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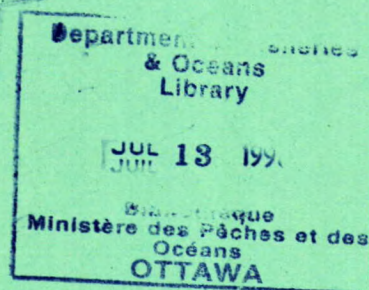


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PACIFIC STOCK ASSESSMENT REVIEW COMMITTEE (PSARC) ANNUAL REPORT FOR 1996

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G. Thomas² (Editors)

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Science Branch
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**PACIFIC STOCK ASSESSMENT REVIEW COMMITTEE
(PSARC)**

ANNUAL REPORT FOR 1996

by

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ABSTRACT

Rice, J., B. Leaman, S. Farlinger, L. Richards, R.J. Beamish, B. Holtby, and G. Thomas (Editors). 1997. Pacific Stock Assessment Review Committee (PSARC) Annual Report for 1996. Can. Manuscr. Rep. Fish. Aquat. Sci. 2447: vi + 289 p.

This report summarizes activities undertaken by the Pacific Stock Assessment Review Committee (PSARC) during 1996. During this year, 53 reviewed Working Papers and 14 unreviewed Fishery Updates were presented at meetings of the four PSARC Subcommittees (Salmon, Invertebrates, Groundfish, and Herring). In this annual report, an overview by the Chairperson of the PSARC Steering Committee is followed by eight PSARC Advisory Documents which summarize the Working Papers, reviewers' comments, subcommittee discussions and Steering Committee comments.

RÉSUMÉ

Rice, J., L. Richards, R.J. Beamish, B. Holtby, et G. Thomas (Editeurs). 1997. Comité d'examen de l'évaluation des stocks du Pacifique - Rapport annuel de 1996. Can. Manuscr. Rep. Fish. Aquat. Sci. 2447: iv + 289 p.

Ce rapport décrit les activités du Comité d'examen de l'évaluation des stocks du Pacifique (CEESP) au cours de l'année 1996. Au cours l'année, cinquante-trois documents de travail (relus) et quatorze rapports (non relus) ont été présenté aux réunions des quatre sous-comité du CEEPS (Saumon, Invertébrés, Demerseaux, et Hareng). Ce rapport débute par un tour d'horizon du président du comité directeur du CEEPS suivi de huit documents consultatifs dans lesquels sont résumé les documents de travail, les commentaires des experts, les discussions des sous-comités et les commentaires du comité de direction du CEEPS.

SECTION I - CHAIRPERSON'S REPORT FOR 1996

This is the tenth annual report of the Pacific Stock Assessment Review Committee (PSARC). The report summarizes the eleventh year of operation for this committee, which provides scientific advice for the management of Pacific fisheries resources. The PSARC Terms of Reference are published in Humphreys, et al. (1994). However, a major revision of the PSARC Terms of Reference was completed in 1996. Implementation of the revised PSARC Terms of Reference was deferred, however, because of discussions regarding the establishment and mandate of a Pacific Resource Conservation Council. Until the issues associated with a Pacific Region conservation council are resolved, the revised operational procedures of PSARC cannot be finalized.

PROCESS FOR THE PROVISION OF PSARC ADVICE

Stock assessment advice is provided by PSARC in the form of PSARC Working Papers, Advisory Documents, and minutes of meetings of the PSARC Steering Committee and the Resource Management Executive Committee (RMEC).

There are four PSARC Subcommittees: Herring, Salmon, Invertebrate, and Groundfish. Generally each subcommittee holds one or more meetings annually. Stock assessment documents (Working Papers) are prepared prior to subcommittee meetings and are reviewed by at least one individual before these meetings. Pre-meeting reviewers are normally external to the subcommittee and may be external to the Department of Fisheries and Oceans (DFO). If possible, reviewers' comments are provided to the authors of Working Papers in advance of the Subcommittee meeting, to enable the authors to address concerns raised by the reviewers.

At Subcommittee meetings, draft Working Papers and unreviewed assessment documents (Fishery Updates) are presented, along with reviewers' comments on Working Papers. For each Working Paper, a decision is made by the subcommittee whether to accept the Working Paper in its present form, to request the author(s) to make revisions, or to reject the paper. If revisions are requested, the author is given 45 days to complete them. Each subcommittee produces a Subcommittee Report which contains summaries of Working Papers, summaries of reviewers' comments, the subcommittee's discussions and recommendations to the Steering Committee. Subcommittee Reports often highlight areas of particular concern.

At meetings of the PSARC Steering Committee, Subcommittee Reports are reviewed. The Steering Committee prepares its own report, which is included at the beginning of the Subcommittee Report. This expanded report is a PSARC Advisory Document, which is presented to the Regional Director General (RDG) and Regional Directors at a meeting of the RMEC.

After Advisory Documents have been approved by the RMEC, they are distributed. At the end of each year, all PSARC Advisory Documents produced that year are amalgamated into the PSARC Annual Report, which is published in the DFO Manuscript Report Series. Individual subcommittees may also publish their finalised stock assessments as separate documents.

At PSARC Steering Committee and RMEC meetings, various stock assessment issues are discussed which may not be included in Advisory Documents. Important conclusions and recommendations are documented in the minutes of these meetings. These minutes are widely distributed within DFO. When Advisory Documents are presented to the RDG and the Regional Directors at RMEC meetings, a particular branch, division, section, program or individual is assigned responsibility for each major recommendation made. RMEC meeting minutes record the assignment of responsibility.

Acknowledgements:

The Chair of PSARC would like to thank the Subcommittee Chairs for their hard work during 1996. Also, the Chair thanks Sue Farlinger and Bruce Leaman for their fine work while acting PSARC chairs, during two periods when the Chair was posted out of the Region. All authors of Working Papers or Fishery Updates are thanked for their contributions, particularly those who met deadlines for submission or revision of documents. Individuals who reviewed documents, especially those outside DFO who volunteered time for this important task, are also thanked. Finally, the Chair would like to thank Dee Milton, who provided the administrative support to PSARC, both for her professionalism and superior support in the routine duties of the position, and for her exceptional work to keep PSARC running smoothly through periods of acting chairs, or, a chair who was in travel status more often than he was in the office.

SUMMARY OF 1996 PSARC ACTIVITIES

PSARC produced 8 Advisory Documents in 1996, containing the conclusions and advice from 8 Subcommittee meetings and 5 meetings of PSARC Steering Committee. All Advisory Documents were presented to the Regional Management Executive Committee for approval and action. The body of this Annual Report is comprised of the final Advisory Documents, as approved by Steering Committee and RMEC.

Advisory Document 96-1 reports the results of the meeting of the Salmon Subcommittee from 7-8 February which was scheduled to conclude the review of forecasts of Fraser River sockeye for 1996. It also reports on Steering Committee discussions of that work, plus an additional paper in forecasts of chinook for the West Coast of Vancouver Island. The latter paper was prepared subsequent to the Subcommittee meeting, to deal with an urgent emerging issue. Steering Committee conducted the review of the Working Paper, as well as developing the advice to RMEC.

At its fall 1995 meeting, the Salmon Subcommittee had recommended that final acceptance of Working Paper S95-11, on forecasts of Fraser sockeye, be delayed until

information from the 1995 return year was available and sibling model forecasts were conducted. These additional analysis were presented and reviewed at the February meeting. February 7 was dedicated to a discussion of supplementary data (both quantitative and qualitative) that might influence 1996 returns. Again this year several forecasting models were applied to the major components of the Fraser sockeye stock, with substantial uncertainty in most of the individual forecasts, as well as some differences among the results of alternative forecasting methods. The forecasts based on minimum Root Mean Square error were accepted in most cases. The Subcommittee reached consensus on all run forecasts, and a presentation method which conveyed the uncertainty in the analyses. The 5th, 25th, and 50th percentiles of the combined forecasts are: 720,000, 1,560,000 and 2,660,000 sockeye.

Steering Committee accepted the forecasts, with the minor revisions which had been requested by the Subcommittee. Steering Committee also made two recommendations for future work, to strengthen the statistical bases for selection among forecasting methods.

Working Paper X96-1 was prepared because reduced survival rates have been observed for the 1991 through 1993 brood years. The consecutive poor brood years mean that projections of the 1996 and 1997 terminal runs to Barkley Sound are substantially less than the minimum spawning escapement goal for the Somass system. The analyses used forecasting methods for expected returns and target escapement which had been reviewed and approved previously. The analyses have substantial uncertainty, however, all plausible scenarios indicate that even in the absence of directed chinook fisheries in 1996, the forecasted terminal run of females in 1996 is expected to be less than either goal. Steering Committee accepted the forecast of 15,800 chinook +/- 11%, and advised that there is no harvestable surplus of Barkley Sound chinook in 1996. Moreover, Steering Committee advised that a precautionary approach means that the trends seen in the assessed stocks should be taken as indicative of trends in other wild stocks along WCVI. This means PSARC expects many wild stocks will experience severe depressions in abundance, and significant management measures will be required to preserve biodiversity of wild chinook stocks on the west coast of Vancouver Island.

Advisory Document 96-2 contains the report of the meeting of the Invertebrate Subcommittee from 1-3 April, and the Steering Committee discussions of the Subcommittee Report. The Subcommittee reviewed seven working papers, and discussed a number of other issues.

For the Area 12 prawn fishery (I96-1) the Subcommittee concluded that inadequate sampling of catches precluded an accurate analytical assessment of the status of the resource. However, several recommendations were made to improve the information base on the resource, and to improve the management responses to in-season indicators of stock status.

A review of the possibility of quota-based management of manila clams (I96-2) was accepted by the Subcommittee, as a general framework for management of such

fisheries. The Subcommittee also emphasized the need for explicit management objectives for these fisheries, prior to implementation of new management strategies.

Paper I96-3 reviewed alternative survey methods for geoducks. The Subcommittee concluded that further work was needed on intra- vs. inter-transect variation, but also noted that improvements to survey methodology do not eliminate uncertainties in estimates of total biomass, upon which quota determinations are based.

A review of acoustic survey designs for euphausiids (I96-4) was accepted by the Subcommittee. The Subcommittee agreed that the paper had made a substantive contribution in developing a survey approach to estimating the seasonal patterns in biomass of euphausiids in Jervis Inlet. Furthermore, the Subcommittee expressed concerns that the current catch was not small compared to winter minimums of biomass, and that appropriate harvest levels were uncertain, especially considering (1) the low trophic level of the species; (2) the lack of biological knowledge of the species; (3) the possible effects of migration on biomass estimates; and (4) the causes of the winter decline in biomass.

A Working Paper on crab escape rings was not accepted by the Subcommittee, and directions were given for further work to be done on the topic.

The Subcommittee concluded that a Working Paper in a management approach to new and developing fisheries (I96-6) required further revision, but the general framework suggested would be a major improvement in the Department's approach to this important conservation area. The Subcommittee gave a number of directions for the revisions, and also directions for preliminary actions to be taken when the Region is dealing with proposals for new fisheries.

A Working Paper (I96-7) on optimal size of biological samples of geoducks was accepted by the Subcommittee, with a number of revisions required. The Subcommittee accepted the conclusions of the paper, which should reduce the number of geoducks taken in samples from each bed.

The Subcommittee also discussed a number of other issues, including proposed changes to PSARC Terms of Reference, particularly for inclusion of non-DFO staff in PSARC meetings; the role and proper review of Fishery Updates; and the interactions between assessment biologists and fisheries managers within the framework of preparation, review, and assigning priority to PSARC Working Papers.

Steering Committee accepted the recommendations of the Invertebrate Subcommittee, noting in particular the concerns and progress on interactions between stock assessment biologists and fisheries managers.

Advisory Document 96-3 reports on the meeting of the Salmon Subcommittee 22-26 April, and the Steering Committee discussions of that report. Fourteen working papers were reviewed, and a number of other major issues were discussed.

An application of Bayesian analyses to forecasting Skeena sockeye (WP S96-3) was accepted, with a few qualifications, particularly regarding the applicability of the method in future, if there are noteworthy changes in the way the fishery is prosecuted. A Working Paper (S96-4) on run reconstructions of northern pink and sockeye stocks was also accepted. The Subcommittee noted that migration routing was an important source of uncertainty in these analyses, and suggested ways to improve knowledge of that factor. A working paper on sockeye stocks in the Queen Charlotte Islands (S96-5) was returned for additional analyses. It was noted that many data series are poorly documented, or inconsistently recorded, and a number of recommendations were made to improve the quality of data for use in assessments. An assessment of sockeye and coho in the Taku River, based largely on mark recapture methods (S96-6) was accepted with a number of minor revisions. This paper comprises a major improvement in knowledge of the status of those northern trans-boundary stocks. Working Paper S96-7 collates and reports a large body of information on Skeena River chinook stocks and makes over a dozen recommendations. The Subcommittee accepted the working paper, noting that it stopped short of a full assessment. The Subcommittee accepted most of the recommendations, but requested stock specific assessments and estimation of escapement targets be given more priority.

Working Paper S96-8 described the results of the Strait of Georgia chinook harvest rate program. The Subcommittee accepted the paper, but withheld a decision on endorsing the recommendation to continue the mark recovery program, pending results of further analyses of the data. A Working Paper (S96-9) reporting on the methods used to estimate escapement of chinook to the Nechako was deferred pending substantial further analyses of the data collected in the program, and fuller contrasting of the accuracy and precision of the estimates produced by the alternative methods. The Subcommittee spent substantial time on review and discussion of Working Paper 96-10, on the status of coho stocks on the West Coast of Vancouver Island. The Subcommittee noted in particular that the very large number (>500) of individually small stocks raised a number of questions about the representativeness of the 3 stocks for which data were available, and about the attainment of conservation objectives at a time of apparently poor marine survival. The Subcommittee also accepted Working Paper S96-11, on coho in the Strait of Georgia. PSARC stressed the importance of the findings that marine survival remains very low, many stocks remain at risk, even under the reduced exploitation rate of 1995, and severe conservation measures would be necessary in 1996 fisheries.

The First Nations catch monitoring program was reviewed in Working Paper S96-12. Although the Subcommittee requested a number of modifications to the Working Paper, the work was accepted as a major incremental step in improving the documentation of this program. Working Paper S96-13 was a progress report on the riverine acoustic program for enumeration of Fraser salmon. The Subcommittee was pleased with the progress in this program, and the thoroughness of documentation in the working paper. Based on Working Paper S96-14, on the Fraser Lakes juvenile sockeye acoustic program, the Subcommittee recommended continuation of the program in 1996.

However, the Subcommittee requested expanded work on the statistical design and analyses of the survey, and will await decisions on carrying capacity once further work is reviewed. The Subcommittee requested substantial revisions to a working paper (S96-15) on an ecosystem basis for management of Fraser River Sockeye. The paper reported on a great deal of work supported through the Fraser River Green Plan, including a temperature based model, and other habitat related work. The Subcommittee requested the work be divided into two or more papers, each addressing a clearly defined piece of work. Working Paper S96-16, on the status of chinook in the Puntledge River, was accepted by the Subcommittee, but it was noted that the paper only partly fulfills the past request for quantification of the impacts of seal predation on this stock. Direction was given for the additional work which is required.

The PSARC Steering Committee review of this Subcommittee report highlighted several major concerns, including frequent failures to meet deadlines in preparation of PSARC working papers, the need for clear, explicit management objectives for stocks being assessed, several concerns with data access and management practices, and aspects of the status and data quality for chinook. Steering Committee generally endorsed the recommendations from Subcommittee, and noted there was particular urgency in completing revisions or new work on chinook stocks (particularly in the Strait of Georgia) and the First Nations catch monitoring work. Steering Committee also stressed the conservation concerns for southern coho and chinook stocks, and the need for strong management actions to achieve conservation goals in these stocks.

Advisory Document 96-4 The Groundfish Subcommittee met from 3-7 July, and their Subcommittee Report was reviewed by Steering Committee on 18-19 September. Advisory Document 96-4 reports on the results of these meetings. As major concerns, both the Subcommittee and Steering Committee noted that the reduction in resources has created a situation where it is no longer possible to produce analytical assessments of all groundfish stocks which were assessed in past years, nor possible to provide advice on new stocks and issues which are arising. This issue must be dealt with explicitly in workplanning. It is also noted that past efforts to call attention to the need for reevaluation of management approaches to inshore lingcod and inshore rockfish, particularly in the Strait of Georgia, have not produced action, and both the state of the resources and credibility of the assessments and management plans are deteriorating. The Subcommittee also repeated the need for full participation by oceanographers in the meeting. Finally, the implications of several new international agreements, which commit Canada to a precautionary approach to management, were discussed.

The Subcommittee reviewed nine working papers, assessing the status of many stocks of over 20 species of groundfish. G96-2 evaluated the status of offshore lingcod stocks. PSARC concluded that there was no justification to change yield options, but expressed concern with the great increases in effort in Hecate Strait, and declining indices in Queen Charlotte Islands. G96-3 reported on the status of Pacific cod stocks, but was considered to be an interim document, with further analyses to be completed following acquisition of additional data later in the year. Working Paper G96-4 reported on the status of seven flatfish stocks. The Subcommittee advised status quo yields for

all stocks except English sole in Hecate Strait, where the advised yield options were reduced. Working Paper G96-5 reported a major assessment of Sablefish. Following thorough discussion of the three reviews of the assessment, the Subcommittee deferred a decision on the state of the resource, pending additional analyses and review of a revised Working Paper.

Working Paper G96-6 reports on the status of Pacific Hake. The Subcommittee agreed that the stock is still declining from very high levels earlier in the decade, but the 1994 year-class may be strong and improve status in the coming years. Working Paper G96-7 evaluated the information on the status of walleye pollock. The Subcommittee agreed that the stock appears fairly stable, but there is little information being collected at present which could form a basis for a detailed analytical assessment and empirical advice on yield options. Working Paper G96-8 presents a major assessment of slope rockfish stocks, focusing on Pacific Ocean perch, especially the Goose Island Gully stock. The Subcommittee accepted the evaluation of perch stocks and noted that further rebuilding of the stock may be unlikely. It also noted the increasing harvest and need for more complete assessments and advice on previously minor species of slope rockfish, but such additional work is unlikely without new science resources. Working Paper G96-9 reports on the status of 8 stocks of shelf rockfish. The Subcommittee concurred with the recommendations for minor changes to the yield options for some stocks, and noted the need for close monitoring of indices for trans-boundary yellowtail rockfish. Working Paper G96-10 reports in a major assessment of inshore rockfish. The Subcommittee concurred with the authors that the stocks are in poor condition in the Strait of Georgia and around Queen Charlotte Islands, and of unknown status elsewhere. A large number of concerns with the present approach to management of these resources are also presented in the Working Paper and Subcommittee discussions.

With a few minor exceptions where Steering Committee took a more precautionous view, Steering Committee endorsed the Subcommittee yield recommendations. Steering Committee also supported the major concerns raised by the Subcommittee, and called particular attention to the need for a review of management approaches to inshore rockfish.

Advisory Document 96-5 contains the results of the Herring Subcommittee meeting of 4-6 September and the Steering Committee discussions of 18 September. The Subcommittee concluded that the Queen Charlotte Island stock has increased slightly from the low level reached in 1995, after several years of poor recruitment. The harvest consistent with the current management strategy is 310 tonnes. The Subcommittee concluded that the Prince Rupert stock was a moderate level and increasing with recruitment of the strong 1993 year class. The catch consistent with the current management strategy is 7,218 tonnes. The Central Coast stock is fairly low, following several weak recruiting year classes early in the 1990s. Assuming poor recruitment continues, the 1997 catch consistent with the current management strategy is 3,130 tonnes. The Subcommittee concluded that the Strait of Georgia stock remains at very high levels, and the pattern of strong recruitment is continuing. The 1997 catch

consistent with the current management strategy is 15,450 tonnes. The Subcommittee concluded that the West Coast of Vancouver Island stock is in slightly improved condition compared to recent very low levels, and recruitment may not be as poor as in recent years. The catch in 1997 consistent with the current management strategy is 4,820 tonnes. The Subcommittee also discussed the biological consequences of small harvests when the stock is below Cutoff, and concluded that there is no biological basis for curtailing minor fishery removals on herring stocks below Cutoff, however, the conservation risk associated with fishing increases as the abundance level declines. The conservation risk is increased further if data from all sources of harvest is not made available for assessments. Steering Committee concurred with all the assessments and the advised harvest levels.

Advisory Document 96-6 contains the report of the meeting of the Invertebrate Subcommittee from September 9-13, and the Steering Committee comments on the Subcommittee Report. The Subcommittee reviewed six working papers and fourteen Fishery Updates. The Subcommittee accepted Working Paper I96-8 as a basis for quota estimation for geoducks, and following a detailed discussion of uncertainties and alternatives, endorsed the present approach to management of geoducks, including the present 1% harvest rate. The Subcommittee also accepted Working Paper I96-9 as a basis for quota calculations in green sea urchins, noted several improvements in data bases and methodologies, and highlighted the value of the fishery independent surveys which have begun. The Subcommittee requested major revisions to Working Paper I96-10 on the Seal Island butter clam stock and fishery, and made several comments on weaknesses in the present approach to evaluation and management of that stock in particular, but also any bivalve populations in general. The Subcommittee also requested major revisions to Working Paper I96-11, on status and management of inshore shrimp stocks, but noted the paper was a sufficient basis for a number of observations regarding these stocks and fisheries. Of particular note, the Subcommittee advises that given present uncertainties over sustainable harvest levels in these fisheries, indications that some stocks are presently overexploited and expectations that effort will likely increase, there are considerable risks to the sustainability of these fisheries. The Subcommittee accepted Working Paper I96-12, and on the basis of the working paper and its deliberations, proposed a management approach which would see the quota taken from 25% of the coastline, with a further 25% used for experimental fisheries as part of specific research programs and 50% of the coastline closed as harvest refugia. The Subcommittee also accepted Working Paper I96-13, on euphausiids, requesting a number of sections be removed, and concluded that there is no biological basis for altering the present management approach to euphausiids.

A number of issues arose in the Subcommittee review and discussion of Fishery Updates, particularly on shrimp trawl fisheries (both inshore and offshore) and intertidal clams. Fishery Updates were also reviewed for geoducks, horse clams, prawn trap fisheries, octopus, scallops, squid, goose barnacles, crabs, sea cucumbers, green sea urchins, red sea urchins, and euphausiids. Major emergent issues included problems of data access across sectors, and the need for revitalization of the FMISST initiative in

invertebrates, the need for full adherence to the principles and approach in the Pacific Region Guidelines for the Development of New Invertebrate Fisheries, and the importance of PSARC's role in evaluating environmental impact assessments which address issues within the mandate of PSARC.

Steering Committee accepted the recommendations of the Subcommittee with regard to working papers and fishery updates, and gave special endorsement to the innovative proposals for the developing sea cucumber fishery. Steering Committee expressed special concern with the rapid expansion, technological changes and development in new unlicensed as well as currently licensed invertebrate fisheries and strongly endorsed the Subcommittee comment that a precautionary approach to the management of these fisheries is not easily reconciled with continued passive management characterized by no effort or harvest controls. The Steering Committee also very strongly supports Subcommittee's request that Environmental Impact Assessments (EIA's) come to PSARC for information and that PSARC be considered an appropriate body for review of EIA's on projects thought to have possible impacts on stocks and ecosystems.

Advisory Document 96-7 contains the results of a PSARC Groundfish Subcommittee meeting in November 1996, and the Steering Committee review of the Subcommittee Report. The Subcommittee accepted revised Working Paper G96-3, assessing the status of Pacific cod, and approved the yield table contained in that document. The Subcommittee also accepted revised Working Paper G96-5, on the status of sablefish. The Subcommittee noted the discrepancies in trends estimated using different data sources, the influence of the tagging data on evaluation of trend and status, and concluded that the stock is either stable or declining slightly. The Subcommittee also complemented the authors for the joint work between research staff and industry in preparing the assessment. The Subcommittee also accepted reports of the halibut bycatch reduction program, which has succeeded in reducing halibut bycatches in trawl fisheries to approximately half the 1997 targets, and on transboundary yellowtail rockfish, where the most recent US assessment concluded the US portion of the stock is substantially smaller than estimated in the previous US assessment. The Subcommittee also recommended that there be a special meeting to evaluate the impacts on assessment data of the change to IVQ management of all groundfish fisheries, and the need to identify target and limit reference points for groundfish (and other) stocks. Steering Committee accepted the Subcommittee Report and all the recommendations. It noted in particular the value of direct industry-based collaboration in the assessment of the sablefish stocks.

Advisory Document 96-8 contains the report of the Salmon Subcommittee meeting held from 19-21 November, 1996, and the Steering Committee meeting of 29 November. Both the Subcommittee and Steering Committee highlighted two major concerns. The first was the need for greater participation by Science Branch staff outside of the Stock Assessment Division at PSARC meetings. The second was the

continuing existence within the Region of multiple mechanisms for producing salmon forecasts, with only some of the forecasts undergoing independent peer review. The Subcommittee and Steering Committee also provided direction for ensuring that future reports convey the uncertainty in forecasts in a similar manner across stocks and species of salmon.

Working Paper S96-17 reports on an assessment of chinook salmon in the Strait of Georgia. The Subcommittee accepted the paper with minor revisions. The Subcommittee noted the diversity of scenarios which were explored, and concluded that even optimistic scenarios indicate that wild Strait of Georgia chinook stocks have declined by around 80% since the mid-1970s. Excessive exploitation and unfavourable environmental conditions have contributed to the decline. If exploitation is maintained at the levels of the mid-1990s, and marine survival remains at the level of the past several years, the Strait of Georgia chinook stocks will remain at their present low level, or increase only slightly. Stocks are likely to decline further if marine survival decreases or if exploitation increases. A significant reduction in exploitation rate, relative to the rate in the early 1990s (1990-1992) will be required to achieve any noteworthy rebuilding. The Subcommittee stressed that measures taken to date which were intended to reduce harvest rates on lower Strait of Georgia stocks, particularly in sport fisheries, have not succeeded in actually limiting harvest rates in these fisheries. Steering Committee concurrent with these conclusions of the Subcommittee, recommended formation of a strategic working group to address these serious issues.

Working Paper S96-18 reports on a work to estimate the predation of salmon by harbour seals in the Puntledge River estuary. The Subcommittee agreed with several concerns of the reviewers regarding statistical analyses of the data, but accepted the paper conditional on addressing the major analytical concerns. The Subcommittee agrees that seals are major predators of salmon in the Puntledge River and estuary, although further statistical analyses are required to validate the point estimates and confidence limits. The Steering Committee noted that this report is based on work done in 1990 and that chinook abundance has declined considerably since then. Therefore, the work may not be relevant to current stock sizes. Steering Committee also directed that the working paper not be distributed prior to review by the Subcommittee chair and the chair of PSARC to ensure all revisions are completed. At this time, the Steering Committee also recommends the revised paper be submitted to the National Marine Mammal Committee for review.

Working Paper S96-19 presents forecasts of expected returns for Fraser sockeye and pink salmon in 1997. The Subcommittee accepted the forecasts, and noted that the methods were consistent with the decisions of past reviews of forecast methods. The Subcommittee recognized the authors' emphasis that an extremely high level of uncertainty is associated with the 1997 return estimates. Uncertainty exists because, in general, the models and available data used to generate the sockeye and pink forecasts produce imprecise and unreliable results. Even greater uncertainty exists for the 1997 sockeye forecasts for several reasons, which are outlined in the report. Preseason plans should accommodate the large uncertainties in the forecasts and also

consider sockeye run sizes to the Stuart River that are within the range of historical returns. Steering Committee concurred with the forecasts, and with the Subcommittee cautions that many forecasts involve extrapolations of models outside the range of historic observations.

Working Paper S96-20, presenting forecasts of sockeye, pink, and chum salmon in the Skeena was accepted with minor revisions. The Subcommittee notes that if more accurate short-term forecasts are necessary for management, then greater investments in data quality (accuracy of catch and escapement data by stocks, and particularly, in biological sampling for age structures) will be required. Further, longer term shifts in environmental conditions probably affect salmon production in ways that alter the parameters for forecasting such that long term forecasts will be biased and imprecise. Steering Committee accepted the conclusions and recommendations of the Subcommittee.

Working Paper S96-21 reports on forecasts of sockeye in the Barkley Sound area. The Subcommittee accepted the working paper with minor revisions. The Subcommittee endorsed a 1997 forecast using the SSM methodology. Given the magnitude of smolt releases and salinity conditions in 1994 and 1995, the SSM forecast is for returns of 693,000 (50% level) sockeye to Barkley Sound in 1997. The Subcommittee made additional comments on stock delineation in these stocks, and analyses which may extend the forecasts to other adjacent stock units. Steering Committee stressed the need for estimation of probability profiles for these stocks.

Working Paper S96-22 reports on forecasts of coho salmon on the West Coast of Vancouver Island. The Subcommittee accepted the paper with major revisions, and commented on the validity of three different forecasting models. Based on its evaluation of the three models, it noted that even under a 'no fishing' policy in 1997 and assuming the mean survival (risk neutral), approximately 13% of the stocks would attain escapements of less than 3 females/km and approximately 25% would attain escapements of less than 9 females/km. A risk averse results in about 19% of stocks with escapements of less than 3 females/km or 58% with escapements less than 9 females/km under no fishing. Applying an exploitation rate in 1997 similar to that in 1996 of 50% and a survival rate of 0.053, results in approximately 38% of stocks achieving escapements of less than 3 females/km and 88% of stocks achieving escapements of less than 9 females/km. The Subcommittee discussed limit reference points for coho at length, and recommended that a working paper be prepared on that topic for the next Subcommittee meeting. The Subcommittee also recommended that significant reductions in exploitation rate from recent levels are required in 1997 to ensure the conservation of WCVI coho populations. The magnitude of reductions involves an evaluation of trade-offs between current fishery values and the risk of not maintaining a full suite of viable and productive coho populations. Steering Committee concluded that there are a significant number of stocks that are at risk of major loss of production and possibly at risk of extinction during 1997. Steering Committee further emphasizes that this is not a recoverable situation in the short-term because generations do not overlap in the river. Therefore, this will be a recurring problem every

3 years, which will have a significant impact on the fishery regardless of the status of other stocks.

Working Paper S96-23 reports on the forecasts of chum salmon in the Strait of Georgia, Johnstone Strait, and the Fraser River. The Subcommittee reviewed a number of concerns regarding the forecasting methods used. However, Subcommittee accepted the working paper, with revisions. The forecast for 1997 is for a return of approximately 4.9 million chum salmon. The Subcommittee noted that the R/S model performed poorly in 1995. Inclusion of 1995 data in the calculation of MAPE above increased the error from 27% to 39%. The Subcommittee notes that the uncertainty about the forecast, using past model performance, will not be analogous to confidence statements being made for other stock forecasts such as Fraser sockeye and such differences should be clearly indicated. Steering Committee concurred with the Subcommittee conclusions and recommendations.

Working Paper S96-24 reports on forecasts of chum salmon for the West Coast of Vancouver Island. The Subcommittee agreed that a statistically rigorous methodology had not been applied to the development of 1997 forecasts of WCVI chum salmon. Nonetheless the Subcommittee accepted the Working Paper with revisions. The Subcommittee supports the chum forecasts for Nitinat Lake (1,200,000 chum) and Nootka Sound (328,000 chum). There are commercially harvestable surpluses in both of these areas. The Subcommittee could not comment on the expected status of other WCVI chum stocks in 1997 given the lack of detailed analyses for these stocks. However, the authors' expectation of no surpluses given recent run sizes is prudent advice in the absence of more information. Steering Committee concurred with the conclusions and recommendations of the Subcommittee.

Table 1. Major PSARC Meetings Held During 1996.

Date	Meeting	Location
7-8 February	Salmon	PBS Nanaimo
27 and 29 February	Steering Committee	PBS Nanaimo
12 March	PSARC/RMEC	Vancouver
1-3 April	Invertebrates	PBS Nanaimo
22-26 April	Salmon	PBS, Nanaimo
14-15 May	Steering Committee	PBS, Nanaimo
28 May	PSARC/RMEC	Vancouver
21 June	Steering Committee	Nanaimo
3-7 July	Groundfish	Nanaimo
4-6 September	Herring	Nanaimo
9-13 September	Invertebrates	Nanaimo
18-19 September	Steering Committee	Nanaimo
23 October	PSARC/RMEC	Vancouver
15 November	Groundfish	Nanaimo
19-21 November	Salmon	Nanaimo
29 November	Steering Committee	Nanaimo

Table 2. List of PSARC Working Papers and Fishery Updates Reviewed During 1996.

GROUND FISH SUBCOMMITTEE

Working Papers:

- | | |
|--------|--|
| G96-2 | Offshore lingcod stock assessment and recommended yield options for 1997. G.A. McFarlane, and B.M. Leaman. |
| G96-3 | Pacific cod stock assessments for 1996 and recommended yield options for 1997. V. Haist, and D. Fournier. |
| G96-4 | Flatfish stock assessments for 1996 and recommended yield options for 1997. J. Fargo, and A.R. Kronlund. |
| G96-5 | Sablefish stock assessment for 1996 and recommended yield options for 1997. M.W. Saunders, B.M. Leaman, V. Haist, R. Hilborn and G.A. McFarlane. |
| G96-6 | Pacific hake stock assessment for 1996 and recommended yield options for 1997. M.W. Saunders, and G. A. McFarlane. |
| G96-7 | Walleye pollock stock assessment for 1996 and recommended yield options for 1997. M.W. Saunders, and W. Andrews. |
| G96-8 | Slope rockfishes. L.J. Richards, and N. Olsen. |
| G96-9 | Shelf rockfish assessment for 1996 and recommended yield options for 1997. R.D. Stanley. |
| G96-10 | Inshore rockfish stock assessment for 1996 and recommended yield options for 1997. K.L. Yamanaka, and A.R. Kronlund. |

HERRING SUBCOMMITTEE

Working Papers:

- | | |
|-------|--|
| H96-1 | Stock assessment for British Columbia herring in 1996 and forecasts of the potential catch in 1997. J. Schweigert, C. Fort and L. Hamer. |
| H96-2 | Offshore herring distribution and 1997 recruitment forecast for the West Coast of Vancouver Island stock assessment region. D. Ware and R. Tanasichuk. |

Table 2 (Cont'd)

H96-3	Herring carrying capacity and sustainable harvest rates in different climate regimes. D. Ware.
H96-4	Estimating natural mortality for Pacific Herring (<i>Clupea pallasii</i>) adults from the lower West Coast of Vancouver Island. R. Tanasichuk.
H96-5	A framework of a simulation model for the Pacific Herring (<i>Clupea pallasii</i>) population from the lower West Coast of Vancouver Island - a progress report. R. Tanasichuk.
H96-6	A retrospective analysis of B.C. herring stocks from age-structured model analysis. J. Schweigert.
H96-7	Analysis of recruitment predictions in Georgia Strait - based on juvenile surveys - a progress report. D. Hay and B. McCarter.

INVERTEBRATE SUBCOMMITTEE

Working Papers:

I96-1	Assessment of the Area 12 prawn fishery in relation to declines in annual catch. J. Boutillier.
I96-2	Stock assessment framework for quota based manila clam fisheries in British Columbia. G. Gillespie.
I96-3	Evaluation of survey methods for geoducks. A. Campbell, C.M. Hand, C. Paltiel, K. Rajwani and C.J. Schwartz.
I96-4	Comparisons of repeat acoustic surveys of euphausiid stock in Jervis Inlet, British Columbia: 1990-1996. D.L. Mackas, S.J. Romaine, M.C. Macaulay and D.J. Saxby.
I96-5	Preliminary examination of the biological consequences of implementing a 110mm diameter dungeness crab trap escape ring. A. Phillips and J. Rice.
I96-6	A framework for providing scientific advice for the management of data limited invertebrate fisheries. I. Perry.
I96-7	Optimal sample sizes for geoduck biosamples. A. Campbell and K. Rajwani.

Table 2 (Cont'd)

196-8	Quota options and recommendations for the 1997 and 1998 geoduck clam fisheries. C. Hand, K. Marcus and S. Heizer
196-9	Stock assessment and quota recommendations for 1996/97 for the Green sea urchin fishery in British Columbia. I. Perry and B. Waddell
196-10	Assessment of the 1995 Seal Island intertidal clam survey. J. Osborne and G.D. Heritage.
196-11	Assessing the inshore shrimp fisheries: data status, model requirements, problems. J. Boutillier, M. Joyce, J. Bond and I. Winther.
196-12	Scientific advice for the management of the sea cucumber (<i>Parastichopus californicus</i>) fishery in British Columbia. J. Boutillier, I. Campbell, R. Harbo and S. Neifer.
196-13	The influence of interannual variations in sea temperature on the population biology and production of <i>Thysanoessa spinifera</i> and <i>Euphausia pacifica</i> in Barkley Sound and its implications for the management of commercial krill fishing. R. W. Tanasichuk.

Fishery Updates:

1. Shrimp	8. Squid
2. Sea Cucumber	9. Horseclams
3. Geoduck	10. Goose Barnacles
4. Intertidal Clams	11. Scallops
5. Crabs	12. Green Sea Urchins
6. Euphausiid	13. Red Sea Urchins
7. Octopus	14. Prawns

SALMON SUBCOMMITTEE

Working Papers:

X96-1:	1996 abundance forecast, and preliminary outlook for 1997, for Robertson Creek Hatchery and Stamp River chinook salmon. B. Riddell, A. Tompkins, W. Luedke and S. Lehmann.
S96-2	Forecasts of Fraser River sockeye salmon for return year 1996. A. Cass and D. Blackburn.

Table 2 (Cont'd)

S96-3	In-season forecasting of Skeena River Sockeye run size using Bayesian probability theory. S. Cox-Rogers.
S96-4	Assessment of sockeye and pink salmon stocks in the northern boundary area using run reconstruction techniques, 1982-1992. W.J. Gazey and K.K. English.
S96-5	Assessment of the status of sockeye salmon stocks on the nursery lakes of the Queen Charlotte Islands (Haida Gwaii). K.D. Hyatt and D.P. Rankin
S96-6	Review of adult mark-recapture studies of Taku River salmon stocks 1994-1995. P.A. Milligan, M.Scott Kelley, and A. J. McGregor.
S96-7	A review of stock assessment information for Skeena River chinook. S.D. Peacock, B. Spilsted, and B.Snyder.
S96-8	A review of the Strait of Georgia chinook harvest rate program. C. Murray and B. Riddell.
S96-9	Nechako Fisheries Conservation Programs: Nechako River chinook escapement enumeration methodology. P. Delaney.
S96-10.	Assessment of coho stocks on the West Coast of Vancouver Island. K. Simpson, B. Holtby, R. Kadowaki and W. Luedke.
S96-11	An update of assessment information for Strait of Georgia coho salmon stocks with 1996 forecasts and advice on setting an exploitation rate target. R. Kadowaki, B. Holtby, K. Simpson and D. Blackburn.
S96-12	Report on the Upper Fraser River catch monitoring programs and First Nations Fisheries, 1995. V. Palermo and B. Ennevor.
S96-13	Status report on the Qualark Creek Hydroacoustic Project. T.J. Mulligan.
S96-14	The utility of hydroacoustic estimates of juvenile sockeye in stock assessment with forecast for the 1997 Quesnel Lake return. J.M.B. Hume, A. Cass and K.S. Shortreed.
S96-15	Ecosystem management for Pacific salmon: integrating habitat into the harvest management - stock assessment loop. I.V. Williams and T.J. Brown.
S96-16	Status of the Puntledge River summer chinook. A.W. Trites, C.W. Beggs and B. Riddell.

Table 2 **(Cont'd)**

S96-17	An assessment of chinook salmon (<i>Oncorhynchus tshawytscha</i>) in the Strait of Georgia. C. Walters and B. Riddell.
S96-18	An assessment of harbour seal (<i>Phoca vitulina</i>) predation on pre-spawning adult salmon (<i>Oncorhynchus</i> spp.) in Comox Harbour and the lower Puntledge River, British Columbia. P. Olesiuk, P.E. Cottrell and C.E. Neville.
S96-19	Forecasts of Fraser River sockeye and pink salmon for return year. A. Cass and D. Blackburn.
S96-20	Preseason 1997 run size forecasts for major sockeye, pink, and chum salmon stocks in northern British Columbia. C. Wood, D. Rutherford, D. Peacock and S. Cox-Rogers.
S96-21	An update on 1996 stock status and 1997 forecasts of Barkley Sound sockeye. K.D. Hyatt and W. Luedke.
S96-22	Forecast of 1997 return of coho to west Vancouver Island with comments on the implications of the poor brood year (1994) escapement. B. Holtby and R. Kadowaki.
S96-23	1997 forecasts for Johnstone Strait, Georgia Strait, and Lower Fraser chum salmon. P. Ryall, D. Bailey and N. Schubert.
S96-24	Update on status of WCVI chum salmon stocks and forecast for 1997. W. Luedke and D. Bailey.

Appendix 1. Past and Present Chairpersons of the PSARC Steering Committee and Subcommittees.

PSARC Steering Committee

1985	D. Schutz
1986-88	M. Stocker
1989-90	S. Farlinger
1991-93	J. Irvine
1993 - Aug. 1994	R.D. Humphreys
Aug. 1994 -	J. Rice
Aug. 1995-Jan. 1996	B. Leaman (Acting)
April-June 1996	S. Farlinger (Acting)

Salmon Subcommittee

1986-89	B. Riddell
1989-91	D. Anderson
1991-93	S. McKinnell
1993-94	R. Kadowaki
1994-	L. Richards

Groundfish Subcommittee

1986-90	A. Tyler
1990-93	B. Leaman
1993-95	B. Turris & M. Stocker
1995-	R. Beamish

Invertebrate Subcommittee

1986-87	R. Harbo
1987-89	N. Bourne
1989-91	G. Thomas
1992-93	D. McKone
1993-94	F. Dickson
1995-96	S. McFarlane
1996-	B. Holtby

Herring Subcommittee

1986	S. Farlinger
1987-88	J. Schweigert
1989-90	D. Chalmers
1991-93	V. Haist
1993-95	D. Ware
1995-	G. Thomas

Data & Systems Subcommittee

1986-88	L. Lapi
1988-90	D. Radford
1991-93	R. Stanley
1993-95	D. Welch

Appendix 2. 1996 PSARC Steering Committee Membership.

Dr. J.C. Rice, Chairperson
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Dr. L. Richards, Chairperson
PSARC Salmon Subcommittee
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Dr. D. Noakes, Acting Director
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SECTION II - PSARC Advisory Documents

BIOLOGICAL ADVICE ON PACIFIC SALMON

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I. STEERING COMMITTEE REPORT

The Subcommittee chair provided a summary of the report of the Special Subcommittee meeting on Fraser River sockeye forecasts. The Subcommittee chair confirmed that the revisions requested by the Subcommittee have been incorporated in the report. The Steering Committee requests that the detailed spreadsheet tables outlining the performance of models be appended to the subcommittee report.

A summary table of sockeye forecasts by stock and run timing group for 1996 was examined in detail. This table was derived from the most up-to date information available.

The Steering Committee discussed discrepancies of numbers in the table with numbers provided at the February Subcommittee meetings, and the effects that analyses suggested by the Subcommittee had on the forecasts. The differences were reconciled as follows:

Early Stuart - As suggested by the Subcommittee, a new analysis was carried out using 4 year lagged data. The results indicated that 4 year lagged data did not improve prediction power as indicated by the root-mean-square error (RMSE), and thus the original modelling approach with long-term time series data was maintained. However, the data base was updated by adding two recent years of 5 year old and 4 year old returns. The analysis including these new data resulted in the adoption of the power model for the 1996 forecast. The value of RMSE of the power model was lower than the value of RMSE of the Ricker model which was originally chosen.

Chilko - The multivariate forecasting model suggested by the Subcommittee, using smolts, age-3 returns, and age-3 lengths did not outperform the original model, and thus the advice was based on the original model.

For a few stocks, data files were revised following the February meeting. These changes resulted in some forecasts being different than the preliminary forecasts presented at the February meeting:

Fennel - Age 4 forecast changed downward.

Nadina - Time series of fry data added; model performed better with the additional variable.

Chilko - Updated age 5's.

Stellako - Updated age 5's.

Late Stuart - Estimates of jacks that were originally used were deemed unacceptable and not used in the final forecast.

The Steering Committee accepted the probability distributions of forecasts presented in Table 1 of the Subcommittee report.

The Steering Committee recommends revision of Working Paper S95-11 to include documentation of the forecast process that culminated in Table 1 explicitly. In future PSARC assessments, if the results of more than one forecasting method are considered, each Subcommittee should present the reasons for its selection from among the forecasts clearly and explicitly.

The Steering Committee felt that PSARC is using analytically rigorous methods and the best data available. The retrospective analysis paper requested by the Subcommittee has some merit, but may not be appropriate because the methods used in many historic forecasts are not documented.

The Steering Committee recommends that a paper be prepared to summarize the processes and considerations for choosing among candidate models, particularly among models with a similar goodness of fit but different forecasts. The intent of the review would be to provide a sound basis for Subcommittee discussions of model performance, and not to lock PSARC into use of a single set of criteria for all assessments. For the current forecasts the Root Mean Square Error was used as the major criterion to select the "best" model. It was suggested that different forecast objectives may make other criterion more appropriate.

X96-1: 1996 Abundance Forecast, and Preliminary Outlook for 1997, for Robertson Creek Hatchery and Stamp River Chinook Salmon. B. Riddell, A. Tompkins, W. Luedke and S. Lehmann.

Working Paper Summary

Since the development of the Robertson Creek hatchery in 1971, the Somass River system has become one of Canada's major producers of chinook salmon. The Somass system is located at the head of Alberni Canal in Barkley Sound, on the west coast of Vancouver Island. The system contains naturally spawning chinook in the lower Somass, Sproat and Stamp rivers, and the hatchery located in the upper Stamp. Somass chinook are an important resource to ocean fisheries in British Columbia and S.E. Alaska, have stimulated the development of a major recreational fishery in Barkley Sound, and provide for terminal commercial and Native net fisheries. However, the production is highly variable depending on marine survival conditions. Unfortunately, reduced survival rates have been observed for the 1991 through 1993 brood years (based on poor returns of age 2 and 3 fish). The impact of consecutive poor brood years will be significant. For example, the 1996 and 1997 terminal runs to Barkley Sound are projected to be substantially less than the minimum spawning escapement goal for the Somass system. Following the procedures accepted by PSARC in 1994 and 1995, this Working Paper incorporated the 1995 data and procedures for examining uncertainty in the forecasts, and developed forecasts of terminal run size (to Barkley Sound) for 1996 and 1997. Data

treatment and model descriptions are included in the Working Paper. Forecasts presented are only for Production models 2 and 3 as presented last year:

- Production Model 2 (Prod2): uses total terminal run of hatchery production at one age class to predict total production of a subsequent age or ages from the same brood year. The dependent variable is the total (total ocean fishing mortality plus terminal run) hatchery production at a subsequent age or ages, and independent variable the total terminal run of hatchery chinook of a younger age class or combination of age classes.
- Production Model 3 (Prod3): uses total hatchery production of one age class to predict total hatchery production of subsequent ages class in the same brood year.

Estimation of Forecasting Error

The potential error in the production-based forecasts was examined through a retrospective assessment of the data used in generating the forecasting equations. For each model, one brood year's data point was left out of the data set used to estimate the forecasting equation. The omitted point was then compared to the value expected from the equation and the deviation used as an estimate of the potential estimation error (absolute deviation). For example, if there were 7 brood year's data available for the model, then 7 estimates of error could be determined. These seven deviations would be averaged to estimate the expected error of the forecasts.

These measures of error for each forecast model apply to the forecast of pre-season ocean abundance. To estimate the potential error associated with forecasts of terminal run sizes, the abundance forecasts were applied to a forward spreadsheet model and the expected terminal run estimated. These expected terminal runs were compared with observed terminal runs to estimate the error. Since ocean harvest rates can not be known pre-season, the forward cohort analyses used the average ocean exploitation rates, for the 1984 to 1990 brood years.

Estimation of the Spawning Escapement Goal

Since the age and sex composition of the terminal run varies annually for this stock, the number of animals required for spawning must be evaluated. To estimate a minimum number of eggs for the natural spawners, PSARC (WP S94-1) recommended using the eggs deposited in 1984 as the minimum value. The number of eggs deposited by natural spawners in 1984 was estimated as 50.5 million eggs. The actual number of spawners required to return to the system would also include the egg requirement for Robertson Creek Hatchery (9.3 million eggs for an 8 million smolt rearing capacity); a minimum of 1:1 male:female spawning guideline in the hatchery (SEP spawning guidelines); and a 1.2 multiplier for pre-spawning mortalities (applied to total spawning requirements expressed in numbers of chinook). The escapement goal presented in 1995 for 1996 is repeated in this paper.

Results

Terminal runs of Somass chinook have varied by a factor of almost 7.5 since 1985. Hatchery returns to natural spawning in the river have exceeded returns into the hatchery by 2-4 times in recent years, but production from the hatchery has accounted for 46 to 79% of the total Somass return since 1985, averaging 68% over this period. Consequently, omitting tag recoveries from these spawners has under-estimated survival values and significantly over-estimated exploitation rates.

The 1996 forecasts of ocean abundance resulting from production models Prod2 and Prod3 are summarized in Table 2. The forecasts of ocean abundance include expansions for the unassociated and/or natural production. The terminal run forecasted may vary depending on the model used, the scalars used to increase the hatchery production to total production from the Somass system, and management actions in ocean fisheries. These results assume that the ocean management actions taken in 1995 are maintained in 1996 but other scenarios can be examined. Forecasts for the 1996 terminal run to Barkley Sound range from 9,764 (Prod3) to 24,440 (Prod2) chinook but only vary from 3,932 to 6,775 female chinook. Preliminary forecasts for 1997 returns are more variable resulting from uncertainty in the age 2 regression models and an assumed marine survival rate for age 3 chinook in 1997. Both of these concerns will be corrected following observed returns of age 2 and 3 chinook during 1996.

Estimation of Forecasting Error

The average prediction error varied between 26% and 80% (over the three sibling regression models) of the known data value for the Prod2, and 13% to 40% for the Prod3 model. The error within many of these regressions was frequently less than these averages but the average was inflated by one or two larger deviations in each regression model.

When these age-specific forecasts are combined to predict the total terminal run to Barkley Sound, the forecasting error is less on average. Figure 1 compares the annual deviations from observed total terminal runs and the average deviation for the Prod2 and Prod3 models. The Prod2 model had lower average error and was estimated to be 9% (average absolute deviation) of the observed values, compared to 11% for Prod3.

Spawning Escapement Goals

To achieve the minimum egg requirements for Robertson Creek hatchery and the natural spawners in the Stamp River the estimated numbers of spawners required for 1996 are 46,810 chinook (target number of females 12,627).

These goals are based on projected terminal age composition and are consistent with the minimum egg targets accepted by PSARC (WP S94-1). However, a Supplemental goal may be developed for 1996 in consultation with the Salmonid Enhancement Program. The supplemental escapement target would maintain the numbers of smolts leaving the

system in 1997 but increase the proportion of the smolt production from the hatchery. The supplemental goal would require a terminal run of 31,135 chinook, based on a requirement for 8,850 females. **Even in the absence of directed chinook fisheries in 1996, the forecasted terminal run of females in 1996 is expected to be less than either goal.**

Discussion

This report documents the serious loss of chinook production from the Robertson Creek/Somass system. The projected terminal returns for 1996, and almost assuredly 1997, will require serious conservation actions to prevent longer term loss of production from this major enhanced stock. We must also emphasize though that the survival problem identified in this assessment is very probably also applicable to other west coast Vancouver Island chinook populations. Many of these populations are small and will be severely depressed by survivals as poor as expected for the Somass populations. In many WCVI chinook populations, the numbers of spawners could be reduced to tens or a couple of hundred spawners. Further, these natural populations will not recover from a severe depression in population size as quickly as will occur in a population associated with an enhancement project. Serious depression in these natural populations may have longer term genetic impacts and would require prolonged reductions in fishery harvest rates in order to maintain the stocks and rebuild production.

Working Paper Recommendations

1. The recommended forecast for the total terminal run of chinook (age 3,4, and 5) to Barkley Sound in 1996 is $15,825 \pm 11\%$. These values are based on the simple average of Prod2 and Prod3 models and assume no change from 1995 ocean harvest rates in ocean fisheries from S.E. Alaska down to the west coast of Vancouver Island.

Reviewers' Comments

Reviewer #1

The reviewer had a number of questions about details of the management objectives, data sets, and model performance, but the short time for review had not allowed him to investigate the points. Moreover, the key conclusion of the paper would be unaffected by resolution of the points. The chinook stocks being assessed will be at extremely low levels due to poor ocean survival. Any fishery related mortality will drive the stocks further below previously agreed escapement goals. Such fishing will put a number of wild stocks at risk, and will likely result in substantially greater delays before the stocks would recover following any future changes in ocean conditions. Accordingly, fisheries should be restricted to the greatest possible extent in order to reduce chinook mortality and meet our conservation mandate. Reasons for the poor ocean survival were discussed in the review. The reviewer highlighted the possibility that the lower ocean

survival may not be a temporary change, but may be a regime shift which could persist for some years to come.

Reviewer #2

The reviewer also reviewed S95-03 last year, and noted that most of the Introduction and Methods in this document were identical to the earlier document, although some data tables contained slightly different values. The reviewer recommended the analysis methods, data, and results be accepted, and asked that some technical points be clarified in the revised document. The reviewer also recommended that PSARC stress in its advice that even the most optimistic scenarios fall far short of the escapement goals for these stocks, and that the conservation problems for other wild WCVI stocks are likely to be even more serious than last year.

Steering Committee Discussion

Steering Committee was satisfied with the explanations offered regarding technical points raised by the reviewers and Steering Committee. The WP is accepted with minor revision, primarily adding documentation of changes since 1995 in the fisheries data, and correcting some tabular material. Steering Committee discussed and accepted the forecasts, highlighting the great uncertainty in the forecasts for 1997. Those forecasts depend heavily on forecast numbers of age 2's in 1997, and forecasts of age 2's have much higher uncertainty than forecasts on older ages. Moreover, the low marine survival rates in recent years may reflect an unfavourable oceanographic regime which could persist for some years to come. If so, marine survival rates are likely to continue to be poor.

The recommended forecast for the total terminal run of chinook (ages 3, 4, and 5) to Barkley Sound in 1996 is $15,825 \pm 11\%$, based on the average of Prod2 and Prod3 forecasts, with only 4,810 females. This forecast assumes Canadian fisheries similar to 1995, and no harvest reductions in Southeast Alaska fisheries. This terminal run will not achieve the minimum escapement target for the Robertson Creek and Somass natural chinook stock. Even forecasts which assume no directed Canadian or Alaskan chinook fisheries still fall short of escapement goals by thousands of females. Moreover, Steering Committee agreed based on evidence and discussions from past meetings that the trend in these stocks is likely to be representative of trends in other wild stocks on the WCVI.

Conclusions

1. Given the forecast returns for the Somass chinook stocks and DFO's biological targets, PSARC advises that there is no harvestable surplus of this stock for 1996.

2. The forecasts for 1997 indicate that only modest improvement in stock status is expected. Moreover, these forecasts are highly uncertain, depending greatly on estimates of age 2's about which we have very little information at this time.
3. This assessment is the most complete and technically credible evidence available on the status of chinook stocks on the West Coast of Vancouver Island. The status and trends indicated for Robertson Creek and Somass chinook stocks are corroborated by what evidence has been presented previously for other hatcheries. A precautionary approach means that the trends seen in the stocks assessed here should be taken as indicative of trends in other wild stocks along WCVI. This means PSARC expects many wild stocks will experience severe depressions in abundance, and significant management measures will be required to preserve biodiversity of wild chinook stocks on the west coast of Vancouver Island.

II. SALMON SUBCOMMITTEE REPORT

1. Introduction

The Salmon Subcommittee held a special meeting on February 7-8, 1996, at the Pacific Biological Station, Nanaimo. The meeting was scheduled to conclude the review of 1996 forecasts and forecast methodology for Fraser River sockeye salmon. An earlier version of the forecasts was presented in Working Paper S95-11 by Cass and Blackburn. At its fall 1995 meeting, the Salmon Subcommittee had recommended that final acceptance of Working Paper S95-11 be delayed until information from the 1995 return year was available and sibling model forecasts were conducted. These additional analysis were presented by authors Cass and Blackburn and reviewed at the February meeting. February 7 was dedicated to a discussion of supplementary data (both quantitative and qualitative) that might influence 1996 returns. Specific forecasts and forecast methodologies were reviewed on February 8. Meeting participants are listed in Appendix 1.

2. Data review

The Subcommittee began by reviewing data supplementary to the 1996 forecasts on a stock by stock basis. A summary of the comments by major stock groups follows.

Early Stuart

Relationships of fry versus effective brood year spawning females, and fry versus age-4 returns were presented based on four years of fry data (1988-91). The point estimate of forecast returns from the fry data suggested a return of 50,000 sockeye in 1996, lower than the forecast of 148,000 age-4 sockeye using a longer time series of spawner-recruit data (1963-91). An explanation for the differences between the 'fry' forecast and those produced for the PSARC paper was not apparent. Analysis of data by cycle line

based on average returns per spawner indicated different trends in returns between cycle lines. However, no significant autocorrelation at a 4-year lag was found in a subsequent analysis of residuals from a Ricker curve fit to data that excluded the highly cyclic Driftwood stock. Furthermore, the Ricker curve fit to data from the 1996 cycle line was nearly indistinguishable from the fit to all years of data. High water temperatures in terminal areas and the poor condition of spawning sockeye (high incidence of net marks) in 1992, as well as the absence of age 3₂ spawning fish were noted and suggested to contribute to potentially lower returns in 1996.

