary.

In discussing the adequacy of this program to estimate the recreational catch of all salmonid species in the lower Fraser River, the issue of recreational catch estimates for salmon coastwide was raised. It should be noted that this program provides only partial estimates for two species in part of the lower Fraser River. The magnitude of the estimated catch is small relative to the size of the runs and the catch in other recreational fisheries. The objective of this project and how it fits with any assessment programs are unclear. There are many areas where recreational catch is not currently estimated. The need for a regional strategy for recreational catch estimation programs to assist in allocating resources was identified.

**Subcommittee Recommendations**

The methodology and the catch estimates generated from this program are accepted.

The objectives and application of the data from this program are not established and need to be developed/evaluated

A recreational fishery catch monitoring strategy is required if available resources are to be optimally distributed by species, time and area. There are currently many recreational fisheries that are not rigorously assessed or assessed on a regular basis.

***S97-5*** **A 1996 Update of Assessment Information for Strait of Georgia Coho Salmon Stocks (Including the Fraser River). Kent Simpson, Ron Diewert, Ron Kadowaki, Carol Cross and Sue Lehmann**

Working Paper Summary

This paper presents 1996 stock status information for coho populations in the Georgia Basin. Once again in 1996 virtually all coho migrated to the west coast of Vancouver Island (Figure 2). This previously unusual occurrence has happened four times since 1990, three times (1991,1995 and 1996) with unprecedented strength. The catch in the Strait of Georgia is estimated to have been 133,000 in 1996, compared to a normal distribution year such as 1992 when the catch was 745,000. Coho catches in all of southern BC began to decline in 1990 (Figure 3). This is not primarily the result of a decline in hatchery smolt production which has decreased only slightly in Washington. The west coast troll fleet caught 783,000, falling short of the 1 million quota.

We think catches are largely reflecting increasingly poor marine survival. Escapements to indicator stocks have been trending down for at least the last 12 years. 1996 escapements were extremely poor even though the exploitation rates of our Vancouver Island and lower Fraser indicator stocks were mostly about the same as 1995 (55%-60%) and less than in the early 1990's (>70%). Escapements were worst on Vancouver Island and in the Thompson system. Marine survivals began to drop in the late 1980's and continued to decline in 1996 on Vancouver Island (Figures 4 & 5). We do not have survival and exploitation data from the mainland inlets and Thompson system.

Fry abundances were good on central Vancouver Island compared to the previous five years and were average in the lower Fraser and on southeast Vancouver Island. Abundances in the Thompson system and on the Sunshine Coast were more difficult to interpret but Thompson densities were better than in 1995. It will be important to assess 1997 fry densities to determine if last year's escapement was so low that fry densities have been affected despite the species' very strong compensatory mechanisms.

Exploitation rates must be reduced substantially in 1997 to prevent back to back poor brood years, especially since there is little inter-brood line interchange in southern coho. We recommend that managers be prepared to implement stringent conservation measures in 1999, the 1996 brood year return. Reliable escapement data is required from more populations, especially in these years of poor survival. Besides recommending that this deficiency be remedied, we note that wild indicator stocks are

needed in the Thompson and mainland inlets/Sunshine Coast areas where fry, smolt, catch and escapement data would obtained.

**Reviewers' Comments**

Reviewer # 1

The reviewer recommended rejecting the paper pending major review as the paper did not adequately describe the available data and failed to draw together the individual assessment elements into a coherent and unified statement on stock status. He felt that there should be an explicit description of the assessment framework and that all methods of data collection should be completely described within the paper. He also noted that 1996 data was incomplete in three areas: escapement data for Inch and Chehalis stocks were not available, the Salmon River (Langley) escapement estimate was still indicated to be preliminary and CWT information was not yet available for US fisheries. For these reasons he suggested a further review of the paper next fall.

Reviewer # 2

The reviewer notes that this paper is an update of information previously considered by PSARC and recommended that it be accepted with minor revisions. He did note however that extensive editing would be required for publication. He recommended further evaluation of fry density in 1997, due to severe flooding in the winter of 1996/97 and as well, further investigation of the Black Creek exploitation rate which appeared to be unusually high.