Early Summer

Early summer stocks consist of an aggregate of small populations for which forecasts must be based on poorer quality data. Several factors may have value as forecast "risk" qualifiers that are relevant to specific stocks. Discussion suggested that anomalously high riverine temperatures during migration by the 1992 brood year may have negatively influenced returns for the Nadina stock. Similarly, extensive net scarring observed on fish from all early summer stocks (along with an impression that spawners were in poor condition) might be considered as evidence that returns will be lower than currently forecast. Data on net scarring were assembled and reported in the "en route mortality report" to the Fraser River Public Review Board and should be evaluated in future assessments.

Forecasts of Gates Creek returns may benefit from further assembly and analysis of fry observations. The fry data may lead to improved statistical performance of forecasts currently based on jack observations.

Because of their importance to both managers and some user groups, data should be collated for small stocks not currently considered (e.g. Upper Adams) to determine whether the basis for a forecast is available. For the sake of completeness, stocks for which forecasts are not conducted should be listed explicitly, along with a brief explanation as to why no forecast is currently possible.

Mid Summer

For mid-summer runs, forecasts are currently based on long time series observations of biological data. In addition, climate data are available for the Chilko stock. Size and age data could be examined further to determine whether strong temporal trends exist and also whether such trends may be responsible for recent changes in the goodness of fit of the forecast models. Few additional observations specific to the mid-summer runs are available to improve the forecasts. Some evidence suggests that managers should consider regime shifts in productive capacity of either marine or freshwater environments for their potential influence on returns for all stocks of sockeye in 1996.

Late Summer

The key late summer stocks for 1996 are Birkenhead and Weaver. The Subcommittee

raised a number of qualitative data issues including incorporation of river discharge data, estimates of age-4 returns, and relationships between age-4 and age-5 returns.

Higher river discharge in the fall and winter may be related to lower survival. For Birkenhead, some years of high discharge were associated with low sockeye survival, but the relationship between model residuals and discharge was poor. (Low discharge rates were also associated with low survivals.) Inclusion of river discharge data in the forecast analyses may be important for years of high flood conditions. However, discharge rates affecting 1996 returns of Birkenhead sockeye were not extreme. The age-5 component is also a critical factor for this stock and there are relationships between age-4 and subsequent age-5 returns. The Subcommittee must define a process for choosing among candidate models with a similar goodness of fit but which produce very different forecasts.

General issues related to all stocks

Although no specific analyses were presented, the Subcommittee discussed the possibility that ocean productivity has been at lower levels since 1989-90, reducing early marine survival of recent brood years. In general, high inter-annual variation in survival can mask other signals in the data. The Subcommittee considered an analysis of the Chilko smolt data to test for evidence of different parameter estimates in the forecast models for the specified ocean productivity periods. Given the small number of spawners for this stock in 1992, the Subcommittee concluded that a change in model parameters would have a minimal effect on the 1996 forecast.

3. Forecast review

The Subcommittee reviewed the authors' revised table of forecasts and decision criteria. For the most part, the forecasts were accepted as presented, based on the model which resulted in the lowest value of the root mean square (RMSE) criterion. Exceptions were raised for age-4 forecasts for Early Stuart, Chilko, Portage, Birkenhead and Weaver stocks and for the age-5 forecasts.

Early Stuart

Discussion focused on selecting among alternative forecasting procedures involving different data sets or shorter time series than those presented to the Subcommittee. The Subcommittee agreed that the highly cyclic Driftwood River population should be excluded from the analysis. After reviewing egg-to-fry survival data available only for brood years 1988-1993, the Subcommittee agreed that the low egg-to-fry survival measured for the 1992 brood year was not sufficiently different from other recent years to warrant special consideration in developing forecasts for 1996. The Subcommittee did agree that overall survival (returns per spawner) was lower for the last four brood years than for previous brood years, but saw no compelling evidence to suggest that a regime shift had lowered egg-to-fry or marine survival. Without compelling evidence for a regime shift, the Subcommittee concluded that there was no defensible reason to

prefer forecasts using only data from the four most recent years unless forecasts based on the most recent 4-year time series performed better in retrospective analyses. Accordingly, the Subcommittee recommended that the authors augment their retrospective analyses to include a modified return-per-spawner forecast based on the most recent four years. This short-time series method will be adopted for the 1996 forecast if it outperforms other methods in retrospective analysis under the criterion.

Chilko

The authors had preferred the forecast of age-4 sockeye based on smolt numbers because this model produced the lowest RMSE value for the historical series. The 1996 age-4 forecasts developed from the smolt model were 75% higher than those developed from models that included 1995 jack returns. The 1994 forecast for the 1995 return did not use the 1994 jack data, yet these data provided the only information that survival of the 1991 brood year might have been low. To address the concern that the most current data be used in the forecast, the Subcommittee recommended that the authors examine a forecast based on a multiple regression model of smolts, jacks, and jack lengths.

Birkenhead

The RMSE criterion for the age 4 forecast was nearly identical for the power model and the sibling model that included jack length. However, these two models produced different forecasts (402,000 sockeye and 84,000 sockeye, respectively). Jack returns in 1995 were the second lowest on record and their mean size had increased in recent years. Plots of predicted versus observed returns indicated that power model forecasts tended to be biased high at low observed returns. Conversely, predictions for the sibling model were relatively unbiased at low return levels. Thus, the sibling model was chosen as the more reliable model for the 1996 forecast.

Weaver

Two forecast models with very similar RMSE values produced different age-4 forecasts. The forecast developed from estimates of fry abundance was more optimistic than that produced from estimates of jacks and jack length data. Weaver sockeye rear in the same lake as Birkenhead sockeye. Because jack abundance in 1995 was low, the forecast based on jacks and jack length was preferred, consistent with the choice of forecast model for Birkenhead sockeye.

Age-5 forecasts

Discussion focused on whether the low age-4 returns in 1995 might provide a reliable warning of poor returns of age-5 fish in 1996. The age-5 forecast is particularly important for Birkenhead, where returns typically include a significant proportion of age-5 fish. The sibling regression model and the return per spawner model performed similarly in retrospective comparisons of age-5 forecasts for the Birkenhead stock.

However, if progeny of the 1991 brood year experienced *exceptionally* poor marine survival, the sibling model should be more reliable because the poor survival would be reflected in the age-4 returns. Accordingly, the Subcommittee examined available evidence and concluded that age-4 returns from the 1991 brood year have in fact been exceptionally low (a statistical outlier in the available time series).

The Subcommittee considered two hypotheses to account for the low age-4 returns:

1. Survival (expressed as log [returns per spawner]) of the 1991 brood was exceptionally poor but the ratio of age-4 to age-5 fish is as predicted from the long-term regression of arcsine-square-root transformed proportions of age-5 on mean length of fish from the same brood year returning at age-4;
2. Age at maturity was delayed (hence fewer age-4 returns in 1995), but overall survival is average.

In tests of both hypothesis, mortality between age-4 and age-5 was ignored. Under the first hypothesis, returns per spawner for the 1991 brood year must be significantly less than average (1.5 compared with 12.0, $p < 0.01$, t-test). Under the second hypothesis, the proportion of the 1991 brood returning at age-5 must be significantly higher than average (94.5% compared with 28.6% expected given the length of age-4 fish in 1995, $p < 0.001$). Thus, the 1991 brood year was clearly unusual, but given the probabilities obtained in the tests above, a change in survival (hypothesis 1) was 364 times more likely to have occurred as a random deviation from average conditions than a shift in age at maturity (hypothesis 2).

On the basis of this analysis, the Subcommittee agreed that age-5 forecasts which included age-4 data were preferred for all stocks, even though these forecast models may have inferior performance in retrospective analyses under more usual conditions. Where more than one forecast model used age-4 data, the Subcommittee preferred the model with the lowest RMSE value.

General forecasting issues

One reviewer had recommended that forecasts be conducted using only data for the specific cycle line. The authors presented an analysis to examine the cycle line effects on deviations in forecast predictions from a Ricker model. The Subcommittee concluded that cycle line analysis did not provide additional information for the 1996 forecast because the data were well modeled by the Ricker curve.

Presentation of forecast advice

Managers present at the meeting requested that forecast advice include graphical presentation of stock size probability distributions and stock sizes corresponding to the various percentiles of the forecast distribution.

4. Subcommittee Recommendations

The Subcommittee accepted Working Paper S95-11(renumbered S97-2) subject to the following revisions:

1. A short-term forecast should be prepared for the Early Stuart data. The analysis should be based on returns per spawner over consecutive four year periods. This forecast will be used to provide the advice if it performs better in retrospective analyses; otherwise, the forecast based on the Power model will be used to provide the advice.
2. A multivariate forecast model should be examined for the Chilko stock, using smolts, age-3 returns, and age-3 lengths as predictors for age-4 returns. This forecast will be used to provide the advice if it outperforms other models in retrospective analyses based on the RMSE criterion.
3. Tables and figures should be provided that summarize the advice on a stock-by-stock basis with summaries by run timing group and for the overall returns. Confidence limits around the forecasts should be included by assuming independence of the individual stock estimates, recognizing that these confidence intervals will underestimate the true variance.
4. The Working Paper should be updated to incorporate 1995 return information and the forecast analyses undertaken for and as a result of the Subcommittee meeting.

Final forecasts resulting from these analyses are presented in Table 1, with detailed results in Appendix 2.

The Subcommittee also recommended that a retrospective analysis be conducted for the next full assessment which permits a comparison of current forecast methods with methods used historically by the PSC.

Table 1. Fraser River sockeye forecasts by stock and run timing group for 1996 based on recommendations from the February 1996 PSARC Subcommittee meeting.

STOCK/TIMING	Probability of Achieving Specified Run Sizes				
	95%	90%	80%	75%	50%
Early Stuart	41,000	55,000	79,000	90,000	154,000
Early Summer	71,000	101,000	148,000	172,000	307,000
Fennell	7,000	10,000	15,000	18,000	33,000
Bowron	4,000	6,000	8,000	10,000	17,000
Raft	5,000	8,000	12,000	14,000	25,000
Gates	30,000	41,000	60,000	69,000	120,000
Nadina	10,000	14,000	19,000	21,000	33,000
Pitt	6,000	9,000	14,000	16,000	32,000
Seymour	7,000	9,000	13,000	15,000	24,000
Scotch	2,000	4,000	7,000	9,000	23,000
Mid Summer	538,000	712,000	998,000	1,134,000	1,909,000
Chilko	336,000	433,000	586,000	657,000	1,036,000
Quesnel	8,000	12,000	20,000	23,000	48,000
Stellako	177,000	238,000	339,000	387,000	659,000
Late Stuart	17,000	29,000	53,000	67,000	166,000
Birkenhead	29,000	40,000	59,000	68,000	123,000
Late Summer	41,000	56,000	83,000	96,000	169,000
Late Shuswap	3,000	5,000	8,000	10,000	20,000
Cultus	2,000	2,000	4,000	4,000	8,000
Portage	3,000	5,000	8,000	10,000	20,000
Weaver	33,000	44,000	63,000	72,000	121,000
TOTAL	720,000	964,000	1,367,000	1,560,000	2,662,000

Table 2 Summary of ocean mortality and terminal run size by age (numbers of chinook) resulting from reduction in harvest rates. Terminal run includes the total return to the Somass system, including hatchery and wild production.

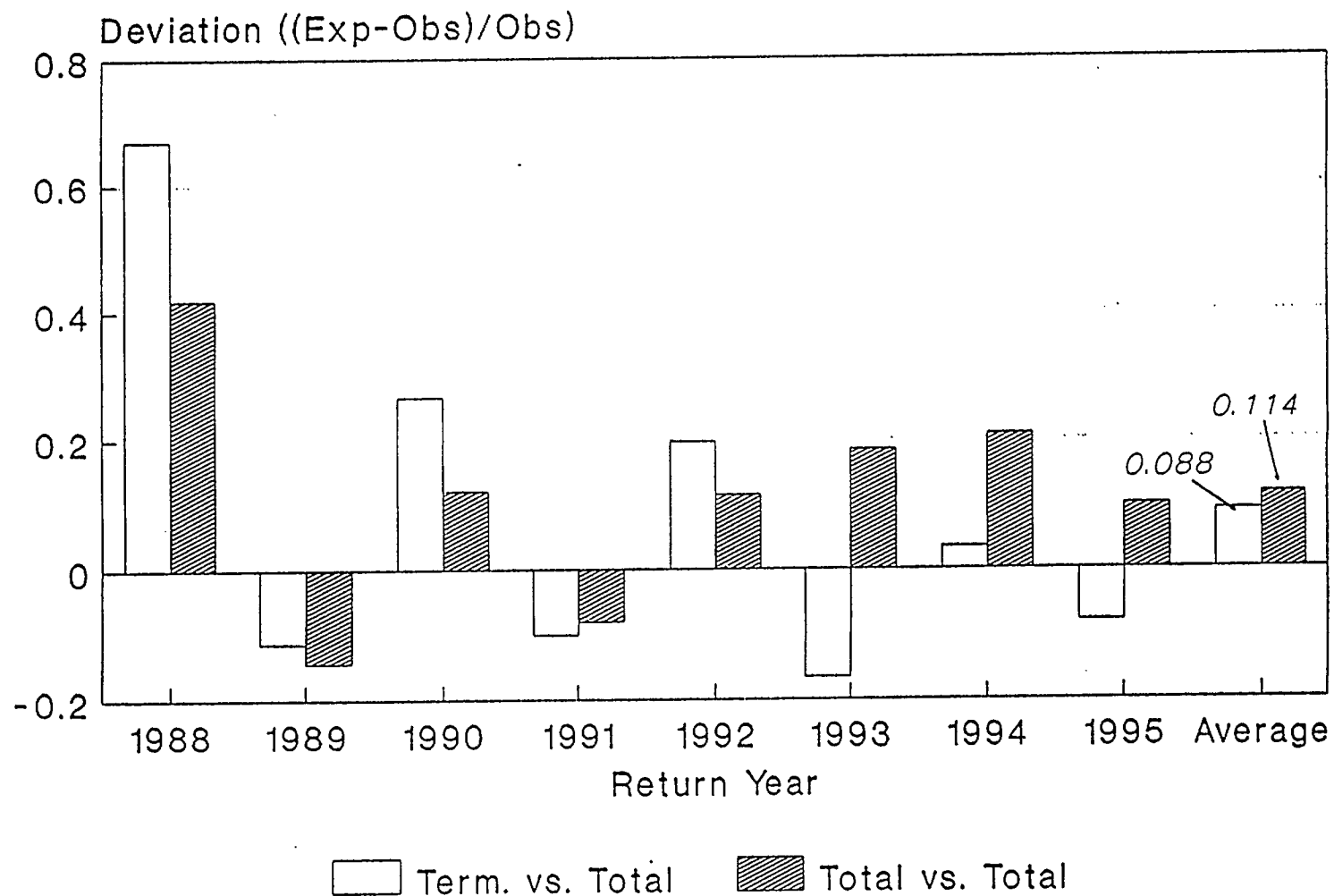
i) Forecast method: Model 2 (Terminal Return vs. Total production)

Harvest Scenarios				
1996	Base: 1984-1990 Brood Averaged Ocean hr; WCVI troll hr limited to pre-1992 values.	Scenario 1: Cdn. reductions as in 1995	Scenario 2: Scenario 1 plus Alaskan fisheries reduced 50%	Scenario 3: No directed ocean chinook fisheries in Alaska or Cdn
Ocean mortality	18600	13580	8410	1870
Terminal Run	19050	20610	22240	24440
Number of females in terminal run	4163	4884	5634	6710
1997				
Ocean mortality	43200	32510	20470	4660
Terminal Run	46020	51340	57210	65160
Number of females in terminal run	13390	15640	18160	21640

ii) Forecast method: Model 3 (Total Production vs. Total Production)

Harvest Scenarios				
1996	Base: 1984-1990 Brood Averaged Ocean hr; WCVI troll hr limited to pre-1992 values.	Scenario 1: Cdn. reductions as in 1995	Scenario 2: Scenario 1 plus Alaskan fisheries reduced 50%	Scenario 3: No directed ocean chinook fisheries in Alaska or Cdn
Ocean mortality	9214	6780	4263	932
Terminal Run	9764	11040	12367	14240
Number of females in terminal run	3932	4733	5568	6775
1997				
Ocean mortality	29484	21777	13530	3062
Terminal Run	30355	32800	35450	38950
Number of females in terminal run	5533	6342	7242	8480

Figure 1 Estimated error in prediction of the terminal run to Barkley Sound based on the Prod2 and Prod3 models.



Appendix 1 Participants at the February 7-8, 1996 meeting of the PSARC Salmon Subcommittee.

L. Richards	Salmon Subcommittee chair
D. Anderson	Science Branch
S. Argue (Feb. 7)	Program Planning and Economics
D. Blackburn	Science Branch
A. Cass	Science Branch
K. Hyatt	Science Branch
A. Lill	Chair, Fraser Panel
A. MacDonald	Operations, Fraser River
K. McGivney	Fraser Panel
S. McKinnell (Feb. 8)	Science Branch
D. Meerburg (Feb. 8)	Fisheries Research, Ottawa
C. Neville (Feb. 7)	Science Branch
M. Stocker	Science Branch
C. Wood (Feb. 8)	Science Branch
J. Woodey	Pacific Salmon Commission

Appendix 2

Forecast of Fraser River sockeye stocks (millions) for 1996 model with associated variance and root-mean-square error (RMSE).

EARLY STUART (excluding Driftwood R. systems)

AGE-4				AGE-5			
MODEL	FORECAST	VARIANCE	RMSE	MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.14	1.387	0.992	Ymean	0.012	1.38	0.074
Cmean	0.048	1.688	0.796	Cmean	0.008	1.135	0.077
Ricker	0.186	0.598	0.762	Ricker	0.011	1.814	0.084
Power	0.148	0.569	0.752	Power	0.011	1.466	0.082
R/S (all-years)	0.153	0.762	1.064	R/S	0.024	1.931	0.064
R/S (4-yr intervals)	0.058	0.713	0.85	A5/A4	0.004	2.18	0.082
				A5~A4	0.006	1.555	0.085

EARLY STUART (all sub-stocks)

AGE-4				AGE-5			
MODEL	FORECAST	VARIANCE	RMSE	MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.157	1.646	2.09	Ymean	0.008	1.593	0.087
Cmean	0.063	1.188	1.226	Cmean	0.005	1.294	0.085
Ricker	0.278	0.514	1.109	Ricker	0.01	2.197	0.088
Power	0.233	0.439	0.974	Power	0.006	1.797	0.092
R/S	0.265	0.56	1.092	R/S	0.019	3.096	0.081
				A5/A4	0.004	2.894	0.087
				A5~A4	0.005	1.778	0.092
				A5~A4+A4mg2	0.011	1.201	0.094
				A5~A4+A4fsl	0.007	1.358	0.094

FENNELL

AGE-4				AGE-5			
MODEL	FORECAST	VARIANCE	RMSE	MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.02	3.103	0.079	Ymean	0.032	2.2	0.099
Cmean	0.018	1.31	0.105	Cmean	0.001	5.417	0.015
Ricker	0.039	0.875	0.098	Ricker	0.004	2.635	0.013
Power	0.032	0.815	0.063	Power	0.006	1.371	0.011
R/S	0.088	1.791	0.335	R/S	0.015	1.7	0.01
				A5/A4	0.001	1.738	0.011
				A5~A4	0.001	1.827	0.011

Appendix 2

Cont'd

BOWRONAGE-4

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.028	0.987	0.184
Cmean	0.027	0.464	0.17
Ricker	0.012	0.654	0.155
Power	0.014	0.614	0.152
R/S	0.009	0.712	0.167

AGE-5

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.008	1.001	0.017
Cmean	0.004	1.969	0.017
Ricker	0.003	1.421	0.017
Power	0.002	1.247	0.016
R/S	0.002	1.865	0.017
A5/A4	0.005	2.008	0.023
A5~A4	0.003	1.262	0.019

RAFTAGE-4

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.013	1.573	0.08
Cmean	0.037	0.388	0.061
Ricker	0.026	0.82	0.06
Power	0.025	0.817	0.057
R/S	0.027	0.796	0.06

AGE-5

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.003	1.038	0.014
Cmean	0.002	1.374	0.013
Ricker	0	1.268	0.015
Power	0.001	1.174	0.013
R/S	0	1.415	0.011
A5/A4	0	1.176	0.013
A5~A4	0	0.957	0.013
A5~A4+A4fsl	0.001	1.014	0.014

GATESAGE-4

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.017	3.338	0.386
Cmean	0.114	0.462	0.296
Ricker	0.093	0.684	0.308
Power	0.09	0.645	0.23
R/S	0.114	0.647	0.214
A4/A3	0.113	1.888	0.294
A4~A3	0.179	2.213	0.236
A4~A3+A3msl	0.201	1.486	0.227
A4~Fry	0.128	0.61	0.303

AGE-5

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.008	1.856	0.026
Cmean	0.001	6.183	0.028
Ricker	0.003	1.713	0.026
Power	0.002	1.694	0.026
R/S	0.003	1.804	0.024
A5/A4	0.001	2.386	0.027
A5~A4	0.001	1.98	0.027
A5~A4+A4fsl	0.006	1.015	0.027

NADINAAGE-4

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.038	1.342	0.198

AGE-5

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.011	0.758	0.028

Appendix 2

Cont'd

NADINA (Cont'd)AGE-4

MODEL	FORECAST	VARIANCE	RMSE
Cmean	0.018	0.691	0.141
Ricker	0.022	0.414	0.252
Power	0.02	0.482	0.263
R/S	0.018	0.461	0.237
A4~Fry	0.028	0.286	0.099

AGE-5

MODEL	FORECAST	VARIANCE	RMSE
Cmean	0.012	0.428	0.012
Ricker	0.006	2.102	0.016
Power	0.01	0.991	0.016
R/S	0.029	1.023	0.011
A5/A4	0.005	1.296	0.008
A5~A4	0.005	0.797	0.016

PITTAGE-4

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.015	1.187	0.105
Cmean	0.02	1.174	0.107
Ricker	0.01	1.281	0.111
Power	0.014	1.308	0.11
R/S	0.005	1.468	0.14

AGE-5

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.036	0.636	0.131
Cmean	0.045	0.503	0.129
Ricker	0.036	2.594	0.144
Power	0.037	2.618	0.15
R/S	0.037	2.54	0.151
A5/A4	0.004	0.9	0.163
A5~A4	0.015	0.573	0.112
A5~A4+A4fsl	0.017	0.777	0.103

SEYMOURAGE-4

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.071	1.561	1.087
Cmean	0.021	0.417	0.782
Ricker	0.042	0.765	0.833
Power	0.042	0.765	0.818
R/S	0.034	0.859	1.097

AGE-5

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.023	1.784	0.068
Cmean	0.003	2.973	0.065
Ricker	0.005	3.725	0.065
Power	0.006	2.856	0.064
R/S	0.012	2.781	0.056
A5/A4	0.002	2.282	0.055
A5~A4	0.002	2.275	0.062
A5~A4+A4fsl	0.003	1.21	0.042

SCOTCHAGE-4

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.031	4.218	0.423
Cmean	0.015	5.287	0.627
Ricker	0.022	1.773	0.375

AGE-5

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.234	1.033	0.503
Cmean	0.002	16.456	0.022
Ricker	0.004	8.659	0.023

Appendix 2

Cont'd

SCOTCH (Cont'd) AGE-4

MODEL	FORECAST	VARIANCE	RMSE
Power	0.018	1.523	0.26
R/S	0.022	1.725	0.229

AGE-5

MODEL	FORECAST	VARIANCE	RMSE
Power	0.002	5.758	0.023
R/S	0.005	7.856	0.017
A5/A4	0.001	4.321	0.02
A5~A4	0.001	5.048	0.022

CHILKO AGE-4

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.826	1.105	6.368
Cmean	1.662	0.451	6.455
Ricker	1.835	0.556	5.026
Power	2.044	0.59	5.661
R/S	2.979	0.652	7.228
A4/A3	0.531	1.077	7.769
A4~Sm	0.975	0.385	4.362
A4~Sm+Rn	0.86	0.573	5.744
A4~A3	0.66	0.587	6.095
A4~A3+A3msl	0.558	0.756	5.766
A4~Sm+A3	0.826	0.593	4.857
A4~Sm+A3+A3msl	0.748	0.967	4.43

AGE-5

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.02	2.012	0.584
Cmean	0.025	1.507	0.588
Ricker	0.024	2.406	0.578
Power	0.058	1.882	0.572
R/S	0.13	1.866	0.543
A5/A4	0.061	1.471	0.515
A5~A4	0.138	1.228	0.552
A5~Sm	0.024	1.294	0.556
A5~Sm+Rn	0.023	1.294	0.544
A5~A4+A4fsl	0.031	1.105	0.539

QUESNEL AGE-4

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.026	12.008	20.004
Cmean	0.002	1.537	17.055
Ricker	0.045	0.884	18.388
Power	0.045	0.865	7.383
R/S	0.046	0.861	6.039

AGE-5

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.096	3.917	0.582
Cmean	0.01	1.486	0.689
Ricker	0.005	7.61	0.419
Power	0.006	6.615	0.622
R/S	0.005	7.142	0.47
A5/A4	0.002	6.821	0.41
A5~A4	0.003	5.952	0.613

STELLA KO AGE-4

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.322	0.572	1.895
Cmean	0.266	0.628	1.703

AGE-5

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.033	1.244	0.428
Cmean	0.052	0.999	0.429

STELLA KO
(Cont'd)AGE-4

MODEL	FORECAST	VARIANCE	RMSE
Ricker	0.496	0.324	1.671
Power	0.465	0.348	1.864
R/S	0.543	0.378	2.368
A4/A3	0.544	2.396	7.427
A4~A3	0.363	0.448	1.682
A4~A3+A3msl	0.564	0.574	1.181

AGE-5

MODEL	FORECAST	VARIANCE	RMSE
Ricker	0.05	1.014	0.39
Power	0.046	1.007	0.388
R/S	0.051	0.993	0.364
A5/A4	0.028	0.848	0.372
A5~A4	0.028	0.857	0.385
A5~A4+A4fsl	0.094	0.844	0.346

LATE STUARTAGE-4

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.077	5.216	6.928
Cmean	0.009	3.143	4.94
Ricker	0.17	1.835	4.963
Power	0.136	1.571	5.034
R/S	0.156	1.827	2.663

AGE-5

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.014	3.015	0.224
Cmean	0.003	5.398	0.232
Ricker	0.026	3.692	0.235
Power	0.009	2.916	0.23
R/S	0.022	4.736	0.186
A5/A4	0.003	3.533	0.184
A5~A4	0.004	2.528	0.219
A5~A4+A4fsl	0.01	1.294	0.175

BIRKENHEADAGE-4

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.218	0.612	1.799
Cmean	0.218	0.245	1.791
Ricker	0.426	0.499	1.672
Power	0.402	0.492	1.516
R/S	0.82	0.666	2.239
A4/A3	0.036	0.998	1.694
A4~A3	0.122	0.562	1.725
A4~A3+A3msl	0.084	0.717	1.534

AGE-5

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.048	1.349	0.75
Cmean	0.054	1.273	0.758
Ricker	0.16	1.347	0.668
Power	0.179	1.169	0.649
R/S	0.308	1.073	0.605
A5/A4	0.022	0.758	0.623
A5~A4	0.022	0.795	0.632
A5~A4+A4fsl	0.039	0.837	0.595

LATE SHUSWAPAGE-4

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.185	8.704	16.895
Cmean	0.017	0.855	5.275
Ricker	0.05	0.963	5.832

AGE-5

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.025	4.112	0.188
Cmean	0.002	4.278	0.199
Ricker	0.017	2.757	0.199

Appendix 2

Cont'd

LATE SHUSWAP
(Cont'd)AGE-4

MODEL	FORECAST	VARIANCE	RMSE
Power	0.046	0.99	7.747
R/S	0.045	0.967	8.068

AGE-5

MODEL	FORECAST	VARIANCE	RMSE
Power	0.012	2.508	0.198
R/S	0.018	2.701	0.17
A5/A4	0.003	2.372	0.186
A5~A4	0.003	2.327	0.202
A5~A4+A4fsl	0.005	1.597	0.197

CULTUSAGE-4

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.031	2.511	0.185
Cmean	0.021	1.532	0.246
Ricker	0.007	0.826	0.118
Power	0.007	0.814	0.117
R/S	0.005	0.831	0.131

AGE-5

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.016	1.356	0.046
Cmean	0.002	1.643	0.007
Ricker	0.002	1.342	0.005
Power	0.002	1.291	0.005
R/S	0.002	1.382	0.005
A5/A4	0.001	2.207	0.006
A5~A4	0.001	1.726	0.006
A5~A4+A4fsl	0.001	1.249	0.006

PORTAGEAGE-4

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.015	4.395	0.283
Cmean	0.003	6.495	0.251
Ricker	0.029	1.149	0.209
Power	0.02	1.088	0.184
R/S	0.023	1.417	0.197
A4/A3	0.048	1.702	0.384
A4~A3	0.033	1.246	0.252
A4~A3+A3msl	0.033	0.884	0.215

AGE-5

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.046	2.134	0.289
Cmean	0	3.146	0.032
Ricker	0.001	5.822	0.033
Power	0.001	5.688	0.033
R/S	0.002	5.578	0.033
A5/A4	0	4.727	0.032
A5~A4	0	5.004	0.033

WEAVERAGE-4

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.223	0.771	1.225
Cmean	0.3	0.244	1.191
Ricker	0.332	1.024	1.447
Power	0.255	0.742	1.071

AGE-5

MODEL	FORECAST	VARIANCE	RMSE
Ymean	0.02	1.834	0.288
Cmean	0.006	1.437	0.288
Ricker	0.017	1.385	0.221
Power	0.017	1.359	0.253

WEAVER (Cont'd) AGE-4

MODEL	FORECAST	VARIANCE	RMSE
R/S	0.355	1.115	1.023
A4~Fry	0.31	0.695	0.887
A4/A3	0.061	0.818	1.107
A4~A3	0.119	0.394	1.024
A4~A3+A3msl	0.114	0.567	0.891

AGE-5

MODEL	FORECAST	VARIANCE	RMSE
R/S	0.018	1.326	0.234
A5/A4	0.005	1.143	0.247
A5~A4	0.005	1.298	0.228
A5~Fry	0.032	1.501	0.096
A5~A4+A4fsl	0.007	0.886	0.096

Ymean=all-year mean

Cmean=cycle-year mean

Ricker=Ricker stock-recruit

Power=power stock-recruit

R/S=geo. mean recruit per spawner

A4/A3=ratio of age-4:age-3 siblings

A4~A3=regression of age-4 vs age-3

A4~Sm=regression of age-4 vs smolts

A4~Sm+Rn=regression of age-4 vs smolts+rain index

A4~Sm+A3l=regression of age-4 vs smolts+age-3

A4~Sm+A3+A3msl=regression of age-4 vs smolts+age-3 + age-3 male standard length

A4~A3+A3msl=regression of age-4 vs age-3 + age-3 male standard length

A5/A4=ratio of age-5:age-4 siblings

A5~A4=regression of age-5 vs age-4

A5~A4+A4fsl=regression of age-5 vs age-4 + age-4 female standard length

A4~Fry=regression of age-4 vs fry

BIOLOGICAL ADVICE INVERTEBRATES

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I. STEERING COMMITTEE REPORT

I96-1 Assessment of the Area 12 prawn fishery in relation to declines in annual catch.

The Steering Committee discussed in some detail the issue of whether CPUE provided an index of stock abundance, and noted that an adequate index of abundance may not be available for Area 12 prawns.

The Steering Committee endorsed the recommendations by the Subcommittee after clarification on the revisions, the form of biological sampling required and the type of subarea differences.

The Steering Committee highlights the general paucity of stock assessment data for Area 12 prawns and notes that even fewer data are available for stocks on the Central Coast.

I96-2 Stock assessment framework for quota based manila clam fisheries in British Columbia.

The Steering Committee notes in particular the need for explicit management objectives in order to develop assessment further. The issue of whether the fishery may be better managed by quotas or size limits can be more appropriately examined in the context of the management objectives (tenured sustained harvest, wild open access harvest, for example). The Steering Committee notes this is a general problem for stock assessment and supports the direction of the Shellfish Working group in developing those objectives as discussed at the end of the Subcommittee report.

I96-3 Evaluation of survey methods for geoducks.

The Steering Committee recommended that the improvements to survey methodology be incorporated, noting that significant additional sources of error remain in the estimate of biomass on which the TAC depends. The Steering Committee recommends that attention be directed toward those sources of error and an evaluation made of where progress is most likely.

I96-4 Comparisons of repeat acoustic surveys of euphausiid stock in Jervis Inlet, British Columbia: 1990-1996.

Subcommittee recommendations are endorsed. The Steering Committee notes that this working paper presents no evidence to warrant deviation from the RMEC direction in Advisory Document 95-5. For that reason no expansion of the fishery is recommended.

196-5 Preliminary examination of the biological consequences of implementing a 110 mm diameter dungeness crab trap escape ring.

The Steering Committee endorses the Subcommittee recommendations and notes that additional work could be done on the sensitivity of the results to the changes in soak time. The Steering Committee advises that the working paper should be revised and resubmitted.

196-6 A Framework for providing scientific advice for the management of data limited invertebrate fisheries.

The Steering Committee recognizes the need to set up procedures to deal with data and stock assessment issues for new and developing fisheries. This working paper identifies the need for those procedures, but is not that procedures document itself. This issue is of sufficient importance to merit another review.

The Steering Committee supports the work by the Shellfish Working group to develop these procedures for specific case studies.

The Steering Committee acknowledges the role of PSARC in reviewing the proposals for new fisheries to ensure that these fisheries are developed in accordance with the FAO Guidelines on the precautionary approach to capture fisheries.

196-7 Optimal sample sizes for geoduck biosamples.

The Steering Committee did not endorse the subcommittee's recommendation to process the age data, but recommended that this question be considered in the Steering Committee request (196-3) to identify the major source of uncertainties and where progress can best be made.

The Steering Committee notes the progress inside the Invertebrate Subcommittee towards improving the interface between management and stock assessment. The Subcommittee's work on the PSARC Terms of Reference and process issues are noted in the minutes of the Steering Committee.

II. INVERTEBRATE SUBCOMMITTEE REPORT

1. Introduction

The spring meeting of the Invertebrate Subcommittee was held between 1 April and 3 April 1996 at the Pacific Biological Station, Nanaimo. The meeting was unusually late this year, normally being held in February. The Subcommittee reviewed seven Working Papers and had wide-ranging discussions on several topics whose focus was improving

the interface between stock assessment and management. Details of those discussions follow presentation of the deliberations on the working papers. A list of participants, including reviewers is appended.

2. Working Paper Summaries, Reviews and Discussion

196-1 Assessment of the Area 12 prawn fishery in relation to declines in annual catch. J. Boutillier.

Working Paper Summary

This paper was produced in response to declining catches in the Area 12 prawn fishery. Historically this area has been the largest prawn producing area on the coast. Managers were concerned about the area and wanted a review conducted to establish if these declines were potentially caused by the fishery. The analysis was carried out using data from the logbook program, the spawner monitoring program, and historical fishery notices. The logbook data were analyzed to produce a standard CPUE which was modeled for the area. As a result of this analysis it was found that the CPUE showed similar trends as the catch although CPUE did not decline to the same extent as catch and CPUE showed some recovery in 1995 while catch did not. The analysis of the spawn index data indicated a number of potential problems in managing the area from the perspective of optimizing biological objectives. These included problems with early openings prior to complete egg hatch and delays in closing the fishery after biological reference points had been reached imparting substantial increases in exploitation rates.

Reviewer's Comments

The reviewer of this paper found that, in general, the paper needed clarification in many areas discussed, and in particular (1) reliance on CPUE as an indicator of abundance trends; (2) lack of discussion about potential factors leading to decline; and (3) the general question about whether declines in catch from peak historic levels should be a cause for concern.

Subcommittee Discussion

The Subcommittee noted that the intent of the paper, to illuminate possible reasons for the decline in catch, could not be fully addressed because of the lack of key biosampling data. There was some discussion of the recent redistribution of catch to the early part of the season. Through discussion, the Subcommittee accepted that the redistribution of catch was likely due to substantial increases in effort early in the season with the result that spawner indices were reached sooner, whereupon the fishery was closed. There was agreement that these changes to fishing patterns should

be made explicit in the paper. Discussion ensued over the validity of the CPUE abundance index, given the increasing rapidity of reaching critical female spawner indices that might be indicating technological change and accumulating experience in the industry. The author defended the use of CPUE by pointing out that he does correct for changes in technology in the fishery. The issue of whether declines in catch from historical levels was a cause for concern as this is common and expected in many fisheries. The recent declines in catch should be contrasted with the increases in the early 1990's and it is equally valid to inquire why catches increased. The whole time series of catch should be addressed and not just recent changes.

There was a thorough discussion of the rationale for author's recommendations concerning (1) the timing of fisheries openings and the risk of recruitment overfishing and (2) the potential effects of delaying management actions (closing the fishery) after biological reference points have been reached (spawner index). Management actions were delayed in all or most cases, and the author was requested to document this in the paper.

Subcommittee Recommendations

1. The Subcommittee accepted the paper subject to major revisions as suggested by the reviewer and by the Subcommittee during their discussions.
2. The Subcommittee endorses the recommendation that the development of a system to insure that consistent biological sampling is obtained at critical points throughout the fishery be given priority.
3. The Subcommittee endorses the recommendation that every effort should be made to delay the opening of the fishery until hatching is complete. Collection of information on the prevalence of berried and hatched females during the early portions of the fishery is critical to setting realistic opening dates for Area 12 and other areas, and should be given priority.
4. The Subcommittee endorses the recommendation that efforts should be made by stock assessment staff and fishery managers to shorten the length of time it takes for management action once the spawner index has been reached.
5. The Subcommittee notes that the cooperation between the industry, management and stock assessment in this fishery has been positive and constructive, and should be both commended and encouraged.
6. The Subcommittee notes that fisheries management should be aware that there are subarea differences in the outside areas of Johnstone Strait which may require more specific attention.

196-2: Stock Assessment framework for quota-based Manila clam fisheries in British Columbia. G. Gillespie.

Working Paper Summary

The manila clam fishery in British Columbia developed rapidly in the 1980's to the point where this species accounts for over 80% of recent landings of intertidal clams. The fishery is characterized by excessive effort levels and short intense openings. Production trends in the fishery may be abundance driven. This paper reviews historic and present management actions and assesses their effectiveness in meeting conservation objectives.

The paper outlines a stock assessment framework for quota-based manila clam fisheries . The framework temporally partitions the harvest over a four year period. A second assessment is scheduled after the third year's harvest, and the quotas re-set. Assessment surveys from three First nations Pilot programs are used as examples. For the example fisheries, recommended harvest rates range between 50% for beaches with small legal-size stock and good impending recruitment to the fishery, to less than 15% for beaches with poor impending recruitment. Those harvest rates are substantially less than prevailing harvest rates in these and other intensely harvested areas.

Reviewers' Comments

Reviewer 1 states that although the paper does successfully describe the development of a stock assessment framework for manila clams, much of the work undertaken is inappropriate in a PSARC working paper. The author attempts to formulate management objectives, which is outside the realm of a stock assessment working paper. The reviewer feels it is a management prerogative to determine such objectives, that the paper needs to be concentrated on the task of assessment and that discussion of management issues should be removed.

Reviewer 1 noted that although the paper presented some background information on the relationship of the size limit to the life history of clams, it does not evaluate whether the size limit is optimal for achieving a given management goal. The paper develops an assessment framework and yield options but does not discuss the issue of whether the present size limit addresses any optimization criteria for yield and stock dynamics. Further discussion is required. The four year horizon chosen by the author needs support within the document. Instantaneous mortality rates should be used in the analyses.

Reviewer 1 makes a number of editorial comments about wording in the document and suggests that a figure describing the sampling patterns of the beaches discussed would be helpful.

Reviewer 2 was generally complimentary, but requested that further details be presented concerning the uncertainties in parameter estimates, some justification for the use of the particular models (e.g. the growth model) and discussion of possible problems with survey design (i.e. pitfalls in sampling procedures, the effectiveness of sampling for younger age classes, etc.) Reviewer 2 requested that terms used in the document, "green feed", "depuration fishery" and "pre-digging" needed explanation in the text for those unfamiliar with clam fisheries.

Subcommittee Discussion

Much of the Subcommittee discussion centered around the appropriateness of presenting many management issues in a PSARC document, without a Management co-author. The lack of clear management objectives for the clam fishery remains a problem in responding to requests for stock assessment advice. However, there was agreement that the author presents a reasonable evaluation of one different management strategy that managers and user groups can consider. Managers were concerned that harvest rates proposed for the example fisheries (14% to 52%) were generally much lower than the harvest rates that management currently believes are being exerted (40% to 60%). This document would be more useful to managers if options for different harvest scenarios were presented, such as fishing the quota over 1, 2, 3, or 4 years, and if those scenarios were compared to fishing to the size limit with no quota.

Subcommittee Recommendations:

1. The document was accepted on a scientific basis, with revision of the technical content as suggested by the reviewers, and with shortening of the sections which refer to management actions and management objectives.
2. The Subcommittee recommends that explicit management objectives, biological objectives and reference points be developed through the Shellfish Working Group for the clam fishery.
3. The Subcommittee recommends that the comparison of quota-based management with the existing management model of minimum size limits should be pursued.

I96-3: Evaluation of survey methods for geoducks. A. Campbell, C.M. Hand, C. Paltiel, K. Rajwani, and C.J. Schwarz.

Working Paper Summary

Four survey methods to estimate geoduck density and biomass with the appropriate parametric and bootstrap analytical techniques are described. For all survey types, the sample primary unit is a transect (or cluster of secondary sampling units of 10 m^2), the

placement of which depends on the survey type: (1) systematic, (2) two stage grid (3) three stage or (4) two stage. Example data sets analysed for survey types 1, 3 and 4 provide similar density estimates. However survey types 3 and 4 are more efficient in terms of area covered in a shorter time period than survey 1. Survey type 4 is logistically easier to implement for field crew than survey type 1 or 3.

Reviewers' Comments

Reviewer 1 noted that there is no context given for the surveys and no indication why surveys are undertaken, making it impossible to determine how important it really is to achieve efficiency in survey design. Questions about the measurement of show factors and their extrapolation were raised. The reviewer noted that ancillary information is routinely collected but apparently not included in the determination of biomass. The reviewer wondered if some type of stratified sampling design might be more appropriate. The reviewer commented that changing survey designs might make comparisons with historic data difficult unless there was overlap in the survey designs (i.e., unless both survey designs were used for some period of time).

Reviewer 2 held that the authors should provide a much more careful development of the methodology, including detailed graphical presentation of the observed data to examine spatial trends in location and variability. The reviewer noted that confused descriptions of computational procedures and inadequate attention to notation detracted from the evaluation of the survey designs. The reviewer objected to "data weeding", the exclusion of data based on subjective screening by the analyst. The reviewer concluded that the paper did not contain sufficient supporting analysis to recommend one of the competing survey designs and recommended that the efficiencies of the designs be reconsidered and the relative sources of error assessed using simulation and real data.

Subcommittee Discussion

The Subcommittee discussed at length which survey type was most appropriate. It was decided that the survey methods were not sufficiently evaluated to make this decision, and that the between/within transect variability issue needed to be addressed. The authors agreed to look at among transect variability using survey type 4, applying the methodology to 2 or 3 data sets. There were also discussions about removing transects with many zero counts from the data set, and about including all ancillary data in this report (for use in developing a stratified sampling design).

Show factors are determined daily in small areas and extrapolated to the entire area surveyed that day. Issues associated with this extrapolation and unknown effects of spatial and temporal heterogeneity were acknowledged.

The average density that is calculated and then used for estimating the biomass for a larger area (i.e. the whole coast) is not based on sampling from a random area. Where

the surveys take place is based on funding and assistance of native bands for particular areas. Therefore when density estimates from these surveys are applied to larger areas, there is not a lot of confidence in the overall biomass estimate. Another related issue is that the areal estimates of geoduck beds used for determining overall biomass are obtained from roughly sketched maps in logbooks filled out by fishers. These area estimates need to be confirmed. Biomass estimates used to determine quotas are the product of two uncertain estimates.

Subcommittee Recommendations

1. The Subcommittee accepted the paper subject to revisions that (a) addressed the concerns of the reviewers; (b) clarified the objectives of the surveys in the context of geoduck assessment and management; (c) integrated the addendum (survey type 4) into the WP, and (d) analyzed the concerns raised over between and within transect variance.
2. The Subcommittee recommends that further investigations of show factors and their effects on biomass estimates be given priority.
3. The Subcommittee notes that improvements to survey methodology do not eliminate uncertainties in estimates of total biomass, upon which quota determinations are based, but are, nonetheless, an important first step in resolving those uncertainties.

196-4: Comparisons of repeat acoustic surveys of the euphausiid stock in Jervis Inlet, British Columbia: 1990-1996. D.L. Mackas, S.J. Romaine, M.C. Macaulay, and D.J. Saxby

Working Paper Summary

Management of euphausiid and other Strait of Georgia fisheries requires better information about seasonal and interannual variability of euphausiid stock size and the within-time-period statistical reliability of these stock size estimates. To provide this the authors conducted repeated acoustic surveys in Jervis Inlet over the past six years: twice per year (Oct.-Nov. and Jan.-Feb.) since 1990 and monthly June 1994 - June 1995. Underway echosounding gave spatially detailed measurements along zigzag transect lines. Net tows (Mackas and Moore WP - 194-8) provided species identification and size-frequency distributions. Overall, the survey design produced within-time-period stock size estimates judged reliable to about a factor of 2.5. Total stock size estimates ranged from a minimum of <1,000 tons (Feb. 93) to a maximum of >10,000 tons (April-May 1995). Both seasonal and interannual components of variation were large (3-10 fold). In most years stock biomass declined during the winter. Timing of the decline was coincident with the fishing season but the magnitude of the winter decline (3,000-6,000 tons) was much greater than the removal by the fishery (<500 tons).

Reviewers' Comments

Reviewer 1 identified several problems with the acoustic techniques used in the surveys, one of which was described as "alarming". The reviewer concluded that the identified problems did not invalidate the results but that there was much room for improvement in the acoustic sampling techniques. The reviewer noted concerns with the effects on biomass estimates of non-euphausiids. The reviewer suggested that more details about the fishery, the conversion of signal strength to biomass, the spatial scales of the swarms and the statistical terminology be given. In his rebuttal the senior author noted that most of the apparent problems with the statistical methods were due to incomplete descriptions, which would be clarified. The reviewer also noted that comments about harvest levels and levels of risk associated with the fishery required information and understanding not presented in the paper.

Reviewer 2 concentrated on the biological aspects of the paper and argued that there was insufficient knowledge about euphausiid biology and population dynamics to make any recommendations about potential yields in the fishery and associated risks. The reviewer noted that studies of euphausiids in Barkley Sound indicate that similar loss of biomass during the winter is due mostly to weight loss of individuals and not to mortality, thus questioning the basis for inferring the relative magnitude of fishing compared to natural mortality.

Subcommittee Discussion

The Subcommittee endorsed the view of the reviewers that the authors had made a substantive contribution in developing a survey approach to estimating the seasonal patterns in biomass of euphausiids in Jervis Inlet. The Subcommittee expressed concerns about the current catch was not small compared to winter minimums of biomass, especially considering the unknown extent of migration into or out of the fishing area. Subcommittee discussion focused on the appropriateness of making recommendations about fishing harvest levels and associated risk, especially considering (1) the low trophic level of the species; and (2) the lack of biological knowledge of the species. The Subcommittee was especially concerned about the effects of migration on biomass estimates and about the causes of the winter decline in biomass.

Subcommittee Recommendations

1. The Subcommittee accepted the paper subjected to revisions requested by the reviewer and during Subcommittee discussions, and in particular that the authors remove their recommendations pertaining to the fishery and risks associated with various harvest levels.
2. The Subcommittee recommends that a WP be prepared that provides an updated review of biological knowledge and fisheries experience in this and related species,

structured per the meta-analysis or phase "0" step of the proposed assessment framework for new and developing fisheries.

I96-5: Preliminary examination of the biological consequences of implementing a 110 mm diameter dungeness crab trap escape ring. A. Phillips and J. Rice

Working Paper Summary

Where we are now in relation to the escape ring problem is little changed from our position of 4 years ago. No new data have been collected to specifically address issues surrounding escape ring size. The problems continue to be (1) what is the fate of crabs within 20 mm of legal size? (2) What are the consequences to the fishery of that size fraction failing to molt? (3) Is economic yield being maximized? (4) Is the fishery risk-averse? (5) What are the factors controlling handling mortality? and (6) Are there any data to show any biological benefit of escape rings? Data summarized in the paper suggests that most crabs within 20 mm of legal size die in intensively fished areas where soak times are likely insufficient to allow sublegal crabs to escape. There are no data available to show that escape rings are of any biological benefit in intensely fished areas given current fishery practices.

Reviewers' Comments

Reviewer 1 began with a comment that the paper was adequate in providing arguments for and against escape rings of various sizes. The reviewer then supplied numerous suggestions regarding alternative experimental designs and/or analyses which might be more appropriate in addressing the objectives of the paper.

Reviewer 2 felt that, although the authors' conclusions are probably correct, the analysis and modeling, as presented, are deficient and do not adequately substantiate their conclusions. The reviewer felt that a complete analysis was possible with the data available, although it would require considerable time and effort. The reviewer expressed concern regarding the scientific basis for the present size limit, the interaction of ring size, variation in crab morphology, escape behavior and soak time on sub-legal retention. The reviewer suggested that determination of optimum ring size is an optimization problem involving short-term costs to fishermen, short- and long-term benefits to the resource and long-term benefits to Canadians. The reviewer agreed that the authors could not proceed with further analyses without first considering the effects on mortality and yield of other control measures, especially the minimum size limit. The reviewer suggested a possible direction for future investigation of the problem.

Subcommittee Discussion

Subcommittee consensus was that reviewers' suggestions were beyond the realm of revision, and that the problem needs to be re-assessed, both in light of reviewers'

comments and subcommittee concerns. Particular concerns were: (1) recognition of the geographic component of the problem (i.e. crab morphometrics and fishery characteristics), and awareness that a coastwide solution may be inappropriate, and (2) the importance of the interaction of soak time and escape ring size given the wide variation in fishing patterns.

Subcommittee Recommendations:

1. The Subcommittee did not accept the paper noting that the analyses did not sufficiently support the conclusions.
2. The Subcommittee recommends that the authors and other appropriate staff be directed to re-examine the problem in light of the reviewers' comments and Subcommittee discussion.
3. The Subcommittee notes the multivariate nature of the problem and that there are currently data deficiencies that limit our ability to construct an appropriate model. The Subcommittee further notes that some of these data deficiencies are currently being addressed.

I96-6: A framework for providing scientific advice for the management of data-limited invertebrate fisheries. R.I. Perry

Working Paper Summary

A framework is developed for the provision of scientific advice to support the management of new and developing (i.e. data-limited) invertebrate fisheries. Fisheries managers are responsible for developing alternative management plans, and fisheries scientists are responsible for describing the state of the resource, for advising management on the feasibility of providing stock assessment advice under different management scenarios, and for developing monitoring and analysis programs to provide stock assessment advice. Uncertainties in models, data, results, and environmental conditions must be explicitly considered. The development of a new fishery proceeds through 3 or 4 phases depending on the extent of previous knowledge, with each phase having specific requirements for monitoring. The roles and application of reviews of basic biological information, modeling, fishery-independent surveys, exploratory fishing, and adaptive management techniques are discussed.

Reviewers' Comments

Reviewer 1 expressed concerns that the WP duplicated, in part, the FAO (1995) Guidelines on the Precautionary Approach to Capture Fisheries and Species Introductions and requested an explanation of why the paper was prepared. Despite the overlap, the reviewer indicated three important points in the FAO document, pertaining

to new and developing fisheries, that were not in the WP (controlled access from the outset; conservative caps on fishing capacity and fishing mortality; and closed areas to limit risks). The reviewer was particularly concerned that commentary in the WP on the role of Management, and on how Science (stock assessment) should interact with Management, is not within the scope of a PSARC working paper. The reviewer argued that the WP inappropriately censored the management options on the basis of funding restrictions, rather than emphasizing the data requirements for stock assessment purposes. The reviewer thought that the author was often too optimistic about the utility of information that would be gathered either directly from the fishery or from fishery-independent surveys, and that realistically, fishery and fishery-independent data might only provide relative abundance indices rather than absolute estimates of stock size. The reviewer also felt that the author was too optimistic about the utility of models in data-limited situations, and that greater emphasis should be placed on careful analysis of available data.

Reviewer 2 prefaced his comments by complimenting the author for making an "admirable start toward developing protocols for new fisheries that could avoid some of the problems of the past." The reviewer felt that there is an opportunity to put management on a firm public-policy footing from the outset by asserting: (1) that stocks are public resources for which the Dept. as the public's agent has the full right to demand whatever data and regulations are needed to insure safe use; (2) the public should not bear the costs of acquiring data deemed necessary for safe use and (3) that the assessment framework should state clearly what data are needed from the outset without regard to any assumptions about the space-time course of traditional fishery development, specifying instead what information is needed, and when, to manage properly. The reviewer also argued that the assessment framework could provide advice about how industry could pay for that information most efficiently.

The reviewer forcefully made the point that "all of our assessment procedures are critically dependent on a good relative abundance index that is proportional to actual stock size" and that there is a "critical need to start survey work right at the outset of development." The reviewer maintained that reliable data are required at the early developmental stages of a fishery, prior to the possible accumulation of inertia due to over-capitalization or unrealistic client expectations, and while the pre-fishery state could be properly assessed. The reviewer offered four strategic approaches to addressing the problems of obtaining a good relative abundance indicator and acquiring data early in the development of the fishery: two of those strategies are derivatives of the three key FAO points omitted from the WP (see comments of reviewer 1). The reviewer argued that the ordering of the fishery "Phases" in the document was reversed; much more emphasis should be placed on "front-end loading" the assessment investment with appropriate survey design and fishery-independent measurements.

The reviewer specifically agreed that the synthesis of available information on the target species and similar species, the phase 0 step or meta-analysis, is a key requirement

(note Subcommittee recommendation for the completion of such a study for the euphausiid fishery).

The reviewer made the point several times that assessment and information gathering should not be separated from regulation since regulatory policy, especially regarding licensing and tenure, has a huge effect on the ability of gather useful data and on the ability to arrive at collaborative arrangements for monitoring and enforcement.

Subcommittee Discussion

This WP was prepared in response to management requests for advice on exploratory fishing protocols for green urchins and sea cucumbers in currently closed areas and, consequently, the Subcommittee discussed exploratory fishing protocols at length. Reviewer 2 had argued that references to “exploratory” fishing be removed but had also argued that surveys in closed or reference areas could provide useful contrasts to fished areas and essential base biological data, if designed properly, which the Subcommittee interpreted to mean if designed to obtain essential information for assessment and for managing the fishery in a precautionary manner. Those surveys could be implemented through the regulatory process to provide economic benefits to the fishery. The Subcommittee concluded that “exploratory” fishing as it has been conducted in the past cannot be sanctioned.

The Subcommittee’s view on the developmental phases of fisheries was to strongly endorse revisions of the WP, and hence the framework, along the lines suggested by both reviewers, i.e., that the framework include more comprehensively and explicitly the principles of the FAO (1995) document on precautionary fishery management; that there be a reordering of the phase or step approach proposed in the WP, with increased emphasis on the first step (meta-analysis); and that there be a greater emphasis on the early collection of distributional and abundance data and the early development of a reliable abundance index.

The Subcommittee requested that a lack of clear definitions of terminology in the WP should be addressed as per the FAO (1995) document. Current terminology could be interpreted in a manner that contravenes the FAO precautionary guidelines.

The Subcommittee discussed at length the complex issues surrounding the respective roles of stock assessment and management in invertebrate fisheries and attempted to reconcile the contrasting views of the two reviewers on this topic. These discussions formed the basis for discussion the next day about the interface between stock assessment and management which is summarized below. The Subcommittee requested of the author that all reference to funding responsibilities and selection of management plans be removed from the WP. Nevertheless the Subcommittee agreed that the assessment framework should recognize the interplay between stock assessment management and industry, and should make more explicit the potential roles that industry has in collaborative agreements to provide critical assessment

information, and what the timing of that involvement should be.

Subcommittee Recommendations

1. The Subcommittee concluded that the document be reconsidered after major revision following the suggestions of the reviewers and the Subcommittee. The revised WP will be reviewed by the PSARC Chair, the Invert Subcommittee Chair, Shellfish Section Head StAD and the Shellfish Coordinator. At that time, a decision to accept as revised, seek additional peer review or reject will be made.
2. Pending acceptance of the WP, the Subcommittee recommends that case studies, in the form of working papers, be prepared to illustrate the application of the proposed framework.
3. The Subcommittee recommends that biological information necessary to establish conservation measures for new and developing fisheries, which would be produced in accordance with the framework, be reviewed through PSARC as part of the approval process for those fisheries. The intent of this recommendation is to encourage the development of an organizational framework for initial scientific review of precautionary conservation measures and for review and generation of recommendations on information gathering requirements to be attached to the license(s).
4. The Subcommittee notes that new fisheries have been proposed and are imminent, without the opportunity for the scientific peer review necessary to establish defensible, precautionary measures for their implementation.

196-7: Optimal sample sizes for geoduck biosamples. A. Campbell and K. Rajwani

Working Paper Summary

Sampling for mean weight, mean age or age structure of geoduck populations during field surveys was considered as a three stage subsampling problem. Optimum allocation of sampling resources (in terms of time) was obtained by minimizing the estimated variance for fixed total time cost. Example data of biosamples collected from five geoduck beds located throughout British Columbia were used in the optimizing survey design analyses. These optimal designs were found to be sensitive to costs. Many more geoducks are required if mean age is the variable of interest compared to mean weight because of the higher variability in ages compared to weight. Also the cost of aging geoducks is considerably higher than just weighing geoducks. The most reasonable sample requirement will depend on the objective variable to measure. For mean weights about 30 geoducks/ site / bed with one site / bed and 3 - 4 beds could be sampled per survey (Total = 120 geoducks). For both mean weight and age about 90

geoducks / site / bed with one site / bed and 3 - 4 beds could be sampled per survey (Total = 360 geoducks). For age structure analyses about 100 geoducks/ site / bed with 2 - 3 sites / bed and 1 bed per day or 2 - 3 beds in two days could be sampled per survey (Total = 300 geoducks in one day or up to 900 geoducks per two days).