**Subcommittee Discussion**

Given the urgent need to provide managers with advice on Georgia Strait coho for 1997, the Subcommittee accepts the paper, subject to major revision. The Subcommittee agrees with the reviewers that more details on methods and significant editing is required on this paper.

The Subcommittee noted that this paper is similar to that accepted by PSARC last year and follows on from previous PSARC papers that documented many of the methods of escapement and catch estimation. It is a partial documentation of stock status as it only documents catch and escapement and does not relate escapements to conservation requirements nor does it provide forecasts for the coming year. These two considerations are the subject of other papers, one on forecasting considered at this meeting and an expected paper on coho conservation requirements expected to be available for fall 1997.

The Subcommittee also acknowledges that more mid- to high quality indicators of stock status, relative to conservation requirements, are necessary and priority should be given to wild stock indicators on the mainland coast and on the Thompson River.

There continues to be clear reasons to further reduce fishing mortality on coho stocks:

- Escapements to indicator stocks have been trending down for at least the last 12 years and were extremely low in 1996, especially on Vancouver Island and in the Thompson system

- Marine survivals began to drop in the late 1980s and continued to decline in 1996 on Vancouver Island.

- Catches began to decline in 1990 but dropped substantially in 1996. Catch decreased at a rate that cannot entirely be attributed to a small decrease in smolt releases by US hatcheries

- Exploitation rates on most indicator stocks were similar to 1995 levels in the 55 to 60 % range (except for Black Creek wild coho at 79%) and these rates do not yet include US recoveries.

- Georgia Strait coho stocks are substantially outside of the Strait again this year.

**Subcommittee Recommendations**

Given the continuing low marine survival rate expected in 1997 and the steep declines in catch and escapement observed through 1996, the Subcommittee is concerned that even with no fishing there will be stocks that will not achieve conservation goals. Any exploitation will increase the risk of more stocks not reaching their goals and increase the shortfalls of stocks which have failed to meet their goals. Because there are reasons to expect most Strait of Georgia coho have moved out to the west coast of Vancouver Island, conservation measures would be needed in all fisheries intercepting these stocks.

***S97-6*** **1997 forecasts of survival and distribution for Strait of Georgia coho salmon stocks. Ron Kadowaki**

Working Paper Summary

Forecasts of the marine survival rate and ocean distribution of Strait of Georgia coho and the abundance of coho in the WCVI troll fishery are required for managing the 1997 southern British Columbia coho salmon fishery. This paper presents 1997 forecasts using methodologies similar to 1996.

Marine survival rates of wild stocks have trended in a similar way to hatchery stocks so inferences about wild stock marine survival rates can reasonably be made from forecasts for hatchery stocks. Marine survival rate data are available for the Quinsam River hatchery stock from 1974 (brood year) to the present. The survival of Black

Creek coho, a nearby wild stock, has been consistently higher than the survival of Quinsam River coho but has trended in a similar manner.

The marine survival rate of Quinsam River hatchery coho is estimated at 0.019 (± 0.031, 90% prediction interval) using a sibling regression model. The previous 3-year average survival rate is also 0.019. From these estimates we can conclude that marine survival of the 1994 brood returning in 1997 will not likely improve over that experienced by the 1993 brood and may be slightly lower. Caution should be exercised in 1997 since both the sibling regression model and the 3 year average have over-estimated the actual marine survival rate during the recent decline in marine survival rate.

The distribution of the catch of Strait of Georgia coho has high inter-annual variability, but is synchronous among stocks within a year. Smolt survival was found to be related to salinity at the time of their entry to the ocean. The mean February salinity at the Chrome Island and Sisters Island lighthouses was used to generate forecasts of distribution for three hatchery coho stocks. These forecasts indicate that a high proportion of coho will be distributed to fisheries outside of the Strait of Georgia in a similar manner to 1995 and 1996. (note: Predicted inside proportion is; Chilliwack - 0.102, Big Qualicum - 0.168, Quinsam - 0.212.)