Reviewer's Comments

Reviewer's comments focused on the influence of variability on the conclusions of the paper. For example, what is the effect on the recommendations of non-random distributions of geoducks within beds? Also, it was noted that in general the variance estimates used in the analysis were derived from a single, small set of data. It is unclear to what extent the variances in this subset are representative of geoducks and geoduck beds over a broader area. An analysis of the sensitivity of the results to these variance components was recommended.

Subcommittee Discussion

In the Subcommittee discussions, it was noted that the analysis minimizes DFO's costs in processing samples, and the question was raised as to whether Industry costs were included, for example the cost of sacrificing geoducks for age sampling. Although industry costs of sampling were not directly addressed in the paper, the authors do recommend a reduction in the number of geoducks sampled per bed (e.g. for estimates of weight, from the current practice of 500 animals to about 120 animals). The definition of a "bed" was raised, considering that bed size can be highly variable and that present practice is to survey numbers of geoducks per transect.

The Subcommittee discussed the broader context of present assessment models and the need for biological information as presented in this paper. Information on weight is essential for the biomass models currently used in geoduck assessments. Information on age and the age-structure is used in recruitment estimates, for estimates of growth and mortality, and in age-structured models. However, age-structured models for geoducks are still under development. The Subcommittee endorsed the continued collection of age data through biosampling.

The Subcommittee questioned how much the variance decreased with increasing sample size for each of the sampling objectives (weight, age, age-structure). Such a table or figure would assist in choosing sample sizes other than the optimum if additional sampling components and objectives needed to be considered.

Subcommittee Recommendations

1. The Subcommittee accepted the paper contingent upon revisions based on the reviewer's comments and the inclusion of a table or figure indicating changes in the variance of mean weight with changes in sample size.

2. The Subcommittee recommends that the analysis of age data already collected be given priority.

3. Additional Subcommittee Discussions

PSARC Draft Terms of Reference

Mike Henderson provided an update. The future establishment of a Conservation Council might have a significant effect on PSARC structure and function. The Minister has indicated that the PSARC process will be amended to allow the participation of industry, stakeholders and the public. The Subcommittee was supportive of the intent but was apprehensive about implementation and highlighted four particular concerns: 1) the possible need to seek broad consensus among participants may prove difficult, 2) that industry participants may gain an advantage through involvement in the process if full involvement of all stakeholders was not accomplished, 3) that there is a critical need for a comprehensive set of procedures to be developed that will facilitate smooth and equitable implementation of any new review process, and 4) that the complex nature of the many invertebrate fisheries would make it difficult to accommodate all stakeholders within the current schedule of PSARC Subcommittee meetings. The perceived need to schedule many more meetings would significantly impact DFO staff.

The Subcommittee suggests that management may want to consider establishment of a PSARC "core group" to coordinate public participation. An east coast model of consultation with stakeholders in advance of developing PSARC papers was suggested. The current herring consultation process was also identified as a model which largely meets possible requirements for external participation. At the present time the PSARC Invertebrate Subcommittee will continue to operate under the existing terms of reference, but anticipate that a significant change is likely to occur within a year.

Fisheries Updates

The former Invertebrate Committee chair was of the opinion that too much time was spent in the subcommittee meetings on reading, editing and considering fishery updates. The present chair recommended that the updates should be submitted to Subcommittee members at the same time as the working papers, in advance of the PSARC meetings. He further recommended that a Subcommittee member be assigned to each update, on submission, as a reviewer to ensure uniform style and content, to provide editorial review, and to flag items requiring attention at the PSARC meeting. The Subcommittee agreed that the fishery updates are important documents, and that they should continue to be presented at the PSARC fall meeting. It was suggested and accepted that the updates should include additional information on management actions taken in the preceding year's fishery to establish a centralized record of management actions. This suggestion was forwarded from the Shellfish Working Group. It was agreed that a task group would be struck to establish a standard format

and content guidelines for the fishery updates. This task group will include B. Holtby, J. Boutillier, B. Adkins and R. Harbo. The group was instructed by the Subcommittee to complete the task expeditiously so that the new process could be initiated for the fall meetings.

Making the interface between stock assessment and management efficient and constructive

A draft 'Advice Framework' written by Mike Henderson formed the basis for subcommittee discussion. This framework was prepared to address two deficiencies in the current (management-centric) process: Assessment biologists need to know to whom they should respond given several routes by which requests may originate, and assessment biologists are frequently oversubscribed in their assessment capabilities.

Not stated explicitly in the draft is the additional problem experienced by the Invertebrates Subcommittee of poor communication of the issue or concern that managers need advice on. This results in the frequent occurrence of working papers not meeting the needs of managers. The subcommittee agreed that this problem would be reduced or eliminated if managers were involved with the preparation of working papers throughout the process, not just in the initiation and review stages. At the very least, a management 'sponsor' would be identified for each WP so that the author can consult during the preparation of the WP to ensure that the issue of concern was being properly addressed. The participation of managers could take the form of co-authorship, where each author is responsible and accountable for ensuring that the paper will produce meaningful advice. It was noted that even 'method' papers where management advice was not explicitly requested would benefit from input from managers in identifying potential biases in data, etc.

The process of deciding what papers are to be done was discussed at length. An improvement over the current situation where Stock Assessment and Management operate in isolation is required. The Subcommittee agreed that the clear definition of management objectives for all species was of the utmost importance. There should be a closer working relationship between managers and stock assessment with managers more closely involved with the preparation of WPs, and with stock assessment staff science more closely involved with management in the formulation and prioritization of advice requests and in the definition of long-term and annual objectives. It was suggested that working teams be formed for each species to lay out the management objectives, define the current management and assessment frameworks and decide what advice should be provided. These working teams would be subcommittees of the Shellfish Working Group. This would be a significant task and should proceed with a few example species that are either urgent in terms of industry expectations (e.g. sea cucumbers) or of high value or profile (e.g. geoducks or intertidal clams). A standard format for the request of working papers, where background information is presented, would facilitate the understanding of the reasoning behind the request.

The process for prioritizing the long lists of requests was discussed. Currently there is consultation between the Invertebrate Section Head and the Shellfish Coordinator in finalizing the list of working papers. The Subcommittee endorsed a suggestion that a more inclusive subcommittee of the Shellfish Working Group, including both management and stock assessment staff, and including the Invertebrate Subcommittee chair, be formalized. That subcommittee would insure that the specific expectations for each working paper were clearly outlined within the context of both regional management and stock assessment frameworks, and that the prioritization of the working papers would be made in the context of fishery (management) objectives.

Appendix 1. List of Participants

NAME	AFFILIATION
B. Holtby (Chair)	Stock Assessment Division, PBS
B. Adkins	Shellfish Coordinator, Pacific Region
J. Boutillier	Head Shellfish Section, StAD, PBS
A. Campbell	StAD, PBS
G. Gillespie	StAD, PBS
C. Hand	StAD, PBS
R. Harbo	Operations Branch, SCD
W. Heath	BC Ministry Agriculture, Fisheries & Food
S. Heizer	Operations Branch, SCD
G. Jamieson	StAD, PBS
M. Joyce	Operations Branch, Fraser River Division
R. Kronlund	StAD, PBS
J. Morrison	Operations Branch, SCD
I. Perry	StAD, PBS
A. Phillips	StAD, PBS
H. Powles	Fisheries Research Branch, Ottawa
B. Waddell	StAD, PBS

Appendix 2. List of Working Papers submitted to the PSARC Invertebrate Subcommittee, April 1-3, 1996

- I96-1 Assessment of the Area 12 prawn fishery in relation to declines in annual catch.
Author: J. Boutillier
Reviewer: S. McFarlane, StAD, PBS
 (one reviewer failed to submit a review)
- I96-2 Stock assessment framework for quota-based Manila clam fisheries in British Columbia.
Author: G. Gillespie
Reviewers: B. Leaman, StAD, PBS
 N. Szarzi, Alaska Dept. Fish & Game, Glennallen

Appendix 2 (Cont'd)

- I96-3 Evaluation of survey methods for geoducks.
Authors: A. Campbell, C.M. Hand, C. Patiel, K. Rajwani, and
 C.J. Schwarz
Reviewers: J. Irvine, StAD, PBS
 R. Kronlund, StAD, PBS
- I96-4 Comparisons of repeat acoustic surveys of the euphausiid stock in Jervis
 Inlet, British Columbia: 1990-1996.
Authors: D.L. Mackas, S.J. Romaine, M.C. Macaulay, and D.J. Saxby
Reviewers: M. Trevorrow, Ocean Physics, IOS
 R. Tanasichuk, StAD, PBS
- I96-5 Preliminary examination of the biological consequences of implementing a
 110 mm diameter dungeness crab trap escape ring.
Authors: A. Phillips, and J. Rice
Reviewers: W. Donaldson, Alaska Dept. Fish & Game, Kodiak
 C. Wood, StAD, PBS
- I96-6 A framework for providing stock assessment advice for data-limited
 invertebrate fisheries
Author: I. Perry
Reviewers: L. Richards, StAD, PBS
 C. Walters, UBC
- I96-7 Optimal sample sizes for geoduck biosamples
Authors: A. Campbell and K. Rajwani
Reviewers: C. Schwarz, SFU
 S. Cox-Rogers, StAD, Prince Rupert

BIOLOGICAL ADVICE ON PACIFIC SALMON

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I. STEERING COMMITTEE REPORT

Major Concerns

The Steering Committee recognized the serious problems with the meeting of deadlines, resulting in insufficient time to provide a thorough review. It was noted that Senior Management should be informed of papers which may be deferred because of late submission. This issue is related to the scheduling of subcommittee meetings which is discussed in the Steering Committee minutes.

The Steering Committee concurred with the requirements for clarity in the requests from management for stock assessment advice, often necessitating clarification of management objectives for the particular assessment.

The Steering Committee recommends that StAD provide a draft policy to PSARC for documentation of data and analysis.

The Steering Committee recommends that an assessment for Strait of Georgia chinook be given a high priority.

The Steering Committee notes a significant concern about chinook age determination and recommends that an individual be assigned to review the available methods of age

determination, make recommendations on appropriate structures and methods and report to the Salmon Subcommittee.

S96-3 In-season forecasting of Skeena River sockeye run size using Bayesian probability theory.

Subcommittee recommendations endorsed.

S96-4 Assessment of sockeye and pink salmon stocks in the northern boundary area using run reconstruction techniques, 1982-1992.

Subcommittee recommendations endorsed.

S96-5 Assessment of the status of sockeye salmon stocks on the nursery lakes of the Queen Charlotte Islands (Haida Gwaii).

The Steering Committee expressed concern about the status of small and medium size sockeye stocks on QCI and elsewhere on the B.C. coast. The Steering Committee recommends that a paper be prepared for the next meeting of the Salmon Subcommittee to provide:

- (i) the location of small and medium sized coastal sockeye stocks of B.C. and;
- (ii) identify those which appear to be at risk or at low stock levels.

S96-6 Review of adult mark-recapture studies of Taku River salmon stocks 1994-1995.

Subcommittee recommendations are endorsed.

S96-7 A review of stock assessment information for Skeena River chinook.

The Steering Committee strongly recommends that a stock specific assessment of Skeena chinook be conducted. Until then, comments on escapement targets cannot be evaluated.

In addition, the Steering Committee reiterates the importance of catch and CWT tag recoveries for coho and chinook in the Bulkley and wishes to encourage the working relationships developed at the Skeena Watershed Committee which have begun to address this important element.

S96-8 A review of the Strait of Georgia chinook harvest rate program.

The Steering Committee recommends that the working paper be resubmitted and reviewed. In particular, the Steering Committee notes that an assessment of Strait of Georgia chinook is required, and that the assessment will provide, among other important information, a context to evaluate the usefulness of this program in producing

input for the cohort analysis.

The stock assessment should be prepared as soon as possible.

S96-9 Nechako Fisheries Conservation Programs: Nechako River chinook escapement enumeration methodology.

The Steering Committee concurs that the paper should be revised and resubmitted after consultation with statistical experts within DFO.

The Steering Committee recommends a broader statistical review of the "area under the curve" methodology.

The Steering Committee advises that statistical advice should be sought immediately to make improvements prior to the 1996 field season

S96-10. Assessment of coho stocks on the west coast of Vancouver Island.

The Steering Committee did not endorse the first subcommittee recommendation as a priority.

The 1997 forecasts for coho are a high priority, noting that availability of the necessary data pushes the forecast to the spring subcommittee meeting. This is one of several scheduling problems which are addressed in the Steering Committee minutes.

S96-11 An update of assessment information for Strait of Georgia coho salmon stocks with 1996 forecasts and advice on setting an exploitation rate target.

The Steering Committee concurs with the recommendations and notes particularly that the coho management plan should be reviewed and updated in light of new information and changing conditions.

S96-12 Report on the Upper Fraser River catch monitoring programs and First Nations Fisheries, 1995.

The Steering Committee requested a more complete summary of the paper. The Steering Committee noted that the lack of night time catch information occurred because that part of the design was not implemented for operational reasons. Additional resources may be required to obtain night data.

The Subcommittee recommendations were endorsed, and the Steering Committee noted that the resubmitted paper should be reviewed through the Subcommittee and Steering Committee process as appropriate.

Concern was expressed at the Steering Committee about a reviewer who had publicized information in the confidential working paper.

S96-13 Status report on the Qualark Creek Hydroacoustic Project.

The Steering Committee concurs with Subcommittee recommendations and further notes on recommendation 5 that considerable resources and efforts have been expended in the development of this project. Continued support of this system should be justified by a demonstration to PSARC of its usefulness for in-season management decisions.

S96-14 The utility of hydroacoustic estimates of juvenile sockeye in stock assessment with forecast for the 1997 Quesnel Lake return.

The Steering Committee endorses the recommendations noting, given the widespread use of similar techniques, the requirement for a formal statistical review of techniques and survey design.

S96-15 Ecosystem management for Pacific salmon; integrating habitat into the harvest management - stock assessment loop.

Recommendations are endorsed including the need to prepare the working papers on temperature and integration of model predictions with management. The Steering Committee acknowledges the potential contribution to stock assessment from freshwater and marine habitat advice.

S96-16 Status of the Puntledge River summer chinook.

The Steering Committee expands on the Subcommittee recommendation to recommend that a paper be prepared and submitted to PSARC to examine the impact of size limit on sex and size bias in the harvest.

The Steering Committee is concerned that the stock levels indicated in this paper represent a critical conservation problem, mortality should be reduced, and that an assessment is required. (Note recommendation for Strait of Georgia assessment - S96-8).

The documentation and analysis of existing data on seal predation on chinook in the Puntledge should be completed and reported at the next Salmon Subcommittee meeting.

II. SALMON SUBCOMMITTEE REPORT

1. Introduction

The Salmon Subcommittee met April 22-26, 1996, at the Pacific Biological Station, Nanaimo. Fourteen 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

Deadlines for Working Papers

Only four of the 14 Working Papers were received by the due date (three weeks in advance of the meeting). Delays in submission of Working Papers resulted in delays in their distribution to Subcommittee members and to reviewers. Many of the reviewers complained about late delivery of Working Papers and insufficient time for thorough review. Thus, late submissions have compromised the review process. The Subcommittee **recommends** that Working Papers be considered only if the Subcommittee Chair receives them by the deadline. The review of late submissions will be deferred until the following Subcommittee meeting.

Management Objectives

A number of Working Papers identified the need to specify explicit management objectives for stocks to be assessed. For example, a clear definition of stock-specific management objectives is required before harvest rate targets can be identified for Strait of Georgia coho. The Subcommittee **recommends** that stock assessment and management staff collaborate on identifying stock-specific objectives within the context of precautionary fisheries, data available for analysis, and management constraints. These objectives should be specified prior to the preparation of Working Papers for specific stocks.

Data Documentation

Several Working Papers commented on the lack of documentation for archival data. Thus, the archival data (e.g., catch, escapement, and biological traits) are often not accepted as reliable. The Subcommittee **recommends** that policies be established for documentation of methods for acquisition and analysis of assessment data to address such problems.

Chinook Ageing Methods

Two Working Papers identified problems with the reliability of chinook age

determination. The Subcommittee **recommends** that a study be conducted by chinook assessment and age determination staff to examine these discrepancies and recommend procedures for chinook ageing.

3. Working Paper Summaries, Reviews and Discussion

S96-3 In-season forecasting of Skeena River sockeye run-size using Bayesian probability theory. S. Cox-Rogers

Working Paper Summary

This Working Paper examines the utility of using Bayesian probability theory to combine several in-season estimators of Area 4 Skeena River sockeye run-size into a single "best" estimate of total return. The in-season estimators include Area 3x cumulative CPUE and catch by statistical week, Area 4 cumulative CPUE and catch by statistical week, and the Inshore Run (Area 4 catch plus escapement) by statistical week. Non-linear regressions of Area 4 total return versus each of these predictors were evaluated in a hindcast retrospective analysis for the years 1984-94. The Bayesian composite forecasts were always more accurate than the least accurate component forecast, and sometimes better than the most accurate component forecast. Confidence intervals, calculated directly from the Bayes posterior distribution, included the true run size for all but the very largest return years. Prior probabilities, expressed as prior five-year average returns, had a variable impact on the Bayes composite forecasts, with some years benefiting from the use of priors, and other years not benefiting from the use of priors. The Mean Absolute Percent Error (MAPE) criterion identified the Bayes model using non-informative priors, Area 3 cumulative CPUE, Area 4 cumulative CPUE, and the cumulative Inshore run, as performing slightly better than any of the other models tested. Forecast performance, for all models tested, improved as the season progressed.

The use of Bayesian logic for in-season forecasting has several advantages. First, since forecast accuracy for each component forecast varied considerably among years and among weeks within years, the Bayesian composite forecast avoided the task of trying to pick the best component forecast from among the several available. Second, the Bayesian composite forecast makes use of all available information to create a self-weighted forecast, as the effect of any component forecast on the final result is directly related to its predictive ability. Third, the method is objective rather than subjective, in that the management task of selecting among contrasting forecasts is reduced to a single step. Finally, the Bayes posterior distribution allows managers to incorporate and present forecast uncertainty in a clear and understandable format.

Bayesian forecast techniques offer an objective and consistent framework for in-season run-size forecasting of Skeena River sockeye. Where feasible, Bayesian approaches could also be considered for other north coast stocks where reliable data exist (e.g.

Nass River sockeye, Smith Inlet sockeye, etc.). Calibration of the method using updated run-reconstruction's, in progress, still needs to be done prior to using the methodology for 1996.

Reviewers' Comments

Reviewer #1

Reviewer #1 supports the direction that the author is suggesting with respect to in-season forecasting. However, he expressed a number of concerns about the data and analyses that should be addressed before adopting the authors conclusions. In particular, the author's description of the basic data was inadequate; the author does not acknowledge that the input data are themselves estimates derived from an undocumented sampling and estimation process. The assumptions of (1) a log-normal distribution for the run size and (2) a direct relationship between CPUE and run size should be re-examined.

Reviewer #2

The paper is generally well written and the analytical methods are state of the art for in-season run-size estimation. The paper uses an objective method for combining pre-season stock size estimates, test fishing data, and catch data to provide in-season estimates of run-size and uncertainty about the run-size. The paper presents information in a fashion that is easy for fisheries managers to use. The type of analysis carried out in this Working Paper can easily be replicated by other interested parties because the data can be accessed by other scientists. It should be clearly stated that the use of the Bayesian procedure is recommended by the author, so that PSARC can accept or reject this recommendation.

Subcommittee Discussion

The Subcommittee endorsed the proposed technique of a Bayesian approach to in-season forecasting for Skeena River sockeye as a reasonable approach for stock assessment. However, the Subcommittee had some questions about the appropriate data to include in the analysis (e.g. CPUE). The Subcommittee also recommended continued exploration of other methodologies, such as multivariate regression analysis in order to provide in-season run size estimates. It was also suggested that another comparison for the author to consider for future development would be the performance of the average of all estimation procedures in comparison to the Bayesian procedure.

Subcommittee Recommendations

The Subcommittee accepted the Working Paper subject to minor revision. The Subcommittee accepted the Bayesian forecast technique as offering an objective and consistent framework under which to develop in-season run size forecasts of Skeena River sockeye. The Bayesian approach outlined in this working paper utilizes data from

fisheries that have operated in a consistent manner for a number of years. Given the changes that may occur to the fishery as a result of area licensing and effort modifications, the Bayesian approach will need to be reexamined in the near future.

S96-4 Assessment of sockeye and pink salmon stocks in the northern boundary area using run reconstruction techniques, 1982-92. W.J. Gazey and K. K. English

Working Paper Summary

A substantial amount of information has been accumulated on northern boundary sockeye and pink salmon stocks and fisheries over the past ten years. A multi-time-period method of stock reconstruction was used to estimate harvest and stock interception rates by area and time period, exploitation rates and total (entering) run size by stock. The data required for our reconstructions were catch by time and area, daily escapement by population (stock), the residence time of each population in each harvest area, and the routing of the populations. Migration routes for each stock were defined using information from the 1982-85 north coast tagging studies. The initial set of migration routing parameters were adjusted until the run reconstruction results approximated those from the tagging study years. Two different sets of migration parameters were required to fit the 1982 and 1983 interception rates for sockeye. While the 1983 set provided the best fit to the interception rates for Alaskan fisheries based on scale data for 1984-92, year to year variability can be substantial. Consequently, we recommend that stock composition data for specific key fisheries (Noyes, Sumner and 3x) be incorporated into the sockeye reconstruction analysis. Limited sensitivity analysis on sockeye indicated that uncertainty in migration parameters has a greater effect on stock size estimates than interception rates. For pink salmon, one set of migration parameters was defined that approximated the tagging study results for 1982, 1984 and 1985. Substantial changes in the annual abundance of major pink salmon stocks appear to explain most of the variability observed in the tagging study interception rates. Further examination of input data and reconstruction parameters by Canadian and Alaskan fisheries managers is recommended prior to drawing any conclusions from these preliminary analyses.

Reviewers' Comments

Reviewer #1

Reviewer #1 found the paper to be a clearly written and important study. The method used in the paper to describe the migration routes traveled by sockeye and pink salmon in Alaska and Canada was found to be a useful framework on which to reconstruct runs and stock compositions on a fishery specific basis. There was a good fit between the stock composition estimates as derived from the run reconstruction and the independent estimates derived from scale pattern analysis. The reconstruction model was also considered to be a valuable tool to design and evaluate potential benefits of

genetic stock identification sampling programs.

Reviewer #2

Reviewer #2 similarly found the reconstruction of fishery-specific catches by stock, harvest rates by stock, and catch balances useful. A key point in the Working Paper indicated that the migration patterns for sockeye salmon may change substantially from year to year. Therefore, run reconstruction should be calibrated against actual stock composition data. The methods section would also benefit from the inclusion of some background information on basic results, and on the 1982 and 1983 tagging study. Reviewer #2 indicated that the basic data for pinks are less certain than for sockeye, and the reconstructions are therefore less reliable.

Subcommittee Discussion

The Working Paper was accepted subject to minor revisions. The Subcommittee endorsed the run reconstruction approach as a useful technique, particularly for major stocks. Limitations were noted for pink salmon and when small sockeye stocks were included in the analysis.

The Subcommittee noted that the sockeye migration routes and parameters of the model were not consistent between the two years of tagging. Therefore, additional years of information related to the stock composition of individual fisheries could have significant benefits in the validation of the reconstruction model.

Subcommittee Recommendations

Recognizing one final year of Green Plan funding:

1. The Subcommittee **recommends** that the analysis be extended to include years subsequent to 1992.
2. The Subcommittee **recommends** that a review of the current state of knowledge of migration routes and model parameters be conducted by managers in Alaska and North Coast. Also, the results should be compared with reconstructions for the same stocks conducted by DFO. Comparing salmon harvest rates in specific fisheries was also suggested as a method for checking the model.
3. The Subcommittee **recommends** that stock ID information be considered as a means to delimit migration paths used in the run reconstruction model.

S96-5 Assessment of the status of sockeye salmon stocks originating from nursery lakes of the Queen Charlotte Islands (Haida Gwaii). K.D. Hyatt and D. P. Rankin

Working Paper Summary

This paper provides a review of the history and current status of several small stocks of sockeye salmon originating from nursery lakes located in the Queen Charlotte Islands (QCI). Assembly and analysis activities variously focused on raw observations, unpublished source documents and summary estimates of migratory timing, total abundance in catch and escapement, biological traits (age, sex ratio) of adults, and abundance and biological traits of juveniles. We encountered poor documentation of the raw data for most of the period of record, with largely superficial descriptions of annual changes in field assessment methods, levels of effort or "analytical" procedures. These limitations precluded interpretation of historical changes in stock specific catch and escapement trends over all but the most recent decade for all stocks of QCI sockeye. Historical data sources were adequate to infer that terminal food fish catches account for virtually all sockeye harvests from the Copper, Mathers and Yakoun stocks, most harvests from the Ain-lan, Naden-Eden and Awun stocks, but perhaps not from the Mercer and Fairfax Inlet stocks (Area 2W). Regardless, it remains uncertain whether apparently low stock sizes exhibited by all QCI sockeye stocks in the current decade represent major declines, artifacts of field and "analytical" procedures or combinations of the two.

Development and application of standard techniques, combined with documentation of procedures and raw data to estimate juvenile abundance trends in most lakes and adults in some (e.g. Yakoun and Copper-Skidegate), have produced useful data sets for assessing several aspects of the current status of QCI sockeye stocks. In particular, acoustic and trawl survey (ATS) observations of juveniles and adults in QCI lakes serve as the basis for a number of important inferences as follows: (1) growth, survival and annual production variations for juvenile sockeye in most QCI lakes are weakly to strongly density dependent; (2) unutilized potential to support production of additional sockeye exists in several Charlotte lakes. Accordingly, there are significant enhancement opportunities to increase yield from local stocks in future years given successful development of programs to supplement fry recruitment to specific lakes. Conservative estimates suggest that annual sockeye smolt production could be increased by approximately 45%, 65%, 112% and 300% at Eden, Awun, Skidegate and Ian lakes, respectively; (3) escapement objectives, based on analysis of the relationship between adult stock and smolt recruitment variations, are now available for the Yakoun and Skidegate Lake sockeye stocks. Minimum escapement objectives for both of these stocks should be set at 5,000 adult sockeye (quantified in either foot survey escapement units or in ATS units of abundance).

Recommendations to improve future assessments of QCI stock status include: (1) implementation of systematic retrieval and review of source documentation pertaining to escapement estimates, as well as entry of supplemental comments describing methods

used to generate both raw and summary escapement estimates; (2) continued efforts to improve the reliability of escapement assessment methods and their documentation; (3) maintenance of annual acoustic and trawl surveys to estimate changes in juvenile abundance and adult escapement as a cost effective means to monitor changes in QCI sockeye stock production trends; (4) additional assessment effort to appraise the current status of Area 2W sockeye stocks and especially Mercer Lake sockeye; and (5) annual sampling for age, size and sex composition of sockeye in catch and escapement wherever feasible, but especially for the Yakoun and Copper River sockeye stocks.

Reviewers' Comments

Reviewer #1

This Working Paper was assembled in response to a request from the Haida First Nation to review results from historic and recent assessment activities and to determine the current status of the local sockeye stocks. The data sources, data limitations, and most importantly, the lack of consistent methods and documentation are identified. The authors have done a commendable job in assembling the available information and providing some interpretation regarding the status of the sockeye stocks. However, given the quality and quantity of available information, the authors could not provide an unambiguous analysis. However, the information contained in the report (so far) should be a useful start for evaluating fishery impacts, factors of stock production and opportunities for management and enhancement.

Reviewer #2

The Working Paper attempts to derive escapement goals based on sparse data sets, some of which are contradictory. This is not an uncommon occurrence and the authors have tried to rationalize these contradictions. However, they do this primarily through verbal arguments rather than through data analysis. This is less than satisfying in those instances where analysis is possible, and their conclusions could benefit from this additional support. The escapement goals themselves use stock-smolt relationships as analogues of the traditional stock-recruit functions. They structure these relationships as linear functions, rather than the typical exponential Ricker form, but do not explain the basis for such a choice. This is significant because some of the data suggest that an exponential form might be more appropriate, and result in different escapement goals. The escapement goals suggested are more uncertain than presented in the Working Paper and may be less conservative than indicated.

Subcommittee Discussion

The Subcommittee concurred with the reviewers that the authors have done a commendable job in assembling the available information. The quality and quantity of the information presented, however, are not adequate to evaluate statements on the status of the stocks. To do so, requires annual information on escapement and catch,

both of which need to be sampled for age, size and sex composition. This is particularly important for the larger Yakoun and Copper River stocks. There is also perhaps some further information to be gained by more thorough analysis of source documentation used in the past for escapement and catch estimates. Freshwater investigations (acoustic and trawl surveys) to estimate changes in juvenile abundance should be continued as a cost effective means to monitor changes in production trends.

The Subcommittee notes the biological uniqueness of the QCI sockeye stocks. Although these stocks are small, collection of information to define its current status may be warranted from a biological diversity viewpoint.

The Subcommittee did not accept this Working Paper and **recommends** that the authors, in conjunction with the Haida Fisheries Group, continue with the synthesis of past information and the design and implementation of future sampling programs such that a paper defining the status of these stocks can be prepared in the future.

S96-6 Review of adult mark-recapture studies of Taku River salmon stocks 1994-1995. P.A. Milligan, M.S. Kelley, and A.J. McGregor.

Working Paper Summary

The Taku River is a transboundary river which originates in Northern British Columbia and flows southwest through the Coastal Mountain Range and Southeast Alaska to the Pacific ocean. In-season estimates of the escapement of Taku River salmon are required to fulfill escapement goal requirements as specified under the Canada/U.S. Pacific Salmon Treaty.

Mark-recapture studies of Taku River salmon stocks have been conducted by DFO and the Alaska Department of Fish and Game since 1984. The principal objectives of the program are to provide in-season estimates of the in-river abundance of sockeye and coho salmon and to document the migratory timing and migration rates of specific Taku River salmon stocks. Salmon are live-captured and tagged using fish wheels located at Canyon Island in the lower Taku River on the Alaskan side of the border. Marked to unmarked ratios of salmon harvested up-stream in the Canadian in-river commercial fishery are used to develop estimates of the in-river abundance and escapement of sockeye (since 1984) and coho salmon (since 1987) past Canyon Island using a stratified population estimation technique commonly referred to as the stratified Petersen or Darroch technique.

Abundance and escapement estimates developed for sockeye and coho salmon in 1994 and 1995 are presented in this Working Paper. In 1994, an estimated 129,129 sockeye passed Canyon Island with a 95% confidence interval of 120,815 to 137,443 sockeye. Subtracting the Canadian commercial and aboriginal catches resulted in an estimated spawning escapement of 100,128 sockeye. In 1995, an estimated 145,526 sockeye passed Canon Island with a 95% confidence interval of 137,007 to 154,045 sockeye.

Since approximately 5.7% of the total sockeye fish wheel catch per unit effort (CPUE) occurred prior to the start of the mark-recapture efforts, the in-river run was expanded to 153,820 sockeye. Accounting for the removal of Canadian commercial and aboriginal catches resulted in a spawning escapement estimate of 121,109 sockeye. The 1995 tagging and recovery data were also used to calculate a total in-river abundance estimates of 79,494 large (≥ 520 mm mid-eye fork length (MEF)) and 61,554 small (350-519 mm MEF length) sockeye salmon.

In 1994, the total in-river coho run estimate was calculated at 98,643 coho with a 95% confidence interval of 87,276 to 110,010 coho. The coho run covered an estimated 88.8% of the run based on timing information (CPUE) from the U.S. District 111 fishery. The run size was then expanded to 111,036 coho, and after the removal of commercial and aboriginal catches, the escapement was estimated to be 96,343 coho salmon. In addition to the Darroch estimate, adjusted Petersen estimates were calculated using tagging and recovery information for each fish wheel separately. The estimate for fish wheel #1 was 89,322 coho (95% CI 81,422 to 97,222 coho) while the estimate for fish wheel #2 was 77,749 coho (95% CI 70,065 to 85,433 coho). Independent estimates were made for each fish wheel in an attempt to develop a better understanding of potential bias that could result from bank orientation. In 1995, the in-river run past Canyon Island was estimated to be 61,739 coho with a 95% confidence interval of 56,091 to 67,387 coho. The in-river run size was expanded to 69,471 coho based on the estimated proportion of the run that was missed (11.1% based on U.S. fishery CPUE) and escapement was estimated to be 55,733 coho.

A tag loss study involved the application of a secondary mark and commercial catch sampling in 1994. A total of 1,269 sockeye tags were returned from a commercial catch of 28,750 sockeye for a tagged/untagged ratio of 0.044. In an independent survey of the commercial catch, a total of 178 secondary marks were observed in a sample of 5,014 sockeye for a tagged/untagged ratio of 0.036. A total of 629 coho tags were returned from a commercial catch of 14,531 coho for a tagged/untagged ratio of 0.043. A total of 179 secondary marks were observed in a sample of 3,270 coho for a tagged/untagged ratio of 0.055.

In 1991, sockeye, coho, and pink salmon captured by fish wheel were transported to floating net pens where they were held for a 3-4 day period. No mortalities were observed among the 85 tagged sockeye, 80 untagged sockeye, 64 tagged coho, 59 untagged coho, and 84 untagged pink salmon. One of 83 tagged pink salmon died. It was concluded that both the capture and tagging events induced virtually no short term mortality.

The migratory timing of specific sockeye salmon stocks is described. Sockeye returns to Kuthai Lake and the Nahlin River dominated the early portion of the run while returns to L. Trapper Lake and Tatsamenie lakes occurred during the mid and latter portions of the run. The migration rates of sockeye bound for L. Trapper and Tatsamenie lakes increased throughout the season.

Potential biases associated with the mark-recapture program include tagging induced mortality, physical tag breakage, loss of tags due to downstream migration (i.e. to the marine environment), and the loss of tags due to non reporting of tag recoveries.

A stock recruitment analysis was conducted using available catch, escapement and age structure information for the composite of all Taku sockeye stocks. At this time, there is insufficient information to evaluate the current escapement goal range of 71,000 to 80,000 sockeye salmon or to develop stock recruit relationships for specific stocks. Based on recent returns and an average return per spawner of 3.0, the composite of Taku sockeye stocks appears to be healthy.

Reviewers' Comments

Reviewer #1

This Working Paper covers a tremendous amount of material and in spite of the many typographical errors, was clearly written. Techniques of capture and recovery are described fully. If the raw data had been provided electronically, reviewer #1 could have verified the results. Reviewer #1 noted a potential error in the matrix arithmetic described for the mark-recapture abundance estimates and more details should be provided on the software used. Reviewer #1 also questions the authors' reliance on voluntary tag recoveries from the commercial fisheries.

Reviewer #2

Construction of the fish wheels is explained in considerable detail, and is well worth documenting. It would also be of value to document the problems encountered in operating the fish wheels, and how they were solved. Catchability for the fish wheels is difficult to evaluate but it may be possible to make some inferences regarding size selectivity by comparing fish size at the fish wheels to that at the weirs. The tagged/untagged ratio in the Canadian fishery could be compared to the ratio found at the weirs (after adjusting for removal of tags by the fishery). This comparison could be used to assess the catchability of the tagged versus untagged fish, although tag induced mortality would be another consideration. The non-reporting of tags was assessed only in 1991 by examining the tagged/untagged ratio in fishery catch and resampling the catch for secondary marks. This assessment should be performed annually, or at least periodically.

Subcommittee Discussion

The Subcommittee commended the authors for a well presented paper. Although there were several questions associated with the mark-recapture program, the Subcommittee acknowledged that the analysis and overall program achieved an acceptable standard. Most of the Subcommittee discussion centered around the assumptions inherent in mark-recapture programs.

Data were presented by the authors which demonstrated a slight size bias towards larger fish in the recovery sample. Although there was no evidence of disproportionate tagging, some Subcommittee members suggested that the catchability of fish wheels might vary with water depth and/or velocity. It was also suggested that a comparison of tagged:untagged ratios at various upstream weirs could provide some information about the consistency in tagging rates. The authors pointed out that tag loss would likely be a complicating factor in such an assessment since tag loss increases with migration distance and all weir sites are located in headwater locations.

Questions were raised about the reliability of fishers to report all tags recovered, variability around catch data, and the potential for recoveries in the Aboriginal fishery to be reported with the commercial catch. The authors responded by stating that the tag reward served as a strong incentive for fishers to return tags. The presence of samplers, Fishery Officers and on occasion, AFS participants, in the fishery on a daily basis, combined with the relatively small size of the fishery (both in terms of the number of participants and geography), reduces the likelihood of misrepresentation of catch and tag recovery data. Studies to investigate tag loss and under-reporting of tags were conducted using secondary marks and indicated little cause for concern; the Subcommittee suggested that these studies should be continued on a regular basis.

There was some discussion regarding the small number of tagged fish that were recovered in areas downstream of the tagging site. It was requested that the authors provide a brief explanation of why these recoveries were subtracted from the mark-recapture database.

The Subcommittee concluded that there was not yet sufficient data to adequately assess the status of Taku River sockeye salmon. Therefore, the Subcommittee did not accept the statement that the stock is "healthy". It was felt that the composite stock-recruitment analysis was not particularly useful other than to indicate potential ranges in productivity. Rather, it was suggested that it was more appropriate to build stock specific databases since productivities of stocks within the drainage likely vary widely due to the presence of lake, creek and mainstem spawning populations. The Subcommittee also noted that a proper assessment of stock status should include data on juvenile sockeye production collected as part of a joint Canada-US enhancement evaluation study. It was noted that there was no statement regarding the status of coho salmon in the report.

Subcommittee Recommendations

The Subcommittee accepted the working paper subject to revisions as per the reviewers' comments. Specific recommendations are as follows:

1. Blanket endorsement of the methodology should not be given.
2. Regular testing of the assumptions associated with the mark-recapture program are recommended, although not necessarily on an annual basis.

3. Sockeye stock-specific information should be included in the revision and developed for future stock status report(s).

**S96-7 A review of stock assessment information for Skeena River chinook.
S.D. Peacock, B. Spilsted and B. Snyder**

Working Paper Summary

Skeena River chinook salmon are the second largest wild chinook stock aggregate in British Columbia, second only to the Fraser River. Skeena management has changed significantly with the formation of the Skeena Watershed Committee and interest, concern and the need for chinook assessments on the Skeena are high. PSARC reviewed Skeena chinook in 1989, but there has been considerable new information collected in the interim.

The striking response to the Pacific Salmon Treaty (PST) management changes are evident in the overall escapement increases in the Skeena since 1983. The long term decline in chinook jack escapements to the Babine fence, and the short term decline to the Skeena test fishery are trends for which we have no explanation. The extent to which the Skeena chinook escapement estimates are underestimated is not known but the potential for a large underestimate is present.

We remain unsatisfied that the chinook age determinations are consistent and repeatable. The methodologies for scale reading appear to rely on subjective expertise to determine both the freshwater and total age for chinook. Forecasts using sibling regression relationships suggest 1996 abundance will be higher than the 1995 index of 113.8 but lower than the 1994 index of 175.7. Analysis of age-specific relative abundance patterns indicates there has not been a dramatic shift to lower production levels as is evident for WCVI stocks.

The total ocean exploitation rate averaged 50% for Kitsumkalum and 3% for upper Bulkley. The Alaskan harvests seem to have been stable. The recent changes to the Area 4 gillnet fishery have increased the chinook harvest rate index, mainly because of the shift to an earlier timing in the fishery. The terminal harvest rates (excluding the river-gap-slough) have been generally stable over time; the 1966-83 harvest rate of 26% is very close to the more recent rate of 24% for the period 1984-95.

There are no biologically derived escapement targets for Skeena chinook. The basis for the interim target of 41,770 chinook established in the Pacific Salmon Treaty process is to double the baseline (1979-82) escapement. The objective was met for the Skeena from the first year of the rebuilding program and has exceeded this rebuilding target each year from 1985-94. The 1995 escapement was slightly below the PST target.

Certain Skeena stocks warrant specific concern. Although the Upper Bulkley chinook stock appears to have an extremely low ocean harvest rate, there are still concerns

over the level of harvest in the Moricetown fishery. Continued progress is important to assess this potentially large harvest impact. The Cedar River (early Kitsumkalum) chinook concern is centered around the terminal sport fishery impacts on the stock. This concern is being addressed through local recreational initiatives and Greenplan research programs. Babine chinook are a stock of concern given the particularly low escapements in the last 2 years and the probable increasing impacts of the net management changes.

Working Paper Recommendations

1. The Skeena biological database initiative developed as part of the Skeena Green Plan initiative should be completed, documented and maintained in future years.
2. The Skeena Test Fishery program should be expanded to collect age, length, sex and a tissue sample for all chinook captured in the test fishery including all small chinook 'jacks'.
3. The Babine Counting fence sampling program should be expanded to sample all carcasses recovered and an assessment be conducted of the proportion of the jacks sampled.
4. A documented review and database development for the historical sport catch figures for the Skeena and adjacent areas is necessary to qualify the information currently in use.
5. Native catch figures are currently provided through the native AFS programs. We need to review the historical data and use the expertise of the first nations people to reconstruct catches, and to evaluate the current enumeration programs.
6. The current chinook escapement monitoring program must be evaluated and documented, including visit specific details. There is a broader based stock assessment initiative to rationalize escapement data collection on a regional basis.
7. An evaluation of the chinook ageing standards should be a priority of the new amalgamated scale lab.
8. The evidence in this report indicates a timing proportion curve of a different shape (dome or flat topped) would better represent the Skeena chinook timing in the Skeena model.
9. Stock identification programs for chinook are essential and the research program associated with the Skeena Green Plan should be pursued as a priority.
10. Data on the harvest and CWT mark rate in the Moricetown First Nation fishery is essential to evaluate the exploitation rate for the Upper Bulkley chinook exploitation rate indicator. Estimates of First Nation, and recreational chinook harvests are

required to assess the impacts of these terminal fisheries on the Upper Bulkley chinook stocks.

11. Impact on chinook stocks should be considered as part of the development of the Skeena Area 4 gillnet fishing plan as well as other outside and terminal fishing plans.
12. Skeena chinook assessments and management should continue to evolve towards more stock specific management.
13. We are not able to recommend a biologically based escapement target, or exploitation rate target.

Reviewers' Comments

Reviewer #1

There was a great volume of information presented in this Working Paper involving 41 pages of text, 36 tables, 31 figures, and 102 pages of appendices. The information is timely considering that: (1) Skeena Green Plan funding which has supported some of the chinook initiatives runs out shortly; and (2) the PST chinook rebuilding plan has a target for completion of 1998. Although the Working Paper represents a good first draft, it requires major editing to improve clarification and to correct some errors. The Skeena chinook stock assessment program (as per many of the recommendations) should develop a full biological sampling protocol for a number of key index areas that are sampled annually. Future escapement monitoring programs should be designed and conducted using methodology to reduce uncertainty and determine the total annual escapement to the index areas. For example, aerial surveys of index areas could potentially use the area under the curve estimation; a combined radio tagging and mark-recapture program could improve reliability and accuracy of survey data.

Reviewer #2

This Working Paper was not intended as a detailed stock assessment. A large body of historical data is summarized which should prove an invaluable data reference for Skeena chinook. The authors have clearly done a great deal of work to make this information available. The stock assessment information is frequently lost in the forest of detail. Skeena chinook stocks in aggregate are above the PSC goal based on doubling the 1979-82 average escapement. The picture that emerges is one of a complex stock aggregate that has responded well to the PSC rebuilding process, but with some weaker stocks that are not performing well. The task now is to develop biologically-based escapement goals (to replace the PSC goals), and to begin collecting the catch and escapement data necessary for defensible run reconstructions. Over the long term, this will allow DFO to effectively regulate fisheries to protect weak stocks and meet allocation objectives. Most of the suggested recommendations clearly point in this direction and are supported by the data presented.

Subcommittee Discussion

The Subcommittee accepts the Working Paper subject to many minor revisions noted by the reviewers. The Working Paper contains an extensive assembly and review of data pertaining to Skeena chinook but it does not provide stock assessment advice beyond the analysis presented in 1989. The Working paper provides evidence of substantial variability in escapement trends among stocks with reduced escapements in 1994 and 1995. In aggregate, escapements of Skeena chinook have increased from pre-Treaty levels and are above PSC escapement targets. Nevertheless, the Subcommittee concluded that there is a need for further analysis on the status of component stock groupings. Different interpretations of escapement trends are likely, depending on how stocks are aggregated.

The Subcommittee agreed with the authors that reliable estimates of catch composition by fishery and stock are not attainable and therefore stock-recruit analyses to estimate optimal escapements by stock are not possible. Alternative assessments based on stock-specific exploitation rate indicators are viable and are required for major stocks to establish biologically-based escapement goals. The Subcommittee approved most of the recommendations provided in the Working Paper, but concluded that the recommendations need to be organized as part of an over-all plan for stock assessment of Skeena chinook.

Recognizing that Green Plan funding is now only available for 1996, the Subcommittee agreed that pursuit of key recommendations presented in the Working Paper and summarized here are essential:

1. Complete and document the biological and sports catch databases as well as review historical native catch estimates and estimation methods. Native catch estimates are currently provided by Native AFS programs. The development of defensible Native catch estimation programs is likely to be at considerable cost.
2. Ensure adequate sampling of the Skeena test fishery and Babine counting fence carcass recoveries. The authors note that the test fishery provides about 70% of the information requirements for chinook and further expansion is necessary to encompass the total return of Skeena chinook. This expansion could be achieved with minimal cost.
3. Evaluate escapement monitoring programs including visit-specific information on reliability of estimation methods.
4. Validate age estimation methods that presently are providing inconsistent age composition estimates.

Subcommittee Recommendations

The Subcommittee **recommends** that a stock-specific assessment of Skeena chinook be conducted based on existing data and reported to PSARC.

The Subcommittee **recommends** development of a strategic plan for stock assessment of Skeena chinook that would evaluate and prioritize assessment needs with the ultimate aim of establishing biologically-based escapement goals.

S96-8 A Review of the Strait of Georgia chinook harvest rate program. C. Murray and B. Riddell.

Working Paper Summary

The primary objectives of the Chinook Harvest Rate Program (CHRP) are to examine the residence and movement of chinook tagged in the Strait of Georgia (SG), and to estimate the total size distribution of chinook vulnerable to fisheries within the SG. Both of these parameters are important to assessments of harvest rate changes in the SG sport and troll fisheries. The former develops an understanding of what portion of chinook may leave the Strait and become vulnerable to ocean or gauntlet fisheries, and the latter is essential to assessing changes in size limit regulations.

The CHRP started in 1988 and has compiled eight years of data. The CHRP utilizes chartered commercial trollers, sport fishing charter boats and volunteer anglers to fish for chinook salmon and collect biological data from chinook and coho salmon. Chinook fishing for the CHRP in the SG has been conducted in statistical areas where a high proportion of the SG troll and SG sport catch of chinook has been taken. These areas in SG extend from Area 13 (south of Seymour Narrows) through to Area 19 (north of Cadboro Point), and Areas 28 and 29 (Fraser River and Howe Sound) in the south.

The CHRP has applied 13,645 tags. Fifty percent of the total tag recoveries were in the SG sport fishery and very few tags have been returned from fresh water fisheries, hatcheries, and off the spawning grounds (recovering tags from spawning grounds is notoriously difficult). The rate of CHRP tag recoveries vary by year, between size classes among years, and among geographic areas (Table 8.1). Overall, CHRP tag returns indicate that in the spring there is a general north-westerly migration of chinook along the Vancouver Island side of the SG. Tagging in the spring off the mouth of the Fraser River and Nanaimo results in tag recoveries further north as the seasons progress. Once chinook are near Campbell River, they seem to remain there while they grow and mature. Tagging off Campbell River results in recoveries in the same general area or to the south later in the year.

Coded-wire tags were recovered from 118 chinook heads, representing 18 Canadian and 10 U.S. hatcheries. Coded-wire tag recoveries varied by year, between country of origin and among hatcheries within year. Tag recoveries from known chinook stocks

(i.e. fresh water sport and hatchery CHRP tags and coded-wire tags) collected by the CHRP indicate that 68% and 77%, respectively, of the chinook in the SG are of Canadian origin.

Chinook measured by the CHRP ranged in fork length from 22 to 102 cm between 1990-95. Differences in mean fork length were observed among years, among areas, and among areas within years. Seasonal trends in the SG chinook length for 1994 were also evident from the values among areas, months and seasons (Fig. 8.1). Length at age was also variable among years, areas and ages. As expected, chinook length increased with age (Fig. 8.2). Agreement between ages determined from scales and coded-wire tagged fish occurred in 54 fish (76.1%). Underageing errors occurred with scales in 5 fish (7.0%) and overageing occurred in 4 fish (5.6%). In 8 fish (11.3%), total age was correct but freshwater annuli were identified as saltwater annuli.

Average yearly effort and the combined May and June effort show a declining trend in the average chinook catch per day by the five charter vessels. A decline in CPUE occurred in Area 17 each year except 1991. Trends in the other areas show a similar overall decline in CPUE. A regression model prediction of the total chinook harvest by commercial and sport fishers in 1995 was made with data from 1989-94. Using the 1995 May-June CPUE of 2.39 fish/hour, the predicted catch was 92,961 chinook (95% confidence limit of 58,482 to 128,440 chinook). The total SG catch for 1995 was 46,966 chinook for March to October period. The model over estimated catch by 198%. Additional data are required to improve the model predictions. There was reduced sport fishing effort in the SG during 1995.

Working Paper Conclusions and Recommendations

The CHRP has demonstrated the utility of charter trollers in determining the size distribution of chinook vulnerable to recreational and troll fisheries. Size-at-age distributions varied significantly between years and areas within the Strait. Further, the 62 cm size limit is near the mean size of age 3 chinook in the SG. Thus, continued monitoring of size-at-age within major fishing areas would enhance our assessments of harvest rate change. Any assessment will be sensitive to variation in the size distribution of age 3 chinook since relatively small changes in growth could result in larger changes in the proportion of the age class vulnerable to retention.

While the tagging component of this program provides more qualitative than quantitative information, the recovery patterns show how chinook movements vary between areas of the SG and what stocks are present in the various areas. The recovery of CHRP tags indicates a stock composition which is inconsistent with coded-wire tag recoveries. Given the diversity of chinook populations in the SG and the relatively limited number of tags involved; this issue requires further investigation.

The repeated use of the same charter trollers within specified areas provides an opportunity to develop an early season indicator of chinook, and possibly coho, abundance. Given the recent uncertainty about the survival of chinook and/or coho and

their marine distributions, the development of an abundance index could be useful in developing or modifying fishing plans, particularly if discussions about "abundance-based" management continue.

We recommend continuation of this program on a bi-monthly schedule for each of the four survey areas in the SG. The information available must be incorporated into future assessments and the sensitivity of the assessments to these annual data examined. The program is demonstrating significant variation in size-at-age data and is providing basic biological data for an important stock group and fishing area. It is presently the only program capable of providing unbiased chinook size distributions.

Reviewers' Comments

Reviewer #1

This program is the only source of essential data for a sensitive and important fishery. If the program is to meet its stated objective, chinook harvest rates should be reported for 1987 and subsequent years. Some explanation is required to describe how chinook harvest rates are calculated from the data which the program collects. Additional explanation is required as to how length-at-age data can be used to assess harvest rate.

Reviewer #2

The authors provide a good description of why the program was initiated and what its main objectives were at initiation. The Working Paper does not address whether the 1988 and 1989 regulations reduced the harvest rate of chinook salmon in the Strait of Georgia by 20% from the 1987 levels as intended. One of the important questions is whether inter-year variability exists in size-at-age. Further analyses are required prior to the conclusion that size-at-age of chinook varies significantly among years. The tagging appears to provide some information about the gross movement and residence of chinook within the Strait of Georgia. However, there is no specific study design to the tagging program either in the application of tags or in their recovery. Reviewer #2 questions the continuation of the tagging program until a design is composed.

Subcommittee Discussion

The Subcommittee accepted this Working Paper subject to minor revisions to address the reviewers' comments. Comments from reviewer #1 include requests for a definition of what is meant by the term "harvest rate", how that harvest rate is calculated from the data which the program collects, and information on past year's harvest rates. Comments from reviewer #2 include a request for information to support statements on the short comings of other size-at-age data sets. Analyses in the Working Paper were inadequately stratified (because of area effects within ages) to demonstrate within and among year variations in chinook size-at-age. The Subcommittee further requests that the authors revise the Working Paper to include a comparison of current size at age data

to historical data sets to determine the annual variability or difference between time and area within years and between years. The historical data sets are those from the 1960s, 1970s, and 1980s. These data sets are readily available in published documents.

The Subcommittee's support for continuation of the Harvest Rate Program is contingent on demonstrated differences in the size at age data and the results of these data in a cohort analysis.

S96-9 Nechako Fisheries Conservation Programs: Nechako River chinook escapement enumeration methodology. P. Delaney

Working Paper Summary

In September 1987, the provincial and federal governments and Alcan Aluminum Limited reached an agreement on the fisheries issues surrounding the Kemano Completion Project (KCP). This agreement, known as the Settlement Agreement, defines a staged program of remedial measures, together with flow releases from the Nechako Reservoir, which are aimed at ensuring the conservation of Nechako River chinook and upper Fraser River sockeye populations.

Fundamental to the Settlement Agreement and the Nechako Fisheries Conservation Program (NFCP) is the annual chinook escapement enumeration program and the concept of the chinook conservation goal. The conservation goal was based on the average escapement from 1980-86 (1,550 spawners) and doubled (3,100 spawners) to account for the significant, but unknown, negative bias associated with visual counting methods. The escapement estimates from 1980-86 were based on peak-of-spawn (POS) counts.

In 1989, the NFCP Technical Committee decided that the most appropriate adult enumeration methodology to employ on the Nechako River would be the area-under-the-curve (AUC) with female residence time being the divisor. This technique is the most accurate enumeration methodology, with the exception of a full stream counting fence which was judged to not be feasible. Annual determination of the female residence time is made to determine the inter-annual variability in residence time and improve the accuracy of the escapement estimate.

The difference in escapement enumeration methodologies (AUC versus POS) has been raised as a data management and public profile issue by the NFCP Technical Committee when the annual AUC estimate is compared to the conservation goal (which was based on POS estimates). During the first 5 years of the NFCP, both the AUC and POS estimates were well within the conservation goal limits; however for 1995, the AUC estimate was slightly below the lower limit of the conservation goal, while the POS estimate was within the limits. Further, the apparent long-term trend of the Nechako River chinook escapement estimates has been recently biased because only the NFCP's AUC estimates are now entered into DFO's escapement database.

The purpose of the paper was: (1) to seek PSARC's endorsement of the chinook escapement enumeration methodology used on the Nechako River; and (2) to raise the data management issue associated with the NFCP's chinook escapement estimates.

Reviewers' Comments

Reviewer #1

A primary goal of any population estimation program should be to generate estimates of high accuracy and known precision. The Nechako escapement program produces estimates of unknown accuracy and precision. If the variability associated with the fish count data and the survey life data can be computed, confidence limits can be calculated around the escapement estimate. It should also be possible to assess accuracy (bias). In particular, the visual survey data are biased low since they do not correct for fish not seen by either of the two observers. A stratified approach could be used for data collection which would reduce the bias of the double-count estimators as well as compute variance. Additionally, only survey data for females are obtained. If there is a difference between males and females, the escapement estimates will be biased.

Reviewer #2

The Working Paper provides useful background information and a summary of escapement enumeration results for Nechako River chinook salmon. However, the Working Paper does not include sufficient graphical and numerical analyses to fairly evaluate the performance of the area-under-the-curve (AUC) enumeration methodology. The numerical estimation procedure ignores statistical error inherent in the data; there is a high risk of concluding that escapement goals have been achieved when in fact the target range has not been attained. Variability arising from statistical error in residence time, spatial-temporal sampling in aerial counts, and observer counts are not incorporated into estimates of escapement. This limitation prohibits judging the historical success of the AUC methodology. The essential model equations are not included in the paper. The methodology must be assessed in light of data from all years rather than only the 1994 escapement year. The apparent confusion over the reporting of AUC estimates for comparison with operational targets developed using peak of spawn estimates suggests further analyses comparing the different estimation techniques.

Subcommittee Discussion

The Subcommittee notes that the objectives of this Working Paper were not clearly articulated. The Subcommittee inferred that the objective was to evaluate escapement enumeration methodologies for Nechako River chinook. However, insufficient detail was provided in this Working Paper to fully evaluate the methodologies.

The Subcommittee deferred acceptance of this Working Paper pending resubmission and additional review. The Subcommittee requests that the author revise the Working

Paper to address the following concerns: (1) provide better documentation of the details of the methodology used to generate escapement estimates, (2) conduct additional analyses to provide estimates of precision and, if possible, accuracy, (3) provide electronic copies of all years of raw data used as a basis for annual escapement estimates and (4) provide recommendations on modifications to field survey activities that will generate new observations to clarify the statistical properties of both area under the curve (AUC) and other estimates (e.g. peak of spawner abundance observations) of chinook escapement.

S96-10 Assessment of coho stocks on the west coast of Vancouver Island. K. Simpson, B. Holtby, R. Kadowaki, and W. Luedke

Working Paper Summary

This is the first working paper assessing coho stocks on the west coast of Vancouver Island (WCVI). There are about 700 populations in this aggregate. They are almost entirely caught in the WCVI region. The populations are typically small (only 15% of reported escapements average more than 500 coho). The predominant freshwater age is 1 year. The incidence of age 2's is probably greater in unlogged streams. Escapements are protracted and difficult to enumerate.