Coho abundance in the WCVI troll fishery was forecasted prior to the 1996 fishing season as the basis for the catch ceiling developed for that fishery. The methodology used in that analysis is described with some minor modifications. The approach involves a reconstruction of the coho abundance in the WCVI troll fishing area and a means of predicting it using the marine survival rates and catch distribution forecasts presented above. It should be noted that the utility of this relationship as a forecasting tool is limited by the fact that both the distribution and survival rate of Quinsam River coho are themselves forecasts with associated uncertainty. Based on this regression, the forecast of abundance in the traditional WCVI troll fishing area in 1997 is 2.75 million. This is slightly lower than the 1996 forecast of 2.85 million but caution should exercised in using the mid-point estimate since that forecast over-estimated the return by 0.5 million fish.

**Reviewers' Comments**

Reviewer # 1

The paper uses forecast methods approved by PSARC to predict 1996 coho ocean survival and distribution. The prediction is that low ocean survival and outside distributions will continue in 1997 which is important given the present state of coho stocks. The paper should be accepted subject to revisions. Although noting the paper is really an update of the previous paper with the additional of another data point, the reviewer recommended the paper be fleshed out to represent a stand alone document that does not require readers to ferret out pervious (unpublished) PSARC papers).

Reviewer # 2

The reviewer noted that that this paper is an update of a previously approved PSARC paper and therefore has the strengths and weaknesses inherent in the previous paper. The paper is based on limited data sets (few stocks, short time series) and the reviewer agreed with the authors recommendation that the forecast be used "only to characterise the return and not develop precise management regimes", assuming that this meant characterisation of the return as average, below average or above average and the general direction of inside/outside proportions.

**Subcommittee Discussion**

The Subcommittee accepts the paper with minor revisions.

The Subcommittee expressed concern that the current coho index populations in Georgia Strait may not be capturing total coho production in the Strait very accurately. Marine survivals appear to vary geographically and there are regions in the Strait without any index populations e.g. mainland inlets, south Vancouver Island, and the Thompson River. Where marine survival has been measured, it is very low throughout the Strait but slightly higher in the lower Fraser River populations than those on east Vancouver Island. Where hatcheries and wild indicator stocks occur in close proximity, their production trends are correlated. In those areas of the Strait of Georgia without hatcheries, the Subcommittee was concerned that coho survivals levels in those regions was unknown.

The Subcommittee noted that forecasts of marine survival for the last 3 years have tended to be over-optimistic. In 1997, the marine survival of Strait of Georgia coho (hatchery and wild) is expected to be the lowest observed. Most Strait of Georgia coho are expected to have moved out of Georgia Strait to the west coast of Vancouver Island in 1997 therefore the proportion of Strait of Georgia coho vulnerable to harvest on the west coast is expected to be high in 1997.

**Subcommittee Recommendations**

The Subcommittee recommends that given the uncertainty in the forecasts, survival and abundance values well below the point estimates are possible and should be considered in the formulation of management plans.

***S97-7*** **Changes Associated with the 1990 Ocean Climate Shift, and Effects on British Columbia Salmon Populations. David Welch, Bruce Ward, Barry Smith, and Frank Whitney.**

Working Paper Summary

This document provides a review of evidence that sudden environmental changes occurred in the ocean about 1989-1990, and that the marine survival of steelhead in southern and central regions of British Columbia changed sharply at the same time.

The changes in steelhead recruitment have distinct patterns of geographic and temporal variability in British Columbia that appear to be associated with large scale climatic changes that in the past have affected salmon populations around the Pacific Rim. Juvenile steelhead entering northern BC coastal waters appear to be encountering much better conditions for survival after 1990 than juvenile steelhead entering southern and central BC coastal regions. As a result, southern steelhead populations are declining. In at least some cases, past steelhead population sizes may not be sustainable even in the absence of fishing. The likely reason is that ocean productivity and therefore marine growth of steelhead suddenly declined in south-central B.C. Although this document does not review evidence for a similar effect on other salmon or groundfish species, it is possible that this mechanism will have similar impacts on other species whose pre-recruit life history stages occur in south-central B.C. coastal waters.

As a result of this climate shift, sustainable harvest rates for steelhead following the 1990 climate shift have dropped, and stock assessments based on data collected prior to this time will give misleading conclusions unless corrected for current oceanographic conditions. Making this correction in a statistically rigorous fashion is extremely difficult because there is insufficient new data after the 1990 climate shift to make an accurate direct assessment, and the underlying links between climatic change and biological effects on salmon populations are not yet clear. An important first step is to clearly recognise the potential for sudden changes in ocean climate to affect fish productivity, and to advise client groups that assessments will necessarily be significantly more uncertain than in the past.

Client groups should be advised of the possibility that some species of salmon are responding to a climate shift occurring around 1989/90. Work should be initiated to establish what other species of Pacific salmon appear to share a common response to the climatic change. Research to determine the underlying ocean mechanisms should be started, to determine what reference points can be identified to provide more rapid warning of a change in ocean climate. The possibility of continued poor marine survival needs to be factored into stock assessments, in order to reduce the risk of overfishing the stocks during a period of reduced ocean productivity.

**Reviewers' Comments**

Reviewer # 1

The reviewer acknowledged the working paper dealt with an important and controversial topic. The reviewer noted that the authors had done a commendable job in assembling and comparing the extensive data pertaining to steelhead recruitment. In this reviewer's opinion the Keogh steelhead survival data demonstrate that marine conditions changed for that population after 1989. The reviewer was concerned that the data for other stocks of salmon presented in the paper did not support the hypothesis that a sudden change in ocean productivity in 1989-90 has caused reduced marine survival, growth, and/or recruitment of salmonids in southern and central British Columbia. The reviewer was critical of the paper in that it suffers from lack of appropriate scientific rigour. The reviewer concluded that the paper requires major revisions and new analyses to provide a scientifically defensible test of the hypothesis compared to alternative hypotheses for the available time series of marine survival in Pacific salmon.

Reviewer #2

The reviewer acknowledges the extensive data set on winter steelhead catch performance and agrees that the evidence presented did indicate a sudden change in steelhead production. The reviewer notes that there is undoubtedly wide support for the intent of the paper... "what effects of the ocean influence salmon productivity". However, the reviewer found nothing in the paper to suggest, as the authors state, that "poor marine survival may continue for an indefinite period into the future". The reviewer concluded that the paper does not support the authors' conclusion for a "climate shift" and suffers from excessive generalisations and use of emphatic wording which frequently over-states the results. Further, the reviewer notes that the summary section does not accurately reflect the results presented. In the reviewer's opinion, a fundamental question not addressed in the paper is what constitutes a climate shift versus periodic environmental fluctuations or environmental cycles. The reviewer recommends rejection of the paper and believes a much more accurate and informative presentation of the material can be prepared.

**Subcommittee Discussion**

The paper was accepted with major revisions. The Subcommittee agreed the analysis presented in the paper makes a significant contribution to the understanding of steelhead productivity but concluded that the generalisations to other species of salmon were not well founded. The analysis of the steelhead data demonstrates temporal variations in productivity trends for that species and that geographic clustering of trends are important features to consider when assessing factors affecting fish production.

Data sets for other species that characterise production such as estimates of smolt production, smolt size, and adult return data from indicator stocks were not suitably

evaluated. Moreover, the inconsistencies in the production trends based on the data considered in the paper for other salmonids relative to the 1989-90 reference point were not satisfactorily explained. Tests to differentiate between long-term gradients in survivorship versus stepped or abrupt changes in survival should be considered explicitly to help identify alternative explanations for observed trends in productivity.

The Subcommittee noted that consideration of oceanographic processes is not appropriate for the salmon PSARC Subcommittee and that perhaps a second paper that deals specifically with oceanographic processes be considered by the proposed PSARC Subcommittee dealing with oceanographic/habitat issues. The Subcommittee did note that debate among oceanographers has failed to reach consensus on the processes that control ocean productivity. The Subcommittee concluded that the paper failed to test the hypothesis posed in the paper with sufficient scientific rigor to support the conclusion linking oceanographic processes with salmon production. The authors are encouraged to focus on steelhead survivorship trends and summarise the oceanographic data so as to eliminate the over-generalisations emphasised in the working paper. The Subcommittee strongly endorses studies to explain salmon productivity wherein all alternative hypotheses are considered with focus on specific species groups that avoid over-generalisations to other species or species groups.