The WCVI troll fishery is the largest coho fishery in B.C. with an average catch of about 1.5 million coho. Almost half the catch is US-origin coho, so this fishery is important in the Pacific Salmon Treaty. There can also be a major harvest of Georgia Strait coho in some years. There are no net fisheries directed at coho. Little of the CWT associated net catch in SWVI (Areas 20-24) is from WCVI hatcheries but the proportion increases further north. The sport catch of coho in 1995 is estimated to have been 65,000 - 80,000 coho. A larger proportion of the sport catch is from local stocks.

The best wild coho indicator stock is from Carnation Creek, near Bamfield. Smolt and adult fence counts and watershed studies have been made there since 1972. There has been no trend in Carnation production (catch + escapement) in that period. Freshwater survival has increased since the watershed was logged which has counteracted the decreasing marine survivals seen in this as well as many other south coast stocks. The only WCVI exploitation rate indicator is a hatchery stock, Robertson Creek. The average Robertson exploitation rate since 1975 is 66%. The Carnation exploitation rate corresponding to the MSY is 73% and 83%, based on Ricker and Beverton-Holt models, respectively. However, these rates yield very low escapements and their validity for other stocks is unknown. Target harvest rates would be 69% and 61% if 1.5 x MSY is used (Ricker and Beverton-Holt models, respectively). Considering that (1) these rates reflect long term average marine survivals when there is actually a clear decline in survivals and (2) we can assume many stocks are not as productive as Carnation, we recommend that exploitation rates not exceed 65%.

There are two other escapement time series that we think may indicate wild

escapements, the count at Stamp Falls and swim counts at Gold River. Both series correlate with the better data at Carnation Creek (supporting the notion that Carnation coho are a regional indicator). We have also estimated the total production of WCVI coho based on a stock composition model. Production estimates range from about 270,000 to 930,000 coho from 1984-94. The catch estimates range from 170,000 to 670,000 coho. The annual estimates correlate with marine survivals at Carnation and Robertson creeks and with the escapement time series.

The 1994 escapement of coho was extremely low in many stocks, probably due to predation by mackerel in the 1993 El Nino year. The Carnation, Stamp and Gold escapements, the WCVI production estimate and marine survival estimates for the major hatcheries all indicate that escapements were very poor. It is possible that many smaller stocks had no escapement. SWVI may have been most severely affected, particularly Barkley Sound, but our data are poor elsewhere. An annual coho fry survey of densities and sizes was initiated in 1995. Fry densities generally support this synopsis of the parent escapement, although some streams had adequate numbers of fry. Some escapement information from Areas 24 and 27 also show that not all stocks were severely affected. We give notice in the report that exploitation rates in 1997 should be reduced. One preliminary scenario, to be updated using 1995 data, yielded a target exploitation rate of 41%.

Three methods are described to forecast 1996 returns to Carnation and Robertson creeks. The first uses the escapement of jacks (age .0's) to Carnation Creek to predict the sibling return (catch + escapement) of adults (age .1's) the following year. A variation of this was done for Robertson Creek, where the survival rate of adults is regressed on the survival rate of sibling jacks. The second and third models performed more poorly. One used salinities to predict smolt to adult survivals. The other hypothesizes cyclic marine survivals and predicts survival to be the mean of survivals in the previous three years. The sibling forecast gives a smolt to adult survival of 13.6% for Carnation coho in 1996 which should produce one of the larger escapements in the time series. The forecast for Robertson coho gives a survival like last year, at 1.2%. Robertson coho do not usually survive as well as Conuma and Nitinat hatchery stocks. They have never survived as well as the Carnation wild stock, but they appear to be surviving particularly poorly recently.

The final forecast is of coho abundance in the WCVI troll fishery area, a necessary pre-season prediction if the catch ceiling in this fishery is to reflect annual conservation requirements. Historical abundances were estimated using the WCVI troll harvest rate on Robertson Creek coho and a multiple regression was successfully fit using four variables: Robertson and Quinsam survivals, proportion of Quinsam coho caught in inside fisheries and year. The 1996 prediction is for 2.85 million coho in the WCVI troll area ($\pm 596,000$ coho, 75% CI).

Reviewers' Comments

Reviewer #1

The Working Paper provides a good overview of the work conducted on WCVI coho. Reviewer #1 agrees with the authors recommendation that exploitation rates not exceed 65%. Accurate data are needed to continue assessments on these stocks. The assessment document is based primarily on population dynamics studies done at Robertson Creek and Carnation Creek. The authors argue that Carnation Creek is one of the most productive wild coho streams of WCVI. However, we may be now in a situation where only the most productive stocks have survived and we now use those stocks as the baseline for productivity. Since WCVI stocks are acknowledged to have conservation concerns, the Working Paper should not suggest that the status quo harvest rate has had no impact. At least, it cannot be a risk-averse harvest rate. The recommendation of a 40% harvest rate for 1997 seems high given the dire predictions for survivorship of the 1994 brood and the need to be risk-averse.

Reviewer #2

Although there remains considerable quantitative uncertainty concerning the forecasts and projections included in the Working Paper, the authors have successfully integrated the available information on WCVI to generate a synopsis of coho status. Their care to investigate alternative methods of forecasting 1996 abundance gives confidence that consideration has been given to the possible management ramifications of any forecast made and the limitations of any particular method of forecasting coho abundance.

Subcommittee Discussion

The Subcommittee accepted the Working Paper subject to revisions, and appropriate rewording of recommendations based on the Subcommittee discussion and incorporation of reviewers' comments. Specifically, recommendation 1 needs to be revised to incorporate more of the discussion on exploitation rates from Working Paper directly into the conclusions.

Revisions to the Working Paper should include:

1. Examination of catch expansions in the 1991 sport catch in Barkley Sound and appropriate revisions to catch.
2. Addition of confidence intervals to the Carnation Creek sibling forecast.
3. Addition of analysis and discussion on separating effects of climate, logging, and density on smolt/spawner time series and estimates for Carnation Creek.
4. Generation of baseline production estimates without density dependent compensation for Carnation Creek coho to provide a baseline against which

observed trends can be compared.

There was considerable Subcommittee discussion about the total number of coho stocks on WCVI, the representativeness of an extremely limited number of index streams, and a risk averse harvest rate for coho on WCVI.

Coho spawners have been reported in more than 200 streams on the WCVI. However, many populations are not reported and thus the question of how many coho streams there are presently on WCVI remains unanswered. The Subcommittee **recommends** that a Working Paper be produced to estimate productive capacity of coho streams through remote means (i.e. maps and aerial photography).

The Subcommittee suggested that the authors provide more detail to address concerns that Carnation is atypical of streams on WCVI and to describe the production base around Barkley Sound. The Subcommittee raised concerns about the apparent declines in lake-based production. The Subcommittee supports the authors' recommendation that the existing time series of data for Carnation Creek, Stamp Falls and Gold River be continued to allow maintenance of the existing assessment capability.

The Subcommittee concurs with the authors that over the long-term the current harvest rates (between 60% and 65%) are suitably precautionary for Carnation Creek coho, which is one of the more productive streams. It is not known whether this applies to other coho stocks on WCVI. However, in the short-term, where low marine survival conditions exist, the Subcommittee suggests that in order to be precautionary, a reduction in harvest rate is warranted. To specify what the harvest rate should be requires a clear definition of fisheries management objectives.

The Subcommittee notes that poor returns are anticipated for WCVI coho in 1997. This is a result of a combination of poor returns in 1994 and low ocean survival. The prediction of poor returns in 1997 can be confirmed in 1996 with observations of jack returns and smolt output. The Subcommittee **recommends** that a paper be produced for the 1997 forecasts of WCVI coho.

S96-11 An update of assessment information for Strait of Georgia coho salmon stocks with 1996 forecasts and advice on setting and exploitation rate target. R. Kadowaki, B. Holtby, K. Simpson and D. Blackburn.

Working Paper Summary

Strait of Georgia coho salmon stocks were previously assessed in PSARC Working Paper S94-9. This Working Paper updates the previous assessment with respect to escapement trends, coded wire tag (CWT) based estimates of exploitation rate, survival rate, catch, catch distribution, and juvenile survey results. In addition, forecasting methodologies for survival and distribution and an analysis evaluating the stock impacts of alternative exploitation rates are presented for the first time.

Smolt to adult survival rates continue at low levels (2.0% to 5.1%) for all tagged stocks examined. Based on the 1994 assessment, PSARC recommended that exploitation rates on Strait of Georgia coho be dropped from the 65% to 70% range to below 65%. This was accomplished in 1995, as the exploitation rate on Black Creek and the three hatchery indicators ranged from 54% to 60%. The extremely low inside catch distribution in 1995, the WCVI troll ceiling, and the lack of net fishing time in Johnstone Strait and Juan de Fuca Strait were major factors in achieving this low exploitation rate. The catch of 1.52 million coho in south coast B.C. sport and commercial fisheries is the lowest on record (since 1952). Spawning escapement improved over 1994 levels at Mesachie Creek, Black Creek and Salmon River (wild stock indicators). However, spawning levels were still below the MSY goal for Black Creek (3,150 fish). Fry survey results indicate continued low densities in many streams. Despite the reduced exploitation rates achieved in 1995, conservation concerns still remain for the Strait of Georgia coho stock complex.

Forecasts for the Big Qualicum River and Quinsam River hatchery stocks indicate that the survival rate of 1993 brood coho returning in 1996 will continue to be depressed relative to the long term average (0.054 ± 0.062 and 0.027 ± 0.02 , respectively). Recent cycle year average survival rates provided better forecasts than sibling regression or salinity models. This is likely a result of the cyclical pattern of survival rates over the period of record. Salinity-based forecasts of the proportion of the catch harvested in Strait of Georgia fisheries for three hatchery stocks (Big Qualicum, Quinsam and Chilliwack) indicate a below average distribution to Strait of Georgia fisheries. Other indicators (trawl survey, anecdotal angler information) also point to another year of distribution to outside fisheries.

The loss of habitat around the Strait is associated not only with the increased numbers of people living in the area but also with the ever-increasing intensity of resource use. These trends may well be inexorable and certainly cannot be reversed in the short term. To date there is little convincing evidence that either habitat loss or habitat damage has been a significant factor in the most recent declines in Strait of Georgia coho (over the past two or three years). Importantly, uncertainties about the role of habitat in our current problems should not divert attention from harvest controls, which are the only available short-term solution. Equally important, the availability of harvest controls should not divert attention away from habitat, which must certainly be part of the long-term solution to the problem of maintaining wild coho

Advice on Setting an Exploitation Rate Target

The two important elements of setting an "appropriate" exploitation rate are (1) a clear statement of the goal (management or fishery objective), and (2) determining what level of risk of not achieving the specified goal is acceptable. We have developed a very simple model that allows us to estimate the risk of not achieving a minimum escapement level under a range of fishery exploitation rates.

Using empirical estimates of freshwater productivity (smolts/spawner) and smolt-to-adult survival, we used Monte Carlo simulation to generate a probability distribution of recruits per spawner, which when multiplied by 0.5 (the assumed sex ratio in the smolts), and by the assumed female escapement/km, gives a probability distribution of female recruits/km. We then calculated what exploitation rate would be necessary to reduce the number of female recruits/km to each of the three minimum escapement levels. We ran a series of simulations assuming:

1. three levels of current stock status: 32, 8 and 2 females/km ;
2. three levels of smolt survival: 0.117 (Salmon), 0.0965 (Black), and 0.042 (Mesachie);
3. three levels of intrinsic productivity: Snow Creek - low; Black - moderate, and Carnation - high.

The three levels of stock status describe Black Creek (32 females/km), Carnation Creek (8 females/km) and streams in the Cowichan headwaters, Baynes Sound and possibly parts of the sunshine coast (2 females/km).

Modeled exploitation rates are sensitive to changes in stock status and smolt-to-adult survivals. In particular, further declines in smolt-to-adult survival in populations around the Strait would necessitate revisiting target exploitation rates. If smolt survivals at Black Creek or Salmon River fall into the same range as they are currently in at Mesachie Creek, then the target exploitation rates for those stocks would soon fall below 40%. Further declines in smolt survivals for the upper Cowichan stocks would place those stocks at high risk, especially if fishing continues at current levels.

Working Paper Recommendations

1. In 1996, harvest managers should be prepared for continuing low survival rates for Strait of Georgia coho stocks and another year of outside distribution.
2. The biological model developed to assess the risk to Strait of Georgia coho of alternative exploitation rates suggests a range of targets based on stock productivity, critical minimum escapement levels, a range of stock status and a desired probability level for achieving escapements above the critical level. Given the poor status of Strait of Georgia coho stocks, work on developing and incorporating this methodology into fishery management decision-making should be undertaken immediately in conjunction with fishery managers.

Reviewers' Comments

The authors provide reasonable evidence for their 1996 forecasts of (1) continued low Georgia Strait coho survival rates and (2) an outward migratory pattern from Georgia Strait to the west coast of Vancouver Island. Recommendation 1 follows from these forecasts, although the authors do not specify how it would be translated into management practice. Recommendation 2 proposes a modeling exercise for the future.

Its success depends on careful design and documentation of data requirements, databases, mathematical equations, and software. Like most PSARC papers, this one illustrates the need for lucid data preparation. The reviewer recommends that every PSARC paper be accompanied by an ACCESS database containing all the raw data used in the analysis. Multispecies, multistock salmon fisheries require that managers consider simultaneously the results of several different analyses. Authors and reviewers of a paper like this one should easily be able to reference data from other areas and other species. In the long run, this will be possible only if the entire DFO salmon database is improved and consolidated.

Subcommittee Discussion

The Subcommittee accepted the Working Paper subject to the minor revisions as requested by the reviewer, and inclusion of a table of coho smolt production from relevant hatcheries in Canada and the United States (available in the MRP database). The Subcommittee noted that catch trends have probably been affected by recent changes in hatchery smolt output as well as by declining marine survival. The Subcommittee did not endorse the risk simulation model presented in the Working Paper. The model was not presented in sufficient detail to allow for review at the current time.

The Subcommittee accepted the authors' arguments that the status of coho stocks in the Strait of Georgia has not improved and that most stocks remain at risk. Spawning escapements improved in 1995 over 1994 for some (but not all) indicator stocks as a result of reduced exploitation rates but remain below target levels. Smolt survival rates have been and will likely continue to be low relative to long term averages.

Subcommittee Recommendations

1. The Subcommittee **recommends** that harvest managers be prepared for continued low marine survival and another year of outside distribution in 1996. Forecasts for the marine survival of cohorts returning to two indicator stocks (Quinsam and Big Qualicum) in 1996 range from 2.7 to 5.4%, compared with 2.4 to 2.9% observed in 1995. Forecasts for the percentage of catch available to fisheries inside the Strait of Georgia in 1996 from three indicator stocks (Quinsam, Big Qualicum, and Chilliwack) range from 12% to 23% . However, managers should be aware that this forecasting method overestimated the inside catch percentage in 1995 with predictions ranging from 26% to 35% and actual values ranging from 0% to 10%.
2. The Subcommittee **recommends** that explicit management objectives be developed for Strait of Georgia coho stocks. It is not possible for the Subcommittee to recommend meaningful harvest rate targets or ceilings without stock-specific management objectives.
3. The Subcommittee **recommends** further development of the risk simulation model presented in the Working Paper. The model could be used to assess escapement

levels expected under alternative exploitation rates. This work should receive a high priority given the continued poor status of Strait of Georgia coho stocks. Further development of the model should enable its use in evaluating the risk of alternative harvest scenarios based on explicit management objectives.

S96-12 Report on the Upper Fraser River catch monitoring programs of First Nations Fisheries, 1995. V. Palermo and B. Ennevor.

Working Paper Summary

The goal of the 1995 catch estimation program in the upper Fraser River was to improve upon 1994 methods of data collection, and produce defensible catch estimates. This Working Paper presents a review of the catch monitoring program of 1995 First Nations fisheries directed at sockeye salmon in the area from Sawmill Creek to Kelly Creek and the Thompson River upstream to the confluence of the Bonaparte River. This was the most comprehensive catch monitoring program ever conducted by DFO in this area.

The weekly catch estimates were generated using average weekly estimations of catch per unit effort (CPUE) and effort counts. The data were collected through an extensive randomized sample survey program where a representative portion of the fishery was sampled and these data were subsequently expanded to represent the total fishery in this area. Technicians on helicopter overflights counted the number of nets actively fishing to generate estimates of fishing effort. An attempt was made to collect nighttime effort and CPUE data by patrols conducted in cooperation with fishery officers; however, insufficient data were collected in the 1995 season.

In 1995, we have shown that the implementation of a structured catch monitoring program for First Nations catch in the upper Fraser River fisheries can produce defensible catch estimates. Further, for the first time, this program allowed us to document the nature of the fisheries involved with representative data which can be used to assess the characteristics of the gill net and dip net fisheries. Coupled with effort information from helicopter overflights, the 1,175 interviews in the study area that collected CPUE, catch, and soak time information represent the most complete data set ever gathered for the fisheries in this area. The structured nature of the data collection and its storage in a relational database allow easy access for statistical and assessment analyses.

We believe that continued structured data collection and subsequent easy access to the data will allow us to better understand the behaviour of the fishers and the fisheries in the area. We still need several years of data to ensure that we fully understand the inter-annual variation in the relevant parameters can be measured and assessed. With this knowledge we will then be able to assess the structure of variability of the parameters and assess with greater confidence the variation in the estimation of catch.

Reviewers' Comments

Reviewer #1

This is a very controversial subject and so survey methods and estimation procedures need to be scrutinized very carefully. The following appear to be the major areas of concern that need addressing:

1. Survey methods:

- (a) lack of night time data on number of active nets.
- (b) randomization of overflights into weekday/weekend and within a day
- (c) length-biased sampling for interviews with fishers to ascertain CPUE (fishers with long soak times more likely to be encountered than fishers with short soak times)

2. Data analysis

- (a) adjusting observed net counts for soak time
- (b) properly weighting observed data for stratum sizes and area observed
- (c) variance component estimation and overall precision.

Some of these concerns can be corrected using the current data. For others, a simulation study will have to be undertaken to estimate the potential size of the biases introduced by the methods used and to estimate the precision of the estimates.

Reviewer #2

The Working Paper does not provide the reader with a clear understanding of the actual calculation of catch. Most importantly, the authors avoid discussion of a major error in the experimental design which has caused a significant underestimate of catch. This error was the assumption that the instantaneous gear counts obtained from overflights would provide a correct estimate of the total number of nets which fished in a 24-hour period. The magnitude of the bias resulting from the underestimation of effort is difficult to estimate from the summary data presented. However, the total catch estimates presented for the Sawmill to Texas Creek area could be as low as about 43% of the true values. Despite this criticism of the existing methods, the authors have collected the necessary data to produce nearly unbiased catch estimates.

The authors should estimate the actual effort in net hours using weekly data on instantaneous overflight gear counts and weekly effort profiles for each gear and area from the interview data. Revised estimates of catch by area, week and gear must be made to ensure that the calculation of 1995 salmon catches is accurate. In 1996, the data collection and analysis program should be revised to: (a) Randomize the times of overflight gear counts during the daylight period; (b) Increase the proportion of the interviews conducted during the night hours; (c) Integrate the effort profiles obtained from

interviews with the overflight gear counts to estimate Effort in net hours; (d) Incorporate a sub-area census program for a small, well-defined fishing area, into the 1996 sampling plan to generate weekly effort and catch profiles independent of the estimates obtained in the full survey program.

Subcommittee Discussion

The Subcommittee concurred with both reviewers that instantaneous gear counts underestimated the fishing effort and catch. The underestimate could be modest (as argued by the authors) or up to a factor of two (as argued by the reviewers). The Subcommittee agreed with the reviewers that data exist to adjust for this error and revise the catch estimates for 1995. The Subcommittee also agreed that only catch estimates based on daylight sampling were defensible because of a paucity of night time effort counts and sampling data. The Subcommittee was also concerned that no precision estimates were given on the reported catches for 1995. The authors indicated that precision data were available on the individual components of the catch estimation equation, but were seeking statistical advice on how these data could be incorporated into the overall catch estimates. The Subcommittee noted that since this was the first year of a likely multi-year program, it would be prudent to document the data validation procedures determining which original data were included in the database and which were rejected. The Subcommittee was also concerned about the potential level of non-catch fishing mortality.

Subcommittee Recommendations

The Subcommittee accepted the Working Paper subject to the following major revisions:

1. Data analysis for 1995 is to incorporate new defensible daytime catch numbers with corrections for fishing effort bias along with available information for estimation of night time catches. Revisions will also include precision estimates surrounding the individual components of the catch estimation equation for the 1995 data.
2. Documentation of the changes for the 1996 field program that address the potential 1995 fishing effort bias and night time sampling deficiencies.
3. Documentation of data archival and data validation procedures.

A procedure should be determined as soon as possible for making overall precision estimates for the catch data.

In 1996, the Program should compile whatever data might be available to assess incidental fishing mortality in the Upper Fraser.

S96-13 Status report on the Qualark Creek Hydroacoustic Project. T.J. Mulligan.

Working Paper Summary

The Riverine Acoustics Program at the Pacific Biological Station has been developing acoustic methods to estimate migrating sockeye salmon in the Fraser River since 1996. This program began as a response to recommendations in the Pearse/Larkin Investigation Report that suggested establishment of an acoustic facility on the Fraser River upstream of Mission.

A split-beam echo sounding system with fish tracking software was selected to collect data on migrating salmon. The relative index of salmon migration obtained during the first three years of operation of this system agrees well with the counts from Mission. Each year of operation, the efficiency of salmon detection relative to Mission has increased, beginning at ~12% in 1993 and rising to ~59% in 1995. Problems of fish avoidance of the acoustic beam, nonuniform fish density over the beam cross section, and high fish density have been encountered. Solutions to these problems have been developed or are under development.

In 1995, an experiment was conducted at Spences Bridge that compared the acoustic estimates from this system with a simultaneous visual count. The results from this experiment have not been completely analyzed. However, preliminary results indicate that for count rates typical of the system used at Qualark Creek, a system configuration can be used that gives accurate estimates of absolute numbers of migrating fish. This new configuration will be used for the 1996 season at Qualark Creek. Thus, it is anticipated that absolute estimates will be available during the coming fishing season.

Reviewers' Comments

Reviewer #1

The team has done a remarkably thorough job of tackling a challenging application of hydroacoustic technology. The experiment at Spences Bridge this past fall has provided essential information in building a reliable scheme for estimating fish passage in the Fraser system. All estimates derived from data in the muddy Fraser will be valid subject to assumptions of similar behavior at the two sites. Some of these will inevitably be untestable, and we shall have to keep this unavoidable limitation in mind when assessing possible sources of error at Qualark Creek.

Reviewer #2

The author has shown a thorough understanding of this relatively new acoustic technology and its applicability to counting migratory salmon in the Fraser River. His well thought out scientific approaches and well-executed programs have yielded intriguing results. These results have demonstrated the potential of the split-beam echosounding system in estimating the Fraser River salmon escapements. The

Working Paper does not provide adequate documentation of the methods used in the analysis of the data. The next phase of this work should develop realistic and physically sound working theories and models that allow extrapolations of tracked fish by the split-beam system to total escapement rates.

Subcommittee Discussion

Both reviewers complimented the authors on the clear description and presentation of a challenging task in development of a unique application. The author noted that the Working Paper was not presented as a definitive description of the technique, but rather a status report with examples of problems encountered and solutions employed to date. The Subcommittee acknowledges the substantial progress made to advance the program for use as an operational fisheries management application.

Currently, potential methods are being examined to perform echo integration measurements at high fish densities; assessment of accuracy of passage estimates with the use of the Spences Bridge experimental work is also required. Outstanding issues to consider for management application include reconstruction of sockeye escapements using Mission and Qualark estimates and in-river harvests. The Subcommittee highlights potential problems of using test fisheries to differentiate among salmon species in the Qualark estimates. If the acoustic technique becomes an operational tool, the Subcommittee noted potential applications for other species, particularly for chinook.

Subcommittee Recommendations

The Subcommittee **recommends** acceptance of the paper, subject to minor revisions, and:

1. Continue work to improve the efficiencies of detection and accuracy of passage estimates,
2. Continue operation and testing of the Qualark facility in 1996, given that analyses are still required,
3. Treat passage estimates in 1996 as preliminary only to test their potential utility for stock assessment and fisheries management.
4. Evaluate additional techniques to determine species composition.
5. Fisheries managers should consider how Qualark Creek passage estimates will be incorporated into current fisheries management plans and with stock assessment information from current sources.

S96-14 The utility of hydroacoustic estimates of juvenile sockeye in stock assessment with forecast for the 1997 Quesnel Lake return. J.M.B. Hume, A. Cass, and K.S. Shortreed.

Working Paper Summary

Population estimates of juvenile sockeye fry have been made in many Fraser River lakes since 1975. Surveys of fry conducted in mid-summer and early fall eliminate uncertainty due to early periods of high and highly variable mortality and provide data more closely related to returns. The information from these surveys allow us to estimate both the rearing capacity of sockeye nursery lakes and to forecast future returns. Comparatively long time series of acoustic/trawl surveys have been collected in Shuswap (17 years) and Quesnel lakes (11 years), while shorter ones are available for Cultus, Fraser, Takla, Trembleur, and Stuart lakes (5-8 years).

In general there was a decline in juvenile populations from the summer to fall in both Quesnel and Shuswap lakes although large confidence limits on three of the data sets resulted in estimated populations increasing from summer to fall. Populations declined much faster in Quesnel Lake, where the average instantaneous mortality was $57\% \cdot \text{mon}^{-1}$, than in Shuswap Lake ($22\% \cdot \text{mon}^{-1}$). One significant source of error in low sockeye spawner years is the presence of kokanee. Methods such as the electrophoretic separation of sockeye and kokanee need to be routinely applied to reduce this problem.

The maximum number of fall fry (carrying capacity) in Shuswap and Quesnel lakes was produced by escapements of 1.38 million total spawners (0.7 million effective female spawners (EFS)) to Shuswap Lake and 1.3 million total spawners (0.6 million EFS) to Quesnel Lake. These were similar to optimum escapements estimated by a lake production based model and both are less than half of the maximum observed escapements or carrying capacity estimates based on adult stock-recruit curves.

Similar carrying capacity estimates can be made from fall fry data on other lakes when an adequate time series encompassing a wide range of densities has been collected. In the absence of such a time series the data required for the photosynthetic rate model can be collected in one or two years. In the Fraser system, we have fry or photosynthetic rate data available for only 43% of the rearing area of sockeye nursery lakes. There is inadequate data available for the three lakes of the Stuart system which encompass 29% of the total lake nursery area. A unique opportunity exists over the next few years to collect low density data using modern acoustical and limnological techniques followed by a potentially record high escapement year in 1997 (1998 sample year). Other major lakes where inadequate data exists to make carrying capacity estimates are Harrison, Lillooet, Adams and Birkenhead.

The forecasted 1997 return to Quesnel Lake from the best performing effective female spawner model (R/E) was 22.7 million fish had a 90% prediction interval of 4.8 to 106.1 million fish. This assumes no density dependent effects at the extreme level of

escapement observed in 1993. The fall fry model performed almost as well as the adult R/E model with a forecast about 2/3 lower at 8.0 million 4_2 returns with a 90% prediction interval of 0.2 to 292 million fish. Since these data are within observed fry densities that implicitly account for egg-to-fry density dependent mortality, the use of fry data is preferred to using spawning escapements to forecast 1997 returns.

Working Paper Recommendations

1. The forecast method used to predict Quesnel sockeye returns in 1997 should be based on fall fry abundance estimates since spawning escapements are beyond historical record. In addition, it is unlikely that reliable sibling jack estimates in 1996 are attainable since Quesnel escapement enumeration methods for the adult off-cycle runs in 1996 will not employ mark-recapture techniques.
2. Hydroacoustic and trawl surveys of Quesnel and Shuswap lakes should be continued in dominant and subdominant years and at least some nondominant years. As performance statistics are related to sample size, these forecasts should improve with additional data. As well, application of electrophoretic techniques to species identification will enable better separation of sockeye from kokanee and a more accurate estimate in low density years.
3. Carrying capacity of the remaining 57% of the sockeye nursery lakes in the Fraser River system should be determined. This should be done through a combination of limnological and sockeye fry surveys. In particular, the greatest potential benefit from further work is for the three lakes of the Stuart system.
4. Consideration should be given to fertilization of Quesnel Lake in 1998 when fry numbers may be the highest ever. At application rates used in other lakes, fertilization should increase primary production by 50% and raise the rearing capacity from 1.1 (photosynthetic rate prediction) to around 1.5 million total adult spawners.

Reviewers' Comments

Reviewer #1

Hydroacoustic estimates of juvenile sockeye may prove to be a feasible method of forecasting future returns and carrying capacity, as some of the uncertainty associated with unknown survival in early life stages may be removed. Obviously, the utility of the method relies heavily on valid acoustic measurements of the juveniles and accurate estimates of returning adult populations. A brief discussion of the accuracy of the adult sockeye estimates should be included and comments on how inaccuracy in the adult estimates would affect the results. More technical information also needs to be presented on how the juvenile densities are measured because the accuracy of the density measurement is central to all of the results. For example, how are the transects broken into depth strata and how is the insonified volume in these strata is determined

for each transect to allow for decreased sampling volume with decreased depth? Further discussion is also needed for the years where a population increase was noted between the summer and the fall surveys.

Reviewer #2

It is difficult to relate fall fry numbers to escapements because in many cases, there seems to be no significant difference between fall fry numbers no matter what the number of spawners might have been. For example, in Quesnel Lake, an EFS of 12 spawners might produce the same number of fall fry as an EFS of 60 spawners. Extra work should be done to reduce the variance around the acoustic estimates.

Subcommittee Discussion

The Subcommittee considered several potential problems associated with the hydroacoustic estimates of summer and fall sockeye fry numbers. One issue was to distinguish between sockeye and kokanee fry when the abundance of sockeye is low. Another issue was the high variation in estimates which sometimes occurs between adjacent transects, resulting from aggregation of the fry. The Subcommittee questioned whether the survey design could be modified to account for the spatial heterogeneity in fry density. The Subcommittee recognized that the authors required additional statistical advice on survey design.

The Subcommittee noted that forecast returns for 1997 based on fall fry abundance are lower than estimates based on returns per spawner for all years of available data (1948-89). The low forecast based on fall fry estimates is not inconsistent with recent trends in returns per spawner for the dominant (1997) cycle. For brood years 1981, 1985 and 1989, rates of returns per spawner have declined coincident with record high escapements. Estimates of returns from these brood years have been similar, ranging from 10 to 12 million age-4 sockeye.

Insufficient details were provided in the Working Paper for the Subcommittee to endorse the recommendation that the carrying capacity of the remaining sockeye nursery lakes be determined. In addition, the Subcommittee noted that potential cycle year effects on carrying capacity were not considered. In Fig. 14.1, fall fry numbers in Quesnel Lake are lower for non-dominant years (1986, 1990, 1994) than for dominant years (1977, 1981, 1985, 1989, 1993).

Subcommittee Recommendations

The Subcommittee **recommends** that hydroacoustic and trawl surveys in Quesnel and Shuswap Lakes continue in 1996.

The Subcommittee **recommends** that the hydroacoustic survey design and data analysis receive a formal statistical review as soon as possible. Until this review is complete, the Subcommittee cannot endorse expansion of the surveys to other lakes.

The Subcommittee accepts the Working Paper subject to addressing the reviewers' comments and the following major revisions:

1. More details are required on the description of the hydroacoustic methods, as suggested by the reviewers.
2. More details are required on the calculation of carrying capacity, in particular for the photosynthetic rate model.
3. Alternate interpretations of the relationships between effective female escapements and summer and fall fry densities should be discussed.
4. Recommendations not based on information in the Working Paper should be removed.

S96-15 Ecosystem management for Pacific salmon; integrating habitat into the harvest management - stock assessment loop. I.V. Williams and T.J. Brown.

Working Paper Summary

An ecosystem approach to resource management is essential for the sustainability of the Pacific Coast salmon fishery. That is, integration of habitat, harvest management and stock assessment is required in a working sense. The concept of an "ecosystem" management approach (integrating habitat with stock assessment and harvest management) has been generally accepted. However, the progression from concept to implementation in Pacific salmon management has been at best intermittent.

The main difficulty in implementing an ecosystem management approach is the large complex of factors that affect salmon in both salt and freshwater. This Working Paper examines two factors affecting production of the Early Stuart and Horsefly sockeye. First, we examine the effect of high temperature and discharge on productivity. Second, we examine the hypothesis that Horsefly River spawning habitat limits sockeye production in the Quesnel watershed.

River discharge and water temperature along the migration path of early Stuart adult sockeye can impact production in several ways. High discharge can block migration. High temperatures can cause a stress-disease-death process prior to arrival at the spawning grounds. High temperature during migration can reduce spawning success. There is evidence that high temperatures can affect development of maturation compromising gamete quality. Spawning ground temperatures in the Stuart-Takla Streams are cool and not considered a problem at this time. Spawning habitat has been fully subscribed in the large number of small streams which historically have produced the majority of Early Stuart sockeye. Increasing production in this system is dependent on the spawning habitat of the Driftwood River. We have little information on this system but believe it can accommodate a further increase in spawners. Rebuilding success depends on maintaining the migration habitat within acceptable limits.

Difficult passage problems plagued the Horsefly run prior to 1927. Horsefly-Quesnel sockeye were reduced from an escapement of 4 million in 1909 to a few hundred fish by the early 1940s. The removal of dams, insertion of the Hells Gate fishways and the cessation of placer mining in the Quesnel-Horsefly area removed obstacles to migration and freshwater production. From a few hundred fish in the late 1940s, the run has grown to become the major population on the 1993-97 cycle year. There is now controversy over the appropriate escapement ceiling for this system. High temperatures have been associated with high prespawning mortalities. Acceptable temperatures during migration and on the spawning grounds are key to the success of Horsefly spawning.

In an attempt to deal with complexity, we are currently building a Fraser River Integrated Model. This model is based on the life history of salmon built on a spatial platform of >1500 1:20,000 digital TRIM (Terrain Resource Information Management) maps. Integration of and easy access to many types of data is the key to building a DFO tool of value to all sectors.

Reviewers' Comments

Reviewer #1

This Working Paper provides a wealth of information regarding the effects of temperature, discharge, and other factors on Fraser River sockeye production. The detailed description of habitat mapping techniques based on air photo interpretation will have broad applications in the Region. The Working Paper also highlights new initiatives such as the Integrated Fraser Model and the in-season temperature monitoring and prediction model. The Working Paper suffers from a lack of explicit objectives and, as a result, fails to mesh its main components into an integrated document.

Reviewer #2

The review was difficult because objectives were not clearly stated, the data, methods, and results did not support the conclusions, and the data and methods were either not provided or provided in insufficient detail to evaluate conclusions adequately. The effects of adverse migration conditions on sockeye production has important ramifications for sockeye management. The focus of the Working Paper should be to evaluate whether current knowledge is sufficient to develop appropriate fisheries management plans, if warranted. Development of a habitat-based spawner capacity estimate in part 2 of the Working Paper has important implications for Fraser sockeye, since escapement targets are currently based on a rebuilding program initiated in 1987. Unfortunately, the poor presentation detracts from an important subject that warrants a thorough examination to assist and support Fraser sockeye escapement policy.

Subcommittee Discussion

The Subcommittee recognizes the importance of such habitat studies in assessing the impact of environmental stressors on Pacific salmon, and their role in determining the productive capacity of salmon habitat. However, based on the reviewers' comments about the organization of this Working Paper and the completeness of various sections, the Subcommittee rejected the Working Paper in its present form. The Subcommittee requests that the Working Paper be revised as at least two separate papers: (1) temperature models and stress on migrating or spawning salmon in the Fraser River, and (2) spawning habitat capacity for sockeye salmon in the Horsefly River. The authors noted that the temperature model is presently submitted for primary publication, but the integration of model predictions with management of Fraser sockeye remains to be reviewed. In the second paper, the Subcommittee suggests inclusion of all spawning areas for Quesnel sockeye, so that the spawning capacity results could be more directly compared with studies on lake-rearing capacity. The Subcommittee **recommends** that these papers be completed and be re-submitted for the fall 1996 or spring 1997 PSARC meetings.

Given the extensive work that has been undertaken during the Fraser Green Plan and the continued uncertainty present in Fraser sockeye spawner-recruit data, the Subcommittee recognizes two important roles for habitat studies: (1) accounting for variation in the stock dynamics data associated with environmental variation in freshwater habitat (both at the juvenile and adult stages); and (2) provision of spawning targets determined independently of the stock dynamics data. The Subcommittee noted, however, that the latter requires translating the habitat capacity into the number of sockeye required (which may still require more information) and comparison of capacities between spawning and rearing habitats. Continued work on such habitat issues is consistent with past direction to PSARC to consider environmental trends/impacts in preparation of stock assessments of Pacific salmon.

S96-16 Status of the Puntledge River summer chinook. W. Trites, C.W. Beggs, and B. Riddell

Working Paper Summary

The population of summer chinook that spawn in British Columbia's Puntledge River once numbered about 3,000 fish, but declined following expansion of hydroelectric development in the early 1950s. By 1965, only a few hundred fish remained (Fig. 16.1). Following enhancement efforts (construction of a spawning channel, fish way, and fishing closures and restrictions), the population slowly recovered and reached a high of 1,200 in the mid 1980s. Numbers of males increased more rapidly than females, which on average outnumber females by a ratio of two-to-one. A second, and potentially more disastrous decline began in 1990. Only 208 spawners returned in 1995 compared to 1,629 spawners five years earlier.

Males return to the river before females and are significantly younger and smaller than

females. Differences in body size and numbers may be partly explained by size selectivity of fisheries that release fish smaller than the size limit. Chinook that use the spawning channel are physically smaller than those that stay in the river to spawn. In 1980, fisheries intercepted 74% of the summer chinook as they returned to the Puntledge River compared to 9% that were taken by harbour seals. In 1990, fisheries and seals caught 32% and 24%, respectively.

The problems faced by the summer chinook are varied and complex. It is not clear whether the Puntledge River can ever again sustain the historic numbers that once made it one of the most important producers of chinook salmon in British Columbia. Development of a conservation plan is urgently needed for the Puntledge River summer chinook and should receive high priority given the recent low levels of spawning escapements, and evidence of high mortalities incurred at sea and in the terminal area.

Reviewers' Comments

The key consideration is whether harbour seal predation in the Courtenay River and its estuary is threatening the continued viability of chinook salmon and in particular summer chinook. In other words, are harbour seals causing a conservation concern for chinook. The depressed status of the Puntledge summer chinook stock is clear even though this point could have been clarified. There are insufficient data to support the conjecture surrounding the impact of size limits and enhancement efforts on the continued viability or genetic integrity of the stock. Undoubtedly, numerous factors have contributed to the biological variability as is the case with all stocks. It is clear that harbour seals are reaping the benefits of conservation measures implemented outside the terminal area. The question remains of whether Puntledge summer chinook can withstand a 56% or perhaps greater harvest rate at their presently reduced numbers.

Subcommittee Discussion

The Subcommittee accepts this Working Paper subject to several minor revisions suggested by the reviewer. The Subcommittee further notes that the requirement (identified in the fall 1995 PSARC meeting) to assemble observations and then report on the impact of seal predation on adult chinook salmon in the Puntledge River has been only partially satisfied by this Working Paper. Documentation remains incomplete for contemporary (post 1989) census information and the detailed methodology used in two recent years of intensive studies conducted by the Marine Mammal Program. In light of upcoming public consultations on the issue of seal impacts on Puntledge salmon, completion of this documentation is urgently required. The Subcommittee supports the recommendation to attach high priority to the development of an effective conservation plan for Puntledge River chinook salmon.

Observations presented in the Working Paper indicate that male chinook salmon in escapements are clearly smaller than females. Given the current chinook size limit of 62 cm, female chinook may experience higher mortality than males in recreational and troll fisheries. The Subcommittee notes that this pattern of size and sex biased harvest could be widespread and **recommends** that it be investigated further.

Appendix 1 Participants at the April 22-26, 1996, meeting of the Salmon PSARC Subcommittee.

Subcommittee chair: L. Richards
PSARC Chair: S. Farlinger

Subcommittee Members:

D. Anderson	S. Argue
D. Bailey	A. Cass
K. Hyatt	A. MacDonald
D. Meerburg	B. Riddell
P. Ryall	W. Saito
M. Stocker	A. Tautz
C. Wood	

Authors/reviewers:

D. Blackbourn	T. Brown
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B. Ennevor	B. Holtby
J. Irvine	R. Kadowaki
C. Murray	V. Palermo
P. Rankin	J. Schnute
C. Schwarz	C. Shirvell
K. Simpson	B. Snyder
B. Spilsted	A. Trites
J. Woodey	Y. Xie

Observers:

M. Henderson
R. Kieser
B. Ottway

Appendix 2 Reviewers of Working Papers

<u>Working Paper</u>	<u>Reviewer #1</u>	<u>Reviewer #2</u>
S96-3	S. McKinnell	M. Stocker
S96-4	C. Wood	S. Cox-Rogers
S96-5	D. Anderson	B. Leaman
S96-6	S. Bates	C. Gosselin
S96-7	S. Johnston	K. Wilson
S96-8	C. Shirvell	P. Ryall
S96-9	J. Irvine	R. Kronlund
S96-10	B. Shaw	B. Smith (Prov. of BC)
S96-11	J. Schnute	
S96-12	C Schwarz (SFU)	J. Woodey (PSC)
S96-13	R. Routledge (SFU)	Y. Xie (PSC)
S96-14	G. Cronkite	P. Rankin
S96-15	N. Schubert	A. MacDonald
S96-16	B. Pearce	

BIOLOGICAL ADVICE ON GROUND FISH

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I. STEERING COMMITTEE REPORT

The Steering Committee met September 18-19, 1996 at the Pacific Biological Station to review the Subcommittee report. The report was accepted, with the following comments and recommendations.

Overall Comment:

Steering Committee notes that assessments of sablefish and Pacific cod in Hecate Strait requires further analyses and will be reviewed at a Subcommittee meeting in November. The Advisory Document from that meeting will also contain a report and advice on bycatch reduction measures in BC trawl fisheries, and results of a further review of indices for yellowtail rockfish in Area 3B/C, should the review suggest further advice on this stock is warranted.

Offshore Lingcod

Steering Committee concurred with the recommended harvests. Steering Committee also noted that for Areas 3C (Southwest coast of Vancouver Island) and 5A/B (Queen Charlotte Sound) a full assessment will be conducted in 1997.

Pacific Cod

Steering Committee acknowledges that the assessment of the Hecate Strait stock will be completed and presented in mid-November, incorporating the results of the 1996 survey.

For Area 3C (Southwest coast of Vancouver Island) Steering Committee advises that any removals are considered high risk. Steering Committee is encouraged by the successful efforts made to curtail bycatch of cod in trawl fisheries in this area, but would have concerns if bycatch in 1997 increases from 1996 levels.

Steering Committee calls attention to the Subcommittee observation that estimates of natural mortality (M) for Pacific cod are very high compared to other gadoids and repeats the past recommendation that work be conducted to develop and validate age determination methods for Pacific cod.

Flatfish

Steering Committee endorses the harvest advice recommended for Flatfish stocks, but shares the Subcommittee concerns regarding reliance on CPUE data for these assessments and continuing low recruitment levels for most stocks. Steering Committee notes that no new information was presented for Area 5C-E Dover sole stocks, so there is insufficient justification to advise a change in quota this year. However, considering the concerns that abundance trends are inferred only from CPUE, and the fact that these stocks have been consistently exploited above the high

risk level, Steering Committee suggests priority should be given to processing age structures available, and a thorough analysis be conducted and presented at next years meeting.

Steering Committee notes that substantially greater research effort would be required to improve our flatfish assessments. Until this additional effort is applied the high uncertainty in these assessments should be recognized, and harvests should not be allowed to exceed the high risk level. For stocks which have experienced recent excessive harvest and declining CPUE, harvests nearer to the low risk level would be desirable.

More generally, Steering Committee is dissatisfied with the level of information presented in several groundfish working paper summaries to support harvest level recommendations. The Working Papers apparently contain an appropriate level of information, but several summaries available to Steering Committee and other users of the Advisory Document do not.

Sablefish

Steering Committee notes that the Subcommittee has requested further analyses and will provide advice when these new analysis are presented in mid-November.

Pacific Hake

Steering Committee concurred with the recommendations presented for the Strait of Georgia Stock.

For the offshore stock Steering Committee endorses the Subcommittee decision to accept a medium level of recruitment for the 1994 year-class, and the grounds used by the Subcommittee in reaching this decision. Monitoring of the age and length composition of the catch early in the 1997 fishing season (off the U.S.) could provide the information to resolve more reliably the strength of the 94 year-class. This information could be evaluated early in the season and allow for in-season adjustments of the quota. If re-evaluation supports changes to yield recommendations this information should be reviewed by PSARC prior to implementation.

Walleye Pollock

Steering Committee endorses the Subcommittee recommendations with the exception of those for Minor Area 12. Steering Committee notes that because this is a recent fishery no biological basis is available to provide advice for this stock. In the absence of sufficient biological information and rapid expansion of the fishery, Steering Committee advises that the best alternative may be to manage the fishery consistent with the Pacific Guidelines for the Development of New Invertebrate Fisheries.

Slope Rockfish

Steering Committee endorses the yield options recommended. Steering Committee agrees with the Subcommittee recommendation to conduct a catch-age analysis for Area 5E (north) Pacific Ocean Perch.

Shelf Rockfish

Steering Committee endorses the yield options recommended. Steering Committee notes that U.S. scientists believe that the transboundary yellowtail stock (Area 3B/3C) has declined in recent years. Steering Committee agrees with the Subcommittee recommendation that alternate indices of abundance be examined and incorporated in the assessment and suggests this be completed in time for the November meeting.

Inshore Rockfish

Steering Committee endorses the recommendations of the Subcommittee. Specifically, Steering Committee recommends using the 25th percentile of the catch history since 1983 as the basis for 1997 quotas where a sufficient catch history is available. Where information is not available, Steering Committee agrees that there is little likelihood of providing scientifically defensible estimates of sustainable harvest levels. If quotas are required, they can only be preemptive, intended to limit expansion of the fishery. Steering Committee recognizes that there is little scientific basis for these quotas (Including 25th. percentile of catch history) but notes they will provide more conservative (precautionary) fishing levels.

However, Steering Committee agrees with the Subcommittee that the entire management approach has to be different; not quota-based management requiring estimates of local stock abundances. Rather than focusing all efforts for future assessments on trying to improve estimate of stock status, the Subcommittee recommends that work should focus on a rigorous review of alternative approaches to management. The purpose of the review is to identify management approaches which are feasible from assessment and management perspectives, and which meet the Department's conservation mandate. Steering Committee recommends that the review team involve DFO assessment biologists and managers and industry representatives. Steering Committee believes this review should encompass more than inshore rockfish, particularly invertebrate species with similar stock structure.

Additional Subcommittee Discussions

1. Steering Committee endorses the need to have oceanographers participate in Subcommittee discussions and suggests this applies equally to all Subcommittees.
2. Steering Committee notes the concern regarding late documents and asks line management to monitor the progress in finalizing these documents. The

Steering Committee also notes that this is an unusual occurrence for the Groundfish Subcommittee documents.

3. Steering Committee calls to the attention of RMEC the discussions which took place on recent international agreements which promote specific guiding principles for management of straddling stocks. If these guiding principles are followed for Pacific Region coastal stocks there will be significant implications for assessment and management. Steering Committee recommends formation of a and planning staff to prepare a document outlining these implications. This document should be prepared and presented at the mid-November meeting.

Major Subcommittee Concerns

1. Steering Committee endorses a more formal linkage between the PSARC process and work planning activities.
2. Alternative management approaches. See discussion under Inshore Rockfish.

Unresolved Issues from 1995 Meeting

Steering Committee asks that the PSARC Chair bring to the attention of RMEC issues raised during the 1994 meeting regarding the assessment and management of lingcod and rockfish in the Strait of Georgia.

II. GROUND FISH SUBCOMMITTEE REPORT

1. Biological Advice on Management of B.C. Groundfish for 1997

This advice is based on assessments and recommendations contained in working papers and peer reviews of these papers. This report includes summaries of both the papers and the reviews. There is a synopsis of the conditions of the stocks that were assessed and recommendations for management that were based on the working papers and discussions of the Subcommittee. The assessment of two important species, sablefish and Pacific cod are not complete. Those assessments, the assessment of the incidental catch of halibut, and the evaluation of the halibut by catch reduction program will be reported later in the year.

In 1991, the Groundfish Subcommittee initiated a multi-year schedule for groundfish stock assessments and yield recommendations. This schedule specifies that major updates for most stocks will occur on a staggered basis, with statistical updates of the fisheries in intervening years. Intervening year assessments will also provide information on any significant changes in stocks, particularly those that may require

more frequent assessment revisions. Recommended yield options will normally remain unchanged between major assessments. In 1996 major assessments were conducted for sablefish, Pacific cod, inshore rockfish and slope rockfish.

Groundfish staff in the Stock Assessment Division conduct their assessments using a multi-year data base of fishery statistics and biological sampling, and a variety of assessment tools including several catch-at-age models, age-independent biomass dynamic models, and yield-per-recruit models. Stock assessments are assigned to reviewers by the Subcommittee chair, and written review comments are provided to the authors prior to the Subcommittee meeting. Reviews for major assessments normally incorporate one external (government or non-government) and one internal reviewer. Assessments and recommended yield options are then reviewed by the Subcommittee, which includes representatives from management and if possible, outside reviewers and experts. The Subcommittee must reach a consensus on any recommendations presented in assessments before submission to the PSARC Steering Committee. There is a standing membership for the Subcommittee, however, non-committee members may also participate in the Subcommittee meetings. A list of participants for the 1996 meeting is appended to the report.

2. 1996 Working Papers and Authors

McFarlane, G. A. and B. M. Leaman. 1996. Offshore lingcod stock assessment and recommended yield options for 1997. G96-2: 23 p.

Haist, V. and D. Fournier. 1996. Pacific cod stock assessments for 1996 and recommended yield options for 1997. G96-3: 15 p.

Fargo, J. and A. R. Kronlund. 1996. Flatfish stock assessments for 1996 and recommended yield options for 1997. G96-4: 133 p.

Saunders, M. W., B. M. Leaman, V. Haist, R. Hilborn and G. A. McFarlane. 1996. Sablefish stock assessment for 1996 and recommended yield options for 1997. G96-5: 53 p.

Saunders, M. W. and G. A. McFarlane. 1996. Pacific hake stock assessment for 1996 and recommended yield options for 1997. G96-6: 58 p.

Saunders, M. W. and W. Andrews. 1996. Walleye pollock stock assessment for 1996 and recommended yield options for 1997. G96-7: 19 p.

Richards, L. J. and N. Olsen. 1996. Slope rockfishes. G96-8: 87 p.

Stanley, R. D. 1995. Shelf rockfish assessment for 1996 and recommended yield options for 1997. G96-9: 43 p.

Yamanaka, K. L. and A. R. Kronlund. 1996. Inshore rockfish stock assessment for 1996 and recommended **yield** options for 1997. G96-10: 69 p.

3. Overview of Current Stock Conditions

PSARC Groundfish Subcommittee overviews on current condition of groundfish species or species groups.

Species or Species Group	Current Stock Condition
Pacific Cod	Very Low
Sablefish	Average
Offshore Lingcod	Average
Strait of Georgia Lingcod	Very Low
Offshore Pacific Hake	Average
Strait of Georgia Pacific Hake	Average to High
Slope Rockfish	Low to Average*
Shelf Rockfish	Low to Average*
Inshore Rockfish	Low to Average*
Walleye Pollock	Low to Average*
Spiny Dogfish	Average to High*
Petrale Sole	Very Low
Rock Sole, English Sole, Dover Sole	Average to High

* depending on specific stock.

Summary of Commercial Landings for 1995 by Value (dollars)¹

	1995 (est.)	Change from 1994	Change from average 1991-1994
Pacific Halibut	31,200,00	-10%	+15%
Sablefish	27,400,000	-15%	-2%
Pacific Cod	1,100,000	-48%	-76%
Lingcod	2,600,000	-37%	-33%
Pacific Hake	12,000,000	-21%	-12%
Rockfish	12,700,000	-32%	-29%
Sole	2,800,000	-62%	-61%
Other	1,900,000	+27%	-38%
Total	91,700,000	-21%	-13%

¹ Source: Commercial Catch Statistics System database

4. Yield Options

A number of categories of yield options are presented. All may not be appropriate for a particular species or stock. The five yield options are: (i) zero yield; (ii) low risk yield; (iii) sustainable yield; (iv) high risk yield; (v) unrestricted yield. These levels of risk are qualitative in that they incorporate neither a formal calculation of probability, nor a precise definition of consequence. Rather, they attempt to convey the degree of uncertainty associated with various yield options. For a detailed description of yield options see Stocker (1994).

Assessment biologists are investigating the quantification of the risks associated with various yield options. Risk is a joint function of the probability of particular outcomes or stock conditions associated with a management action, and the consequences of the outcomes. For stock assessments, biologists are attempting to estimate the probabilities of various outcomes, rather than the broader consequences to the fishery. This process also may involve an analysis of the sensitivity of recommended yields to uncertainty in the input data and the models which describe population dynamics, and an estimation of the probability of particular outcomes associated with parameter choices.

The Subcommittee emphasizes that for some stocks and fisheries, such as inshore rockfish, the biology of the species makes the present approaches to assessment and management inappropriate. Even with a significantly greater investment of people and money, the Subcommittee believes it will remain impossible to provide advice which would ensure sustainability of stocks and fisheries with the present approaches to estimating population abundances and managing through quotas. The Subcommittee expects that the payoff would be much higher if stock assessment staff and managers shifted attention and analyses to alternative management approaches that would be more consistent with the biology of the stocks and the capabilities of the assessment and management staffs.

5. Major Subcommittee Concerns

- (i) The Subcommittee believes it is important to recognize that there are stocks where the information base is inadequate to serve as a basis for scientific advice, and stocks where assessment methodologies exist but the resources are not sufficient to conduct a proper assessment. One solution is to establish a formal linkage between the PSARC process and work planning.
- (ii) The Subcommittee considered several approaches for the assessment and conservation of inshore rockfish. The Subcommittee agreed that further reanalyses of the existing data sets will not increase the quality of advice on the questions presently pursued in the analyses. Further analyses under the current approach to both assessment and management of the stock can, at best, document the decline in local populations after they have been depleted. The Subcommittee also agreed that it is unlikely the Region will have the resources to assess the status of inshore

rockfish on a stock by stock basis. The Subcommittee believes that the entire management approach has to be different; not quota-based management requiring estimates of local stock abundances. Rather than focusing all efforts for future assessments on trying to improve estimates of stock status, the Subcommittee recommends that work should focus on a rigorous review of alternative approaches to management. The purpose of the review is to identify management approaches which are feasible from assessment and management perspectives, and which meet the Department's conservation mandate. Furthermore, the Subcommittee notes that the same problem exists for some other types of species, particularly but not exclusively invertebrates. In all of these cases, work in support of changes to management approaches may have a greater payoff than continued efforts solely to refine abundance estimates.

Important unresolved issues from the 1995 Subcommittee Meeting

The management of lingcod and rockfish in the Strait of Georgia remains a concern.

6. Summaries of Assessments, Reviewers' Comments and Subcommittee Discussions

Offshore Lingcod (G96-2)

In this interim assessment, offshore lingcod stocks were examined for the northwest and southwest coasts of Vancouver Island, Queen Charlotte Sound, Hecate Strait and the west coast of the Queen Charlotte Islands. Interpretation of stock condition relies on recent trends in catch statistics. Off the southwest coast of Vancouver Island (Area 3C) CPUE has declined in recent years from the historic high in 1993 and is well below the long term average. However no new biological information is available to estimate stock size. CPUE off northwest Vancouver Island (Area 3D) suggests stock abundance is declining. Recent declines in CPUE in Queen Charlotte Sound (Areas 5A-5B) may indicate stocks are below the long-term average abundance level. Recommended low to high risk yield levels are unchanged from last year and range from 1400-2800 t, 400-800 t, and 1100-2200 t for Areas 3C, 3D, and 5A-B, respectively. The fishery in Hecate Strait (Area 5C-D) has recently undergone a dramatic increase in effort, but there is little biological information available to guide yield recommendations. A recommended yield level of 1000 t is again provided out of concern for the sensitivity of the species to exploitation and the rapid expansion of the fishery.

Reviewer's Comments

The reviewer noted that the document provides an interim assessment which includes updates of catch, qualified effort and qualified CPUE. The yield options remain essentially unchanged from the previous assessment and the authors advise the managers to be conservative when setting quotas. Although there are no strong

biological signals to support significant changes in advice, the increased effort and decreased catch in some areas would tend to support this approach.

The qualified CPUE data are used as a possible indicator of stock abundance (at least to examine trends). Given the shifts that can occur on a year to year basis (i.e. the number of vessels included, the "actual" vessels included, etc.), the authors are advised to employ age data or other biological factors when determining the condition of the various stocks.

Subcommittee Decision

The Subcommittee agreed with the recommendations in the interim assessment and recommends no changes in yields for 1997. The Subcommittee suggests that the Area 3C lingcod stock be considered as a candidate for a full assessment in the coming year.

The Subcommittee expressed a concern over fishery trends in the Queen Charlotte Sound lingcod stock and suggests that a more detailed review of the fishery data for this stock be considered for the coming assessment cycle.