**Subcommittee Recommendations**

The Subcommittee recommends the paper be accepted with major revisions that limits the analysis to steelhead productivity without generalising to other species of Pacific salmonids. The analysis requires more scientific rigour than presented in original working paper.

Understanding the mechanisms the affect survivorship is an important requirement for stock assessment. As a first step in understanding causal mechanisms affecting production trends in Pacific salmonids the Subcommittee recommends all relevant time series of production data for each species needs to be assembled and analysed to assess production trends and geographic clustering patterns among and within species groups.

**Appendix 1 Participants at the April 29 - May 2, 1997, meeting of the Salmon PSARC Subcommittee.**

Subcommittee Chair: D. Peacock
PSARC Chair: J. Rice

Subcommittee Members:

D. Anderson
D. Bailey
B. Hargreaves
R. Kadowaki
S. McKinnell
P. Ryall
C. Wood
S. Argue
A. Cass
K. Hyatt
A. MacDonald
D. Meerburg
M. Stocker

Authors/Reviewers:

B. Gasey
C. Schwarz
B. Ennevor

Observers:

D. Beamish
K. Wilson
B. Holtby

## Appendix 2 Reviewers of Working Papers

| Working Paper | Reviewer #1 | Reviewer #2 |
|---|---|---|
| S97-1 | A. MacDonald | D. Kolody (UBC) |
| S97-2 | B. Gasey | C. Schwarz (SFU) |
| S97-3 | D. Welch | S. Cox-Rogers |
| S97-4 | T. Gjernes | P. Ryall |
| S97-5 | N. Schubert | D. Bailey |
| S97-6 | A. Cass | K. Hyatt |
| S97-7 | C. Wood | B. Riddell |