Pacific Cod (G96-3)

Stock assessments are presented for two of the coastal B.C. Pacific cod stocks; Hecate Strait (Major Areas 5C and 5D), and the West Coast of Vancouver Island (Major Areas 3C and 3D). The stock reconstructions and stock forecasts are conducted using methods similar to last year. The analytical method used to reconstruct stock abundance is catch-at-length analysis. The catch-at-length model incorporates catch, effort and length-frequency data. One-year ahead stock projections are conducted using stochastic simulation methods. The stochastic elements are the size of the first two year-classes in the population.

The authors of the document considered this assessment to be an interim analysis and suggested a further assessment be conducted prior to the 1997 fishing season. The reasons for this are twofold. First, the catch-length model needs to be modified to account explicitly for the effect of the recent change in the cod-end mesh size used by the commercial trawl fishing fleet in Hecate Strait, but the modification is not yet functional. The increase in cod-end mesh size results from a new regulation and it certainly has effected the catch-effort relationship. Second, a Pacific cod survey is currently underway in Hecate Strait to obtain information on catch-rates and mesh-size effects, and this information should be used to provide advice for 1997.

The probability that the 1997 spawning stock biomass in Hecate Strait will be below the specified minimum level (5015 t) is 0.029. Using the 10% and 90% points of the probability distribution of forecast stock abundance as low and high risk options, the recommended catch range is 1177 t to 2679 t. There is clearly high uncertainty in the

stock forecast as approximately 90% of the projected 1997 spawning stock biomass is comprised of fish in the first two age-classes for which we have minimal information. Results of the Hecate Strait Pacific cod survey should be included in the stock assessment prior to finalizing 1997 catch recommendations of Pacific cod.

The probability that the 1997 spawning stock biomass off the west coast of Vancouver Island will be below the specified minimum level (2700 t) is 0.816. Therefore any Pacific cod fishery in this area is considered a high risk.

Reviewers' Comments

Reviewer 1 reported that the document is well-written, comprehensive and provides an excellent objective framework for future assessments. Two major criticisms involve the timing of the submission of the working paper and our collective failure to provide adequate biological sampling. Due to the influence of current year data the reviewer stated that asking for a report in July for this species is a waste of the author's, the reviewer's and the sub-committee's time.

The reviewer considers the lack of samples to be critical and that resources be found to ensure sampling is conducted with an understanding that it represents a critical mass for assessment.

Reviewer 2 found the document to be concise and straightforward. He recommended inclusion of more details on the harvest rate policy and sampling methods for length-frequency samples. He strongly recommended a detailed analysis of P. Cod abundance from the Hecate Strait surveys in comparison to the fishery CPUE time series, to prepare for use of survey data in the absence of CPUE data, and to attempt to evaluate the applicability of CPUE data as an abundance index for this stock. He also noted the lack of data for the WCVI stock. The reviewer noted that this assessment uses the same model as last year, but does not appear to build on the deficiencies noted in last year's assessment and review. These deficiencies are not documented in the present assessment. Some detail should be provided to indicate the areas and nature of the uncertainty. Given these comments on the need for a detailed assessment before the 1997 fishery, the purpose of the present document wasn't immediately clear to the reviewer. However, he noted that the assessment of risks and ranges of harvest recommendations have changed from last year's document, e.g. for the west coast of Vancouver Island, 1995 recommendation was for no fishery, whereas the 1996 recommendation could allow a fishery (but there is very high uncertainty).

Subcommittee Decision

The Subcommittee recognized that Pacific cod yields are highly dependent on the strength of recruiting year-classes, that can only be assessed in the year preceding the fishery. The Subcommittee agreed with the author and reviewer in recommending that the Hecate Strait assessment be completed in the late fall after inclusion of 1996 survey data.

In the absence of a 1996 fishery or survey activity off the West coast of Vancouver Island, no further data are expected for this stock. It was therefore agreed that the assessment for this area be presented in the current document to provide guidance to managers. The Subcommittee noted the continued decline in abundance and agreed that the assessment indicates that any Pacific cod fishery in this area in 1997 would be considered high risk. However, given uncertainties are large, there is no biological basis for changing from the current management plan. It was further recommended that that surveys be considered for 1997 to provide information on level of recruitment.

The Subcommittee noted that again this year level of natural mortality (M) estimated in this assessment are very high compared to estimates of (M) in other Gadoid assessments worldwide. It was recommended that tagging/and age validation studies be considered to provide more information on this important parameter.

The Subcommittee considered the document to be interim advice, with the final document to be completed and reviewed after the Hecate Strait surveys are completed and the data analyzed. The Subcommittee agreed that there is no biological basis for changing the current management plan.

Flatfish (G96-4)

Interim assessments were prepared for Area 3C and 3D petrale sole, Area 5C-E Dover sole and Area 5A, 5B rock sole. A new catch-age model has been used to analyse data for Area 5C-D rock sole and Area 5C-D English sole. A detailed assessment was prepared for Area 3C-D Dover sole. Petrale sole stocks are at a very low level. Recruitment for the 'southern' stock shows no sign of an increase in more than a decade. Recruitment for the 'northern' stock appears to be increasing based on length frequency anomalies but corroboration of this observation is necessary with additional year's data. Because of the apparent low level of these stocks incidental landings only will be permitted during the 1997 fishery. The fishery for Area 3C-D Dover sole continued to expand in 1995. This fishery began in 1988 and has been treated in the past as a developing fishery with a yield range equivalent to that for stocks off the Washington coast. The catch-effort data available for this stock has now increased to the point where a detailed analysis of the fishery data has been conducted in 1996. CPUE indicators for the commercial fishery all show a decline since 1988. Both the number of vessels participating in the fishery and fishing effort have increased dramatically in recent years. Accordingly, yield options for this stock in 1997 have been reduced from last year. Area 5CDE Dover sole CPUE has been declining over the last six years based on the trend in CPUE. No new analysis has been done for this stock and until a detailed assessment can be completed the yield options remain the same as last year. Rock sole stocks are now declining from the high level of abundance observed in the early 1990s and it appears that the contribution to the fishery of the strong year-classes in the early 1990s is diminishing. Based on trends in CPUE, abundance of the Area 5A stock appears to be similar to last year while that of the Area

5B stock is lower than last year. Thus the yield options for the Area 5A stock are unchanged from last year while the high risk option has been lowered for the area 5B stock. Results from a new catch-age analysis for Hecate Strait rock sole indicate that the decline in abundance for those stocks between 1991 and 1995 is not as serious as last year's analysis indicated. The 1996 Hecate Strait groundfish survey corroborated this. Thus, the yield options for these stocks have been raised from last year's levels. Results of a new catch-age analysis for Hecate Strait English sole indicated that the current biomass for that stock is slightly higher than indicated by last year's analysis. Thus the 1997 yield options for this stock have been raised.

Reviewers' Comments

The reviewers agreed overall with the assessments presented but were concerned over the heavy reliance on CPUE for assessment and the dramatic increase in effort in the 1990s. The reviewers felt that the presentation of confidence intervals for the annual commercial CPUE values might help with interpretation of these data. The authors stated that these intervals were relatively large which only serves to emphasize caution in interpretation of trends in annual CPUE. The reviewers also felt that more explanation was required where yield recommendations had changed from last year.

Subcommittee Decision

The Subcommittee acknowledges the reviewers concerns regarding reliance on CPUE data. However, in the absence of other fishery independent data, it is necessary to rely on CPUE and be cognizant of the problems. The effects of mesh size change in the Hecate Strait English sole fishery should be examined as this may change the selectivity in the model. The Subcommittee expressed concern over very high fishing mortality rates in the Hecate Strait English sole fishery. The Subcommittee agreed with the author's concern that CPUE and recruitment are declining for this stock in Hecate Strait. The Subcommittee concluded that the decrease in the yield is justified for this stock given the information presented in the document.

Sablefish (G96-5)

This paper represents a major assessment for sablefish. Separate analyses are conducted for northern and southern areas of the B.C. coast due to observed differences in age and length compositions, growth and evidence from juvenile tagging that recruitment to the areas are drawn from different origins. The assessment utilizes a new age-based catch-at-age model implemented using the AD model builder software environment, to estimate the current stock size and reconstruct the history of the stock. Independent estimates of exploitation rates for 1992 and 1993, were developed by R. Hilborn (University of Washington), and used to tune the catch-at-age analysis. The tagging analysis explicitly takes into account potential movement of fish out of the zone.

Biomass in 1995 was estimated to range between 14,700 and 44,000 t in the south and between 23,200 and 30,300 t in the north. The wide range in the south reflects uncertainty in both tagging and catch-at-age analyses. The assessment is less pessimistic about the level of exploitable biomass than the previous assessment. In most instances the biomass is considered to be declining at a low rate. The more optimistic scenarios, to which there is less credence, shows a rapidly increasing stock in the south and a modestly increasing stock in the north. The conclusions of increasing stocks are driven entirely by the independent exploitation rate and should be evaluated in the context of the level of confidence in those rates. Yields calculated using an $F=M$ policy ranged from 1180 to 3520 t for the south stock and from 1860-2420 t for the north (coastwide 3040-5940 t).

Reviewers' Comments

There were three reviews for this assessment. One review was by one of the authors (R. Hilborn) and was submitted to the Subcommittee because it did not arrive in time to be incorporated into the assessment. All reviews were extensive.

Reviewer 1 agreed with the new emphasis on tagging data and the reduced emphasis on CPUE. In addition, the reviewer recommended that the trap survey that was started in 1986 be considered as a potential source of an index of abundance. The reviewer also suggested that CPUE might be more useful if an area-based approach for averaging CPUE were used.

In addition to the problems with CPUE, the sparsity of ageing data for some years and the ageing error creates problems with the assessment that requires additional sources of information which in this assessment is tagging data. The reviewer also suggested that standard yield and egg per recruit analyses might be useful.

There was concern that the tagging analyses were preliminary and required further development because the assessment is strongly affected by the tagging data. The tagging analysis should be expanded to include all tag data, finer spatial scale categories and improved estimates of reporting rates.

The reviewer also commented on the problem of the movement of fish into SE Alaska from the northern stock, selectivity and depth distribution, the importance of extending the analysis back into the 1960s and the sensitivity of the model to "plus age classes".

The second review was the combined comments of three assessment scientists. They suggested that the model was unable to explain the CPUE decline and that migration in the northern stock may need to be considered. They acknowledged the importance of using the tagging data to tune the age and catch data in the northern population but noted the problems with the assessment of the southern population when the data are used. The reviewers felt that the tagging analysis needed to consider other factors that could affect the rates of recapture. In particular they did not agree with the use of a constant tag shedding rate. The reviewers were uncomfortable with the authors' use of

an ad hoc choice of results that appeared to de-emphasize both CPUE and tagging data. They suggest that the model might perform better if a reliable index of abundance was available, as well as indices of movement between Alaska, B.C., and California-Washington. Without a reliable index of abundance, estimates of absolute abundance, even from elaborate age structure models are unreliable and largely uninformative. For the Alaska stock, there has been considerable effort spent to develop an annual abundance index using a standardized longline survey. The major concern with the Alaskan fishery is not their ability to measure relative abundance, but the uncertainty regarding the appropriate harvest strategy.

The third reviewer noted that he had not seen the document before and it would need considerable modification. He felt that this year's assessment provided a number of technical improvements over last year's assessment including the use of probability distributions, the use of tagging data, and the use of improved modelling methods. However he felt the assessment was incomplete and should be revised before the management advice is passed on to managers. He requested that the revised document include projections of future trends in stock size under different catch levels. He believes that it is important to compare the current stock size with the historical condition of the stock prior to 1980. He was also concerned with the use of $F=M$. He expressed concern about the reference to the analysis without tagging data as the base case as he thinks this could be interpreted as the preferred analysis. There were specific comments provided that explained some of his concerns in more detail.

Subcommittee Decision

There was an extensive and productive discussion in the Subcommittee with one of the external reviewers present. After this discussion, the Subcommittee agreed that the assessment was incomplete and needed to be revised and reviewed at a later date. The assessment was returned to the authors for a major revision.

Pacific Hake (G96-6)

Strait of Georgia

The fishery in the Strait of Georgia increased 1995 to 11,59 t from 9,631 t in 1994, the first time the full 11,000 t quota has been taken. The stock is estimated to be in good condition based on results of a hydroacoustic survey conducted during February 1996 that found a total of 57,278 t of exploitable biomass throughout the Strait of Georgia. Age and growth data continue to indicate the presence of three strong-year classes in the Strait and a coincidental decline in the mean size-at-age. A major assessment is required to draw the surveys and updated biological data in to an appropriate modelling framework. In the interim the authors have applied low-high risk annual rates of fishing mortality generated for the offshore stock to the current estimate of exploitable biomass (57,258 t). The resulting range in yield is 10,300-20,100 t. The authors recognize that the two stocks have very different recruitment dynamics and for that reason they

recommend caution in choosing a yield level. Proposed annual fishing mortality rates for moderate risk harvest strategies for the offshore stock are 0.19 which when applied to the current estimate of exploitable biomass (130Kt) suggest a yield of 24,700 t. The authors recognize that the two stocks have very different recruitment dynamics and for that reason choose the moderate rather than high risk offshore level.

Offshore

Coastwide catches of Pacific hake decreased from 359 Kt in 1994 to 248 Kt in 1995, a result of less available yield. The all-nation-catch in the Canadian zone was 70.1 Kt in 1995. The approach taken in this assessment is similar to that of the previous one, using catch-at-age analysis tuned to independent Canadian and U.S. survey estimates to assess the current status of the stock, and using an age-structured forward simulation model to examine long term (equilibrium) production and short term (look ahead) yield options. Changes to the assessment include: (1) re-estimation of the 1977-95 survey time series adopting the TS model proposed by Traynor; (2) development of offshore expansion factors to adjust earlier survey results to account for hake habitat not surveyed seaward of the original survey tracklines; (3) the use of a one-area assessment model; (4) modeling fisheries in the U.S. zone as a single combined fishery with time-varying selectivity; and (5) the addition of the 1995 NMFS acoustic survey results and catch-at-age data for the U.S. and Canadian fisheries in 1995. Overall abundance as indicated by Stock Synthesis runs, is declining as the strong 1980 and 1984 year-classes move through the fishery and recruitment in subsequent years has been low. Yield options for two assumptions regarding the strength of the 1994 year-class, and three risk levels are presented, with available coastwide yields for 1977 ranging from 161 Kt to 445 Kt.

Reviewers' Comments

Reviewer 1 drew attention to the commentary on the revised estimates of target strength (TS) for Pacific hake. Since the Strait of Georgia assessment is based entirely on an acoustic survey and the TS is influential, the reviewer believed the estimated biomass for this area should be re-examined in light of this alternate TS value. Since the new value would likely reduce the estimated biomass, the reviewer cautioned that the estimate in the document may not be, as stated, a "sound minimum". The reviewer also agreed that this stock should be the subject of a major assessment since the quota was being fully subscribed.

For the offshore stock, the reviewer endorsed the simplification of the model but was concerned about the use of several expansion factors and whether they should be used over the entire time period under study. In particular, the reviewer noted the difference in depth coverage of the U.S. survey in the early years of the series. The reviewer believed the use of a median value for the strength of the 1994 cohort is appropriate, especially given the declining stock biomass. Finally, it was noted that the projected total catch for 1997 will be the second highest on record, during a period of declining abundance.

Reviewer 2 commented that the Strait of Georgia survey needed to examine the relative selectivity of research and commercial gears, so that the correct estimate of exploitable biomass is obtained. In addition, the reviewer considers that the yield options may be overly conservative in view of the recent strong cohorts recruiting to the fishery.

For the offshore hake stock, the reviewer conducted a very thorough examination and stressed the need for analysis of environmental effects on distribution and abundance, rather than correlation or speculation. In particular, the selectivity impacts of environmental changes on the selectivity of fishing gear should be an explicit process description in the model. The text statements on the relationships of $F_{0.1}$ and F_{MSY} need to be revisited to ensure consistency with other fisheries interpretations. The basis for model selection among candidate options was also questioned and an explicit protocol for model selection was requested. The reviewer requested a number of elaborations on comments in the working paper so that the basis and meaning of them could be properly evaluated.

Subcommittee Decision

The Subcommittee accepted the paper and requested that the authors address the comments of the reviewers. For the Strait of Georgia stock, the Subcommittee requests that the influence of recent length-based target strength calculations on yield option estimates for the inshore hake stock be examined. For the offshore stock, the Subcommittee also requested that the authors check the calculation of the influence of the estimated strength of the 1994 cohort on exploitable biomass, and clarify the basis for the estimate of the strength of this cohort in the working paper. The Subcommittee is concerned about the apparent differences in the U.S. and Canadian management programs with regard to the incoming 1994 cohort and believes that the U.S. assumption of a strong 1994 cohort is not sufficiently precautionary during a period of declining stock abundance. The Subcommittee recommends that a median estimate of strength for the 1994 cohort be adopted and that the yield options be calculated with only this value.

Walleye Pollock (G96-7)

The coastwide catch of walleye pollock changed little from 4734 t in 1994 to 4154 t in 1995 due to quotas implemented in 1995 to cap the development of fisheries in area 12 and Hecate Strait. The 1994 incidental catch in the joint-venture hake fishery decreased to 10 t from 130 t in 1994. The range of sustainable yield options based on Gullands (1983) MSY model is 630 to 2350 t for the Strait of Georgia (excluding area 12) and 330 to 1320 t for Dixon Entrance/Hecate Strait. A precautionary quota of 1000-2580 t is recommended to cap the yield in Queen Charlotte Strait (Minor area 12) until a detailed assessment can be conducted. Yield options are not proposed for stocks off the west coast of Vancouver Island. Given the size of Dixon Entrance/Hecate Strait

and minor Area 12 fisheries, detailed surveys and assessments of these stocks are warranted.

Subcommittee Decision

The Subcommittee noted that the assessment is based primarily on examination of landings records. These are a weak basis for an assessment, and Gulland's method is a weak basis for estimation of yield, particularly for stocks with highly variable recruitment. Nonetheless, to conduct more extensive assessments would require a large increase in scientific effort for a few years, in order to collect and process data and to develop assessment models. In the past the Region has not allocated sufficient resources to this stock to allow a more ambitious assessment to be conducted. Managers should be consulted about the importance of advice on this resource relative to other groundfish species. With present resources there is no expectation that a more complete assessment can be conducted.

The Subcommittee did note that the Gulland method assumes long term average catch, arising from stable recruitment. The Subcommittee has no evidence of average (or good) recruitment in the Strait of Georgia and the west coast of Vancouver Island, and many groundfish in these areas are experiencing poor recruitment. The Subcommittee advises that in absence of evidence of at least average recruitment, managers should use caution in selecting quotas within or below the advised range.

Slope Rockfish (G96-8)

This document represents a major update of the stock status for slope rockfish, which for assessment purposes include Pacific Ocean perch, redstripe rockfish, yellowmouth rockfish, rougheye rockfish, shortraker rockfish and shortspine/longspine thornyheads (collectively referred to as "thornyheads"). Shortraker rockfish and thornyheads were first assessed in 1995 as a result of their growing importance to the trawl fishery (Richards 1995b).

This document represents a major update of the stock status for slope rockfish, which for assessment purposes include Pacific Ocean perch, redstripe rockfish, yellowmouth rockfish, rougheye rockfish, shortraker rockfish and shortspine and longspine thornyheads.

The best information is for the Goose Island Gully stock of Pacific Ocean perch. A catch-age analysis for this stock uses catch-age data available from 1963-95 and a series of trawl surveys, updated with recent surveys in 1994 and 1995. Based on this analysis, the foreign fishery of the late 1960s and early 1970s reduced the stock to about a third of the 1965 exploitable biomass by 1977. Between 1977-84, biomass remained relatively constant. Biomass then increased to over half of the 1965 level by 1995, as a result of above-average recruitment and low fishing mortality rates. The stock is now at an average level of abundance. A yield range of 1,760-2,340 tonnes was

derived from the 25th percentile and the median of the forecasted 1997 biomass, applying a target fishing mortality rate equal to the natural mortality rate of $M=0.05$. Biomass is predicted to decrease under higher fishing mortality rates unless recruitment is above average. The yield range from the previous assessment was 350-1,800 tonnes.

Because of limited data, there is less certainty about the status and potential yields of other stocks of Pacific Ocean perch. Based on catch history, the authors recommended an increased yield in Area 3C, a decreased yield in Area 3D, and no change to other areas. The Goose Island Gully study pointed out the need for reliable survey biomass indices, and surveys are planned for these other areas over the next few years. The authors intend to re-examine yield, pending analysis and review of the survey results.

Yields for redstripe rockfish, yellowmouth rockfish and shortspine thornyheads are derived from 25%, 38%, and 12%, respectively, of the Pacific Ocean perch yield. These percentages are expanded from Goose Island Gully bottom trawl survey information, after considering potential midwater abundance and recent ratios in the catch. Yields for rougheye rockfish are based on the species longevity of up to 147 years of age. Yields for shortraker rockfish are determined from the ratio of shortraker to rougheye rockfish in monitored landings. The authors said they had no scientific basis for recommending yields for longspine thornyheads.

Reviewers' Comments

The reviewers of the slope rockfish document were both from outside the Region.

The first reviewer did not find any technical problem, but was surprised by the number of stock indices. The reviewer suggested some additions to the document that would assist outside reviewers, who are not familiar with the fisheries. A suggestion was that yearly TAC's may not be very appropriate with the limited information. Management measures based on the specific biological characteristics, such as closed areas for non-migratory species, could have a greater likelihood of achieving conservation than TAC's.

The second reviewer found that the document was generally very well written and provided useful information. The reviewer wondered if the levels of risk actually were consistent among stocks and species. The reviewer noted that there may be an increase in the effort to fish longspine rockfish and other rockfish in deep water and suggested that some collaborative studies with the U.S. might assist in the assessment process. The reviewer had some minor suggestions and editorial comments that included, clarifying the reason for changes in species composition, explaining why fish were discarded, the natural mortality values, and the use of known ageing errors.

Subcommittee Decision

Initial Subcommittee discussion clarified how natural mortality was estimated and the

influence of the 1995 survey on the assessment. The Subcommittee agreed with the conclusion that the Queen Charlotte Sound Pacific Ocean perch stock is at an average level of abundance. Further rebuilding to stock levels available during the foreign fishery is unlikely since an extremely large recruitment coincided with that fishery. The concept of establishing critical spawning biomass, or similar reference points, was supported by the Subcommittee for this stock.

Considerable Subcommittee discussion was devoted to quota recommendations for roughey and shortraker rockfish. Both roughey and shortraker stocks are much more susceptible to fishing mortality than shorter-lived species. The Subcommittee noted recent increases in catch for these species, and that the concurrent operation of trawl and line gears in the fishery compounded assessment difficulties. The 1995 catch in the trawl fishery alone is equal to the suggested quota for 1997. This may cause allocation issues associated with these stocks. It was suggested that alternative management measures for these stocks should be investigated particularly because it is unlikely that it will be possible to improve data quality in the foreseeable future.

The Subcommittee agreed that there was no scientific basis for yield recommendations for longspine thornyheads and recommended that managers exercise caution for this species.

Subcommittee discussion also noted the need to conduct a catch-age analyses in area 5E North (Langara) in the future.

Shelf Rockfish (G96-9)

Interim update assessments are provided for silvergray, yellowtail, widow and canary rockfish. Recommended yield ranges for the updated assessments are virtually unchanged from the previous year. The ranges for silvergray rockfish in PMFC Area 3C+3D (Vancouver Island), 5A+5B (Queen Charlotte Sound), and 5C+5D (Hecate Strait) are 150-425 t, 350-725 t, and 125-425 t respectively. The latter two high risk values have been increased 25 t. Under assemblage management, silvergray rockfish landings from these three stocks were 20% above the sum of the high risk recommendations. For the first time, the authors recommended a yield range for silvergray rockfish for PMFC Area 5E, the west coast of the Queen Charlotte Islands. The range of 175-300 t is based on a protocol similar to that used for other shelf rockfish stocks.

Recommended yield ranges for the canary rockfish stocks of Area 3C+3D and Area 5A+5B are 350-525 t, and 200-400 t, respectively. The high risk value for the former stock is increased 25 t from the previous year. Landings of canary rockfish for these two stocks were 16% below the sum of the high risk yields. The recommended coastwide yield range for widow rockfish is unchanged at 1,100-3,000 t. Landings in 1995 were approximately midway between the yield range endpoints.

The yield recommendation for the coastal yellowtail rockfish fishery (PMFC Areas 3D-5E) remains 2750-5100 t. The 1995 landings of 2,877 were near to low risk yield recommendation. The yield recommendation for the yellowtail rockfish stock of PMFC Area 3C fishery (south Vancouver Island) is combined with the northern Washington fishery (PMFC Areas 3C-US and 3B). The range is unchanged at 1,000-2,000 t for the combined U.S. and Canadian fishery. The sum of the total low risk and high yields is 6,200-12,925, 2-3% higher than the total range of 1995, 6,025-12,550.

Reviewers' Comments

One reviewer had minor comments, but felt that the sections of the report could be a little more self contained. The description of the algorithm to choose acceptable yield ranges could be improved as it was unclear why the actual percentages of the mean annual landings was selected. The procedure for determining the mean annual landings was also questioned. The reviewer asked for clarification of the evidence that indicates that overharvesting of yellowtail in Area 3C might be occurring. Other comments related to the break in the 1990 catch series and the information relating to the belief that inaccurate reporting has increased as well as an increase in discarding.

The second reviewer noted the difficulty of reviewing an interim document that did not contain all of the necessary assumptions and definitions. The reviewer noted that some of the basic biological information was missing making it difficult to know if the structure of the population had changed over the course of the fishery. Is it possible that the fluctuations in catch have more to do with catchability variation and fleet dynamics than fishing effects. The repeated reliance on the long-term average catch as the benchmark yield is potentially misleading. In particular, there is no justification as to why the particular percentages of the mean catch that are used should be considered high or low risk. Although the text comments on misreporting of catch, the assessment should address whether or not substantial catches are not reported, through an examination of age-structure changes.

The reviewer provided a number of specific suggestions for improvement and clarification that included requests to clarify the use of CPUE data and the possibility that a change in climate affected the dynamics of stocks after 1990. In general, the reviewer felt that a number of the statements were not supported by data in the document, making it a difficult document to review.

Subcommittee Decision

The Subcommittee agrees with the reviewers concerns and asks that these concerns be addressed in the final document. In addition, the Subcommittee notes that recent analysis by U.S. scientists indicates dramatic declines in Area 3C-3B yellowtail stocks. The Subcommittee notes that other sources of information (bycatch in the P. hake fishery; P. hake annual survey data) are available which may be suitable to provide an annual index of abundance for this stock. The Subcommittee recommends reviewing this information for evidence of stock decline.

The Subcommittee accepts the yield recommendations presented in this working paper.

Inshore Rockfish (G96-10)

After the Subcommittee discussion, the working paper was revised and the following is the summary of the revised document.

This paper provides a major assessment of inshore rockfish inhabiting the waters of British Columbia, Canada. Fishery catch and effort data, research survey data, and biological data are used to assess the status of inshore rockfish in 31 statistical areas on the British Columbia coast. Advice to managers in the form of yield options is changed from previous assessments when yield options based on habitat analysis were recommended for *red snapper* and *other rockfish* species categories in each statistical area. Instead, yield recommendations are given only in areas where the catch history and effort are relatively high. The habitat-based analysis performed in past assessments is applied to a few areas where adequate data are available. For these cases, revised estimates of fishing depths from logbook records are incorporated into the yield calculations. In most other areas, the recommended yield is the 25th percentile of the catch history since 1983. No yield recommendations are provided in areas where the catch and effort are low over the available time series. Where yield options are recommended, options for yelloweye rockfish and quillback rockfish are provided in addition to the traditional categories of *red snapper* and *other rockfish*.

New information on the species composition of the catch from fish slip records is included in the assessment. In addition, new graphical analysis suggests fleet movement consistent with a coastwide progressive depletion of inshore rockfish. Catch statistics are updated and information from the directed fishery on the Bowie Seamount is summarized.

In general, the stock condition is poor in the Strait of Georgia, portions of the west coast of Vancouver Island and Queen Charlotte Islands and unknown in other areas. Managers are advised to adopt a precautionary approach to harvest by setting low, pre-emptive quotas.

Reviewers' Comments

Reviewer 1 noted that the migration of effort to more remote locations was an indication that the fleet is fishing down the initial biomass. Thus, there is a concern that overfishing may be occurring but masked by the relocation of effort. The reviewer was concerned that managers had been unable to maintain catches at the proposed quotas, suggesting that managers and assessment biologists have different objectives for these species. There was a comment that if the marine habitat changes for natural reasons, the resulting impact on fish abundance would be interpreted as a fishing effect. There was concern about the complexity of the organization of the document and the absence

of equations. The major concern, however, was that the assessment and management approach may be effectively documenting the decline of many stocks.

Reviewer 2 noted that this is a detailed assessment which includes new analysis of catch-effort information from fish slip records and logbook records. The habitat analysis used in past assessments has been updated using the new catch information to refine estimates of yield for these stocks. An analysis of the spatial data for this fishery is also included. In addition biological data is also analyzed and annual changes in mean age as a stock response to the fishery are discussed. Yield options are proposed for individual species as opposed to species groups. Yield has been estimated using a different procedure than the last assessment. This is an improvement and reflects the distribution of the catch data properly. It has also resulted in more conservative estimates which seem appropriate given the changes in age composition that have taken place and declines in the CPUE index for various stocks.

Subcommittee Decision

The authors have done a good job of incorporating fishing logbook and fish slip information into the assessment and yield estimation. The analytical techniques applied reflect the data distribution and are a significant improvement from previous assessments. As well, all available data are analyzed. The results of the analysis indicate that many of these stocks are in decline. Commercial catch is outstripping estimated median yield for all areas of the coast. Even the stocks on the seamounts are showing signs of decline. Results from the spatial analysis clearly show a pattern of movement by the fleet from the southern areas, where CPUE is low, to northern areas, where CPUE is higher. The emphasis of the fleet on roughey rockfish, which was not a target species in the past, is also cause for concern. Stocks of inshore rockfish in the Strait of Georgia and adjacent areas are in obvious decline and stocks on the central coast and north coast could also decline if the fishery in those areas is not controlled.

The Working Paper is accepted with major revisions to some of the tabular information, and minor revision to the text. In particular, the numbers in Tables 11.19 and 11.20 come from a variety of sources, and have very different levels of uncertainty. The authors are to rework the tables, in consultation with fisheries managers, to differentiate numbers based on different types of information. Also Table 2 inaccurately reflects the relationship between catch and quota. The table should be revised to ensure that catches and quotas in a row are based on similar types of information.

The Subcommittee agreed that CUPE data from the recreational fishery are highly suspect. For the commercial fishery the level of sampling is so low now that the Subcommittee cannot have confidence in any results from analyses of the sampling data. For the next assessment which analyzes stock status, detailed logbook data will be available. These data should be the focus of any new analyses. When they are undertaken, the new analyses should include examination of the consequences of rotational management of inshore rockfish stocks. The Subcommittee notes that there

may not be sufficient data for this task to be done in a meaningful way in 1997, and that future modifications to the management plan may make such analyses unnecessary.

The Subcommittee agreed that further analyses of the existing data sets will not increase the quality of advice on the questions presently pursued in the analyses. Further analyses under the current approach to both assessment and management of the stock can, at best, document the decline in local populations after they have been depleted. The Subcommittee also agreed that it is unlikely the Region will have the resources to assess the status of inshore rockfish on a stock by stock basis.

With regard to advice for 1997, PSARC acknowledges that provisions of the management plan in recent years have forced some movement of the fishery. However, the pattern and extensiveness of the relocation of the fishery to new areas is interpreted as evidence that at current level of harvest local stocks in many areas continue to be depleted. The Subcommittee has serious reservations about basing advice on catch histories under any circumstances. However, for the stocks of inshore rockfish in the Strait of Georgia, West coast of Vancouver Island, and the Central Coast, the catch histories are long and effort has been reasonably high over the series. In those cases the catch history combined with habitat analyses are the best basis available for scientific advice on stock status. For statistical areas where information may be available to estimate a sustainable level of harvest from the catch history, those estimates should be the basis for the 1997 quotas. For the other statistical areas of the Strait of Georgia, WCVI, and Central Coast, the Subcommittee will accept the 25th percentile of the catch history since 1983 as the basis for 1997 quotas. However, it is noted that the 25th percentile is selected arbitrarily, and there are no scientific grounds to evaluate the sustainability of that level of harvest.

When the catch history is short or effort is low over the time series, then the catch history is not accepted as an appropriate basis for TACs. In the Queen Charlotte Islands and North Coast, histories of catch and research data do not exist, and cannot be accumulated in the foreseeable future. In those areas the Subcommittee sees little likelihood of being able to provide scientifically defensible estimates of sustainable harvest levels on spatial scales which are biologically meaningful and realistic for the needs of managers. If quotas are requested in those areas, the advised quotas can only be preemptive, intended to limit expansion of the fishery. The life history parameters and relatively sedentary nature of adult inshore rockfish suggest that at this time provisions of the Regional Policy on New and Developing Fisheries provide the best guidance available for management of inshore rockfish fisheries in areas where catch histories and habitat data are scarce..

Notwithstanding the advice on quotas for 1997, the Subcommittee emphasizes that the basis for TAC management of inshore rockfish is weak. There is a serious mismatch of spatial scale between the biology of rockfish and activities which are feasible for stock assessment and fisheries management. It may be possible to make some progress on the scale problem with logbook data, and the Subcommittee expects future assessments to focus on those data. It may also be useful to follow a few index areas

intensively, and extrapolate to other areas. However, the Subcommittee has serious concerns that such approaches will still not be an adequate basis for sustainable management of these stocks. The Subcommittee believes that the entire management approach has to be different; not quota-based management requiring estimates of local stock abundances. Rather than focusing all efforts for future assessments on trying to improve estimates of stock status, the Subcommittee recommends that work should focus on a rigorous review of alternative approaches to management. The purpose of the review is to identify management approaches which are feasible from assessment and management perspectives, and which meet the Department's conservation mandate. Furthermore, the Subcommittee notes that the same problem exists for some other types of species, particularly but not exclusively invertebrates. In all of these cases, work in support of changes to management approaches may have a greater payoff than continued efforts solely to refine abundance estimates.

Marine Protected Areas are one approach which have been proposed as a management tool for inshore rockfish. The Subcommittee advises that MPAS are unlikely to be effective, by themselves, as tools for sustainable management of inshore rockfish. However, some form of spatial management, with MPAs as a component of the spatial management, is thought to be necessary as a basic approach to inshore rockfish (as well as for other species with similar life histories). Managers, assessment staff, and industry should commence planning appropriate measures to move in that direction. The Subcommittee further stresses that stock assessment staff and fisheries managers should have prominent roles in any Regional work addressing MPAs.

A comment on the reviews and the assessment was that the hook and line industry has contributed to a dockside monitoring program as well as a log book program and future assessments need to include these data.

Halibut Bycatch

In review.

7. Additional Subcommittee Discussions

- (i) The Subcommittee reiterated the need to have oceanographers participate in the meeting. It was noted that assessment meetings on the east coast always included several oceanographers. Ocean changes can have important impacts on the dynamics of Groundfish populations. Effective management needs to be able to separate natural changes from fishing effects. Both interannual and decadal scale information on ocean and climate changes is needed to assist in the interpretation of stock abundance fluctuations. As this information becomes available it will be used to improve the performance of the stock assessment models.

There was also concern that some Subcommittee members did not attend the whole meeting; some committee members felt it was essential to participate in all discussions in order to fully appreciate the issues facing stock assessment staff, managers and industry. The Subcommittee would like to ensure that members make a concerted effort to be present at all meetings.

- (ii) There was a lengthy discussion about the timing, length and content of the meeting. Many documents were submitted well after the deadline, resulting in difficulties in the peer review process and in the general planning the meeting. This is the first year that so many documents were late and it may be a result of the major organizational and budget issues occurring at the same time. No solutions were apparent, other than to request that line management work with the chair of PSARC and the Groundfish Subcommittee chair to monitor the progress in finalizing documents.
- (iii) A presentation was made to the Subcommittee on international agreements which have implications for groundfish stock assessment. The major agreements are (1) the Code of Conduct for Responsible Fisheries adopted by the FAO Committee on Fisheries in November 1995; and (2) the Agreement for the Implementation of the Provisions of the United Nations Convention of the Law of the Sea of December 10, 1982, relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks adopted by the UN General Assembly in August 1995.

Implications of these agreements were discussed at the June 1996 meeting of the ICES Comprehensive Fishery Evaluation Working Group. If Pacific Region stocks are to be managed as conservatively as required for straddling and highly migratory stocks, then

- fishing should be limited to sustainable levels;
- uncertainty should not be a reason to maintain high fishing mortality;
- stock biomass should be kept above B_{MSY} ;
- fishing mortality should be kept below F_{MSY} ;
- in the absence of other information, F_{MSY} may be taken as a limit reference point;
- in the absence of other information, B_{MSY} may also be taken as a limit reference point;
- there should be only low probability that limit reference points are exceeded.

All of these statements are made explicitly in the conventions and there is little room for misinterpretation. Thus, fishing mortality should remain below estimated values of F_{MSY} and stock biomass should remain above B_{MSY} with high probability. In particular, F_{MSY} and B_{MSY} should not be considered as management targets but as limits to acceptable harvest policies. Unfortunately, estimates of F_{MSY} and B_{MSY} are rarely available, and

even if given, tend to be highly uncertain. Harvest rate policies should ensure that conservative estimates of F_{MSY} are not exceeded unless it can be shown that higher estimates are sustainable.

In order to apply these statements, biological reference points (based on fishing mortality rates or stock biomass) should be calculated as a routine component of a stock assessment. Furthermore, PSARC advice on harvest levels should be stated in terms relative to the probability of exceeding harvest rate limit reference points (i.e., F_{med} , F_{MSY}) or falling below biomass limit reference points (i.e., B_{MSY}). At present, reference points are not examined for most stocks, and where they are calculated, they are usually treated as target (rather than limit) reference points.

Table 1. Recommended Yield Option Summary

The recommended yield options for 1995 and 1996, and the new yield options presented for 1997.

AREA	SPECIES	1995 YIELD OPTIONS	1996 YIELD OPTIONS	1997 YIELD OPTIONS
4B	Lingcod	Zero yield	Zero yield (no options proposed)	Zero yield (no options proposed)
Minor Area 12	Lingcod	Winter closure 65 cm size limit	No options proposed	No options proposed
3C	Lingcod	Low risk yield 1400 t High risk yield 2800 t	Low risk yield 1400 t High risk yield 2800 t	Low risk yield 1400 t High risk yield 2800 t
3D	Lingcod	Low risk yield 400 t High risk yield 800 t	Low risk yield 400 t High risk yield 800 t	Low risk yield 400 t High risk yield 800 t
5A/B	Lingcod	Low risk yield 1100 t High risk yield 2200 t	Low risk yield 1100 t High risk yield 2200 t	Low risk yield 1100 t High risk yield 2200 t
5C/D	Lingcod	Low risk yield 1000 t	Low risk yield 1000 t	Low risk yield 1000 t
4B	Pacific cod	No options proposed	No options proposed	No options proposed
3C/D	Pacific cod	Low risk yield 1300 t Sustainable yield 2220 t High risk yield 5330 t	Low risk yield no fishery Sustainable yield 694 t High risk yield 916 t	No change in Management Plan
5A/B	Pacific cod	No options proposed	No options proposed	No options

Table 1 (Cont'd)

AREA	SPECIES	1995 YIELD OPTIONS	1996 YIELD OPTIONS	1997 YIELD OPTIONS
5C/D	Pacific cod	Low risk yield 1870 t Sustainable yield 3040 t High risk yield 5520 t	No fishery No fishery No fishery	In Review
5E	Pacific cod	No options proposed	No options proposed	No options proposed
Coastwide	Petrale sole	No options proposed	No options proposed	No options proposed
4B	Flatfish	No options proposed	No options proposed	No options
3C/D	Dover sole	Low risk yield 1300 t High risk yield 2000 t	Low risk yield 1300 t High risk yield 2000 t	Low risk yield 1000 t High risk yield 1500 t
5A	Rock sole	Low risk yield 250 t High risk yield 500 t	Low risk yield 250 t High risk yield 500 t	Low risk yield 250 t High risk yield 500 t
5B	Rock sole	Low risk yield 250 t High risk yield 600 t	Low risk yield 250 t High risk yield 600 t	Low risk yield 250 t High risk yield 700 t
5C/D	Rock sole	Low risk yield 1200 t High risk yield 1850 t	Low risk yield 1200 t (350 t revised 1996) High risk yield 1850 t (700 t revised 1996)	Low risk yield 800 t High risk yield 1100 t
5C/D	English sole	Low risk yield 800 t High risk yield 1300 t	Low risk yield 800 t (300 t revised 1996) High risk yield 1300 t (500 t revised 1996)	Low risk yield 500 t High risk yield 600 t
5C-5E	Dover sole	Low risk yield 800 t High risk yield 1200 t	Low risk yield 800 t High risk yield 1200 t	Low risk yield 800 t High risk yield 1200 t

Table 1 (Cont'd)

AREA	SPECIES	1995 YIELD OPTIONS	1996 YIELD OPTIONS	1997 YIELD OPTIONS
Coastwide	Sablefish	Low risk yield 2725 t Sustainable yield 4140 t High risk yield 5550 t	Low risk yield 690 t High risk yield 2580 t	In review
South Stock	Sablefish	No options proposed	Low risk yield 275 t High risk yield 1000 t	In review
North Stock		No options proposed	Low risk yield 465 t High risk yield 1580 t	
4B, except MSA 19, 20	Pacific hake	Low risk yield 8000 t Sustainable yield 11000 t High risk yield 14000 t	Low risk yield 8000 t High risk yield 14000 t	Low risk yield 10300 t High risk yield 20100 t
3C	Pacific hake	Yield options to be announced at a later time, when joint arrangements with U.S. completed	Yield options to be announced at a later time, when joint arrangements with U.S. completed	Yield options to be announced at a later time, when joint arrangements with U.S. completed
Coastwide (including U.S. waters)	Spiny dogfish	Low risk yield 9000 t High risk yield 15000 t	Low risk yield 9000 t High risk yield 15000 t	Low risk yield 9000 t High risk yield 15000 t
4B (Strait of Georgia)	Spiny dogfish	Low risk yield 2000 t High risk yield 3000 t	Low risk yield 4000 t High risk yield 6000 t	Low risk yield 4000 t High risk yield 6000 t

Table 1 (Cont'd)

AREA	SPECIES	1995 YIELD OPTIONS	1996 YIELD OPTIONS	1997 YIELD OPTIONS
4B	Walleye pollock	Low risk yield 1300 t High risk yield 2700 t	Low risk yield 630 t High risk yield 2350 t	Low risk yield 470 t High risk yield 1760 t
5C/D	Walleye pollock	Low risk yield 880 t High risk yield 2640 t	Low risk yield 440 t High risk yield 1760 t	Low risk yield 330 t High risk yield 1320 t
Area 12	Walleye pollock	No yield options are proposed	Low risk yield 1000 t High risk yield 2450 t	Low risk yield 1000 t High risk yield 2580 t
Coastwide (Area 3C to 5E)	Pacific Ocean perch	Low risk yield 3400 t High risk yield 5700 t	Low risk yield 3400 t High risk yield 5700 t	Low risk yield 4060 t High risk yield 7210 t
5A/B	Pacific Ocean perch	Low risk yield 350 t High risk yield 1800 t	Low risk yield 350 t High risk yield 1800 t	Low risk yield 1760 t High risk yield 2340 t
5C/D	Pacific Ocean perch	Low risk yield 1500 t High risk yield 3400 t	Low risk yield 1500 t High risk yield 3400 t	Low risk yield 1500 t High risk yield 3400 t
Coastwide (Area 3C to 5E)	Redstripe rockfish	Low risk yield 950 t High risk yield 2570 t	Low risk yield 950 t High risk yield 2570 t	Low risk yield 1020 t High risk yield 1800 t
Coastwide (Area 3C to 5E)	Yellowmouth rockfish	Low risk yield 1100 t High risk yield 1850 t	Low risk yield 1100 t High risk yield 1850 t	Low risk yield 1540 t High risk yield 2740 t
Coastwide (Area 3C to 5E)	Rougheye rockfish	Low risk yield 500 t High risk yield 900 t	Low risk yield 500 t High risk yield 900 t	Low risk yield 500 t High risk yield 900 t
Area 3C to 5E	Shortraker rockfish	No options proposed	Average of 1993 and 1994 catches	Low risk yield 100 t High risk yield 180 t
Area 3C to 5E	Thornyhead rockfish	No options proposed	Average of 1993 and 1994 catches	Shortspine 490-870 t Longspine 250-440 t

Table 1 (Cont'd)

AREA	SPECIES	1995 YIELD OPTIONS	1996 YIELD OPTIONS	1997 YIELD OPTIONS
3B-3C (Combined U.S. and Canadian quota)	Yellowtail rockfish	Low risk yield 1000 t High risk yield 2000 t	Low risk yield 1000 t High risk yield 2000 t	In review
3D-5E	Yellowtail rockfish	Low risk yield 2500 t High risk yield 4900 t	Low risk yield 2750 t High risk yield 5100 t	Low risk yield 2750 t High risk yield 5100 t
Coastwide	Widow rockfish	Low risk yield 1100 t High risk yield 3000 t	Low risk yield 1100 t High risk yield 3000 t	Low risk yield 1100 t High risk yield 3000 t
3C/D	Silvergray rockfish	Low risk yield 150 t High risk yield 425 t	Low risk yield 150 t High risk yield 425 t	Low risk yield 150 t High risk yield 425 t
5A/B	Silvergray rockfish	Low risk yield 375 t High risk yield 725 t	Low risk yield 350 t High risk yield 700 t	Low risk yield 350 t High risk yield 700 t
5C/D	Silvergray rockfish	Low risk yield 150 t High risk yield 425 t	Low risk yield 125 t High risk yield 400 t	Low risk yield 125 t High risk yield 400 t
5E(S)	Silvergray rockfish	No options proposed	No options proposed	Low risk yield 175 t High risk yield 300 t
3C/D	Canary rockfish	Low risk yield 175 t High risk yield 550 t	Low risk yield 350 t High risk yield 525 t	Low risk yield 350 t High risk yield 525 t
5A/B	Canary rockfish	Low risk yield 200 t High risk yield 375 t	Low risk yield 200 t High risk yield 400 t	Low risk yield 200 t High risk yield 400 t

Table 2A. Recommended yields for red snapper and yelloweye rockfish by statistical area and method of determining recommendations. Methods used to derive yields are based on habitat analysis (Habitat), the 25th percentile of the catch history from 1983 to 1995 (Catch history), or no recommendation (None)¹.

Region	Area	Method	Red Snapper Yield (t)	Proportion Yelloweye	Yelloweye Yield (t)
Strait of Georgia	12	Catch history	20	1.0	20
	13	Catch history	7		7
	14	Catch history	1		1
	15	Catch history	1		1
	16	Catch history	1		1
	17	Catch history	3		3
	18	Catch history	1		1
	19	None			
	20	None			
	28	None			
	29	None			
West Coast Vancouver Island	11	Catch history	33	0.95	31
	21	None			
	22	None			
	23	Catch history	5		5
	24	Catch history	9		9
	25	Catch history	10		10
	26	Catch history	14		13
Queen Charlotte Islands	27	Catch history	66	0.97	63
	1	Catch history	15		15
	2	Catch history	35		34
	130	None			
Central Coast	142	Catch history	12	0.74	12
	6	Catch history	8		6
	7	Catch history	5		4
	8	Catch history	5		4
	9	None			
North Coast	10	Catch history	3	0.86	2
	3	None			
	4	Catch history	12		10
	5	Catch history	8		7

¹ The Subcommittee requested that there no longer be a yield range because there is no basis for evaluating sustainability. This table therefore is a new format for reporting recommended yields.

Table 2B. Recommended yields for other rockfish and quillback rockfish by statistical area and method of determining recommendations. Methods used to derive yields are based on habitat analysis (Habitat), the 25th percentile of the catch history from 1983 to 1995 (Catch history), or no recommendation (None)¹

Region	Area	Method	Other Rockfish Yield (t)	Proportion Quillback	Quillback Yield (t)
Strait of Georgia	12	Habitat	23	0.85	20
	13	Habitat	11		9
	14	Habitat	12		10
	15	Habitat	7		6
	16	Habitat	6		5
	17	Habitat	10		9
	18	Habitat	7		6
	19	Habitat	13		11
	20	None			
	28	None			
	29	None			
West Coast Vancouver Island	11	Catch history	27	0.22	6
	21	Catch history	3		1
	22	None			
	23	Catch history	8		2
	24	Catch history	20		4
	25	Catch history	13		3
	26	Catch history	8		2
	27	Catch history	42		9
Queen Charlotte Islands	1	Catch history	15	0.06	1
	2	Catch history	31		2
	130	None			
	142	Catch history	27		2
Central Coast	6	Catch history	9	0.58	5
	7	Catch history	8		5
	8	Catch history	13		8
	9	None			
	10	Catch history	4		2
North Coast	3	None		0.56	
	4	Catch history	5		3
	5	Catch history	7		4

¹ The Subcommittee requested that there no longer be a yield range because there is no basis for evaluating sustainability. This table therefore is a new format for reporting recommended yields.

Appendix 1. Participants at the Groundfish Subcommittee Meeting, July 24-26, 1996

Subcommittee Chair: R. Beamish
Ocean Science & Productivity Division, PBS

NAME	AFFILIATION
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Internal (DFO)

B. Ackerman	Operations Branch, RHQ Vancouver
D. Adams	Operations Branch, RHQ Vancouver
R.J. Beamish	Chair, Groundfish PSARC Subcommittee
J. Fargo	Stock Assessment Division, PBS
V. Haist	Stock Assessment Division, PBS
B. Holtby	Stock Assessment Division, PBS
R. Kronlund	Stock Assessment Division, PBS
B. Leaman	Stock Assessment Division, PBS
S. McFarlane	Stock Assessment Division, PBS
H. Powles	Biological Science Directorate, Ottawa
L. Richards	Stock Assessment Division, PBS
M. Saunders	Stock Assessment Division, PBS
R. Stanley	Stock Assessment Division, PBS
B. Turris	Operations Branch, RHQ, Vancouver
L. Yamanaka	Stock Assessment Division, PBS
M. Stocker	Stock Assessment Division, PBS

External

A. Parma	International Pacific Halibut Commission, Seattle
J.J. McGuire	Consultant

Appendix 2. List of reviewers of working papers presented at the Groundfish Subcommittee Meeting July 24-26, 1996

Reviewers:

Internal (DFO):

J. Fargo	Stock Assessment Division, PBS, Nanaimo
V. Haist	Stock Assessment Division, PBS, Nanaimo
R. Kronlund	Stock Assessment Division, PBS, Nanaimo
S. McKinnell	Ocean Science and Productivity Division, PBS, Nanaimo
D. Noakes	Aquaculture Division, PBS, Nanaimo
I. Perry	Stock Assessment Division, PBS, Nanaimo
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BIOLOGICAL ADVICE ON PACIFIC HERRING

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I. STEERING COMMITTEE REPORT

The Steering Committee met September 18-19, 1996 at the Pacific Biological Station to review the Subcommittee report. The report was accepted, with the following comments and recommendations.

Queen Charlotte Islands

Steering Committee concurred with the estimated stock size and forecast for poor recruitment in 1997. The Steering Committee endorses the Subcommittees recommended catch, calculated as the difference between forecast abundance and CUTOFF, of 310 tonnes.

Prince Rupert District

Steering Committee concurred with the evaluation of stock status, forecast of average recruitment, and a recommended yield of 7,218 tonnes for 1997. Steering Committee notes that the recommendation is based solely on the escapement model. The Steering Committee notes that the Subcommittee reports progress in the assessment of problems leading to the divergence of the AS and ESC model estimates and urges the Subcommittee to continue work to resolve this issue.

Central Coast

Steering Committee agreed with the Subcommittee prediction of poor recruitment. The Steering Committee notes that a 20% harvest would reduce the forecast stock below CUTOFF in 1997. The Steering Committee agreed with the recommended catch level, calculated as the difference between forecast abundance and CUTOFF, of 3,130 tonnes.

Strait of Georgia

Steering Committee concurred with stock status estimates based on average recruitment for this stock. Both assessment models indicate an increase in abundance in the Strait of Georgia in 1996 over 1995 levels. The Steering Committee agreed with the recommended catch level of 15,450 tonnes for 1997.

West Coast Vancouver Island

Steering Committee concurred with the assessment of stock status and agreed that recruitment is likely to be poor in 1997. The Steering Committee endorsed the recommended yield of 4820 t for 1997.

Harvest Below CUTOFF

The Steering Committee encourages the Subcommittee to pursue biologically based conservation thresholds for the major herring stocks.

Minor Stocks

Steering Committee endorses the Subcommittee's recommendation that the maximum biomass of fish harvested for minor stocks should not exceed 10% of the estimated previous season biomass.

Appendix 4

The Steering Committee endorses the Subcommittee's recommendations. Currently studies of recruitment processes and the influence of environmental factors are focused on WCVI. Steering Committee stresses the Subcommittee recommendation that these studies should be expanded to other major stocks on the coast. Steering Committee notes in particular that the Strait of Georgia herring stocks have been exceptionally productive at a time when stocks on the West Coast of Vancouver Island and the Queen Charlottes have been relatively unproductive. It would be valuable to have an explanation for these differences among stocks.

II. PSARC HERRING SUBCOMMITTEE REPORT

1. PSARC Herring Subcommittee Objectives

The Subcommittee met on September 4-6, 1996 to derive a consensus on the status of herring stocks in 1996 and to forecast abundance and potential catch levels for 1997. The list of working papers (Appendix 1), participants (Appendix 2), criteria used to evaluate stock status in each region (Appendix 3), Subcommittee recommendations (Appendix 4), Progress report on 1995 recommendations (Appendix 5); and summaries, reviews, and Subcommittee discussions of working papers (Appendix 6) are attached.

The objectives of the meeting were to:

- (a) Review the stock assessment source documents and other pertinent stock assessment information contained in the working papers, discuss stock status in 1995/1996, forecasts of abundance in 1996/97, and recommend 1997 catch levels for consideration by the PSARC Steering Committee.
- (b) Identify areas where further assessment work is most needed for management purposes and develop recommendations regarding these areas (Appendix 4).
- (c) Discuss other issues relating to herring stock assessment.

For each stock assessment region the following criteria were evaluated in order to make recommendations regarding stock status and potential catch levels (Appendix 3):

- Data quality - catch, spawn survey, age composition.
- Spawn and stock trends - age-structured model, escapement model, spawn indices and in-season hydroacoustic estimates.
- Perception of stock status - charter skippers, district staff.
- Recruitment trends - age-structured model, escapement model, and other abundance surveys.
- Cutoff level (Spawning biomass threshold for stock conservation).
- Forecast weighted run size - weighting and recruitment levels.
- Additional information.

Based on the evaluation of these criteria for each of the five major assessment regions, conclusions were drawn about the current biological status of the stocks, and recommendations made as to the potential catch levels for each.

2. Management Framework

Five major British Columbia herring stocks are currently managed by a fixed harvest rate policy in conjunction with a CUTOFF level. Cutoff levels have been set at 25% of the estimated unfished average biomass, as determined by simulation analyses. To attempt

to harvest herring conservatively, recommended catch levels are set at 20% of the forecast biomass for each of the major assessment regions unless the forecast is below the CUTOFF level. In that event, the decision may be made to close the fishery to rebuild the stock. The intent of the 20% harvest rate is to minimise fluctuations in both catch and spawning biomass. This harvesting policy has been in place since 1983 prior to which the fishery was managed through a fixed escapement policy. A recent review (provided in H95-2) determined that "... the current management policy provides an adequate level of protection to conserve the stocks from a fishery collapse, and generates high long-term yields."

A measure of the performance of the forecasting procedures for 1996 herring fisheries is provided in Appendix 7, which compares forecast abundance in each stock assessment region (made in 1995) to observed biomass in 1996. In four of the five assessment regions, forecast abundance agreed reasonably well with observed abundances. In the Queen Charlotte Islands area, the forecast was conservative relative to observed returns in 1996.

There are also small or "minor" herring stocks which exist outside the five major stock assessment regions. Because of their inaccessibility the minor stocks are assessed opportunistically, so the data base is neither continuous nor extensive. In its 1993 report the PSARC Herring Subcommittee advised that there is no basis for fishing minor stocks above the 20% harvest rate established for the major stocks, and that DFO should also protect a minimum spawning biomass for the minor stocks. The Subcommittee also noted that some minor stocks exhibit large fluctuations in abundance and, therefore, there is no guarantee that allocated quotas for minor stocks are sustainable.

3. Catch Trends

Herring in British Columbia waters have supported some form of commercial fishery since 1877. Reliable records of place, date, and quantity caught are available since 1950. A fishery for a dry salted market from 1904-1934 (with catches up to 85,000 t annually) was followed by a reduction fishery (1935-1967). During the reduction fishery catches were taken during the inshore spawning migrations from October to February. Very large catches (200,000 t annually) in the early 1960s, in conjunction with a series of poor recruitments, led to the collapse of the reduction fishery and subsequent closure in 1968. Cessation of the intensive reduction fishery resulted in a gradual recovery of stocks. The roe herring fishery began in 1972. Herring are now caught on or near the spawning grounds by both gillnets and purse seines. In 1996 the number of eligible seine and gillnet licences were 252 and 1306 respectively. Of these, only 134 seines and 516 gillnets were eligible to be fished because a substantial number of licences were inactivated for multi-licensed roe fisheries and for S-O-K. Total roe landings have averaged 32,000 t over the last five years. The total landed value of the commercial roe herring catch in 1995 was \$60 million, and for the spawn-on-kelp fishery was \$ 23 million.

The roe fishery first came under quota regulations in 1983. Prior to this, guidelines of anticipated roe catches were given. The PSARC recommended potential yield, actual quota in the roe fishery, and roe catches (thousands of tonnes) since 1983 are listed below:

		1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996 ^d
QCI	PSARCSf ^f					15.3	12.1	13.7	35.3	23.2	18.1	17.7	12.4	7.7	6.7
	PSARCPy ^a					2.2	0.0	2.7	7.1	4.6	3.6	3.5	1.0	0.0	0.0
	Quota	*	4.6	5.0	3.8	1.4	0.0	0.9	5.5	4.7	3.3	2.1	0.0	0.0	0.0
	Catch	8.1	5.0	6.3	3.6	2.0	0.3 ^a	1.5	9.0 ^b	7.0 ^b	3.3 ^b	2.7	0.3	0.0	0.0
PRD	PSARCSf ^f					32.1	43.8	42.6	23.3	19.4	30.5	55.1	34.1	21.9	21.2
	PSARC ^c					6.4	8.7	8.5	4.7	3.9	6.1	11.0	6.8	4.4	4.2
	Quota	*	4.0	5.0	6.4	5.4	7.5	7.3	3.5	2.6	4.2	5.4	5.0	2.3	2.4
	Catch	0.0	3.5	6.5	8.3	6.1	7.9	8.5	4.7	3.5	4.7	6.3	4.7	2.1	3.1
C.C.	PSARCSf ^f					23	23.8	48.5	43.2	38.2	37.7	70.1	69.8	54.4	25.8
	PSARC ^c					4.6	4.8	9.7	8.6	7.6	7.5	14.0	14.0	10.9	5.2
	Quota	*	6.6	4.1	2.3	3.4	3.7	7.8	7.4	6.2	5.3	7.8	10.4	8.6	3.2
	Catch	5.6	7.2	5.2	3.3	3.6	4.5	9.4	8.4	8.9	7.3	10.5	11.9	10.0	3.9
GULF	PSARCSf ^f					53.0	46.7	49.4	55.2	53.7	59.2	91.8	97.4	69.5	63.4
	PSARC ^c					10.6	9.3	9.9	11.0	14.0	11.8	18.3	19.5	13.9	12.7
	Quota	11.7	11.6	4.7	0.0	8.1	6.4	7.4	7.1	9.1	9.3	11.0	14.4	11.9	10.8
	Catch	16.4	10.2	6.2	0.2 ^e	9.1	7.5	8.4	8.1	10.5	11.6	13.1	16.7	12.1	12.8
WCVI	PSARCSf ^f					48.3	39.6	52.6	35.9	33.9	29.1		36.3	20.8	21.4
	PSARC ^c					9.7	7.9	10.5	7.2	6.8	5.8	3.4 ^a	7.3	2.0	2.0
	Quota	4.5	4.5	0.0	0.0	9.4	8.1	10.3	7.2	6.7	2.9	2.7	5.3	1.3	0.9
	Catch	8.7	6.7	0.2 ^a	0.2 ^a	15.9	9.7	13.3	9.8	8.6	3.4	5.6	6.4	1.5	0.8
PSARCSf	Total ^f					171.6	165.9	206.8	192.9	184.5	174.5		250.0	174.4	138.4
PSARCPy	Total ^a					33.5	30.7	41.3	38.6	36.9	34.8	50.2	48.6	31.2	24.1
Coast	Quota	28.0	31.3	18.8	12.5	27.7	25.8	33.7	30.7	29.3	30.7	29.0	35.1	24.1	17.3
Total	Catch	38.8	32.6	24.4	15.6	36.7	29.9	41.7	40.0	38.5	35.4	38.2	40.0	25.7	20.5

* North of Cape Caution the quota for 1983 was 11.8;

^a Charter boat removals;

^b Includes removals from Area 2W;

^c PSARC recommended potential yield, includes allocations to non-roë fisheries;

^d 1996 catch data are preliminary fish slip information;

^e Catch recommended not to exceed that for 1992.

^f PSARC stock forecast used to derive potential yield.

4. Stock Status and Forecasts for Major Assessment Regions

For northern B.C., the stock assessment regions used for the 1996 assessments are the same as those used in previous years. In the Queen Charlotte Islands, the assessment region extends from Cumshewa Inlet in the north to Louscoone Inlet in the south. The Prince Rupert District stock assessment region includes all of Statistical Areas 3 to 5. The Central Coast assessment region encompasses Area 7, Kitasu Bay in Area 6, and Kwakshua Channel in Area 8. As recommended by the Herring PSARC Subcommittee in 1991, the Strait of Georgia is considered a single stock complex which includes Deepwater Bay and Okisollo Channel in Area 13 and all of Areas 14 through 19. In 1993 the northern (Area 25) and southern (Area 23/24) west coast of Vancouver Island assessment regions were combined into a single assessment unit (Area 23 to 25).

The assessment criteria are listed in Appendix Table 3 and the spawning stock biomass trends are plotted in Figures 1 and 2. To provide an overall estimate of stock abundance in 1996 and forecast abundance for 1997, subjective probabilities are assigned to the two analytical models (Escapement and Age-structured). In general, the two models are weighted equally unless there is information which suggests that one of the models does

not provide consistent stock estimates, such as the Prince Rupert District (see below). The potential recruitment of age 2+ fish to each stock is calculated as the mean of the third best, the middle third and the third poorest recruitments as estimated by the two analytical models for the 1951-96 time series. Generally, the expectation used for the forecast year is average, unless there is additional information to forecast recruitment. Recruitments are added to the expected age 3+ and older abundance to obtain the forecast run. The recommended catch is 20% of the weighted, forecast run. If this harvest rate would take the spawning escapement biomass of the stock below Cutoff, then the recommended catch is calculated from the following equation:

$$\text{Catch} = \text{Weighted run} - \text{Cutoff}$$

Thus smaller fisheries are recommended when the stocks approach their respective Cutoffs.

Minimum Harvest Levels (Cutoff) are calculated for each stock assessment region. In 1994 and 1995, Cutoffs were based on simulations using the age-structured model only. These Cutoff levels have been retained for current forecasts with the exception of the Central Coast area. It was noted by the Subcommittee that the Cutoff level for the Central Coast appeared to be unreasonably high relative to observed long term productivity levels. As a result of a re-evaluation of Cutoff with current data, a revised level was adopted for the 1997 forecast.

Queen Charlotte Islands

Landings during the reduction fishery period (1951-1968) were highly variable, targeting on a few strong year classes. The maximum catch taken during this period was over 77,000 t, however, there were 6 years when catches were less than 1,000 t. Catches have been more stable since the beginning of the roe fishery and have generally been in the range of 4,000 to 8,000 t. The area was closed to roe herring fisheries in 1988 and 1989 due to stock concerns. The stock recovered after the closure but has been declining since 1990. In response to the observed decline, annual roe fishery catches were reduced from 7800 t in 1990 to 2700 t in 1993. In 1994, the forecast return was close to Cutoff, and fishing was restricted to Section 35 and S-O-K only. In 1995 and 1996, the forecast abundance was below Cutoff so fishing was limited to Section 35 harvest only.

Although commercial fisheries were absent in the Queen Charlotte Islands in 1996, in-season stock sampling and spawn assessment programs were carried out in a manner consistent with other assessment areas. In general, the level of biological sampling was adequate and all major spawns were covered by dive survey. Information provided by aboriginal guardians indicate Section 35 catches were minimal in 1996.

Both the age-structured and escapement models indicate a decline in abundance from 1990 to 1995 and a slight increase in 1996. The declining stock trend observed between 1990 and 1995 resulted from a series of poor recruitments. Abundance has been

stabilised by the introduction of the 1993 year class, which has recruited at an above average level of abundance and accounted for approximately 50% of the stock in 1996. The trend in spawn indices supports the thesis that stock abundance has stabilised at low relative levels of abundance.

The local fishery manager and charter skipper agree that the Queen Charlotte Islands stock remains at a low level of abundance. Peak sounded tonnage increased slightly in 1996 but is similar to the relatively low levels observed in the previous two years.

All assessment criteria examined for this stock indicate abundance remains at low levels in 1996. As well, recruitment trends indicate the stock is in a poor productivity regime so that a precautionary harvest policy is warranted. The Subcommittee has, therefore, adopted a poor recruitment assumption (1994 year class) in forecasting abundance for 1997. With a 50:50 weighting of the forecasts from the two analytical models, the forecast prefishery biomass in 1997 is 11,010 tonnes. A 20% harvest of the forecast return would reduce the stock to a level less than Cutoff, therefore **the recommended catch is calculated as the difference between forecast abundance and Cutoff, equal to 310 tonnes.**

Prince Rupert District

During the period of the reduction fisheries, herring catches in the Prince Rupert District were generally in the range of 10,000 to 50,000 t annually. Since the beginning of the roe-herring fishery catches have averaged 5,000 t and not exceeded 9,000 t. The fishery has been closed in only one year, 1983, since 1972. The area has supported substantial herring roe and S-O-K fisheries in recent years; however, there was no seine fishery carried out in the traditional location (Kitkatla Inlet) in 1996.

The two assessment models show similar trends in abundance; however, the age-structured model estimates abundance at unreasonably high levels and only the escapement model is used in forecasting. Efforts to rationalise the model estimates have continued with a re-examination of age composition data but further review is required. Stock abundance has declined from a peak in 1992 to moderate levels in 1995, followed by an increase in 1996. The stock has been supported in recent years by good 1988 and 1989 year classes which are now leaving the population. The increase in abundance observed in 1996 results from a strong recruiting year class, with the 1993 year class comprising 64% of the spawning biomass.

The quality of assessment data in 1996 was adequate and the trend in spawn indices supports abundance trends from the assessment models. Comments from fishery managers and charter skippers in 1996 indicate that returns to the northern portion of the assessment area (Big Bay) were strong but that returns were again low in southern locations (Kitkatla Inlet).

Projected stock abundances indicate there is zero probability that the Prince Rupert stock will be below Cutoff in 1997. The Subcommittee therefore had no basis on which to adopt

a recruitment assumption other than average. The forecast run size based solely on the escapement model estimate with an average recruitment assumption is 36,090 tonnes. **The total recommended catch at a 20% harvest rate is 7,218 tonnes.**

Central Coast

Landings during the reduction fishery period (1950-1968) ranged to just over 44,000 t and were generally around 10-35,000 t. During the subsequent roe fishery period (1972-present), landings have averaged 7,400 t and reached a maximum of 14,000 t in 1978. No roe harvest occurred in the Central Coast in 1979 but fisheries have occurred annually since that time. Harvests greater than 10,000 t were achieved in the three years, 1993 to 1995, then were reduced to 5,200 t in 1996 in response to an observed population decline.

Abundance trends provided by the two assessment models agree closely and indicate a recent decline in stock abundance from a near historic high in the early 1990's. The last good recruitment to the stock occurred in 1992 (1989 year class) and three of the last four recruitments have been poor. The 1989 year class still comprised 30% of the stock in 1996. Other stock indicators support the perception of a declining stock trend in the Central Coast. The spawn indices continue to decline and the maximum sounded tonnage in 1996, of 30,000 t, is similar to the previous year but well below the level reported in 1992.

The quality of assessment data collected in 1996 is considered to be good. The use of dive spawn surveys has been expanded to cover all spawns in the assessment area.

The Subcommittee notes the series of poor recruitments in recent years as well as the declining abundance trend in recent years. As well, projected stock abundances indicate there is a slight chance that the 1997 stock abundance could be less than Cutoff. As a result, the Subcommittee has adopted a poor recruitment assumption in forecasting stock abundance in 1997. The total forecast abundance using a 50:50 weighting of the two model estimates is 20,730 t. A 20% harvest would reduce the forecast stock below Cutoff, therefore, a catch level was calculated as the difference between forecast biomass and Cutoff (17,600 t). **The recommended total catch in 1997 is 3,130 t.**

Strait of Georgia

Annual herring landings from the Strait of Georgia during the reduction fishery period (1951-68) were less variable than from other areas of the coast. With the exception of the 1952/53 season when industry disputes curtailed the herring fishery, and the 1967/68 season when stocks had collapsed, landings ranged from 31,000 t (1966/67) to 72,000 t (1955/56). During the period of roe herring fisheries, catches have averaged 11,400 t. The area was closed to roe herring fishing in 1986, after which time harvests have increased to a peak of 16,700 t in 1994.

The high catches in the 1990's have been supported by near record high stock abundances in the Georgia Strait. The two assessment models indicate a decline in abundance from about 90,000 t in 1993 to moderate levels in 1995, followed by a moderate increase in 1996. The stock has been supported by above average recruitments in five of the last seven years, with the most recent recruiting year class (1993 year class) appearing to be of average size. The recruiting year class contributed 50% of the stock in 1996. Comments from fishery managers and charter skippers are consistent with the view that stock abundance remains at high levels. The total sounded tonnage estimated at 85,000 t is the highest observed in recent years.

All the catch data were reported, and all major spawns were surveyed in 1995.

Projected stock abundances indicate this stock remains well above Cutoff. An analysis of juvenile abundance trends carried out in 1996 suggest that recruitment in 1997 should be higher than the 1992 and 1993 year classes. The juvenile data is preliminary however and has considerable uncertainty, therefore the Subcommittee adopted an assumption of average recruitment in the forecast for 1997. Using an equal weighting of the two assessment model estimates, the forecast abundance in 1997 is 77,230 t. **The recommended yield in 1997 based on a 20% harvest rate is 15,450 t.**

West Coast Vancouver Island

During the period of the reduction fishery, catches from the west coast of Vancouver Island reached nearly 70,000 t in the 1958/59 season. In general, catches were in the range of 10,000 to 25,000 t. During this period, annual harvests in the southern region (Area 23/24) exceeded harvests in the north (Area 25) for all but three years (51/52, 59/60, 62/63), often by large amounts. Since the roe fishery began in 1972 catches have been below the earlier levels, except from 1975 to 1978 when they ranged from 26,000 to 39,000 t. Since 1983 harvests have been very low in the northern region. In 1985 and 1986 the commercial fishery was closed along the entire west coast of Vancouver Island due to serious stock concerns. The stock subsequently rebuilt and the 1987 harvest of nearly 16,000 t was the largest since 1979. However, the stock has been in a declining trend since 1989; catches have averaged 5,600 t since 1990 compared to an average harvest of 22,200 t prior to 1980. In 1995 and 1996, forecast abundances were just above Cutoff and, as a result, a precautionary management approach was adopted.

The two assessment models indicate a declining abundance trend since 1989 with the escapement model indicating a slight increase since 1994 and the age-structured model showing a continued decline. The long term abundance decline resulted from a series of years of poor recruitments, interrupted by only one year of above average recruitment in the last eight. The strength of the year class recruiting in 1996, as estimated by the age-structured model, was improved slightly from the previous year but remained at low levels. The recruiting year class did account for 20% of the stock in 1996 and encouraging evidence of more favourable recruitment in 1997 was provided by the relatively high incidence of 1+ herring (14%) in the spawning stock. An increasing trend in

spawn indices supports the recent positive abundance trend indicated by the escapement model.

The quality of assessment sampling and data collected was good in 1996. Some difficulty was experienced in distinguishing age 1+ and 2+ fish from scale analysis.

In developing a forecast for 1997, a number of additional analyses were available for consideration by the Subcommittee. The evidence considered in forecasting stock abundance and recommending yield for 1997 is itemized below:

1. A retrospective analysis of outputs of the age-structured model (see H96-6) indicates the model has likely underestimated the size of 1996 spawning biomass on the west coast of Vancouver Island. This would, in turn, result in a conservative forecast of abundance in 1997.
2. A recruitment forecast presented in H96-2 predicts recruitment in 1997 (1994 year class) at a level between average and poor. This prediction is based on environmental factors, which indicate ocean temperature and predator biomass were moderately favourable, and an offshore survey, which found age 2+ herring (recruiting in 1997) make up a substantial portion of the offshore stock (40%) in 1996. Additionally, there was a significant showing of age 1+ herring in the spawning stock in 1996 which likely was underestimated by the age-structured model. This evidence supports a more optimistic recruitment forecast for 1997.
3. Surplus production analysis presented in H96-3 shows that present abundance levels are optimal in the current warm temperature regime.
4. Projected stock abundances indicate there is little chance of the stock being below Cutoff in 1997.

Considering the evidence provided above, the Subcommittee concluded that a recommended yield for 1997 based on application of standard harvest policy to the empirical abundance forecast would be sufficiently conservative. Using an equal weighting of the forecasts by the two assessment models and an assumption of poor recruitment, a total run size of 24,100 t is forecast. **The recommended yield based on a 20% harvest rate is 4,820 t.**

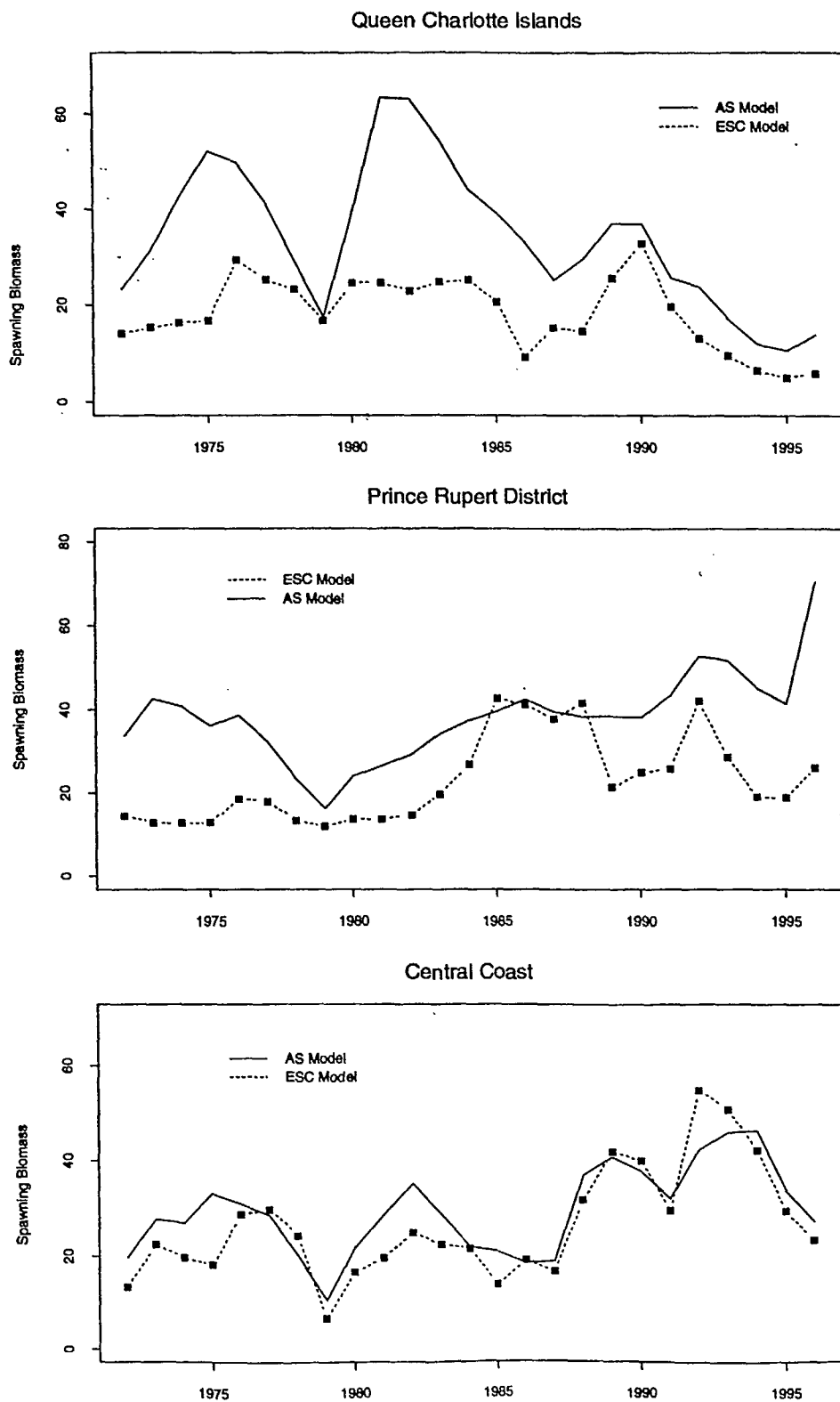


Fig. 1

Estimates of spawning stock biomass (tonnes x 1000) from age-structured and escapement model analyses for northern B.C. herring stock assessment regions, 1972 - 1996.

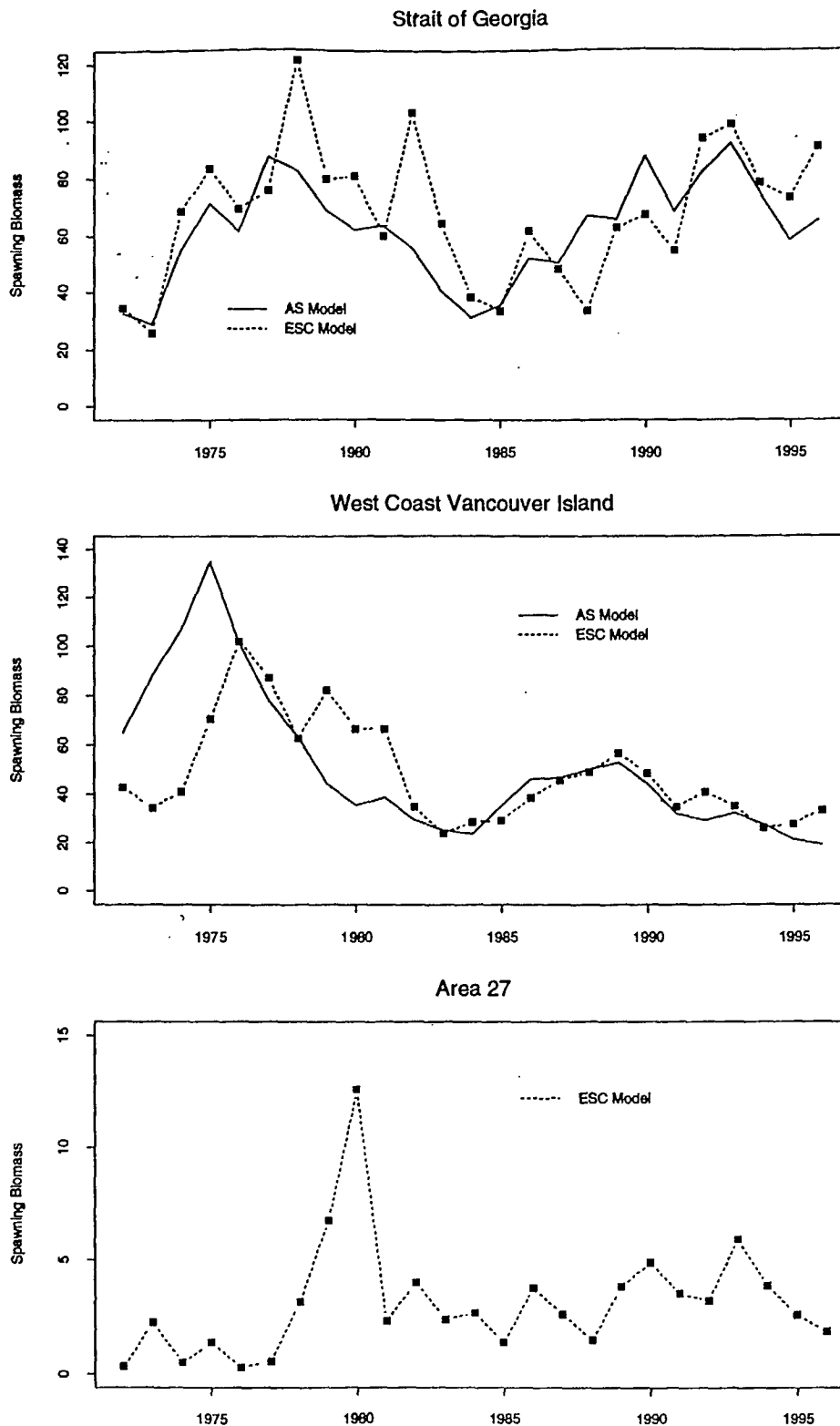


Fig. 2

Estimates of spawning stock biomass (tonnes x 1000) from age-structured and escapement model analyses for southern B.C. herring stock assessment regions, 1972 - 1996.

5. Recommended Coastwide 1997 Harvest

For each major stock, the recruitment assumption, the corresponding 1997 pre-fishery biomass forecasts, and the recommended catches (in tonnes) are summarised below (also see Appendix 3). The Subcommittee notes that the total recommended harvest of approximately 31,000 t for 1997 is a moderate increase from the harvest recommended for 1996 (24,000 t), but remains below the decade average of 37,000 t.

Stock Assessment Region	Cutoff Biomass	Recruitment Assumption	Forecast	Recommended Harvest
Queen Charlotte Islands	10,700	poor	11,010	310
Prince Rupert District	12,100	average	36,090	7,218
Central Coast	17,600	poor	20,730	3,130
Strait of Georgia	21,200	average	77,230	15,450
West Coast Vancouver Island	18,800	poor	24,100	4,820
TOTAL			169,160	30,928

6. Harvest Below Cutoff

The Subcommittee discussed the objectives of current Cutoff levels (25% of average unfished biomass) and the impact of small harvests of Section 35 fish on herring stocks below Cutoff levels of abundance. The objective of a Cutoff, as currently employed, is to prevent relatively large fishery removals on stocks at low levels of abundance. A herring stock fished down to very low levels will require considerable time to recover or may not recover at all. The policy of curtailing commercial fisheries on stocks below a minimum threshold of abundance will minimise stock recovery time, which is critical for stocks in a low productivity regime (eg. Queen Charlotte Islands). There is no biological basis for curtailing minor fishery removals on herring stocks below Cutoff; however, the conservation risk associated with fishing increases as the abundance level declines. The conservation risk is increased further if data from all sources of harvest is not made available for assessments. It is particularly important that all catches be documented and that fishery harvests be controlled on stocks at low abundance levels. In practise, Section 35 harvests are difficult to monitor and estimate, and catch figures have not been provided in some areas.

7. Recommended Harvest Levels for Minor Herring Stocks

At the 1994 Herring PSARC meeting the Subcommittee recommended the following harvest policy for minor stocks. Because of incomplete historic data, the Subcommittee confirmed that minor stock harvests have to be based on the estimated biomass of spawners observed in the previous season. The Subcommittee recommends that the maximum biomass of fish harvested should not exceed 10% of the estimated previous season biomass. This recommended harvest rate for minor stocks is more conservative than the rate adopted for the major stocks, and is intended to compensate for the fact that minor stock survival and recruitment levels cannot be accurately predicted. The data also do not allow accurate estimation of minor stock Cutoff levels.

The Subcommittee also recommends that DFO should review biomass levels in light of available historic information before allocating minor stock harvests to clients.

8. Partnerships with Clients

In 1995 a meeting was convened with client groups immediately following the internal DFO review of herring stock assessments. This meeting, termed a "Biological Review", had the objective of fostering improved partnerships with client groups, which had expressed displeasure with being excluded from the PSARC process. At this meeting Science Branch staff presented herring stock assessments and forecasts for the subsequent year; discussion was confined to the biological basis for these assessments. Unfortunately, the meeting was poorly attended by clients in 1995 and the Subcommittee is not optimistic regarding participation in 1996. As a result, the Biological Review will not be held in 1996; however, efforts will be made to widely circulate a Stock Status report and a response to this report will be solicited from client groups. The Subcommittee is also examining innovative strategies such as video tape reviews for cable television, to disseminate information to the public.

9. Nomination of a new Subcommittee Chair

The Subcommittee will require a new chair for the two upcoming cycles of PSARC. No willing candidate for the position has been identified to date. It should be noted that, in keeping with the tradition of alternating responsibility for this role between Branches, the new chair should be recruited from within Science Branch.

Appendix 1. 1995 PSARC Herring Subcommittee Working Papers.

No.	Title	Authors	Reviewers
H96-1	Stock assessment for British Columbia herring in 1996 and forecasts of the potential catch in 1997.	J. Schweigert C. Fort L. Hamer	V. Wespestad
H96-2	Offshore herring distribution and 1997 recruitment forecast for the west coast of Vancouver Island stock assessment region.	D. Ware R. Tanasichuk	H. Powles
H96-3	Herring carrying capacity and sustainable harvest rates in different climate regimes.	D. Ware	R. Stanley C. Walters
H96-4	Estimating natural mortality for Pacific Herring (<i>Clupea pallasii</i>) adults from the lower west coast of Vancouver Island.	R. Tanasichuk	M. Bradford T. Courtney
H96-5	A framework of a simulation model for the Pacific Herring (<i>Clupea pallasii</i>) population from the lower west coast of Vancouver Island - a progress report.	R. Tanasichuk	J. Schnute S. Cox-Rogers
H96-6	A retrospective analysis of B.C. herring stocks from age-structured model analysis.	J. Schweigert	R. Tanasichuk C. Walters
H96-7	Analysis of recruitment predictions in Georgia Strait - based on juvenile surveys - a progress report.	D. Hay B. McCarter	C. Walters

Appendix 2. List of Participants

Name	Association	Telephone
Jake Rice (PSARC Chair)	DFO, Pacific Biological Stn, Nanaimo	756-7136
Greg Thomas (Subcommittee Chair)	DFO, North Coast Div., Prince Rupert	627-3465
Jake Schweigert	DFO, Pacific Biological Stn, Nanaimo	756-7136
Ron Tanasichuk	DFO, Pacific Biological Stn, Nanaimo	756-7197
Sandy McFarlane	DFO, Pacific Biological Stn, Nanaimo	756-7052
Doug Hay	DFO, Pacific Biological Stn, Nanaimo	756-7201
Bruce McCarter	DFO, Pacific Biological Stn, Nanaimo	756-7198
Chuck Fort	DFO, Pacific Biological Stn, Nanaimo	756-7259
Dan Ware	DFO, Pacific Biological Stn, Nanaimo	756-7199
Ivan Winther	DFO, North Coast Div., Prince Rupert	627-3459
Dennis Chalmers	DFO, South Coast Div., Nanaimo	756-7287
Lorena Hamer	DFO, South Coast Div., Nanaimo	756-7196
Laurie Gordon	DFO, South Coast Div., Pt. Alberni	723-0118
Gord McEachen	DFO, South Coast Div., Comox	339-1029
Howard Powles	DFO, Science Directorate, Ottawa	(613) 990-0285

Appendix 3.1. Criteria used in the assessment of stock status for the Queen Charlotte Islands stock assessment region in 1996.

<u>Criteria</u>	<u>Status</u>
1. Data Quality	
(a) all catch reported	No commercial harvest, minimal S35
(b) all spawn surveyed	Yes
(c) consistent age composition	Louscoone 72% 1+; Juan Perez and Selwyn showed higher proportion 2+
2. Spawn and stock trends	
(a) age-structured model	Slight increase from 1995 historic low
(b) escapement model	Remains low, slight increase from 1995 level
(c) spawn indices	Stable at low levels
(d) in-season echo- soundings	Peak sounding 5800 T, similar to previous 2 yrs.
(e) consistent trend info	Yes
3. Perception of stock status	
(a) charter skippers comments	Stocks weak; 6-8000 T total sounded stock
(b) management staff	Stocks similar to 1995
4. Recruitment trends	1993 year-class above average; previous 3 year-classes were poor
5. Cutoff	10,700 t
6. Forecast weighted run size	
(a) weighting	50:50 (AS:ES)
(b) recruitment assumption	
• poor	11,010 tonnes
• average	
• good	
7. Additional information	None
8. Quota Recommendation	310 tonnes (calculated as the difference between forecast run size and Cutoff)

Appendix 3.2. Criteria used in the assessment of stock status for the Prince Rupert District stock assessment region in 1996.

<u>Criteria</u>	<u>Status</u>
1. Data Quality	
(a) all catch reported	Yes
(b) all spawn surveyed	Yes
(c) consistent age composition	Yes
2. Spawn and stock trends	
(a) age-structured model	Model not used; N/A
(b) escapement model	Increase from 1995
(c) spawn indices	Increase from 1995
(d) in-season echo- soundings	No relationship between sounded and assessed tonnage
(e) consistent trend info	Yes
3. Perception of stock status	
(a) charter skippers comments	Area 3/4 very good
(b) management staff	Big Bay very good; Kitkatla poor
4. Recruitment trends	1993 year-class good and 3 previous ones were poor
5. Cutoff	12,100 t
6. Forecast weighted run size	
(a) weighting	0:100 (AS:ES)
(b) recruitment assumption	
• poor	
• average	36,090 tonnes
• good	
7. Additional information	None
8. Quota Recommendation	7,218 tonnes

Appendix 3.3. Criteria used in the assessment of stock status for the Central Coast stock assessment region in 1996.

<u>Criteria</u>	<u>Status</u>
1. Data Quality	
(a) all catch reported	Yes
(b) all spawn surveyed	Yes
(c) consistent age composition	Yes
2. Spawn and stock trends	
(a) age-structured model	Decreasing
(b) escapement model	Decreasing
(c) spawn indices	Decreasing
(d) in-season echo- soundings	30,000 Tons
(e) consistent trend info	Yes
3. Perception of stock status	
(a) charter skippers comments	Stocks down from 1995
(b) management staff	Consistent with charter skipper's
4. Recruitment trends	Poor recruitment in last 3 of 4 years
5. Cutoff	17,600 tonnes (revised)
6. Forecast weighted run size	
(a) weighting	50:50 (AS:ES)
(b) recruitment assumption	
• poor	20,730 tonnes
• average	
• good	
7. Additional information	None
8. Quota Recommendation	3,130 tonnes (calculated as the difference between forecast run size and Cutoff)

Appendix 3.4. Criteria used in the assessment of stock status for the Strait of Georgia stock assessment region in 1996.

<u>Criteria</u>	<u>Status</u>
1. Data Quality	
(a) all catch reported	Yes
(b) all spawn surveyed	Yes
(c) consistent age composition	Yes
2. Spawn and stock trends	
(a) age-structured model	Increasing; above average
(b) escapement model	Increasing; historic high
(c) spawn indices	Up; relatively high
(d) in-season echo- soundings	85,000 tons; highest in recent years
(e) consistent trend info	Yes
3. Perception of stock status	
(a) charter skippers comments	Stocks very good except for Area 15; good recruitment
(b) management staff	Stocks very good
4. Recruitment trends	5 of last 7 years above average
5. Cutoff	21,200 t
6. Forecast weighted run size	
(a) weighting	50:50 (AS:ES)
(b) recruitment assumption	
• poor	
• average	77,230 tonnes
• good	
7. Additional information	Juvenile survey (H96-7) suggests recruitment better than 1992, 93 year-classes
8. Quota Recommendation	15,450 tonnes

Appendix 3.5. Criteria used in the assessment of stock status for the west coast of Vancouver Island stock assessment region in 1996.

<u>Criteria</u>	<u>Status</u>
1. Data Quality	
(a) all catch reported	Yes
(b) all spawn surveyed	Missing minor spawns (Matilda Inlet)
(c) consistent age composition	Yes; some difficulty in ageing 1+ and 2+
2. Spawn and stock trends	
(a) age-structured model	Decreasing
(b) escapement model	Increasing
(c) spawn indices	Increasing
(d) in-season echo- soundings	Area 23 - 18,370 tons, Area 24 - 4250 tons, Area 25 - 5000 tons
(e) consistent trend info	No
3. Perception of stock status	
(a) charter skippers comments	No change in 1995-96; Optimistic about appearance of small fish
(b) management staff	Same as charter skippers
4. Recruitment trends	Nothing above poor since 1989 year-class; slight increase
5. Cutoff	18,800 t
6. Forecast weighted run size	
(a) weighting	50:50 (AS:ES)
(b) recruitment assumption	
• poor	24,100 tonnes
• average	
• good	
7. Additional information	Offshore survey (H96-3) indicates below average recruitment; Stocks remain in unproductive oceanographic regime (H96-2)
8. Quota Recommendation	4,820 tonnes

Appendix 4. 1996 recommendations for stock assessment and related activities.

1. The provision of removals data in herring fisheries remained somewhat of a problem in 1996; however, there was an improvement in 1996 over previous years. The Subcommittee compliments those organizations which have compiled and submitted catch data, in particular a number of native fisheries programs.
2. The Subcommittee recognizes management measures taken in 1996 to prevent quota over-runs in critical areas. These measures should be continued in future fisheries.
3. Spawn Surveys: Herring spawn information is critical, not only in the assessment of major stocks, but in dealing with current and future issues such as habitat degradation, near shore developments, and land claims. The Subcommittee makes the following recommendations:
 - (a) There has been a recent reduction in coverage of herring spawns occurring outside major stock assessment areas. Mechanisms should be explored to carry out spawn surveys in peripheral areas.
 - (b) The majority of spawns are now surveyed by dive teams contracted from the herring industry. These surveys should continue to be audited by DFO personnel in-season to ensure the integrity of data collected.
4. Recruitment makes up a large proportion of the herring spawning biomass (30-49%) and is therefore an extremely important process in determining the productivity of the stocks, and the resulting harvests. The Subcommittee recommends that the forecasting work evaluating the effect of environmental factors on west coast Vancouver Island herring recruitment and surplus production be continued, and extended to the other major stocks.
5. A further working paper on analytical aspects of herring juvenile distribution and abundance estimates in Georgia Strait is requested for 1997. The work should expand on the working paper H96-7 by including data on the 1994 cohort (recruiting in 1997) and revised estimates of recruitment. The paper should also present substantial revisions of the spatial analysis, as recommended by reviewers and PSARC Subcommittee.
6. The Subcommittee recommends that the work on the components of the revised spawn index (the egg index) should continue to be investigated via bootstrapping, so the empirical variability in the spawn data can be incorporated in the biomass estimates and stock forecasts. A working paper describing the analysis should be tabled in 1997 and the results used in the stock assessment if appropriate.

Appendix 4. (Cont'd)

7. Data analysis in 1996 suggested the need for a more in-depth review of sampling data. The Subcommittee requested further information and analyses on the properties of biological samples. Specific concerns relate to the times and locations of research and catch samples relative to the timings of commercial fisheries and spawn deposition. This could include analyses of data related to age specific maturity.
8. An alternative method of estimating survival for WCVI stocks was provided in working paper H96-4. The Subcommittee recommends a retrospective comparison of forecasts of abundance from the escapement model be carried out using the two available estimates of survival (age-specific apparent survival currently used in the escapement model and estimates from the regression described in H96-4).

Appendix 5. Progress report on recommendations made in 1994.

1. An attempt was made to augment coverage of peripheral spawns in 1996 by providing chartered assessment teams with training and equipment to carry out surface surveys.
2. Work on the effect of environmental factors on recruitment to the WCVI stock was continued in 1996 and presented in working papers H96-2 and -3.
3. Juvenile herring surveys were carried out both in the St. of Georgia and on the WCVI with funding provided by the Herring Conservation and Research Society. Progress reports from the two surveys were provided to the Subcommittee and a preliminary analysis of the predictive capability for the St. of Georgia was given in working paper H96-7.
4. An analysis of the variability associated with the revised spawn index (egg index) was initiated and results are expected to be presented in 1997.
5. Progress was made in the assessment of problems leading to the divergence of the AS and ES estimates of abundance in the Prince Rupert area. An update was provided in the assessment document, H96-1.
6. The work documenting changes in spawn distribution was continued in 1996 and a presentation was made to the Subcommittee. Future presentations will be made to the 1996 PICES Meeting in Nanaimo during October.
7. The objectives of the previous year's Subcommittee recommendation regarding the S-O-K fishery were met, in part, in 1996 through the introduction of an industry funded catch monitoring program. As well, surveys of mortalities in herring impoundments were carried out by DFO personnel and estimates of mortality reported to the Subcommittee.

Appendix 6. Summary of working papers, reviewers comments and Subcommittee discussions.

H96-1 Stock assessment for British Columbia herring in 1996 and forecasts of the potential catch in 1997. J.F. Schweigert, C. Fort., and L. Hamer.

Herring stock abundance in British Columbia waters was assessed for 1996 and forecasts were made for 1997 using two analytical methods: (1) escapement model; and (2) age-structured model. These models have been applied to assess herring abundance since 1984. Coastwide, the estimated pre-fishery stock biomass for all assessment regions in 1996 was 169,500 tonnes which represents a 16% increase from 1995 abundance levels. This increase reflects the recruitment of an average 1993 year-class in 1996 in most assessment areas except the west coast of Vancouver Island where recruitment was poor. There was also a good showing of 1994 year-class fish as two year olds which may indicate an increased recruitment for 1997.

Forecasts of the pre-fishery spawning stock biomass in 1997 are obtained by weighting the estimates from the two analytical models. Stock forecasts for the northern stock assessment regions are 73,110 and 108,080 tonnes for the southern regions assuming average recruitment to all areas.

The recommended 1997 catch (20% of the 1997 forecast herring run) is 36,240 tonnes for the entire B.C. coast assuming average recruitment to all areas. However, stock levels in the Queen Charlotte Islands remain near the Cutoff and uncertainty exists about the status of the west coast of Vancouver Island stock so available harvestable surpluses may be modified following the PSARC review of these data.

Introductory Discussions

The Subcommittee Chair presented a tabulation of the PSARC forecasts in 1995 of 1996 biomass, and the observed biomass, catch, and escapement in 1996 (Appendix 7). The Subcommittee was generally pleased with the performance of the 1995 forecasts, and felt the information should be called to the attention of departmental managers and clients.

Summary of Reviews and Subcommittee Discussions:

The external reviewer had few comments on the paper. He concluded that the assessment is making the best use of the available data, and is trying to compensate for inadequacies in the databases in a conservative manner. He noted the possibility that the observed high residuals in the fit to the gill-net catch data might result from fishers varying mesh size to target specific cohorts, and that density dependence in recruitment of cohorts to the fishery might contribute additional uncertainty to the

Appendix 6 (Cont'd)

estimates of partial recruitment. The authors and Subcommittee discussed both concerns, concluding that any variation in gill-net mesh sizes has been a slight trend to smaller meshes, and the effects of any density dependence in recruitment to the fishery would be captured in other parameters of the assessment model.

The paper was accepted with minor revisions. The Subcommittee noted that a number of tables included in past assessment documents were not presented this year. Acknowledging that their deletion had been advised by a reviewer in 1995, the Subcommittee asked that they be included in the revision to the document, and in future assessment documents. It was also requested that further detail on the basis for Escapement Model be included in the revision.

The Subcommittee expressed confidence that the core assessment component of the paper had matured in response to reviews in past years. Results of the two models were accepted readily. Discussion focused on the relative accuracy of each model in the various regions. It was suggested that the authors and Subcommittee begin to explore ways to assign differential weight to the forecasts of the two models, to reflect their historic relative performances and the relative uncertainty estimated for each forecast.

The very strong recruitment to the Prince Rupert herring stock in 1996 was discussed as well. It was noted that historically, there is some covariance of occurrence of strong cohorts in Prince Rupert, QCI, and Central Coast, but in 1996, the recruitment estimates for QCI and Central Coast do not differ substantially from recent levels. Few samples were collected in QCI in 1996, and it is possible that the number of 2+'s was underestimated in those samples. However, this is not a major source of inaccuracy in the assessment, and samples in 1997 onward will clarify this point.

In addition, after further discussion, the Subcommittee requested the author re-examine Cutoff for the Central Coast and incorporate the revised estimate into the assessment document.

H96-2 Offshore herring distribution and 1997 recruitment forecast for the west coast of Vancouver Island stock assessment region. D. Ware and R. Tanasichuk.

A multispecies mid-water trawl survey off the south-west coast of Vancouver Island was conducted between July 30 - August 6, 1996. Eighteen tows were made to assess the species composition, catch-per-unit-of effort, diet, condition factor, and size and age compositions of the dominant pelagic fish species in the region. The distribution of offshore herring was a bit unusual this year. The apparent abundance was low because

Appendix 6 (Cont'd)

the schools were highly dispersed and not very visible on the echo-sounder. This distribution pattern might have affected the recruitment estimate. Five tows targeted on herring. Analysis of the resulting length compositions suggests that 43 % of the west coast of Vancouver Island herring spawning stock will be age 2+ recruits in March 1997. Our long-term research on the west coast of Vancouver indicates that herring recruitment tends to improve when ocean temperatures are cool, and the summer biomass of migratory predators (like hake and mackerel) in the region is low. The state of both risk factors, were moderately favourable during the formation of the 1994 year-class. Based on age-structured model projections of the biomass of surviving repeat spawners, we estimate that the recruiting 1994 year-class will be between "poor to average" (about 8,700 t). However, the relatively large difference in the 1996 spawning stock estimates between the two assessment models (ASM = 19,200 t and Escapement = 33,400 t) increases the uncertainty in the forecasts this year. Considering the estimates from both models independently, suggests a projected 1997 recruitment range of 6,400 to 11,100 t, 21,300 to 37,000 t of prefishery biomass, and a 2,900 to 7,100 t potential catch, depending upon the weight placed on each assessment model. We note that the lowest prefishery biomass estimate is only 2,900 t above the Cutoff. This should be considered when PSARC recommends the 1997 catch. Age 1+ fish (1995 year-class) were not abundant in the survey area this year. This poor showing provides an advanced indication that recruitment may decline again in 1998, so we recommend that the 1997 harvest be precautionary.

Summary of Reviews and Subcommittee Discussions

Only one review of this paper was available. This reviewer noted the small sample size and the vertical distribution of fish during this year's survey, and queried whether this might indicate less confidence in this year's results. The classification used for recruitment classification was addressed, as well as the need for references to hake and temperature time series data.

The paper was accepted with revisions. The Subcommittee discussion ranged over the technical aspects of availability factors, the timing of recruits arriving on the spawning grounds, survey protocol, heteroscedasity of the data, and the predictive value of this year's data point. The Subcommittee felt that the predicted range of 1997 recruitment should be acknowledged, but that the paper should give some indication of the uncertainty in the analytical approach used. In this regard, it was agreed that statistical advice would be provided to the author by the Subcommittee

Appendix 6 (Cont'd)

H96-3 Herring carrying capacity and sustainable harvest rates in different climate regimes. D. Ware

The south-west Vancouver Island herring (WCVI) population undergoes large changes in productivity in response to interannual and decadal timescale variations in spawning biomass, and the state of the ocean ("climate regimes"). Protracted warm climate regimes along the B.C. coast have occurred twice in this century, shorter warm and cool regimes have occurred alternately about every 11 years. Recruitment is the most important process determining the biomass and productivity of the WCVI herring population. Stock reconstructions indicate that year-classes born in cool years (and cool climate regimes) are twice as large, on average, as those born in warm years. Surplus production calculations indicate that the unfished carrying capacity of this population is about 111 thousand tonnes when the environment and ecosystem are in a cool climate state, but is less than half as large (49 thousand tonnes) during a warm climate state. The population biomass is usually in transition between these two "equilibrium" states, as it responds to interannual variations in ocean climate and fishing mortality. This paper supports the following conclusions: 1) The WCVI herring stock can sustain catches exceeding 15 thousand tonnes during cool climate regimes. However, during warm climate regimes the sustainable catch is less than 8,000 t ; 2) The current low productivity (and catches) of the stock will not improve until the prevailing warm climate moderates and returns to an average, or cool state; 3) The current size of the population (ca. 29,000t) is close to the level which yields maximum productivity during warm climate states; 4) PSARC's herring management policy protects the spawning biomass and productive capacity of the stock, but the belief that a 20% target harvest rate is conservative everywhere, all the time, is not true for the WCVI population. A 20% harvest rate is close to the maximum this population can sustain at this time.

Summary of Reviews and Subcommittee Discussions

There were three reviews provided for this paper. The internal reviewer expressed the view that the paper was a useful and timely contribution. The classification of climate regimes as warm or cold was questioned. It was suggested that a more flexible analytical approach would be to consider the relationship as a multivariate problem, relating recruitment to temperature and spawn abundance and providing estimates of error in the relationship. A second reviewer addressed the sustainability of the 20% harvest rate and indicated advice resulting from the paper should be more conservative. The third reviewer supported the methodology for long term production analysis and identified disturbing patterns in long term production and sustainable exploitation rates. It was recommended that the conclusion, that exploitation rates be adjusted downward during periods of low productivity, be evaluated.

Appendix 6 (Cont'd)

The paper was accepted with revision. The Subcommittee agreed that evidence supported the contention for differential productivity of WCVI herring based on changing climate regimes. A number of revisions were suggested for the document: the method of classifying year classes into warm/cold regimes should be clarified; adult growth factors in varying climate regimes could be examined and incorporated in the calculation of sustainable harvest rate; the relationship between biomass and surplus production (fig. 6 and 8) could be interpreted as curvilinear rather than linear; the statement that 'an increase of 1° C doubles predator biomass' should be qualified; and previously derived surplus production estimates should be compared with those provided here. The Subcommittee addressed the concern raised by reviewers that the 20% harvest rate may not be sustainable. Given that the present exploitation rate has carried the stock through a very poor productivity phase, together with CUTOFF levels, the Subcommittee considers the present harvest strategy protects the stock in all climate regimes.

H96-4 Estimating natural mortality for Pacific Herring (*Clupea pallasii*) adults from the lower west coast of Vancouver Island. R. Tanasichuk.

I developed a regression equation which gives age- and year-specific estimates of natural mortality. Estimates of numbers of fish-at-age were made using the sampling database. I screened data using catch curves. The time series of catch curves suggested that some year-classes were sampled incompletely and that some are biased, based on the current state of knowledge regarding herring age-at-maturity. Therefore, I restricted analysis to the 1977-88 year classes. Regression analyses showed that natural mortality is negatively related to body size and sea temperatures in the late summer. Regression estimates of natural mortality agree favourably with those made by the age-structured but not the escapement assessment model.

Summary of Reviews and Subcommittee Discussions

There were three reviews of this manuscript.

Reviewer #1

The reviewer stated the results provided were interesting and the project worthwhile. Concern was expressed about the low r^2 values for the regression models fitted to the survival data and about their suitability as predictors. There was also some concern about the goodness of fit of the temperature data at 50m and how sensitive the resulting mortality regression is to variability in this relationship. Some confusion in the use of instantaneous and arithmetic mortality rates was noted and it was suggested that one consistent method be used throughout. The use of temperature as a surrogate for

Appendix 6 (Cont'd)

hake abundance was questioned and it was suggested that the hake abundance time series be used directly.

Reviewer #2

The assumption that the sampling gear used to obtain samples of age-structured and used to estimate M may be violated since it is unlikely that all gears will be unselective and have similar catchabilities. A question is also raised about the accuracy of the spawning stock estimates, error in which will bias the natural mortality estimates. The reviewer questions the structure of the regression model which appears to lump all ages and years and does not provide age-specific estimates of these parameters. More detailed description of the methodologies used in the estimation procedures are required. The non-independence of M -estimates is questioned since each estimate of numbers at age is used twice to provide an estimate of M at age x and time t and at age $x+1$ and time $t+1$ and so may bias the parameter estimates from regression. Additional statistics on the precision of regression parameter estimates should be provided. The paper is not consistent in its use of instantaneous mortality, percentage mortality and percentage survival.

Reviewer #3

Estimates of M for other B.C. stocks should be calculated and compared. Salinity is described as a possible mortality correlate but results of analyses are not presented. Other literature estimates of mortality not included in this review were noted.

This paper was accepted with minor revisions. There was extensive discussion within the Subcommittee of the possible underlying causes of the lack of agreement between estimates of natural mortality given in the paper and estimates of apparent survival rate estimated for the escapement model and used in forecasting abundance in the coming season. The discrepancy may result from the difference between biological maturity and availability to fishing and sampling gear. This could be examined through analysis of age composition of samples taken over the course of a season within an area. It was suggested that the two estimates of survival be evaluated as forecasting tools through a retrospective assessment of recent escapement model forecasts of abundance.

H96-5 The framework for a simulation model for the Pacific Herring (*Clupea pallasii*) population from the lower west coast of Vancouver Island - a progress report. R. Tanasichuk.

This paper presents the basic design for a herring population simulation model. The intended audience includes fisheries scientists, fisheries managers and clients. The

Appendix 6 (Cont'd)

goal is to develop a model which shows how variations in environmental conditions and various fishing strategies affect this herring population over 100 years.. Environmental conditions would influence growth, mortality and recruitment. Fishing strategies include CUTOFF and harvest rate. Basic outputs would be biomass and number of fish-at-age estimates, catch and number of years that fisheries would occur. This is not a simulation model yet. It does not include a variety of components which are required for a simulator. There are a number of limitations including consideration of parameter estimate variability and confidence limits for any outputs.

Summary of Reviews and Subcommittee Discussions

There were two reviews of the paper. The two reviewers agreed that the objectives of the paper were important: to incorporate environmental data into the herring assessment, and to provide managers and fishermen with a tool for exploring the consequences of management actions. However the model was inadequately described and documented and as a result could not be thoroughly reviewed. Both reviewers indicated that such a model should incorporate uncertainty such that those using it would be aware of the consequences of uncertainty about data and processes on management decisions.

A number of technical questions about relationships underlying the model were raised by one reviewer (eg. the formulation of the recruitment function, whether random allocation of temperatures was appropriate for exploring environmental effects). The other reviewer suggested that such a model should be tested with historical data to see whether these were well described; that expansion of the existing herring assessment model to include environmental data might be a better approach than building a new model; and that a spreadsheet application of such a model was unlikely to be satisfactory.

The Subcommittee accepted the paper as a progress report toward development of a model, on the understanding that reviewers' comments would be addressed in the final version. The Subcommittee noted that two objectives for a simulation model had been put forward in past discussions: (a) to provide a tool for exploring the consequences of management scenarios (b) to provide data on a known simulated herring population which could be subsampled and analysed using the age-structured model, with a view to better understanding how the ASM works under different conditions. The first objective did not appear to be a high priority at present but a model to meet the second objective would be very useful.

The work presented represents a valuable step toward meeting the second objective, in that a good biological framework for a simulation model has been developed. More

Appendix 6 (Cont'd)

sophisticated modeling and programming work would be necessary to build on the framework and develop a working model to allow exploration of performance of the ASM. The Subcommittee concluded that such work would be worthwhile and should be addressed during work planning for 1997/98.

H96-6 Retrospective analysis of B.C. herring stocks from age-structured model analysis. J. Schweigert.

Retrospective analysis of the abundance and trajectory of the five major B.C. herring stocks were conducted for the period 1986-1995. The retrospective stock trajectories for all areas were consistent with the most recent or baseline analysis of stock status. Performance of the age-structure model remains poor for the Prince Rupert area stocks but good for the other four stocks. The retrospective analysis indicates a tendency for the model to underestimate abundance for the Strait of Georgia and west coast of Vancouver Island with a small overestimation of abundance in a couple of years in the Queen Charlotte Islands and Central Coast areas.

The results of the retrospective analysis is generally consistent with the previous study by Haist (1991) lending some confidence to the stock assessment based on this catch-at-age model. The most interesting question for further study or refinement relates to need for a better understanding of the opposite tendencies to over and underestimate abundance in the northern and southern areas which would facilitate decisions on sustainable harvest levels during periods of stock declines.

Summary of Reviews and Subcommittee Discussions

There were three reviews provided for this paper:

Reviewer # 1

This external reviewer remarked that retrospective analyses have been a real eye-opener for a number of fish stocks, showing gross discrepancies between stock size estimates made each year and estimates made later with more information from the year classes present when the estimate was made. This is an important check on the assessment methods. The reviewer agreed strongly with the main conclusion of the paper that a priority should be given to examine reasons for the north-south trend in errors, including at least the possibilities that (1) there is a north to south movement of adults between first and later spawnings, and 2) there is a cline in vulnerability or maturation that is incorrectly appearing in the estimation as differences in natural mortality between areas. The reviewer raised some specific points that he requested be addressed in the revised paper.

Appendix 6 (Cont'd)

Reviewer # 2

This external reviewer remarked that the paper was successful in producing a retrospective analysis for the years 1991 -1995, but questioned why the analysis was not conducted back to 1986. The reviewer also noted that the time span of four years used in the analysis is unlikely to show large differences if the data quality has been consistent and the model has not changed. A retrospective analysis over a much longer time scale may show where estimates have been wrong in the past. A number of other minor points were raised that should be addressed in the revision.

Reviewer # 3

This internal reviewer concluded that this paper was not what he would consider to be an effective retrospective analysis, because it only compares model output over time. Therefore it describes model consistency but not model accuracy. This reviewer felt that a more appropriate test would be to compare model output with observational information about stock size, derived by adding the estimated spawn and the catch.

The Subcommittee discussed the implications of the north-south bias in the model estimates (the model overestimates in the north and underestimates in the south coast) and accepted the paper with revision. The author noted that he intends to incorporate retrospective analyses into future stock assessment reports. For future work, the Subcommittee recommended that the author use the spawning biomass and the natural mortality rates estimated by the escapement and age-structured models to retrospectively examine the ability of each model to forecast stock biomass. The results should identify which model is more accurate, and the differences, if significant, could be used to derive new weighting factors to improve the accuracy of future stock forecasts.

H96-7 Analysis of recruitment predictions in Georgia Strait - based on juvenile surveys - a progress report. D. Hay and B. McCarter.

Estimates of juvenile density (mean number per hectare) were determined from seine surveys from 1991 to 1994 in Georgia Strait (Haegele 1995 and Haegele *in prep*). The main objective was to develop a predictive capability for estimating the *relative* size of the recruiting (age 3) year class to the fishery, 2-3 years following the juvenile survey. In some years, a substantial part of the fished population (20-50%) consists of herring that were recruited in the same year. Present techniques provide no basis for anticipating the proportion of recruits in the fished stock. In previous PSARC meetings, participants have agreed that even a rough but accurate prediction into a few broad categories (i.e. poor average good) would be useful for setting future quotas. In this

Appendix 6 (Cont'd)

paper we compare the estimated juvenile density with the number of age 3 fish estimated independently 2-3 years later, from the age-structure analyses used for the annual assessments.