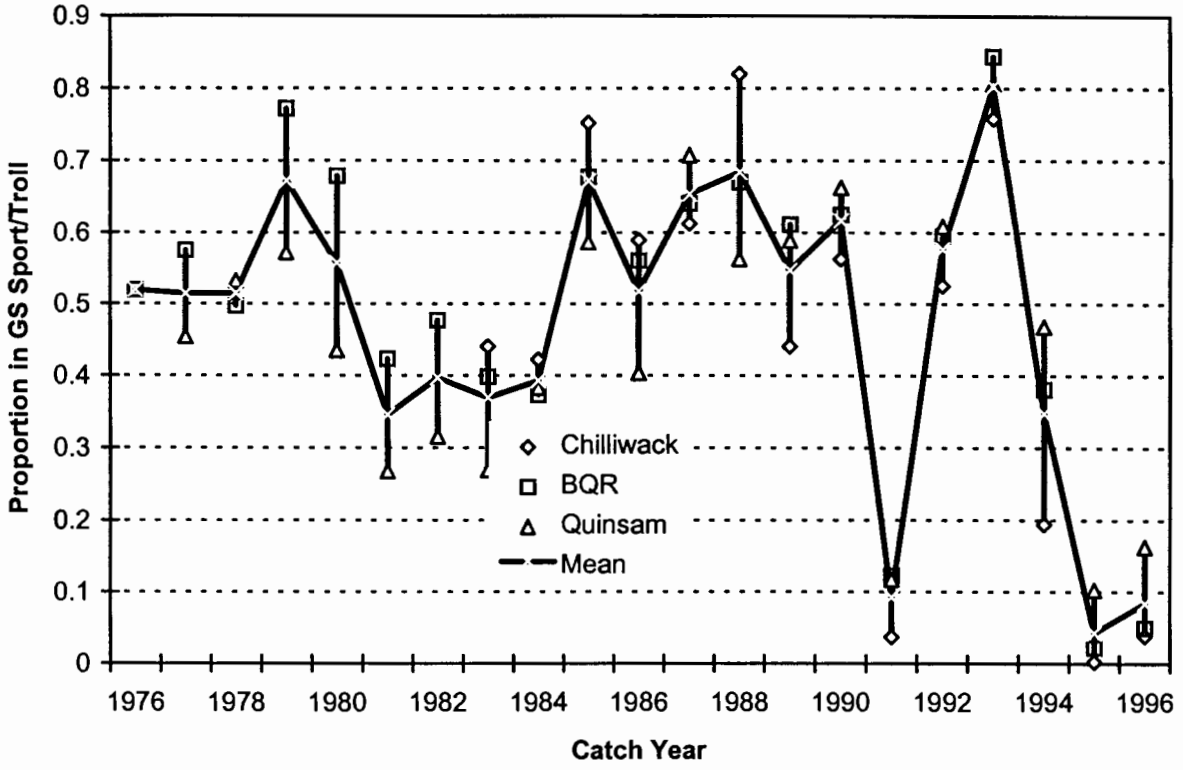


**Figure 2. Proportion of CWT'd coho caught in Strait of Georgia troll and sport fisheries for three hatchery indicator stocks.**