Herring spawn mainly in March and can first be captured by fine-mesh seines at about 80 days of age, in June. Generally, two survey times were used in the juvenile surveys: June and September. The June survey provides an estimate of the present year's (0+) cohort (age approx. 80 days), and the previous (1+) cohort (about 450 days of age). The September survey provides a second estimate of the 0+ cohort (at about 150 days of age) but the previous (1+) cohort was no longer present, and presumably had migrated out of Georgia Strait. Although the numbers of years for comparison are few (4), there is almost no coherent relationship between juvenile density and the estimated numbers of age 3 herring - as determined from the age-structured analysis. The estimated differences in juvenile density among years, however, are substantial (about a 10-fold difference) so even with few data points, we examine and *tentatively* reject the hypothesis that recruitment (defined as the number of age 3 recruits from age-structure analyses) is positively related to juvenile density - as it was estimated or measured in these surveys. We discuss the reasons for the low correlation between the two estimates and some assumptions about herring biology that may affect the results of juvenile surveys.

Summary of Reviews and Subcommittee Discussions

There were two reviews provided for this paper. Both reviewers were positive about the potential for this survey as a recruitment predictor and provided a number of suggestions for improving survey design. One reviewer recommended the survey be designed to encompass the changes in spatial and temporal distribution. He also recommended predator studies be incorporated into the survey design. The second reviewer suggested three possible reasons for the disappointing preliminary results:

1. Density dependence mortality between the time of the survey and the time of recruitment to the fishery;
2. Problems with variability in the survey itself and;
3. Problems with the estimates of recruitment.

The reviewer did however recommend that the survey continue for at least two more years in order to test the methods, and expressed concern that the present preliminary results not be misinterpreted.

Appendix 6 (Cont'd)

The Subcommittee accepted the paper, with revision, on the basis that it is an interim progress report. The Subcommittee discussion highlighted a number of further analyses that should be conducted with the data. Analyses of spatial distributions should be done, both to evaluate the present survey design and to explore spatially based indicators of the status of juvenile herring. Analyses relating components of survey results (abundance, distribution, etc.) to attributes such as temperature, salinity, etc. also need to be examined. Juvenile survey techniques employed in Washington State (mid-water trawl and hydroacoustics) may be considered for use in this program. It was noted that the recent years of consistent strong recruitment have not provided the contrasts in levels of abundance required to effectively assess the predictive ability of the surveys. It was also strongly recommended that available data be intensely analysed.

Appendix 7. Comparison of 1995 PSARC forecasts of 1996 herring abundance with estimates of 1996 observed biomass, catch, and escapement (all weights in tonnes).

ASSESSMENT REGION	1995 Forecast of 1996 Abundance		1996 Observed Biomass		1996 Catch	1996 Escapement
Queen Charlotte Isl.	6690	(poor)	9801	(good)	0	9801
Prince Rupert	21160	(avg)	26034	(good)	3930	22104
Central Coast	25770	(avg)	25132	(poor)	5178	19954
Georgia Strait	63350	(avg)	77949	(avg)	14012	63937
W.C. Vancouver Isl.	21440	(poor)	26279	(poor)	1445	24834
Totals	138410		165195		24565	140630

BIOLOGICAL ADVICE ON INVERTEBRATES

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I. STEERING COMMITTEE REPORT

The Steering Committee met September 18-19, 1996 at the Pacific Biological Station to review the Subcommittee report. The report was accepted, with the following comments and recommendations

The Steering Committee reviewed six Working Papers and major issues arising from the Invertebrate Fisheries Update presented by the PSARC Invertebrate Subcommittee.

The Steering Committee is encouraged with the progress made in the cooperative efforts between Stock Assessment and Fisheries Management in the preparation of the Working Papers for the fall PSARC Invertebrate Subcommittee meeting. The chair and Subcommittee members are acknowledged for their efforts in formalizing both the request for advice and preparation of Working Papers by Stock Assessment and Fisheries Management co-authors.

The Steering Committee supports and brings to the attention of RMEC four major concerns related to the assessment and management of Invertebrate fisheries:

- The issue of data sharing between sectors was raised as an issue affecting some major invertebrate fisheries. While significant progress has been made by Stock Assessment in data organization and inter-sectoral communications, problems exist in retrieving information and cross-referencing the various enforcement, licensing and management databases. The Steering Committee supports Subcommittee's recommendation that the status of FMISST be clarified and that commitment to the work be renewed.
- Concern was raised over the rapid expansion, technological changes and development in new unlicensed as well as currently licensed invertebrate fisheries. The Steering Committee supports the Subcommittee recommendation that both new fisheries and fisheries in new areas or with new gear on currently licensed species

be subject to the provisions of the "Pacific Region Guidelines for the Development of New Invertebrate Fisheries" (PacGDNIF). Steering Committee strongly endorses the Subcommittee comment that a precautionary approach to the management of these fisheries is not easily reconciled with continued passive management characterized by no effort or harvest controls.

- The Steering Committee supports the concern of the Subcommittee that the changes in the level of enforcement will compromise the current measures to achieve conservation and that alternative strategies should be evaluated if significant reductions are implemented. This issue was highlighted in the crab fishery with increasing evidence of illegal harvest.
- The Steering Committee very strongly supports Subcommittee's request that Environmental Impact Assessments (EIA's) come to PSARC for information and that PSARC be considered an appropriate body for review of EIA's on projects thought to have possible impacts on stocks and ecosystems.

Steering Committee provided the following comments pertaining to individual Working Papers summarized in the Subcommittee Report.

196-8 Quota options and recommendations for the 1997 and 1998 geoduck clam fisheries.

Steering Committee accepts the quota recommendations as presented and calls attention to Subcommittee recommendation #3 supporting the need to continuing with research underway investigating methods to provide estimates of sustainable harvest rates.

196-9 Stock assessment and quota recommendations for 1996-1997 for the Green sea urchin fishery in British Columbia.

This is the second green sea urchin assessment which includes the validation and correction of logbook data, estimates of variance and a recalculation using a more appropriate division of the fishing year. Steering Committee questions the use of CPUE in this fishery assessment. However, it was recognized that there are problems with local depletion but noted that by using the median value calculated on individual logbook records a more conservative estimate of quota is provided.

Steering Committee is realistically comfortable that the current management is sufficiently conservative. Steering Committee supports the expansion of fishery independent surveys and encourages research on both biological parameters and management regimes.

Steering Committee endorses the recommendation in the Subcommittee report on yield options and research recommendations and notes that the Subcommittee advises using caution in setting TAC's.

196-10 Assessment of the 1995 Seal Island intertidal clam survey.

Steering Committee recognizes that this paper provides an estimate of butter clam biomass on Seal Island. However, lacking information on other biological parameters (for example; recruitment), advice on the management of this fishery cannot be given. Steering Committee supports ongoing research on biological stock parameters and the presentation of these results. Steering Committee notes that this work will be, in part, completed as graduate work by an SFU student. Steering Committee supports the first three recommendations from the Subcommittee.

Steering Committee reiterates its call for a paper evaluating the feasibility of alternative management regimes for intertidal clams. The general issue is addressed in Major Steering Committee Comments. In the specific case of inshore clams, there may be areas where past harvests are well documented and current and future removals are believed to be fully regulated. In such areas PSARC may be able to provide evaluations of resource status and advise managers of harvest options. In many areas, however, even such basic circumstances do not apply and Steering Committee advises that there would be no basis for advice, if it were requested.

196-11 Assessing the inshore shrimp fisheries: Data status, model requirement and problems.

Steering Committee supported the Subcommittee recommendations in this Working Paper. Steering Committee noted that the inshore shrimp fisheries have no restrictions (time, gear, area) to effectively protect this fishery from over exploitation. Steering Committee noted that this paper indicated that there is evidence of increasing fishing pressure and that some stocks (Area 28/29) are showing signs of over-exploitation.

Steering Committee stresses the importance of Recommendation #2 that "given present uncertainties over sustainable harvest levels in these fisheries, indications that some stocks are presently overexploited and expectations that effort will likely increase, there are considerable risks to the sustainability of these fisheries".

196-12 Scientific advice for the management of the sea cucumber fishery in British Columbia.

Steering Committee reviewed the Subcommittee's summary of this paper and the proposal put forth by the Subcommittee for an experimental approach to the management of this fishery. Steering Committee advises that recommendations for management of this fishery will require extensive consultation and cooperative efforts between all DFO sectors and all stakeholders. Steering Committee stresses that the Subcommittee recommendations are to ensure conservation, minimize disruptions to the existing fishery and improve our ability to collect the necessary biological information required to manage the fishery in a sustainable manner. This is a unique opportunity as it is a relatively new fishery and industry supports an innovative management regime.

Steering Committee supports the Subcommittee recommendations including allocating a set 50% of the coastline be excluded from harvest for the foreseeable future for conservation. Steering Committee advises that the identification of areas for exclusion is an important issue which needs to be done in consultation with Science, Management and stakeholders.

196-13 The influence of interannual variations in sea temperatures on the population biology and production of *Thysanoessa spinifera* and *Euphausia pacifica* in Barkley Sound and its implications for the management of commercial krill fishing.

The Steering Committee accepts this paper with the understanding that the Subcommittee recommendations for revisions outlined in the Subcommittee report will be done. The Steering Committee supports the Subcommittee in considering that there is not adequate information available to provide advice on changes to harvest levels of euphausiids.

Major Issues Arising from the Fisheries Updates

In addition to the general recommendations and comments outlined in the Introduction of this report, the Steering Committee wishes to highlight the following issues arising from the Fishery Updates:

Clams

Concern was raised related to the harvest of sub-legal clam from Aquaculture leases and its impact on progress being made in the enforcement of the size limit in wild clam fisheries. Steering Committee urges RMEC to pursue this concern with officials in Headquarters. In the meantime, the Steering Committee urges RMEC, in consultation with industry and the Province, to develop marketing arrangements that will minimize the disruption to enforcement of the size limit in the wild clam fishery.

Crab

The Steering Committee noted that the catches from Area A, Hecate Strait, which currently comprises the bulk of the catch, are beginning to decline. This is an example of an existing fishery where we are unable to collect the necessary biological information to evaluate fluctuations in populations and the impact of the fishery on these stocks. The need for the collection of biological information and evaluation of alternative management approaches was highlighted.

Non-reporting and incorrect reporting of catch remain a problem in the crab fisheries. This fishery would benefit from improved cross validation of harvest logs and sale slips, one of the issues which could be addressed for through revitalization of FMISST.

Shrimp Trawl

Concerns related to sustainability of the inshore shrimp fisheries under the current passive management regime are noted under Working Paper I96-11. The Steering Committee highlights the continued increase in effort in 1996 in both traditional and non-traditional fishing areas. Steering Committee notes similar concerns in the offshore shrimp fisheries.

Subcommittee advised Steering Committee of the expansion of the Shrimp Trawl fishery into traditional prawn by trap fishing areas to target on humpback shrimp and potential prawn by-catch concerns and gear conflicts. Steering Committee notes that a briefing note is being prepared for consideration by RMEC.

II. INVERTEBRATE SUBCOMMITTEE REPORT

1. Introduction

The fall meeting was held at the Pacific Biological Station, beginning on Monday, September 9, 1996 and adjourning on Friday, September 13, 1996. A list of participants is appended. The Chair congratulated authors of Working Papers who had, possibly for the first time in PSARC history, succeeded in submitting their papers on time (and without too many dire threats from the Chair!) Timely submission allowed for thorough review of all papers by a diverse set of reviewers. In addition to the six Working Papers, the Subcommittee discussed 14 Fishery Updates and from them formulated fishery-specific recommendations. The Subcommittee also discussed four other issues relevant to PSARC and to invertebrate fisheries in the Pacific Region. At the conclusion of the meeting there was consensus that substantial progress continues to be made in improving the assessment of invertebrate stocks in the Region and in the provision of quality advice to Management.

2. Summaries of Working Papers, Reviewers' Comments, Subcommittee Discussions and Recommendations

I96-8 Quota options and recommendations for the 1997 and 1998 geoduck clam fisheries. C. Hand, K. Marcus and S. Heizer

Working Paper Summary

Geoduck (*Panopea abrupta*, Conrad 1849) stocks were examined for the north coast, west coast of Vancouver Island, and waters inside Vancouver Island. The assessment methodology has not changed from previous assessments. It is a habitat-based approach where the area of geoduck habitat reported by fishers, estimated geoduck densities and mean weights, and an estimated sustainable harvest rate are

incorporated into quota calculations.

In response to a request by fishers for more stable quotas, data were compiled from the 1994 and 1995 fisheries and quota options are presented for the 1997 and 1998 fisheries. Changes in biomass and quota calculations include the use of new survey data for estimates of geoduck density, the use of new estimates of mean geoduck weight from commercial market samples, and increased measurements of harvest areas from new geoduck beds. The approach initiated in 1994 of reducing quotas where over-harvesting had occurred, according to stock status relative to a 50-year cycle, was continued coast-wide, as was the correction of landings reported on harvest logs with sales slip or port validator information. A range of quota options are presented, based on the uncertainty around mean geoduck densities from survey data.

For the 1997 fishery, recommended low medium and high quota options are 3,442,381 lb. 4,020,356 lb. and 4,807,743 lb. Quota options for the 1998 fishery are 3,220,588 lb., 3,840,172 lb. and 4,487,985 lb.

Reviewers' Comments

The first reviewer found the paper thorough and well presented, and noted admirable progress has been made in geoduck assessment methods and work which is planned. The reviewer did state that the high and low bounds on the quota estimates have little meaning, and suggested additional calculations which he believed were necessary for the range of quotas to reflect the actual uncertainty in sustainable harvest levels. The reviewer also questioned the statement in the Working Paper that errors in estimating bed area and bed density would compensate for each other.

The second reviewer provided an extensive review, which questioned most of the basis for the assessment and quota estimates. The reviewer rejected the present ITQ management approach to geoducks, and believes that a lease tenure system was necessary for such species. A number of comments followed from that argument, but will not be summarized.

With regard to the actual Working Paper and current management approach, the second reviewer:

1. expressed belief that "The fishery is in a fishing up phase, such that there is no biological reason to limit catches in the short term";
2. noted the spatial scale of geoduck population dynamics is very small compared to the units being managed;
3. questioned Gulland's method for estimating harvest, and has little confidence that the improvements present in the Breen equation used for geoducks overcame the shortcomings of the method;
4. presented a number of criticisms of the methods for estimating both M (the natural mortality rate) and B_0 (the virgin biomass), two parameters which are used to estimate quotas;

5. conjectured that If all the sources of uncertainty were included in the quota estimates, the range would so wide as to be of no use to managers, and noted that the present quotas grossly underestimate the actual uncertainty in quotas;
6. objected that the Gulland-Breen method provides only equilibrium estimates of harvest levels, but the stock is not presently in equilibrium, and will not reach equilibrium for decades;
7. suggested that for the present assessment, the quotas should be recalculated with an exploitation rate half or less the present 1%, and all sources of uncertainty should be included in the estimates; and
8. indicated that a discussion of the non-equilibrium dynamics of geoducks should be added to the paper.

The reviewer also had several criticisms of the survey methods, relating to bed definition, biological patchiness, data management, replication and fishing history.

Subcommittee Discussion

In response to the reviewers' comments, the authors noted that the exploitation history of geoducks differs greatly among sites. Although some areas may be in a "fishing up" state, other beds now should have the characteristics of a fully exploited resource. The survey results and catch histories are being used at present to address the history of each fished area. The survey methods were reviewed thoroughly in the Spring 1996 meeting, and accepted by the Subcommittee. Most of the problems with area surveyed mentioned by the reviewer occurred with the early surveys. Improvements in survey design, and re-analysis of the earlier survey data should ensure survey results are now consistent over the full time series.

The Subcommittee requested that more detail be included in the Working Paper, perhaps as an Appendix, so the paper would contain the information needed by managers to allocate catches on a bed by bed basis.

With regard to reviewers' comments on appropriate harvest rates, the Subcommittee strongly endorsed the current management approach of determining the TAC. The extremely long life span of geoducks, past revisions to estimates of B_0 , and lack of knowledge of the relationship between productivity and standing stock, all justify the current management strategy. After substantial discussion the Subcommittee acknowledged that there is uncertainty about the biological basis of the present value of 1% of estimated biomass. However, the Subcommittee endorsed the advice from Subcommittee Report 92-6 [to be checked] that the current harvest rate of 1% will not damage the resource, even if sustained over a decade or more. The Subcommittee also noted that only by maintaining the harvest rate a consistent value over a number of years will it be possible to evaluate the sustainability of the harvest rate. Therefore the Subcommittee advised continued use of the 1% harvest rate while multi-year research projects designed to evaluate the sustainability of that harvest rate are completed, analyzed, and reported on.

The Subcommittee noted that even without considering uncertainty in the target harvesting rate, the range of quotas reported in the draft Working Paper is smaller than the range of quotas that would result from including the full uncertainty in the B_0 estimates from the surveys. In the revised Working Paper the quota estimates should include uncertainty due to bed area, and mean weight, as well as uncertainty due to bed density. While inclusion of these additional sources of uncertainty means the final advised quota range is likely to be wider than the range available when RMEC considers the Subcommittee Report, the midpoint of the range is not expected to change.

The Subcommittee discussed at length the multiple sources of uncertainty in making biomass estimates. With regard to uncertainty in bed area, it was acknowledged that the area and density estimated for a bed are inter-related. Bed boundaries are not abrupt, and different surveyors may apply different criteria to deciding on the boundaries of geoduck beds. However, as long as a bed, once defined, was surveyed in an unbiased manner, B_0 contains the product of density and area, and should be sufficiently robust. For the present analysis the uncertainty in bed area to be included in the advised quotas is the uncertainty due to inaccuracies in transcribing bed areas from logbooks, compared to bed areas estimated from other sources, including surveys, monitored fishing, and on-grounds observers. The level of transcription inaccuracy should be estimated for sites where logbook estimates of bed area can be augmented by data from other sources, and be applied to all estimates of bed areas from logbooks. Other sources of uncertainty, such as the estimation and use of show factors, and the extrapolation of survey result from sampled beds that are not selected at random from the area being extrapolated to, were mentioned. The Subcommittee was of the opinion that substantial progress is being made on resolving those issues and that it is now necessary to pursue reductions in the uncertainties associated with natural mortality rates, recruitment processes, and determining sustainable harvest rates.

Subcommittee Recommendations

1. The Working Paper is accepted with the revisions noted above, and modifications to equations and text which clarify points where the reviewers found the draft unclear.
2. Conditional on the completion of the required revisions, the quota estimates are accepted and are recommended for use in determining fishing quotas.
3. Research to quantify how criteria for setting bed boundaries affects estimates of bed area and density would be of value, but the Subcommittee considers such research to be a lower priority than research on other parameters used in calculating quotas. *The Subcommittee recommends that priority should be given to completing and reporting on research to improve estimates of sustainable harvest rates.* Research on recruitment to beds which have been harvested previously, where experimental manipulations have been performed, or where enhancement activities have been undertaken, is particularly important.

**196-9 Stock assessment and quota recommendations for 1996-1997 for the
Green sea urchin fishery in British Columbia. I. Perry and B. Waddell**

Working Paper Summary

The fishery for green sea urchins (*Strongylocentrotus droebachiensis*) on the British Columbia coast developed rapidly from 1987 to 1991, and peaked in 1992 with landings of 1042 t. Declining landings and catch per unit of effort followed and management restrictions were implemented in 1992. In 1995, coast-wide landings were 159.3 t, with South Coast landings of 153 t, slightly below the quota of 173.4 t. The principal Pacific Fishery Management Areas for green sea urchins are 12, 13 (Queen Charlotte and Johnstone Straits) and 18, 19, 20 (Gulf Islands - Juan de Fuca Strait). Harvest logbook information was examined, and required extensive editing. Median catch per unit of effort (CPUE) was calculated from the harvest logbook data to provide a robust index of potential changes in stock size. Analyses were conducted on a fishing season basis (1 October of year i to 31 March of year $i+1$); key results are also presented on a calendar year basis for comparison. In general the comparison was good, with the fishing season data providing slightly better results. Biomass dynamic models were developed for coast-wide, South coast - inside waters northern region (PFMA 12,13) and South coast - inside waters southern region (PFMA 17-20,28). Precautionary reductions of 30-50% from the estimated MSY are recommended to account for uncertainties in the input CPUE data and weaknesses in the dynamic production models. Recommended yield options for the South coast range from 175-244 t, very similar to those proposed for the 1995-96 fishing season. Yield options are provided for the North coast but are based on very little data. Three fishery-independent surveys were conducted in a core fishing area; the estimates of MSY from these surveys for PFMA 12,13 is similar (within 13%) to the MSY estimated by the dynamic production model. Results from a single exploratory fishing operation to the west coast of Vancouver Island are presented for information. Recommendations are provided on improvements to the harvest logbook process and database, quotas by management area, and provision of fishery-independent and biological information.

Reviewers' Comments

The first reviewer argued that the analysis was not adequately supported by biological or fishery data. The reviewer expressed concern over the estimation of the parameters used in the Gulland model employed by the authors and cautioned that the elegance of the model masked the uncertainty in the data. The reviewer suggested omitting calculation of MSY and substituting 'a more intuitive approach' to quota setting. The reviewer liked the fishery independent surveys.

The second review was favorable. The reviewer supported setting the TAC at 30% to 50% of the calculated MSY and would favor the more conservative value. The reviewer also liked the use of fishery independent surveys. The reviewer suggested using alternatives to Hoenig's model that was used by the authors to estimate natural mortality (M).

Subcommittee Discussion

The paper was generally well received. The Subcommittee discussed alternative analytical approaches that might be applicable to these data. While accepting the current analysis, the Subcommittee concurred with the suggestion of the second reviewer that a time series model should be pursued in further analyses. The Subcommittee discussed and accepted the scaling factor used in determining TAC from the calculated MSY. The subcommittee endorses the improvements made to the database design and implementation and also endorsed the change made to the time period of the analysis, which was changed from the calendar year to a 'fishing season' year. The Subcommittee also strongly endorsed the expansion in fishery-independent surveys that has been made in this fishery.

Subcommittee Recommendations

1. The Subcommittee accepted the paper with several minor revisions:
 - (i) the clarification of uncertainties in input parameters to the biomass production model;
 - (ii) clarification of how the scaling factors used to calculate the recommended TAC from the MSY were derived;
 - (iii) removal of commentary about fishing plans from the author's recommendations;
2. The Subcommittee endorses the range of yield options recommended by the paper and urges the usual exercise of caution in assigning TACs.
3. The Subcommittee recommends continuation of fishery-independent surveys with core or traditional fishing areas and recommends that such surveys be extended to other areas.

196-10 Assessment of the 1995 Seal Island intertidal clam survey. J. Osborne and G.D. Heritage.

Working Paper Summary

Intertidal clam surveys have been conducted at Seal Island, British Columbia (49° 37.8'N, 124° 51.8'W) since 1940 to provide information on recruitment, growth, age structure, natural and fishing mortality of butter clams (*Saxidomus giganteus* [Deshayes]) and co-occurring species. These surveys were conducted triennially from 1940-1982 and have been conducted twice since 1982 (1992 and 1995).

The 1995 intertidal clam survey at Seal Island was conducted in response to concerns that butter clam stocks were declining and that few sublegal butter clams were present during 1994. We provide point estimates of legal and sublegal butter clam abundance

and biomass for 1995 and compare these to similar estimates from previous surveys. A relative recruitment index is defined and calculated for legal butter clam stocks from 1945-1995. Brody-von Bertalanffy growth parameters are calculated and presented. Length, weight and age frequencies of sampled clams are also presented. Abundance of legal clams is significantly above the long-term average (1949-1995). Abundance of sublegal clams is below the long-term average but not significantly so.

Reviewers' Comments

Both reviewers had similar comments and suggestions. Both comment that the paper did not build sufficiently on recent studies, and that it was not likely to help managers to understand the biological consequences of possible management options.

Reviewer 1 in particular felt that it was time to move beyond the analysis of a survey as the only output of the assessment process. Both reviewers were critical of the recruitment index developed in the paper, critical for statistical reasons and because it did not address the question of potential future yield. Both reviewers also criticized the use of the term "healthy" to describe this stock, as it was defined to imply only that the abundance estimate of legal-size clams in 1995 was above the historical mean.

Reviewer 1 provided a number of detailed comments on the statistical methodology, in particular the inappropriateness of the "mean model" for evaluation of this type of survey data, and the process used for sorting for small sized clams (screening vs. non-screening).

Reviewer 2 commented on the inappropriateness of including analyses of littleneck clams in this paper since the survey did not cover the full local distribution.

Subcommittee Discussion

Discussion centered on whether the original purpose of the manuscript was an analysis of the 1995 survey data or a synthesis of all historical surveys. The primary purpose of the manuscript was to report on the current status of the stock, i.e. the survey results. However, there is a need for scientific evaluation of the present management strategy and in particular whether or not the current fishery closure should be maintained. It was agreed that this paper should provide an analysis of the survey results, and secondarily provide comparisons with historical data where possible. It was also noted that inclusion of littleneck clams is inappropriate as the survey area did not encompass the full distribution of littleneck clam. The Subcommittee requires the following revisions to the paper as outlined below:

1. deletion from the paper of analyses and discussion of littleneck clams;
2. removal of commentary on the "health" of the stock;
3. clarification and improvements to sections on the procedures used for screening of samples and, in particular, whether the purpose of this procedure was to estimate the biomass of sublegals or was to compare the efficiency of digging

- versus screening for the sampling of sublegals;
4. correction of survey methods by replacing the "mean method" with alternatives as suggested by the reviewers;
 5. following the recommendations of Kingzett and Bourne (1995) the authors are requested to determine whether there were gains in efficiency due to the adoption of a stratified sampling design;
 6. deletion of Objective 3 (".. provide other relevant information for management..") and modification of objective 1 to include "provision of relevant biological information";
 7. deletion Objective 4 (".. provide recommendations on the status of the fishery");
 8. deletion Objective 5 ("..recommendations regarding the ..data set) as an explicit objective, but continue to include comments in the paper.
 9. inclusion of a comparison of recent and historical data on abundance and biomass of legal-sized butter clams in the Seal Island survey area;
 10. inclusion of comparisons of biological characteristics over the historical data series, such as: age, size, growth parameters (calculated following Mittertreiner and Schnute 1985);
 11. inclusion of a table of historical catches from this area.

Subcommittee Recommendations

1. The Subcommittee accepted the paper subject to the major revisions detailed above.
2. The Subcommittee notes that estimates of the abundance of young (i.e., small or sub-legal) clams is important for furthering our understanding of recruitment processes and in the short-term is critical for the formulation of suitably risk-averse management.

The Subcommittee recommends that further work on the cost-effectiveness, efficiency, and benefits of screening for small clams during surveys be undertaken.

3. The Subcommittee continues to support recording of all removals of clams from this area on spatial scales that are comparable to survey data.
4. The Subcommittee notes that Management continues to request advice on whether there are biological benefits to continued closures in the Seal Island clam fishery. The Subcommittee is of the opinion that scientifically defensible advice on this matter cannot be generated from existing survey data given our lack of understanding of recruitment processes in clams. The Subcommittee endorses both continued analysis of existing data and experimentation with the objective of providing such advice.

196-11 Assessing the inshore shrimp fisheries: Data status, model requirements and problems. J. Boutillier, M. Joyce, J. Bond and I. Winther

Working Paper Summary

Managers expressed concern about increased effort in the small inshore shrimp trawl fisheries. In response to this concern, we analyzed landing slip, logbook and biological sampling data from the Area 4, 14, 17 and 28/ 29 shrimp trawl fisheries. The paper tries to answer these questions:

1. Is there any evidence that the inside stocks of shrimp are being subject too increased fishing pressure?
2. Are there any indications that stocks are being put at risk with these increased pressures?
3. What are the options for controlling the fishery in a manner that assures sustainability,

Effort is increasing in most areas. Shrimp populations in the most heavily exploited area (Area 28/29) are showing signs of over-exploitation. To address the third question we discuss a framework for developing a management system for these fisheries.

The recommendations for the fishery include implementing an active management program for these fisheries and improving the information gathering systems.

Reviewers' Comments

The comments of the first reviewer were largely favorable. The reviewer cautioned about inferences drawn from the presence of primary females, noting that explanations other than high fisheries mortality could account for their presence. The reviewer suggested that the inclusion of information about experiences in other coastal shrimp fisheries would have bolstered the authors' arguments in several instances. The reviewer also suggested the nature of data limitations be made more explicit in the paper. Doing so would provide more direct support for some of the recommendations. The reviewer requested that a map be included showing all of the areas mentioned in the WP.

The second reviewer provided comments on specific points of the Working Paper but no overview comments. By way of editorial comments, the review requested maps of the referenced areas and suggested that the descriptions of individual fisheries could be succinctly presented in tables rather than in narrative form. The reviewer questioned how much high quality habitat was available to shrimp in the fished areas and cautioned that if the shrimp populations expanded the areal extent of habitat used as their numbers increased (i.e., maintained a nearly constant density) then one of the models used to estimated production (the Leslie Depletion Model) was not appropriate.

The reviewer requested that summary statistics be presented for at least the CPUE data presented. The reviewer expressed confusion over the section of the Working Paper on gear standardization and questioned the inclusion of results of modeling that were either not explicable or that provided a poor fit to the data.

Subcommittee Discussion

The Subcommittee agreed that inclusion of information on shrimp fisheries in other jurisdictions would be useful but noted that that information would largely be for offshore or open water areas. The possibility that the stock dynamics of at least some inshore populations can be described by stock-recruitment relationships would suggest that offshore experiences where stock-recruitment relationships are not applicable will be of limited utility. Since stock-recruitment models might provide "better" estimates of sustainable harvest rates the Subcommittee recommended that the data needed to further explore their applicability should be collected. Any improvement to habitat information or to the delineation of core habitat (where the shrimp are found at low abundance levels) would require geo-referencing of logbook data, and the Subcommittee agreed that the necessary change to the logbook program to accomplish this should be instituted. The Subcommittee expressed concerns of any situation where assessment is dependent on CPUE calculations where there is evidence of "hyperstability" (CPUE is invariant over wide ranges of abundance). That discussion led to a recommendation for the development of fishery-independent surveys for the inshore shrimp fisheries.

The Subcommittee agreed that the WP had provided adequate evidence of increased fishing pressure in those areas studied but not necessarily for all coastal areas. The Subcommittee noted that the authors had provided no definition of risk and had provided no risk analysis in the WP and so had not achieved their second objective as stated. However, the Subcommittee did agree that some of the stocks (Area 28/29) are showing signs of over-exploitation.

The Subcommittee had a wide ranging discussion on the stock assessment options for this fishery. The Subcommittee agreed that there was insufficient data available from the current assessment activities to select among the alternative stock assessment and management approaches suggested. The Subcommittee notes that the information required to select and develop an appropriate assessment and management strategy could be collected through fishery-independent surveys, geo-referencing of harvest log data and biological sampling in all fisheries.

Subcommittee Recommendations

1. The Subcommittee accepted the paper subject to major revision as follows:
 - (i) inclusion of maps showing all areas referenced;
 - (ii) providing descriptions of the existing fisheries in tabular rather than narrative form;

- (iii) inclusion of information and experiences from shrimp fisheries in other jurisdictions;
- (iv) clarification of the effort standardization attempted and why it was not used in subsequent analyses; and
- (v) clarification of data limitations throughout the analyses.

2. ***The Subcommittee advises that given present uncertainties over sustainable harvest levels in these fisheries, indications that some stocks are presently overexploited and expectations that effort will likely increase, there are considerable risks to the sustainability of these fisheries.***
3. The Subcommittee endorses recommendations in the Working Paper for fishery independent surveys, geo-referencing of harvest logbook data and biological sampling in all areas.

196-12 Scientific advice for the management of the sea cucumber (*Parastichopus californicus*) fishery in British Columbia. J. Boutillier, I. Campbell, R. Harbo and S. Neifer.

Working Paper Summary

At present the fishery on sea cucumber (*Parastichopus californicus*) populations in British Columbia is not providing the necessary information to allow assessment and evaluation of the impacts (if any) that exploitation is having on the stocks and their ecosystems. This paper suggests a theoretical management approach (Phase 0) based on all known information on *P. californicus*. Estimates initial biomass are derived by measuring shoreline lengths, applying a conservative estimate of sea cucumber density (previously estimated in Alaska) per meter of shoreline and calculating the biomass using fishery related measures of local mean weights of sea cucumbers. Estimates of quotas are base of several theoretical exploitation rates (7.4%, 6.4%, 4.2%) applied to the initial biomass estimates. The fishery is recommended to proceed using the present arbitrary quota proportioned on an annual bases by area depending on the proposed exploitation options chosen. Thereafter within the next Phase 1 of the fishery, the objective is to conduct the fishery in a manner which either proves or disproves the theoretical management system. That is fishery independent data must be collected in a manner which allows the testing and refinement of the initial theoretical management system and the associated uncertainties. This could include alternatives as follows:

1. Identifying and establishing general commercial fishing areas to be fished on an annual basis at a conservative sustainable level (quotas should be based on the smallest spatial scale practical i.e. the sub-area level). The actual area required to meet these conservative levels, varies from 14% to 25% of the total B.C. coastline. There should be no change in the present quota until surveys indicate otherwise.
2. Identifying and establishing "experimental management " areas at the sub-area level where different exploitation levels are conducted on an annual basis.

3. Identifying and establishing reference areas closed to fishing to act as "controls" to compare population dynamic responses with fished areas and determine their potential as refuges for brood stock protection. These areas should include all the areas not harvested, ie., 75% to 86% of the total B.C. coastline.
4. Identifying random locations for "test fishery" sampling areas. These areas would be about 100 m of shoreline randomly placed in statistical sub-areas where an attempt would be made to remove all sea cucumbers. The optimal size, number, placement of these "test fishery" sampling areas will need to be determined after some preliminary data is collected with respect to variance of the density, this initial information may be collected this year prior to the 1996 fishery, if a voluntary transect assessment program can be arranged. Prior to the removal of animals in the test fishery, a transect survey would be conducted in the test fishery area. In this way, two measurements of biomass could be made and the sea cucumbers harvested could be used to pay for the survey.
5. Conduct annual fishery independent surveys to determine biomass in identified areas for:
 - (i) modifying the quota calculation i.e. improving the estimates of density of cucumbers;
 - (ii) evaluating the effects of various exploitation rates in the experimental management areas including zero exploitation reference areas. From the data collected, information obtained on biomass, growth, and mortality, could be used in other production models to produce more detailed estimates of production and quotas for sea cucumbers in British Columbia.

Reviewers' Comments

Both reviewers lauded the authors efforts in providing an overview of status of current knowledge related to sea cucumber fisheries and biology, and their proposed plans for management of the fishery and for collection of scientific data required for assessment of sea cucumbers. Each reviewer had specific comments on the manuscript in general, the management plan and the recommendations presented.

The first reviewer suggested a more rapid fishing down of the resource in experimental areas before different harvest rates are examined. He agreed that survey estimates were superior to commercial CPUE estimates, but questioned the authors assertion of hyperstability of CPUE, in relation to the spatial scale of resource distribution, recruitment patterns and the scale on which information is collected and analyzed. He further recommended survey design options to be considered regarding hypotheses of the spatial distribution of cucumbers. He also felt that the longevity information presented in the paper was more uncertain than the authors presented, particularly in

view of its importance in the production model employed.

The first reviewer suggested modification of the management plan to provide increased incentive (i.e. increased access to the resource) to clients to participate in experimental fisheries. He further discussed the time scale of the experimental fishery for depletion estimates of B_0 , recruitment overfishing and ecosystem changes.

The second reviewer expressed concern that predictions regarding cucumber productivity (the basis for the range of proposed harvest rates) may not be measurably different under the experimental policies presented. He suggested that more immediate work regarding recruitment patterns and life history be undertaken with the goal of determining which population model is appropriate before attempting to estimate model parameters.

Both reviewers expressed concern regarding the derivation of confidence intervals in the calculation of virgin biomass (B_0), in particular the variation of the estimate of habitat size, which is treated as a measured constant, and the selection of the lower confidence limit of mean density from a single site (the lowest estimated density of Alaskan surveys) rather than from the pooled results of all Alaskan surveys. The second author suggested an alternative model relating sustainable harvest to habitat size (as estimated by shoreline length) scaled by a constant.

Subcommittee Discussion

Subcommittee members re-iterated the authors concerns regarding expansion of the fishery in light of the dearth of biological knowledge available for cucumbers, and recognized the value of an experimental fishery approach to provide the biological information required to formulate defensible assessments of the cucumber fishery. Further discussion concerned the defensibility of the TACs presented in light of reviewers' concerns regarding the analyses used to derive them, the spatial scales of the resource and the resolution of the experimental design and proposed data collection, the appropriate extent of the coastline to put into the refuge areas, and the defensibility of proposed exploitation rates in light of the uncertainty in determining cucumber ages and the reliance of the production model on mortality rates.

The Subcommittee stated that, in light of uncertainties regarding cucumber longevity, mortality rates and productivity, a risk-averse management approach would require that at least 50% of the coast be excluded from harvest. They recognize, however, that the experimental fishery is required to assess the response of the resource to harvest on various spatial scales and to resolve biological uncertainties. They recommend that the precautionary TAC of 238 t coast-wide be maintained. The harvest rates and density estimate presented in the paper indicate that the current TAC can be achieved using no more than 25% of the coastline, and recommend that this be divided into a number of non-contiguous harvest areas. Additional experimental harvests can be conducted cooperatively over up to an additional 25% of the coastline. Removals from the experimental areas would be only in conjunction with research activities and could be

incremental to the precautionary quota. At least 50% of the coast will be retained as a refuge, to address conservation concerns. The Subcommittee advises RMEC that further development of the cucumber fishery is critically dependent on provision of biological information identified in the Working Paper.

Subcommittee Recommendations

1. The Subcommittee accepts the WP subject to minor revisions, notably clarification of the selection of average sea cucumber density (D_0). The Subcommittee notes that the WP has provided a well-presented and comprehensive summary of the biology and fisheries experience for sea cucumbers as required by the phase 0 component of the Framework for the Assessment of Data-limited Invertebrate Fisheries (I96-6).
2. Given the significant uncertainties in our knowledge of such important biological parameters as natural mortality rates, longevity, age distribution and productivity, the Subcommittee advises that the coast-wide TAC recommendations in the WP are conservative and recommends their acceptance.
3. The Subcommittee recognized that the harvest rates presented in the Working Paper are conservative, and that the recommended coast-wide TAC could be achieved with these harvest rates by exploiting less than or equal to 25% of the British Columbia coastline. The Subcommittee recommends that this 25% (consisting of numerous non-contiguous harvest areas) be identified for commercial harvest.
4. In accordance with a risk-averse stance in this fishery the Subcommittee recommends that at least 50% of the coastline be excluded from harvest for the foreseeable future.
5. Resolution of biological uncertainties requires an experimental fishing approach that explores population responses to varied spatial scales of harvest. The Subcommittee recommends that approximately 25% of the coastline be identified and set aside for the experimental fishery. The Subcommittee notes that prosecution of an experimental fishery will probably result in a catch above the advised precautionary TAC.

I96-13 The influence of interannual variations in sea temperature on the population biology and production of *Thysanoessa spinifera* and *Euphausia pacifica* in Barkley Sound and its implications for the management of commercial krill fishing. R. W. Tanasichuk.

Working Paper Summary

The author monitored the growth, mortality, reproduction and productivity of euphausiids (*Thysanoessa spinifera*, *Euphausia pacifica*) in Barkley Sound between

May 1991 and March 1996. The impetus for the work was their importance to planktivorous fish. Significant ocean warming events (El Nino Southern Oscillations, ENSO) occurred in 1992 and 1993, which affected mortality but not growth. Abundance, biomass and production declined steadily since 1992. In 1995, they were 32, 25 and 20% respectively of the 1991 levels. Changes in the adult euphausiid biomass may be due to increases in hake (*Merluccius productus*) and mackerel (*Scomber japonicus*, *Trachurus symmetricus*) abundance during the ENSO events. The author found no relationship between parental and recruit abundance. This indicates that ocean conditions have not favored recruitment since 1992. Fish (hake, Pacific herring) abundance along the lower west coast of Vancouver Island appear to have declined over the last few years. The large decline in euphausiid production may have implications for nutrient recycling because of the loss of the euphausiid contribution to detritus as molts and feces. This work suggests that euphausiid production characteristics are highly variable. Therefore, the ability to predict stock levels would occur only after intensive study over a long period.

Reviewers' Comments

The comments of the first reviewer were very brief and highly favorable. The reviewer expressed concerns with aspects of the quantitative sampling procedures used (i.e. net avoidance) and suggested that in future surveys supplementary estimates should be obtained from high frequency echosounders.

The second reviewer was more critical, but agreed with the major conclusions of the paper. The reviewer's concerns regarding methods and analysis that will require attention and/or revision are as follows:

1. calculation of total population abundance per square meter ($\#/m^3 \times$ sampled water column depth) is incorrectly formulated;
2. the stability/accuracy of cohort discrimination by MULTIFAN given the seasonal compression of length distribution was questioned and requires clarification;
3. the author used an unconventional function to fit growth curves which requires some further justification;
4. the reviewer cautions against liberal interpretation of the relationships of sea-surface temperatures, food availability and growth, since krill do not occupy the surface and temperature and food availability are confounded. Interpretations of these relationships require more qualification in the WP;
5. the choice of model for mortality and the procedures used to fit that model require clarification;
6. the author's method of manipulating data for input to a stock-recruit analysis require explanation;
7. the reviewer presents information suggesting that there is movement of juvenile krill into Barkley Sound, which, if the case would affect modeling of the mortality rate. This issue requires further discussion in the paper;
8. the calculation of P:B ratios requires clarification and in particular an clarification of the weighting calculations is required.

Subcommittee Discussion

The Subcommittee questioned the spatial variability of the abundance indices and requested that summary statistics be provided on the abundance estimates. The Subcommittee discussed the basis on which recommendations of harvest can be made in krill fisheries. The Subcommittee considers that there is not adequate information available to provide advice on changes to levels of euphausiid harvest. The Subcommittee requested that the author remove speculative sections of the paper that refer to the role of euphausiids in the ecosystem and to the consequences of krill harvest because no biological basis for those speculations were presented in the paper. For similar reasons the Subcommittee also requested that speculative recommendations on harvest levels within the paper be removed.

Subcommittee Recommendations

The paper is accepted subject to minor revision following the reviewers and Subcommittee comments as outlined above.

3. Issues arising out of the fishery updates

In addition to the fishery specific issues detailed below, two general issues arose that are common to several or many of the invertebrate fisheries.

Data-sharing Between Sectors

This is an long-standing issue which is significantly affecting stock assessment, management and enforcement in the shrimp and crab fisheries. The Subcommittee notes that substantial progress has been made by stock assessment in inter-sectoral communications and that most of the problems lie in enforcement and management interactions. The FMISST program was designed as a beginning to a comprehensive solution to this problem. The status of FMISST following reorganization of the Informatics Branch is unclear. The Subcommittee recommends that the status of FMISST be clarified and that commitment to the work be renewed.

New and Developing Fisheries

Many of the invertebrate fisheries, including the valuable inshore shrimp-trawl fishery, are essentially unmanaged and that for many of these fisheries there is little or no biological data on which to either determine stock status or provide advice on sustainable harvest levels. Development of a management plan is underway for offshore shrimp. Experience in offshore fisheries has shown that biological information of the sort provided by fishery-independent surveys is critical for the development of management plans. Rapid expansion, increases in effort and technological change could lead to significant stock, management and enforcement problems. Technological

changes are ongoing or proposed in several of these fisheries which would either make the fishery more efficient or would expose larger proportions of the populations to harvest. Regulatory changes in other fisheries or the non-performance of other fisheries has already resulted in, or may result in, increased effort in many of these fisheries, and notably in both the inshore and offshore shrimp-trawl fisheries. The Subcommittee cautions that a precautionary approach to the management of these fisheries is not easily reconciled with continued passive management characterized by no effort or harvest controls.

The Subcommittee notes that both proposed fisheries that would harvest species currently unlicensed and fisheries in new areas or with new gear that would harvest currently licensed species are subject to the provisions of the "Pacific Region Guidelines for the Development of New Invertebrate Fisheries" (PacGDNIF)

The following table outlines the species and fisheries of concern. Many of the comments in this table are expanded on in the detailed comments by species below.

Species/gear	What is new	Fishery notes	Status of assessment	Recommended phase in application of PacGDNIF
humpback shrimp by trawl	new directed fishery	species has been harvested as bycatch, principally by trap	no assessment information	phase 0/1; management plan to be developed based on existing prawn model (fixed escapement)
humpback shrimp by trap	new directed fishery in all but two small areas of the NCoast	species has been harvested as bycatch, principally by trap	no assessment information	same as new trawl fishery
octopus by trap	new directed fishery	species is currently harvested as incidental catch in prawn-trap fisheries, and in a directed dive fishery	no assessment information	phase 0/1 for both fisheries

Species/gear	What is new	Fishery notes	Status of assessment	Recommended phase in application of PacGDNIF
offshore prawn by trap	new areas	managed with a fixed escapement model	little assessment information in new areas	phase 1 with application of current model and fishery independent surveys to monitor response to exploitation.
goose barnacle by diving	new gear	species is currently harvested manually in inter-tidal zone	passive management premised on inaccessibility of 90% of populations	phase 0/1
squid by lampara net	new gear	species is currently harvested with gill and seine net gear; there are potential bycatch and habitat damage issues for all gear types	no information	phase 0/1
shrimp (pink, sidestripe) by trawl	new areas	fishery is currently unmanaged	phase 0 has been completed, fishery data and some biological data are available.	phase 1 activities are required in all areas, particularly fishery-independent surveys.

Currently there are three invertebrate fisheries that are being evaluated under PacGDNIF (offshore neon flying squid; Venus clam by dredge/drag, and offshore tanner crab by trap). The biological evaluation required prior to approval of a new fishery and the biological monitoring of developing fisheries is described by PSARC Working Paper I96-6 ("A Framework for Providing Scientific Advice for the Management of Data-limited Invertebrate Fisheries" by Ian Perry). The Subcommittee notes that many of the potential problems associated with technological and regulatory change and with the expansion of existing fisheries into new areas might be avoided by a more

rigorous application of the provisions of PacGDNIF within the accepted framework described by I96-6.

Shrimp Trawl Fishery

1. The Subcommittee notes with concern that effort and catches continue to escalate in some areas. Some of the increases are occurring in areas and on species (e.g. humpback shrimp) with little or no catch history. This escalation is probably as a result of several factors including regulation changes in other fisheries, poor returns of salmon, stock declines of shrimp in traditional areas and increasing prices. The current management regime places no restrictions on time or gear. The increased effort in inshore areas may put some of the inshore stocks at risk. The Subcommittee strongly recommends that extreme caution be exercised in the management of these fisheries.
2. The Subcommittee notes continued declines in the shrimp stocks in Areas 124 and 125. Advice was solicited on the advisability of a winter closure in Areas 121, 123 and 124. The rationale for existing winter closures is to allow larvae to recruit into the more northern areas (Areas 24/124 and 25/125) where the declines are being observed. The Subcommittee has no information on which to base a recommendation but, in the absence of information, urges the precautionary stance adopted in 1996 be continued. The Subcommittee further recommends that a WP be prepared to examine stock status in the offshore areas of W Vancouver Island.
3. Management, enforcement and stock assessment activities in the shrimp fisheries continue to be affected by problems in inter-sectoral communication and data sharing, particularly between the management and enforcement sectors. These problems have been raised in earlier years and the FMISST program was established as the issue resolution mechanism. The status of FMISST following recent reorganization is unclear. The Subcommittee urges RMEC to revisit this issue.
4. The Subcommittee expressed concern with the possibility of increased harvest of humpback shrimp with trawl gear modified to work in areas with hard bottoms. Allowing trawl harvest of humpback shrimp would place trawl gear in areas with significant numbers of prawns and would effectively allow prawn to be harvested with non-selective (i.e., causing bycatch mortality) during periods when selective harvest of prawn with traps was closed for conservation reasons. The Subcommittee has directed J. Morrison, J. Boutillier and I. Winther to prepare a briefing note with background information and a detailing of concerns, to be forwarded to RMEC as soon as possible.

Intertidal Clams

1. The Subcommittee notes that there is uncertainty over the status of many intertidal clam stocks largely because of undocumented harvest. In the presence of undocumented harvest, the Subcommittee is of the opinion that further progress in improving advice on stock status or sustainable harvest levels for those stocks is unlikely.
2. The Subcommittee notes that progress is being made on documenting harvest fully in some areas.
3. ***The Subcommittee expressed concerns that that decisions permitting the harvest of sub-legal clams in aquaculture operations will have significant and deleterious impacts on progress being made in the enforcement of the size limit in wild clam fisheries.***
4. In connection with point 3, the Subcommittee notes that the Province has conducted trials of culling to evaluate its biological benefits, that commitments have been made to present the results of those trials to PSARC, but that no Working Paper has yet been produced.

Geoducks

The Subcommittee notes that there is increasing concern over undocumented harvest and "high-grading" in the geoduck fishery. While these problems are common to most of the invertebrate fisheries they are of particular importance in the geoduck fisheries because of the very low imposed fishing mortality (1%).

Horseclams

No significant issues arose in Subcommittee discussions of the fishery update.

Prawn Trap-Fishery

1. Traps limits and observer program funded by industry were put into effect in 1995. The observer program improved in-season assessments and permitted a timely response to increases in effort in 1995 and 1996;
2. The timeliness of the closures was further improved by better communication between StAD and fisheries management as recommended by PSARC in the spring of 1996;
3. The Subcommittee recommends continuation of this successful program especially in view of increasing capacity in this industry.

4. Harvest of humpback shrimp has increased because of improved acceptance of the product and because of earlier closures in the prawn trap-fishery. The Subcommittee cautions that there is currently no biological basis for the management plan in place for this species and recommends that one be developed.
5. The Subcommittee recommends that the directed fishery on humpback shrimp be characterized as a new invertebrate fishery and that it be subject to the provisions of PacGDNIF (Pacific Region Guidelines for the Development of New Invertebrate Fisheries).

Octopus

1. Octopus-by-trap are largely a bycatch in prawn traps and the fisheries have been managed in tandem. The increasingly early closure in the prawn trap-fishery have led industry to suggest that the fisheries be uncoupled. Such an uncoupling would lead to an increase in effort on octopus. There is currently no biological information with which to determine sustainable harvest levels in this fishery. Consequently the Subcommittee recommends that no regulatory changes be made that would lead to increases in effort on octopus;
2. The Subcommittee notes that development of a directed trap fishery would be possible under the Framework for Data-limited Fisheries as described in WP I96-6.

Scallops

The Subcommittee notes that this is another fishery with little available biological information and unlimited entry. The Subcommittee notes that preliminary data on the depth distribution of dive catches may indicate that some decline in abundance has occurred. Although some limited determination of whether the stock has declined in some areas may be possible through more extensive of the available data, there is currently insufficient information on which to judge the sustainability of the current harvest.

Squid (*Loligo*)

1. The Subcommittee notes that industry has proposed the use of a "lampara" net, which is a hybrid seine net and trawl. This proposal highlights problems in unmanaged fisheries where the impacts of harvest methods on habitat and bycatch are not assessed.
2. The Subcommittee notes a dramatic increase in the number of licenses issued which may lead to equally dramatic in effort.

Goose Barnacles

1. There is no biological information available for this species and the current passive management of this species is based on the belief that 90% of the population is inaccessible or unmarketable. Experienced fishers are apparently concerned with local depletion and claim that in some areas a much larger proportion of the population is accessible.
2. The Subcommittee strongly supports the formation of a sectoral committee in the hopes that it would provide increased levels of biological information, and contribute to both market stability and worker training. The Subcommittee recommends that RMEC encourage anew the formation of this sectoral committee.
3. There is apparently industry interest in developing a dive fishery for this species. The Subcommittee notes that it would be appropriate to review this fishery under PacGDNIF.

Crabs

1. The Subcommittee notes that substantial increases in the catches in Area A (Hecate Strait) beginning in 1991 were due to a recruitment pulse which now appears to be waning. There is a need to examine long-term variability in this fishery and to initiate the investigation of alternative management approaches to this and similar fisheries where recruitment is pulsed, and the Subcommittee recommends that a Working Paper be prepared to do so.
2. The Subcommittee notes that illegal harvest (both undersize crabs, females, and egg-bearing females) is a priority issue in this fishery and that the biological consequences of that harvest are likely to worsen with the scheduled reduction in the number of operating patrol vessels.
3. The Subcommittee notes that both non-reporting and incorrect reporting of catch remain a major problem in the crab fisheries. Although progress is being made in improving the quality of the data, and although further resolution of problems is immediately possible through more detailed cross-validation of catch and sales slips to license area, major problems will remain in the lack of timely or proper reporting in all fishing areas. Some of the problems could be resolved through an expeditious revitalization of the FMISST initiative and the Subcommittee recommends that this be instigated.

Sea Cucumbers

The Subcommittee notes that management control (IQs) of this fishery now appears adequate to constrain catch at or below assigned TACs

Green Sea Urchins

The Subcommittee notes that significant progress has been made in collecting the biological information required to improve management of this species.

Red Sea Urchins

1. The Subcommittee notes and encourages the support and participation of the Pacific Urchin Harvesters Association in studies to obtain biological information important to improving management of this species.
2. The Subcommittee expressed concerns over the extent of undocumented fisheries related mortality that results from testing for high quality roe.

Euphausiids

The Subcommittee expressed concerns over evidence of multiple and serious data problems in this fishery. The Subcommittee notes that an industry funded observer program may be an appropriate solution to these problems.

4. Further Subcommittee Discussions

Environmental impact study of harvest component of proposed Venus clam fishery

This environmental impact assessment (EIA) falls under the purview of this Subcommittee because it relates directly to the ecosystem impacts of a proposed new fishery on Venus clams. The Subcommittee understands that review of environmental impact assessments are normally handled through the Habitat Division within the Science Branch. Nevertheless many proposed projects have significant potential impacts on commercially exploited stocks and the ecosystems on which their production depends. Consequently, the Subcommittee recommends that RMEC direct that all EIAs are copied to PSARC for information and review of possible impacts on stocks and ecosystems. Those EIAs associated with projects likely to have significant impacts either on fish stocks or their ecosystems will be reviewed through PSARC.

Humschitt/Vickers Abalone court case

The Subcommittee discussed a communication from Greg Thomas to Bruce Adkins that drew attention to what were, in the opinion of the author, speculative comments contained in past Subcommittee reports. The Subcommittee was satisfied that the comments examined were adequately qualified. The Subcommittee affirmed that where speculative advice is required (i.e., advice provided with little or no scientific basis) that that advice must be carefully qualified.

Cooperation between Stock Assessment and Management in preparation of Working Papers

The Working Papers presented at this meeting were the first products of an agreement developed at the last Subcommittee meeting that would see staff from the Stock Assessment Division and from Management jointly agree on what Working Papers would be presented and prepare "accountability accords" that would specify the advice being solicited, the data sources that would be used, and in a general sense the analytical approaches that would be used. The agreement also stipulated that at the very least, Management would identify a contact person with whom the authors would consult throughout the preparation of the Working Paper and that preferably that the Management person would be a participating co-author. The Subcommittee members who participated in the process agreed that this mechanism worked reasonably well and that for the most part, that the Working Papers presented did provide the advice that was solicited. The Subcommittee strongly endorsed continuing with this process. The Subcommittee recommended that the accords be formalized by memos between the Section Head of Invertebrate Stock Assessment and the Regional Invertebrate Coordinator with copies to PSARC.

Number and timing of Subcommittee meetings

This discussion was requested by both the Section Head of Invertebrate Stock Assessment and the Regional Coordinator of Invertebrates because both groups felt that the number and timing of meetings were not congruent with the timing requirements of the fisheries or fisheries management. The discussion was prefaced by comments from Jake Rice about the likely future form of the scientific review/consultative process which highlighted the move toward producing Stock Status Reports and the likely creation of a Conservation Council. The discussion proceeded by first identifying that the release of a fishery management plan was a readily identifiable critical event. for all fisheries. The species were then divided into two groups determined by current timing in the fisheries.

1. crabs, geoduck, inshore/offshore shrimp, clams, urchins, minor species
December
2. prawns, cucumbers
March

We then allowed three months for a consultative/review process, that may include a conservation council at some time in the future. The input to this consultative/review process would be draft management plan provided by the Shellfish Working Group (SWG). The SWG would draft those plans during July and August for group 1 and during January for group 2. The shorter period for group 2 is feasible because there are only two species compared to approximately 12 in group 1. The earliest availability of data from the previous fishing season determines the earliest a meeting could be held

(late February for group 1 species). The best times for Subcommittee meetings become the last week of June for group 1 species and the beginning of January or late December for group 2 species. The Dec./Jan. could also deal with methodological and special papers that were not directly solicited by Management and any issues that arose out of the consultative/review process during the preceding fall. ***The Subcommittee recommends that this meeting schedule be adopted beginning in January 1997.***

5. Figures and Tables

Table 12. Summary of geoduck quota options for consideration in the 1997 and 1998 fisheries, compared to quotas from the last area rotation

YEAR 3 - 1997		1994		1997			
	Region	Quotas	Area (ha)	low	med	high	Area (ha)
QCI	North Coast	2,430,000	1,204	1,363,776	1,818,368	2,500,256	1,678
24:Tofino, 25: Nootka	West Coast	1,620,000	3,075	1,404,975	1,426,197	1,446,910	3,632
17-19:Victoria 15: Lund	Inside Waters	900,000	2,326	525,079	678,285	678,285	2,271
	Total	4,950,000	6,605	3,293,830	3,922,850	4,625,451	7,581

YEAR 1 - 1998		1995		1998			
	Region	Quotas	Area (ha)	low	med	high	Area (ha)
CC	North Coast	2,520,900	1,079	934,048	1,401,072	1,790,258	1,619
24:Tofino, 23:Barkley 27: Brooks N	West Coast	1,176,000	3,663	1,354,759	1,375,981	1,396,694	3,804
11-14: Johnstone-Comox	Inside Waters	924,300	3,278	590,794	660,435	676,327	3,091
	Total	4,621,200	8,020	2,879,601	3,437,488	3,863,279	8,514

Figure 1. Summary of geoduck quota options for 1997 and 1998 compared to quotas from last rotation (From 196-8).