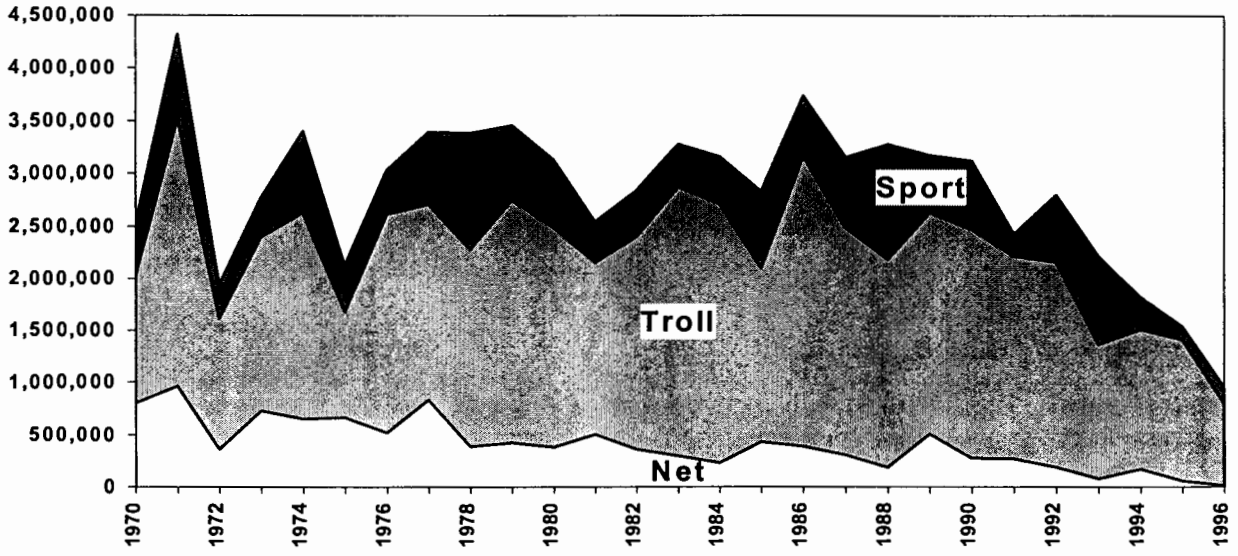


**Figure 3. Coho catch in the sport, net and troll fisheries of south coast BC, 1970 to 1996.**

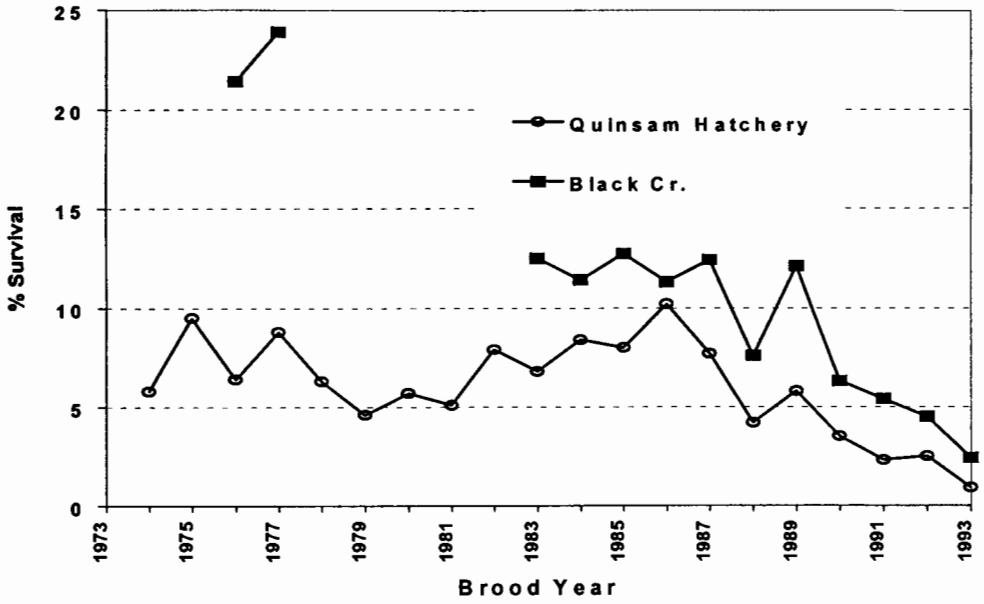


**Figure 4. Smolt to adult survival of Quinsam Hatchery and Black Creek coho.**

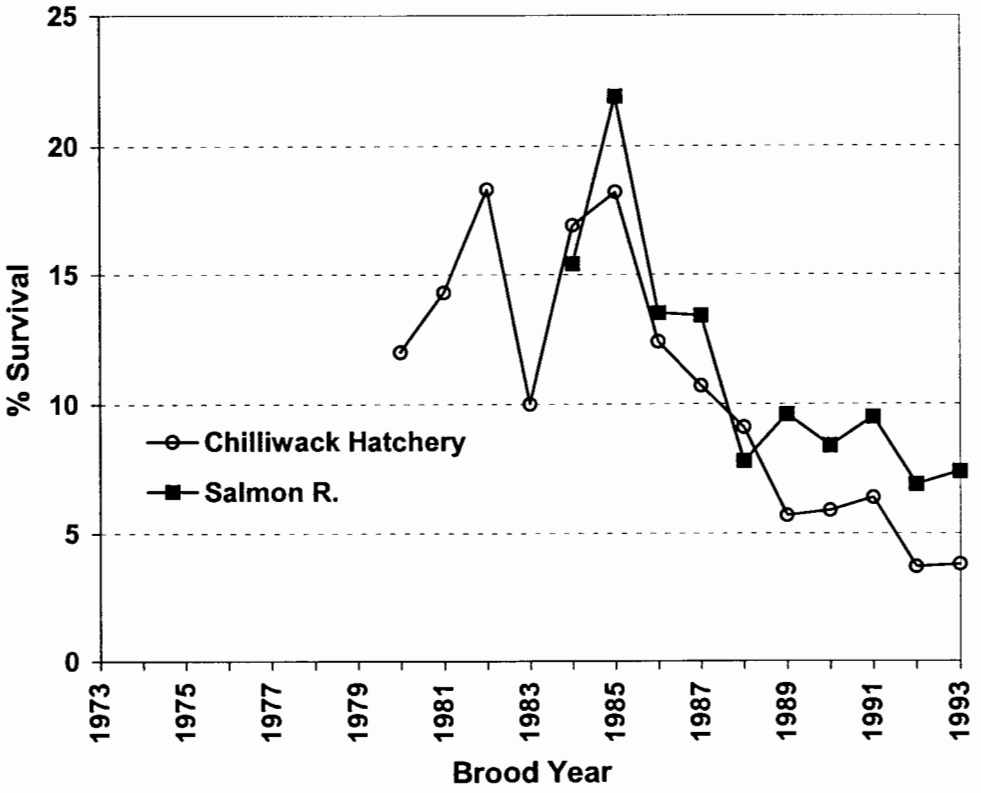


**Figure 5. Smolt to adult survival of Chilliwack Hatchery and Salmon River coho.**