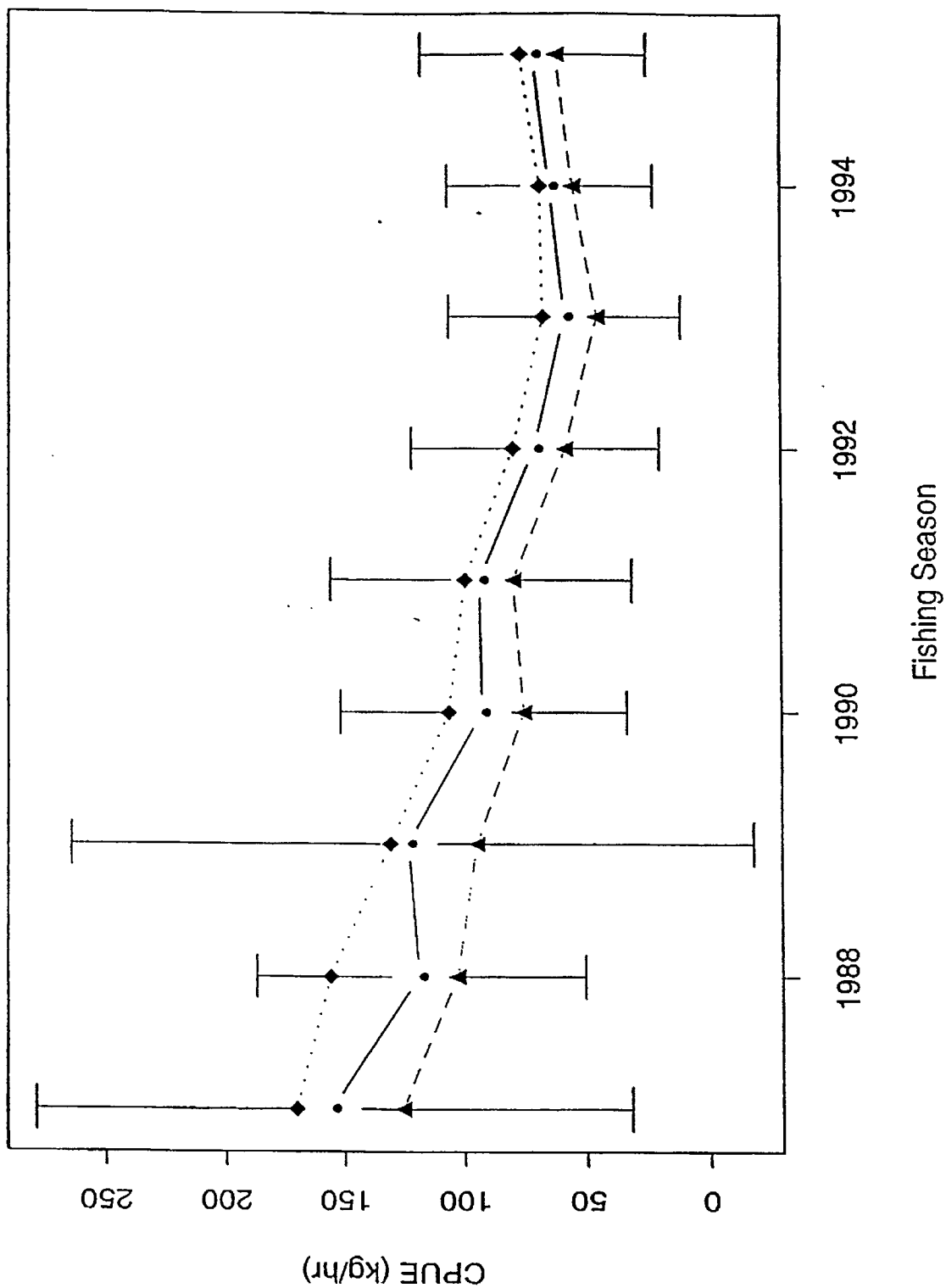


Figure 2 Coast wide trends for different measures of CPUE for green sea urchins. (From 196-9)

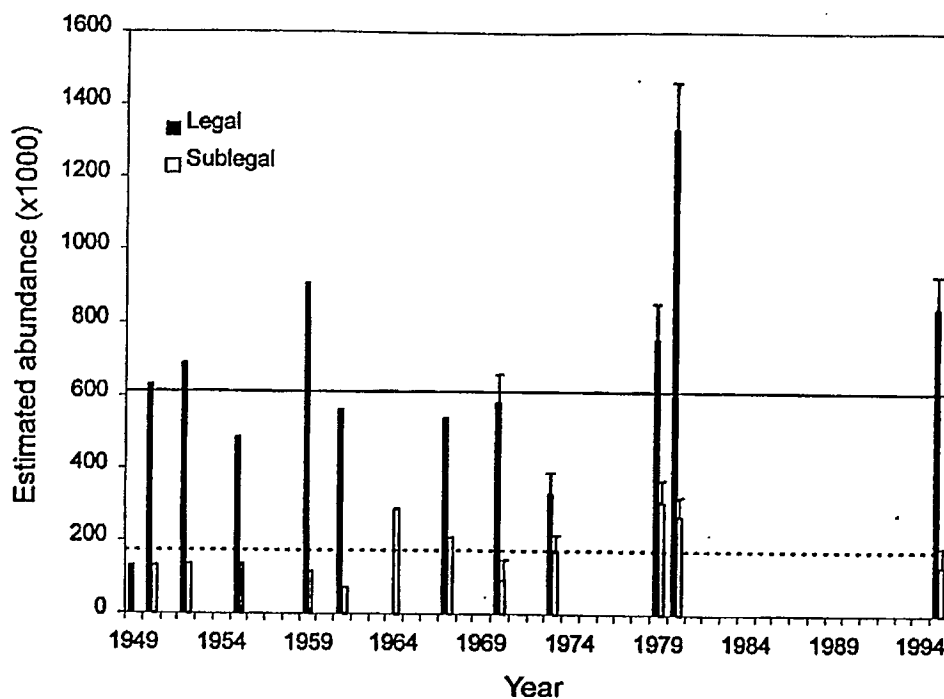


Figure 2. Estimate of the population of legal and sublegal butter clams (1949-1995) at Seal Island. Error estimates are 95% confidence limits. Estimates after 1969 made following mean method of Kronlund et al. (1995). Estimates prior to 1969 from Kingzett and Bourne (1995) (error estimates unavailable). Solid line indicates mean legal total abundance (600 958), hatched line indicates mean sublegal total abundance (171 094).

Figure 3. Abundance and biomass estimates for legal and sublegal butter clams at Seal Island (From 196-10).

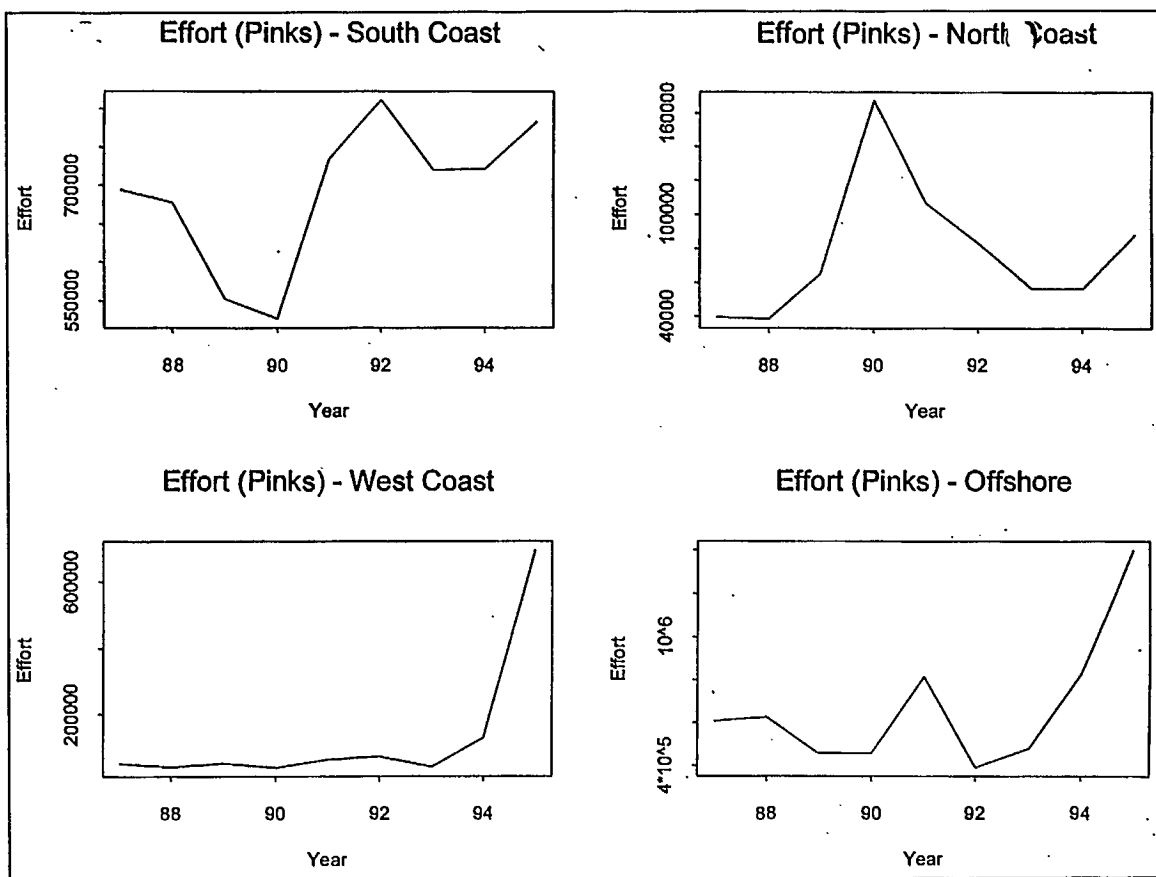


Figure 4. Effort trends for pink shrimp in four areas between 1987 and 1995.
(From I96-11)

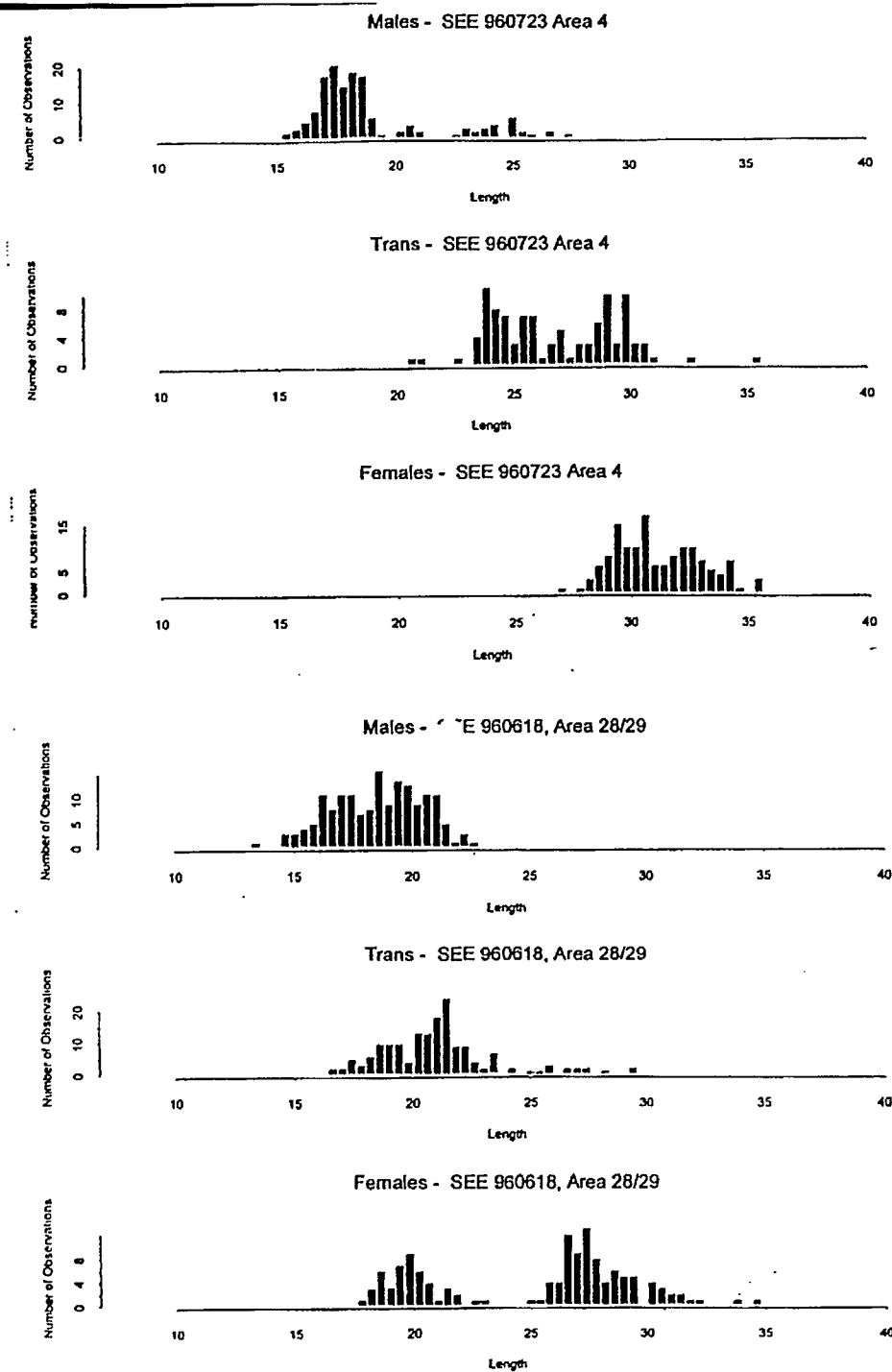


Figure 5. Length-frequency distributions of sexed shrimp in 1995 from a relatively unexploited area (4, top 3 panels) and a heavily exploited area (28/29, bottom 3 panels). (From I96-11)

**Appendix 1. Participants at the Invertebrate Subcommittee Meeting,
September 9-13, 1996**

NAME

AFFILIATION

Subcommittee Members

B. Holtby (Chair)	Stock Assessment Division, PBS
B. Adkins	Shellfish Coordinator, Pacific Region
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Appendix 2 Reviewers of Working Papers presented at the Invertebrate Subcommittee meeting, September 9-13, 1996

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D. Sameoto	Science, Maritimes
R. Stanley	Science, Maritimes
C. Walters	Zoology, UBC
C. Wood	StAD, PBS
D. Woodby	Alaska Dept., Fish and Game

Table 2. Landings of invertebrates in tonnes in British Columbia, 1981-1995

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995*
INTERTIDAL CLAMS - Commercial Fishery:															
Razor	30	88	31	100	90	142	142	155	117	114	117	55	44	105	140
Butter	120	103	77	130	251	158	68	134	92	109	42	132	102	174	101
Manila ¹	317	597	1048	1677	1913	1893	3607	3909	2764	1456	982	923	1047	1391	1369
Nat. Ln.	179	241	324	294	191	284	373	290	433	465	201	116	131	180	167
Mixed	161	155	279	410	477	371	87	27	159	339	137	112	121	2	3
SubTotal: Commercial Fishery	807	1164	1759	2611	2922	2848	4277	4515	3565	2483	1479	1338	1445	1652	1781
FARMED CLAMS					4	7	25	30	31	39	169	300	300	500	800
TOTAL INTERTIDAL CLAMS	807	1164	1759	2611	2926	2855	4302	4545	3596	2522	1648	1638	1745	2352	2581
GEODUCK	2704	3135	2636	3483	5370	5006	5734	4567	3985	3956	3333	2864	2455	2235	2061
HORSE CLAM	51	321	21	7	6	96	355	325	115	124	110	2	23	62	1
SHRIMP	581	413	411	408	678	768	2644	2561	2299	1940	3285	2683	3283	3192	6779
PRAWN	358	274	331	505	514	550	620	720	820	761	961	1168	1215	1309	1299
CRAB ³	1317	1003	960	1155	1165	1321	1631	1508	1522	2168	1887	3355	6306	6002	4547
ABALONE	85	82	56	58	42	52	49	49	49	50	N/A	N/A	N/A	N/A	N/A
OCTOPUS		18	30	25	32	53	129	209	217	198	131	117	145	72	75
SEA URCHIN	116	160	986	1764	1815	2067	2223								
RED								2116	2658	3158	6945	12018	6388	5829	6255
GREEN ⁴								444	609	475	607	1042	714	332	157
SEA CUCUMBER ¹				113	346	766	1722	1922	1144	870	1340	1242	812	568	500
SCALLOP		8	11	18	53	68	66	67	75	69	82	91	90	104	93
PLANKTON	19		47	103	131	166	130	247	360	530	450	380	53	333	579
SQUID		29	15	69	111	79	66	88	70	72	116	93	13	175	76
MUSSELS			tr	1	tr	2	2	3	4	1	tr	0	0	0	0
GOOSENECK BARNACLES					tr	2	32	49	30	37	40	38	30	19	7
OYSTERS - Farmed		1579	2453	2897	3420	2864	3482	3702	3721	4547	4482	4500	4000	4900	5300
TOTAL TONNES	6038	8186	9716	13217	16609	16735	23207	23122	21274	21478	25397	31231	27272	27472	30312

* preliminary landings for 1995

¹ the sum of commercial fishery landings and production from clam tenures

² landings are round weight

³ crab landings include tanner, king, other and dungeness crabs (1989 to 1995)

⁴ green sea urchin landings in 1995/96 taken from validation logs

Table 3. Landed value of invertebrates in thousands of dollars in British Columbia, 1981-1995

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994*	1995*
INTERTIDAL CLAMS - Commercial Fishery:															
Razor	24	55	24	123	95	127	126	137	124	130	129	82	67	186	247
Butter	42	36	33	55	138	75	40	63	44	53	34	81	60	103	71
Manila	323	611	1043	1813	2278	2762	6003	7175	6003	3761	2574	2180	2570	3848	4710
Nat. Ln.	195	263	329	311	202	327	474	359	588	710	327	190	212	283	288
Mixed	175	169	293	455	575	510	132	36	196	625	238	187	215	4	8
SubTotal: Commercial Fishery:	759	1134	1722	2757	3288	3801	6775	7770	6955	5279	3302	2720	3124	4424	5324
Farmed Clams:					4	14	43	59	96	140	556	1000	1200	1900	3800
TOTAL INTERTIDAL CLAMS	759	1134	1722	2757	3292	3815	59	7829	7051	5419	3858	3720	4324	6324	9124
GEODUCK	2434	2814	1818	2937	4605	4294	6184	9762	12967	10582	9659	16237	26994	33426	42518
HORSE CLAM	42	235	12	5	6	63	309	300	144	274	119	2	46	111	2
SHRIMP	912	644	1073	1022	1180	1240	4609	2802	2985	2637	4430	2831	3494	4772	13795
PRAWN	2019	1545	2138	3262	3379	3734	4326	5724	7083	7006	7726	8380	10121	12133	17748
CRAB	3556	2345	3320	4558	4719	5661	6452	5945	6088	9311	8688	11203	16761	25886	23286
ABALONE	721	696	462	530	442	734	973	1076	1170	1347	N/A	N/A	N/A	N/A	N/A
OCTOPUS		39	63	56	82	136	381	651	707	657	415	350	447	231	272
SEA URCHIN	34	56	358	712	763	1011	1276								
RED								1241	1631	1953	4187	8680	5271	8038	11269
GREEN								584	1020	948	1795	4424	3777	2122	1080
SEA CUCUMBER				22	94	236	768	961	898	1168	1029	1363	962	1035	784
SCALLOP		17	24	56	95	212	244	285	316	317	387	420	423	490	463
PLANKTON	6	0	19	42	89	113	102	192	223	415	390	318	41	259	369
SQUID		22	21	84	184	127	132	113	94	81	148	135	17	199	97
MUSSELS		tr	tr	tr	0	tr	tr	tr	tr	1	tr	0	0	0	0
GOOSENECK BARNACLES					1	4	211	479	343	413	418	448	320	181	71
OYSTERS - Farmed		981	1554	2109	2813	2515	2548	2725	2938	3613	3485	3600	4700	4500	5500
TOTAL VALUE (\$000)	10483	10528	12584	18152	21544	23895	28574	40669	45758	46142	46716	62091	79718	99507	126378

*preliminary values for 1995

¹ the sum of commercial fishery landings and production from clam tenures

² landings include tanner, king, other and dungeness crabs (1989 to 1995)

³ value estimated from sales slips for 1995/96

Table 5. Management framework for invertebrate fisheries, 1996.

SPECIES	LICENCES	QUOTA	SEASONS	COMMENTS
Geoduck	Limited entry (G tab). 55 licenses. Vessels may have more than licence (stacked licences) Licence conditions include notification, validation and catch reporting requirements Validation costs funded by licence holders.	1996 quota reduced to 1840.8 t for I.V.Q.'s of 33.5 t (73,785 lb) 1/55 of coastwide quota). Quota not taken in 1996 cannot be carried to 1997.	Varies by area - Product is marketed live round, highest demand in December/January	Fishery areas are in a three year rotation. Quotas based on an annual yield of 1% of the virgin biomass. Harvest in PSP closed areas for processing allowed with permit and decontamination plan. Combined Validation/Harvest Log pilot expanded to all licence areas in 1996.
Horse Clam	Limited to the 55 geoduck licences	Catch ceilings set based on historic landings in south coast areas: West: 30 t Inside: 50 t	Varies by area and only in areas open to geoduck harvesting	Area 24 has been divided into 3 areas with a three year rotation, to Epper Pass - Bedwell Sound in 1996
Green Sea Urchin	Limited entry - ZA - 49 licences Individual Vessel Quotas implemented in fall 1995 Licence year Nov 20/95 to May 31/96. Up to 3 licence tabs per vessel and licences became transferable. Licence conditions include notification, validation and catch reporting requirements Validation costs funded by licence holders.	Southcoast quota reduced to 173.4 t IVQ 3.539 t (7802 lb) per licence (1/49 of quota) North: 90.7 t set for areas 3 and 4.	South Nov 20/95 to May 31/96 North: Jan 2 to Feb 28/95 and Nov 20/95 to Jan 31/96.	Minimum size limit in effect. Provision for exploratory fishing under an exploratory protocol developed inseason.

Table 5. (continued)

SPECIES	LICENCES	QUOTA	SEASONS	COMMENTS
Red Sea Urchin	Limited entry. 110 licences ZC tab with area election. Individual Vessel Quotas Up to 3 licence tabs per vessel and licences became transferable. Licence conditions include notification, validation and catch reporting requirements Validation costs funded by licence holders.	1996 quota slightly reduced to 6624.3 t for I.V.Q.'s of 60.2 t (132,763 lb) 1/110 of coastwide quota. Quota not taken in 1996 cannot be carried to 1997.	South coast: Jan, Feb Oct - Dec, summer expl. variable days with IVQ North coast fishing year round with openings scheduled for each month throughout 1996.	Rotational areas in the north Minimum size limit in effect. Voluntary I.V.Q. system of 1994/95 was replaced by DFO sanctioned IVQ system in 1996.
Gooseneck Barnacle	Not limited entry (Z6 tab) 64 licences issued in 1995.	None.	All year.	Less than 10% of the stock is available for harvest due to harvest conditions or unsuitable size and quality for the available markets.
Pink and Spiny Scallop (Net Gear)	Not limited entry. ZR - 43 licences issued in 1995 for trawl or drag .	None. Managed by size limit.	Some permanent area closures	Limited market, must land at a registered Shellfish plant, PSP monitoring
Pink and Spiny Scallop (Dive Gear)	Not limited entry. ZI - 29 licences issued in 1995 for diving.	None. Managed by size limit.	Some permanent area closures	Must be landed at a registered Shellfish plant, PSP monitoring by fishers at key stations in 1996
Plankton - Euphausiids	Limited entry. 19 ZF eligible licences, 18 issued in 1995 Notification and hail requirements	Mainland inlets: 275 t. Strait of Georgia: 215 t.	Inlets closed June 1 to August 15. Strait of Georgia open Oct 1.	Scientific Licence - 10t for development of value added products in 1996.

Table 5. (continued)

SPECIES	LICENCES	QUOTA	SEASONS	COMMENTS
Octopus (by Trap)	Not limited entry. ZP tab. 80 licences issued in 1995 - Combined with W licences for 1995 only.	None.	Inshore: Apr to Dec subject to prawn closures Off shore: all year. Seasonal closures for spawning	Open only in times and areas open to prawn/shrimp trap in Inside. Offshore open Jan 1 to Dec 31.
Octopus (by Dive)	Not limited entry. ZG tab. 57 licences issued in 1995	None.	All year with seasonal closures for spawning	Harvest from vessel only. Poor markets have limited fishery since 1993..
Prawn/Shrimp by Trap	Limited entry. W tab. 258 licences eligible 1995, 253 issued Vessel Trap limits and industry funded in-season monitoring and surveillance.	Managed by time and area closures based on a minimum escapement of the spawner cohort. Minimum size limit and gear escapement regulations.	Seasonal closure implemented Oct 31/95 to Apr 15/96. Higher prawn prices resulted in more concentrated effort as fewer boats left to fish for salmon in the summer	Delayed openings in Salmon/ Secht Inlets, Saanich Inlet, Howe Snd., Alberni Inlet Some re-opening of dioxin closures. Increased monitoring resulted in earlier closures Trap limits and industry monitoring adopted in 1995.
Shrimp Trawl	Limited entry. 249 S tab licences, 247 issued in 1995.	None.	All year with area closures for by catch, dioxins, navigation and reserves. No prawn retention in areas closed to prawn trap fishing	Bycatch: Prawn - not exceeding the greater of 2% or 5 lb. of total weight of shrimp on board. Groundfish: no retention Squid: not exceeding 2% Octopus: may retain all incidental caught octopus. No fin fish. 1995 catch more than double 1994 - early closure was rejected by Sectoral Committee in Nov/95.
Squid	Not limited entry. ZE tab. 81 licences issued in 1995. (for opal squid only) 44% increase in licences over 1994.	None.	Permanent area closures.	Pacific Rim National park closed in 1995 except in portions of 123-1, 123-5 and 124-1

Table 5. (continued)

SPECIES	LICENCES	QUOTA	SEASONS	COMMENTS
Crab	Limited entry. R tab. 224 licences were eligible in 1994. 223 were issued in 1995.	Managed by size limit. No quota. Area-specific trap limits. Trap escapement regulations.	Area licencing, area closures due to softshell or allocation to aboriginal or sport fisheries.	Non-retention of females. Rot panel size set for traps without hinged lids from 20 to 11 cm Crab traps to be fitted with one escape hole at least 100 mm diameter
Intertidal Clam	Not limited entry. Z2 tab. 1844 licences issued in 1994. In 1995 2452 licences were issued.	Managed by minimum size limits. No quota.	Seasonal openings and closures, with a series of staggered openings designed to maintain market supply, however of very short duration, due to high levels of effort. Allocation closures for aboriginal and recreational fisheries.	Area-specific licences, licence holders choose 1 of 7 areas. Ongoing federal/provincial consultation for changes to fishery management with all user groups. Depurated harvest and clam culture issues. One Community Management Board - Area C. Ongoing consultation with 2 other licence areas.
Sea Cucumber	Limited entry. 85 licences ZD tab with area election. Individual Vessel Quotas Up to 3 licence tabs per vessel and licences became transferable. Licence conditions include notification, validation and catch reporting requirements. Validation costs funded by licence holders.	1995 quotas set at 6049 lb (2.75 t) per licence. A total of 5 Area licences. Coast wide Quota unchanged at 55 t split wt (South Coast) and 183 t split wt in the North.	Fishery was delayed to Nov 15, in 1995, pending adoption of IVQ program. Fishery was open for up to 3 weeks, as compared to a few days in 1994. Area rotation in both north and south coast areas.	Quota overruns are removed from TAC the following year. Voluntary IVQ program failed in 1994, but a DFO sanctioned IVQ program was adopted prior to the 1995 fishery.

BIOLOGICAL ADVICE ON GROUND FISH

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I. STEERING COMMITTEE REPORT

The PSARC Steering Committee met November 29, 1996 in the Conference Room at PBS, Nanaimo to review the Groundfish Subcommittee Report. Steering Committee provided the following comments pertaining to individual Working Papers summarized in the Subcommittee Report.

Major Subcommittee Concerns

Steering Committee had no comment on the major subcommittee concerns.

Pacific Cod

Steering Committee discussed comments in the Subcommittee report which suggested that CPUE indices from the surveys in Hecate Strait may not be comparable to the historical CPUE index from the commercial fishery. Steering Committee agreed that the comparability between the survey CPUE (in the absence of a fishery) and fishery CPUE could not be evaluated. However, the surveys also established that recruitment from the 1994 year-class was average or above average. Data for this year-class provide additional evidence that the stock status has improved from the previous low level.

Steering Committee requested clarification on the calculation of yield options and recommended that the Table on p. 9 of the working paper and Fig. 7 be added to the Subcommittee report. Yield ranges in the working paper are based on probabilities of 10 and 90% that the stock is larger than estimated, combined with a target fishing mortality rate (F) of 0.3. All plausible estimates of natural mortality suggest that the $F=0.3$ policy is conservative. However, a precautionary approach would not assume a stock size larger than the median of the stock size distribution, with a corresponding yield of 1367 tonnes.

Sablefish

Steering Committee requested minor clarification of yield options and trends in biomass presented in the working paper summary. The Subcommittee had endorsed preparation of a table of biomass projections under different constant yields. This table was presented to the Steering Committee. Steering Committee highlighted the overall uncertainty with this analysis including short-term projections. However, even the most pessimistic scenario projections indicate that harvests of up to 4100 tonnes would leave the stock at a status quo spawning biomass at the beginning of 1998.

The Steering Committee encourages further improvements to this important assessment, including the incorporation of survey catch rate data and continued refinement of the tagging data.

Yellowtail Rockfish

Steering Committee endorsed the yield recommendations.

II. GROUND FISH SUBCOMMITTEE REPORT

1. Introduction

This meeting of the Groundfish Subcommittee was required to complete the review of assessments for sablefish and Pacific cod that were originally submitted at the July meeting. New documents were prepared, reviewed and discussed and the results of the subcommittee discussions are presented in this report. In addition to the two assessments, the Subcommittee received a report on the halibut bycatch program and an update on the Area 3C yellowtail rockfish assessment. The meeting was held at the Pacific Biological Station and Dr. Ray Hillborn participated in the sablefish discussions by conference call.

2. Major Subcommittee Concerns

- (i) The Subcommittee recommends that clear rationale in support of the choice of reference points be presented in all assessment documents. Where possible, supporting analysis demonstrating the consequences of departure from the selected reference point should be incorporated into the document (e.g. probability of exceeding a threshold reference point under specified assumptions or a decision table analysis). The document on biological reference points may, in some situations, provide appropriate guidance.

The Subcommittee notes that assessments differ in the selection of precautionary yield limits. For each situation the underlying basis for the selection of precautionary yield recommendations should be incorporated into the document.

- (ii) The Subcommittee recommends that a special meeting be convened to identify the impacts of an IVQ fishery on groundfish databases.
- (iii) The Subcommittee recommends that the next annual meeting of the Committee be scheduled June 24-27, 1997.

3. Working Paper Summaries, Reviews and Discussion

G96-3 Hecate Strait Pacific Cod Stock Assessment Incorporating 1996 Fishing Survey Data and Recommended Yield Options for 1997 and 1998. V. Haist and D. Fournier.

Working Paper Summary

The commercial trawl fishery in Hecate Strait was limited to by-catch only for Pacific cod in 1996 and as a result abundance indices in 1996 are not comparable to those for previous years. A Pacific cod survey, using commercial fishing vessels, was conducted in Hecate Strait during the summer of 1996 to obtain catch rate data and data on the effects of cod-end mesh size changes on catch rates and size-selectivity. This document presents results from analyses of survey catch rate data and incorporates this information into stock assessment for Hecate Strait Pacific cod.

Four CPUE indices were calculated from the survey data obtained with large-mesh cod-ends for comparison to indices calculated for previous years. All indices indicate an increase in the catch rate from 1995 to 1996, with increases ranging from 66% to 180% (The authors compared results from large and small mesh codends).

Assessment of Hecate Strait Pacific cod abundance was conducted using MULTIFAN CL, a catch-at-length model that integrates length frequency and catch-age analysis. Analyses were conducted using both "calculated effort" indices and "total effort" indices. The "calculated effort" indices, which have been used in previous stock assessments, are the total catch divided by the median CPUE. The "total effort" indices are estimates of total hours fished. The model fit to data observations when using the "total effort" indices was significantly better than when the "calculated effort" indices were used. The results using this index were adopted as those providing the most appropriate assessment for Hecate Strait Pacific cod.

Stock abundance and catch levels under a $F=0.30$ policy are forecast for 1997 and 1998 using stochastic simulations. The stochastic elements are the size of the first recruited year-class for the 1997 projections and the size of the first two recruited year-classes for the 1998 projection. The stock projections for 1997 identified a probability of 0.015 i.e., a very low probability, that the spawning stock biomass will be less than the threshold level of 4570. 1000 stock projections identified the impact of variable recruitment on the various spawning stock biomassess and the resulting catch at $F=0.30$ (Table 1). The 10% and 90% of the probability range of the stock abundance distribution, produced a catch range from 1075 t to 2165 t respectively. The 50% level catch is 1367 t i.e., there is a 50% probability that recruitment will result in a spawning stock biomass of 5652 t or a catch of 1367 t. If this level of catch were selected, the last column in Table 1, indicates that in 1998, there is a 0.098 probability that the spawning stock biomass would be below the threshold in 1998.

Table 1 **Quantiles of the projected exploitable biomass, catch and spawning stock biomass (SSB) from 1000 stock projects, generated by resampling from the distribution of 1996 recruits. The probability that the 1998 SSB will be less than the threshold of 4570 is also shown for each of the various quantile levels of 1997 catch.**

Quantile	1997 SSB (t)	1997 Exploitable Biomass (t)	1997 Catch (F=0.30)	Probability 1998 SSB < threshold
5	4679	3939	1033	0.064
10	4803	4090	1075	0.066
25	5110	4464	1181	0.081
50	5652	5124	1367	0.098
75	6509	6168	1661	0.135
90	7981	7960	2165	0.212
95	8971	9166	2505	0.260

Reviewers' Comments

Reviewer #1

This reviewer had no major criticisms with the catch-at-length analysis or with the creation of the 1996 CPUE value. The reviewer also supported the yield recommendations. There was some question of the relevance of the mesh size information to the stock assessment. The reviewer noted a number of issues relating to the mesh size data and analysis and recommended that either (1) the data be incorporated into the analysis, or (2) the report should say that the data were not incorporated and discuss how future work might use this information.

Additional comments were that the 10 trip summer-long survey to make up for the absence of the regular trawl fishery was a remarkable achievement. The reviewer was concerned about the precedent and wonders if every time a fishery closure is recommended, a survey will be necessary as this represents a major commitment of resources.

The reviewer noted that resampling from the existing series is reasonable, but since there is significant auto-correlation, the probability distribution of expected recruitment in 1998 could be conditioned by using this auto-correlation. It is not clear to the reviewer how the 1991-1995/6 to pre-1991 data was linked in the overall time series of effort.

Reviewer #2

This reviewer had several questions about the analysis and some suggestions for clarification. None of the questions or suggestions were considered to be major and the reviewer considered the assessment to be elegant and clear.

Subcommittee Discussion

Subcommittee discussion centered on three issues:

1. Pacific cod surveys: The Subcommittee compliments the author for "filling" in the time series of catch/effort data by conducting a 10 trip summer long survey to make up for the absence of a fishery. However, the Subcommittee had concerns regarding the effect of a trawl fishing closure on the CPUE indices, i.e., did generating a pseudo-fishery give false (high) CPUE values for 1996. The Subcommittee questioned whether any analyses could be conducted to examine this question. In addition, there was concern about the precedent set. The costs associated with such surveys are extremely high. The Subcommittee suggests that if future closures result in a need for extensive surveys, then consideration of this work must entertain cost sharing with industry.
2. Mesh size analysis. The Subcommittee notes that considerable data on mesh size changes was presented in the working paper but agrees with the review that this information was not fully analyzed and incorporated in the assessment. The Subcommittee feels that presentation of this information is premature. Further analyses should be conducted and incorporated in the next assessment, if appropriate.
3. Fisheries reference points. The Subcommittee discussed the choice of fisheries reference points for this assessment. The Subcommittee suggests that a more complete rationale for the reference points chosen be included in the document.

Subcommittee Recommendations

The Subcommittee accepted the working paper with minor revisions. The Subcommittee recommends the mesh size change information be removed from this document as it is not currently incorporated in the analysis. The Subcommittee suggests that this information be more completely analyzed and included in the next assessment if appropriate. The Subcommittee recommends that the yield options table include the probabilities that 1998 spawning stock biomass is below the threshold at the various catch levels presented for 1997. Table 1 shows that the 50th quantile produces a catch of 1367 that has a probability of 0.098 of reducing the 1998 SSB below the threshold levels.

G96-5 Sablefish Stock Assessment for 1996 and Recommended Yield Options for 1997. M.W. Saunders, B.M. Leaman, V. Haist, R. Hilborn and G.A. McFarlane.

Working Paper Summary

This paper represents a major assessment for sablefish. Separate analyses are conducted for northern and southern areas of the B.C. coast due to observed differences in age and length compositions, growth and evidence from juvenile tagging that recruitment to the areas are drawn from different origins. The assessment utilizes a new age-based catch-at-age model implemented using the AD Model Builder software environment, to estimate the current stock size and reconstruct the history of the stock. Independent estimates of exploitation rates for 1992 and 1993, based on 1991 tagging releases and recaptures from 1992 and 1993, were developed by R. Hilborn, (University of Washington) and used to tune the catch-at-age analysis. The tagging analysis explicitly takes into account potential movement of fish out of the zone. In addition, alternative exploitation rates that acknowledge the impact of more recent tagging data not yet analyzed, are investigated. These alternative rates are approximately double those obtained through the tagging analysis.

Biomass in the south and north was estimated to range between approximately 28-60,000 t in the north and 22-62,000 t in the south. The large range in stock estimates is based on different assumptions concerning the historical exploitation rate. The assessment is less pessimistic about the level of exploitable biomass than the previous assessment. If historical exploitation rate has been as low as the nominal values from the tagging analysis, then stock biomass in the north and south has been increasing steadily throughout the period of analysis. If historical exploitation rates have been at the higher values investigated, then the stock has been approximately stable over the same period. A review of fisheries harvest reference points is conducted and yields under a commonly used reference point ($F_{45\%}$) estimated. However, the assumptions of random recruitment variation inherent in the use of such a reference point contrasts with observed sablefish recruitment, and its use is not recommended in the assessment. Instead, short term (5 y), deterministic simulations of the impact of fixed coastwide harvest levels (3100 t, 3600 t, 4100 t, and 4600 t) on exploitable biomass are presented. Under assumed low historical exploitation rates, harvests at all simulated levels will keep the northern stock approximately stable or increasing. For the southern stock harvest levels under the same exploitation scenario will keep the stock stable or initiate slightly (<5%) declining trajectories of stock biomass. For higher rates of assumed historical exploitation, harvests above present levels will initiate modest declines (5-10%) for both northern and southern stocks over the 1997-2001 period simulated.

Reviewers' Comments

Reviewer #1

The reviewer noted that during the July Subcommittee meeting a number of problems and alternatives for improving the sablefish assessments were discussed, but were not do-able this year. These revisions identified in the July report are still important and should be incorporated into next years assessment. In this revised document the sablefish assessment hinges on the estimates of exploitation rates resulting from the analysis of tagging data. The analysis of the tagging data has been revised, and some problems in the interpretation of the catch records have been corrected. The estimates are still preliminary, as only a subset of all the available information has been analyzed so far. In addition, ad hoc adjustments have been applied to the estimates of harvest rates to correct for depth-related stratification in the southern area, and for non-trap catch not considered in the tagging analysis. The reviewer acknowledged that the authors will complete this analysis during the coming year, and agrees that this should be the first priority. The reviewer commented that the possibility of conducting a joint estimation using both tagging and catch-age data simultaneously raised during the PSARC meeting in July is promising and recommends that this be done.

In terms of harvest rates and yield options, the reviewer commented that the authors conducted short-term projections using two sets of assumptions about the status of the stocks, and evaluated consequences of applying a range of exploitation rates. The most optimistic set of assumptions was based on the results of the catch-age model tuned to the tagging estimates of exploitation rate; the more conservative scenario was produced using higher exploitation rates for the tuning. This is a sensible approach considering the uncertainty about some of the parameters and assumptions in the tagging analysis. The reviewer observed that historical biomass trajectories under both sets of assumptions show that the stocks have been either stable or increasing.

The key results of the short-term projections are presented only in table format (tables 5.17 and 5.18). These show projected yield and biomass trends for a range of fishing mortalities for the two sets of assumptions. A figure showing these results, together with the corresponding historical trends, would have been most helpful to discuss yield options with the managers. The authors recommend a range of yield options based on choosing, for each scenario, the yield level that would result in stable exploitable stock sizes over the short term. While trying to maintain the stock size at the current levels may be sensible under the conservative set of assumptions, there is no reason why that should be the goal under the optimistic scenario considering that the stock is estimated to be ~60% of the unfished level. The reviewer recommended that a summary table be included under yield options to show what the managers need to see in order to make a decision, i.e., the consequences of choosing different yield or harvest rate levels under the different scenarios.

Reviewer #2

Dr. Ray Hilborn, who was also an author, provided his comments on the current paper to the Subcommittee. Dr. Hilborn considered that the estimated current stock sizes using the tagging data was roughly 60,000 tons in the north and 60,000 tons in the south, for a total stock of 120,000 tons. An examination of a longer time series of tagging data will provide a lower estimated stock size, and as a lower bound he suggests that 60,000 tons total biomass be considered as a worst case.

The estimated fishing mortality reference points, of F40% and F45% are $F=0.13$ and $F=0.11$. Combining the F45% reference point with the tagging estimate of biomass produces a yield of over 12,000 tons. Using the worst case 60,000 tons total biomass the F45% yield would be over 6,000 tons. This would be well above current removals. Therefore, he suggests that if the worst case current stock size is used, the current removals would result in a roughly stable populations size.

Review #3

The third reviewer commended the authors for providing a very comprehensive assessment of this stock which represents a significant improvement over the document reviewed last year. Unfortunately, given the short lead time for the review it was not possible to provide a comprehensive assessment of all of the new material particularly the new catch-at-age analysis. However, the reviewer did not identify serious problems with the assessment methodologies and conclusions. He concurred with the need for a cautious approach in the management of this resource given the uncertainties in the available assessment data and hope that these concerns are conveyed to the managers. The reviewer particularly supported the emphasis on status quo management given the low natural mortality and longevity of this species. Maintaining the current apparently conservative harvesting strategy should buy time to gather better data for assessment to evaluate true stock productivity without significantly impacting longer term yield.

Given the strong reliance on the tagging data in the current assessment and the likely continuing use of these data as a tuning index for the catch-at-age analysis the reviewer believed it would be prudent to have this part of the analysis reviewed externally. One of the world authorities on the use of tagging data and its analysis, Dr. Carl Schwarz, is located at Simon Fraser University and he may be able to provide some additional insights and suggestions on how to optimally utilize this information in the assessment.

Mark-recapture studies are always plagued by uncertainties in the validity and degree of adherence to the many assumptions inherent in the analysis of these data. Consequently, the reviewer believes that efforts should continue to be directed towards developing some other fishery independent means of assessing stock abundance.

The reviewer found it somewhat troubling that the likelihood profiles for stocks in both the northern and southern areas differ by more than a factor of 2 when the tagging exploitation rate is used to estimate the exploitable biomass. Given the high degree of

uncertainty in all the assessment data including the tagging information the 'risk averse' management strategy for this stock should be to adopt the lower range in the estimates of stock abundance as the current best estimate of exploitable biomass unless there is some clear indication that the tagging analysis provides superior estimates. The current document does not convince the reviewer that this is the case.

The options for yield have almost a 100 percent increase from low to high which is unusual but not unexpected given the uncertainties in the assessment data. Given the reservations about stock biomass trajectory in section 5.2.6, the reviewer felt that managers should be made aware of the risk of focussing on the higher harvest by assuming that they will not have any long term impacts on the stock.

Subcommittee Discussion

The Subcommittee had considerable discussion regarding the estimation of exploitation rates based on tag/recapture analysis. The Subcommittee concurs with the reviewers' comments regarding the preliminary nature of this analysis, and notes that the estimation of exploitation rates is an integral part of the assessment as these estimates determined the absolute abundance of sablefish in the model. The Subcommittee agreed with the authors that the lowest exploitation rates estimated were overly optimistic given other indicators of stock trends (i.e. recruitment, survey data). The Subcommittee notes that not all the current information had been analyzed to date and that an additional two years of tagging results (1994, 1995) would be available early in 1997. In particular, the tagging analysis needs to incorporate depth stratification of release and recoveries in order to more precisely estimate abundance, particularly in deeper waters. Analysis of this information should be a priority.

Based on the information presented in the abstract and yield option sections, the Subcommittee also found it difficult to identify meaningful trends in stock abundance and the range of potential yields associated with various exploitation rates. In addition, discussion took place on the consequences of choosing a particular yield option on future stock abundance. The Subcommittee also discussed the appropriateness of incorporating the tagging analysis directly into the catch/age model in order to ensure consistency in parameter estimation, and notes that this has been initiated.

The Subcommittee also noted the need for an independent "tuning" index or stock trend estimator (other than tagging data) to provide additional support for abundance estimated by the model. Annual survey information, available since 1989, may prove suitable as an index.

Subcommittee Recommendations

The Subcommittee commended the authors on the extensive analysis conducted and the level of detail provided in the report. The Subcommittee accepted the working paper with modifications. The Subcommittee recommends that the abstract be expanded to include a clear statement of biomass trends and potential yield options,

and that the existing yield table be replaced with a table that identifies the impacts of yield ranges on stock abundance.

Based on the evidence presented, the Subcommittee considers sablefish stocks to be stable or declining slightly. The Subcommittee recognizes that this assessment is still developing and that there is a reasonable expectation that with the inclusion of the additional tagging information and modifications of the tagging and the catch/age methodologies, the existing uncertainties in stock abundance will be reduced. The impacts of a range of yields are identified in Table 2. This table identifies the potential effects of a series of quota levels (under assumed historical harvest levels) on biomass levels from 1997 to 2001. There is not a specific recommended quota, but the impact of yields in relation to the 1996 quota should be assessed using Table 2. The Subcommittee notes that this assessment was conducted jointly by DFO assessment staff and representatives of the Blackcod Fishermen's Association and commends all authors for the progress made. The Subcommittee encourages continued joint work.

Table 2 Simulated exploitable biomass and yield for the period 1997-2001 resulting from fixed harvest quotas of 3100 t, 3600 t, 4100 t, and 4600 t. figures are deterministic projections from estimated 1996 north and south stock biomass, based on catch at age analysis for the 10980-1995 period and assuming either low or high historical exploitation rate (Mu).

Low Historical Mu			High Historical Mu		Low Historical Mu			High Historical Mu	
COASTWIDE QUOTA 3100 t			NORTH					SOUTH	
Year	Biomass	Yield	Bioma	Yield		Biomass	Yield	Biomass	Yield
1997	61966	1700	29410	1700		60597	1400	21551	1400
1998	63571	1700	29732	1700		59903	1400	21099	1400
1999	63262	1700	29380	1700		59386	1400	20890	1400
2000	63104	1700	29337	1700		59455	1400	20945	1400
2001	64117	1700	30007	1700		59794	1400	21149	1400
COASTWIDE QUOTA 3600 t									
Year	Biomass	Yield	Bioma	Yield		Biomass	Yield	Biomass	Yield
1997	61966	2000	29410	2000		60597	1600	21551	1600
1998	63350	2000	29509	2000		59751	1600	20943	1600
1999	62829	2000	28950	2000		59094	1600	20594	1600
2000	62484	2000	28730	2000		59036	1600	20524	1600
2001	63321	2000	29235	2000		59258	1600	20614	1600
COASTWIDE QUOTA 4100 t									
Year	Biomass	Yield	Bioma	Yield		Biomass	Yield	Biomass	Yield
1997	61966	2250	29410	2250		60597	1850	21551	1850
1998	63155	2250	29315	2250		59569	1850	20757	1850
1999	62448	2250	28580	2250		58746	1850	20246	1850
2000	61940	2250	28213	2250		58537	1850	20032	1850
2001	62623	2250	28581	2250		58622	1850	19994	1850
COASTWIDE QUOTA 4600 t									
Year	Biomass	Yield	Bioma	Yield		Biomass	Yield	Biomass	Yield
1997	61966	2500	29410	2500		60597	2100	21551	2100
1998	62961	2500	29080	2500		59402	2100	20543	2100
1999	62069	2500	28135	2500		58429	2100	19847	2100
2000	61401	2500	27596	2500		58084	2100	19476	2100
2001	61935	2500	27809	2500		58045	2100	19300	2100

Update on the Canadian halibut bycatch plan. B. Ackerman

This document was for the information of the Subcommittee and was not reviewed. The document reviews the history of the Canadian halibut bycatch mortality reduction plan. In the late 1980s, the total halibut bycatch mortality approached historic high levels and was believed to affect both recruitment and catches by commercial longline fishermen. In 1991, Canada and the United States reached an agreement to reduce halibut bycatch mortality, most of which occurred in U.S. waters. In 1993, Canada implemented its program, which had a target reduction of 50% to approximately 1,000,000 lbs by the end of 1997 and required a review of the bycatch mortality estimates by PSARC. The reduction was to be accomplished by monitoring commercial catches and through a variety of regulatory measures to achieve a 10% reduction each year. The document identifies the measures that were taken and notes that in 1995, concern over bycatch, was part of the reason that the entire trawl fishery was closed on October 1st. In 1996, the groundfish management plan was designed to continue to reduce bycatch as well as wastage and to generally promote "cleaner" fishery practices. Measures used to achieve these objectives included a 100% on-board observer program, option A vessels, and an individual vessel bycatch limit for Pacific cod, sablefish and halibut. The report provides the details of these new management actions as well as new approaches to ensuring a year round fishery.

The results of the bycatch reduction program have been impressive. The preliminary estimates for halibut, indicate that bycatch mortality will be less than 500,000 lbs and may be as low as 350,000 lbs in 1996. This is substantially below the target of 1,000,000 by the end of 1997. Part of the reason for the low bycatch is the absence of a fishery for cod in Hecate Strait, but even with this fishery, it appears that the management measures taken in 1996 have achieved Canada's target, one year ahead of the schedule. In addition, it appears that wastage (overall) has been reduced.

4. Additional Subcommittee Discussions

Update on the stock assessment of Yellowtail Rockfish in the boundary area off S.W. Vancouver Island

This oral report provided an update to the assessment that was reviewed at the July meeting. The recommended yield range for the Boundary stock (southwest coast of Vancouver Island and northern Washington) of yellowtail rockfish has been changed from the 1996 yield option of 1,000-2,000 t, to 500-2,000 t. The lower limit has been reduced in response to a comprehensive stock assessment prepared by the Washington Department of Fisheries and Wildlife (WDFW). This assessment recommends a harvest of approximately 500 t, down from the approximately 2,000 t recommended for the previous year. While the author felt this assessment provides a reasonable and objective basis for a "conservative" yield point, he is not yet prepared to accept the general WDFW conclusion on the degree of the decline of stock abundance.

The Pacific Marine Fisheries Council is recommending a coastwide U.S. yield which assumes approximately a 1,150 t contribution from this stock. The author noted that the mean annual harvest of this stock has been 2,000 t, much of which is bycatch in the hake fisheries for both countries.

Appendix 1 Participants at the PSARC Groundfish Subcommittee Meeting held on November 14, 1996 in Nanaimo

B. Ackerman	Fisheries Branch, Vancouver
R. Beamish	Ocean Science & Productivity Division, PBS - Nanaimo
J. Fargo	Stock Assessment Division. PBS - Nanaimo
T. Gjernes	South Coast Division, Nanaimo
V. Haist	Stock Assessment Division. PBS - Nanaimo
R. Kronlund	Stock Assessment Division. PBS - Nanaimo
B. Leaman	Stock Assessment Division. PBS - Nanaimo
G. McFarlane	Stock Assessment Division. PBS - Nanaimo
N. Olsen	Stock Assessment Division. PBS - Nanaimo
M. Saunders	Stock Assessment Division. PBS - Nanaimo
R. Stanley	Stock Assessment Division. PBS - Nanaimo

Appendix 2 Reviewer Assignments for Groundfish Stock Assessments

<u>#</u>	<u>Title</u>	<u>Authors</u>	<u>Reviewers</u>
G96-3	Pacific Cod Stock Assessment	V. Haist D. Fournier	C. Hand R. Stanley
G96-5	Sablefish Stock Assessment	M. Saunders B. Leaman V. Haist R. Hilborn G.A. McFarlane	R. Hilborn A. Parma J. Schweigert

BIOLOGICAL ADVICE ON PACIFIC SALMON

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I. STEERING COMMITTEE REPORT

The PSARC Steering Committee met November 29, 1996 in the Conference 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.

Major Subcommittee Concerns:

The Steering Committee concurs with the concerns presented in the Subcommittee report. In particular, steering committee supports the subcommittee request for a greater involvement of ocean science personnel in the preparation and review of assessment documents. As a concrete measure, in addition to continuing to inform all Science Division Heads of the dates and agendas of all Subcommittee meetings, Steering Committee recommends that Subcommittee Chairs consider IOS staff when selecting reviewers for stock assessment documents.

Steering Committee notes the Subcommittees statements that parallel processes continue to be used within DFO to generate forecasts for some salmon stocks. Steering Committee notes that more of these forecasts have been submitted through PSARC and encourages the inclusion of all forecasts in the peer review process.

S96-17 An assessment of chinook salmon in the Strait of Georgia

The Steering Committee agrees that the most likely scenario of the trajectory of the Strait of Georgia chinook stock since 1960 is produced between the low catchability growth and the medium catchability growth scenarios. The steering committee also agrees that it is impossible to identify any single "best" runs.

The Steering Committee notes that even optimistic scenarios indicate that wild Strait of Georgia chinook stocks have declined by around 80% since the mid 1970's; and notes that this 80% reduction is relative to the period prior to the mid 1970's.

The Steering Committee notes that at current low stock levels even small catches keep stock levels low and observe that significant potential yield is being foregone at current levels of exploitation (which are low relative to the recent past because of restrictions on commercial troll and net fisheries). All evidence suggests that traditional approaches to regulating exploitation have not resulted in improved stock rebuilding. The Steering Committee recommends forming a strategic working group to:

- (a) communicate stock status and prognosis to user groups, and
- (b) develop a cooperative (with user groups) management program to rebuild stocks and manage fisheries

The Steering Committee notes the absence of any research programs directed at the Strait of Georgia sport fishery. This lack of research limits any ability for Science to play a constructive role in providing advice, and limits DFO's ability to provide empirical and scientifically based evidence that management measures taken in this fishery would benefit stock status.

S96-18 An assessment of harbour seal predation on pre-spawning adult salmon in Comox Harbour and the lower Puntledge River, British Columbia

The Steering Committee notes that this report is based on work done in 1990 and that chinook abundance has declined considerably since. Therefore the work may not be relevant to current stock sizes. Steering Committee notes the working paper is approved subject to a number of revisions. Because of the sensitivity of marine mammal issues and the prominence of the concerns of the Subcommittee on statistical analyses this working paper should not be distributed prior to review by the Subcommittee chair and the chair of PSARC to ensure all revisions are completed. At this time, the Steering Committee also recommends the revised paper be submitted to the National Marine Mammal Committee for review, assuming that this group meets within the next 6 months. Steering Committee suggests that before other data sets are analysed the statistical methodology should be verified with appropriate statistical experts.

S96-19 Forecasts of Fraser River sockeye and pink salmon for return year 1997

The Steering Committee notes that the early and late Stuart sockeye forecasts are based on extrapolations well beyond the historical range. It would be prudent not to plan for run sizes beyond the historical maximum, that is, 1.4 million early Stuart sockeye and 5.8 million late Stuart sockeye.

S96-20 Pre-season 1997 run size forecasts for major sockeye, pink, and chum salmon stocks in northern British Columbia

The Steering Committee concurs with the forecasts presented and the Subcommittee's concern about the uncertainty associated with the forecasts. The Steering Committee notes that the 5-year running average stock size used in the forecasts are weak in the best of situations and may be inadequate for development of current management strategies.

S96-21 An update on 1996 stock status and 1997 forecasts of Barkley Sound sockeye

The Steering Committee notes that an index correlation was presented between Hobeton River sockeye returns (early) and Barkley Sound sockeye returns (later) that possibly could be used to improve forecasts prior to the Barkley Sound runs. The Steering Committee encourages other authors to provide managers with documented

in-season indicators where appropriate that may help improve in-season planning for fisheries. The Steering Committee also notes the forecast return of 693,000 sockeye is a point estimate, and places a high priority on receiving the probability profile table for this estimate prior to submitting this information to RMEC.

S96-22 Forecast of 1997 return of coho to west Vancouver Island with comments on the implications of the poor brood-year

The Steering Committee endorses the 2 recommendations presented and highlights the need (Rec 2) for a working paper documenting the evidence for an appropriate Limit Reference Point for WCVI coho spawning escapement.

The Steering Committee supports the Subcommittee in rejecting the sibling regression model (SRM) for Carnation Creek this year. Steering Committee rejects this model because there is good justification to conclude the 1995 jacking rate was a result of anomalously large smolt lengths, and is not representative of the time series used to estimate model parameters and performance.

The Steering Committee notes that this is the first year that fry survey data has been collected. However, given the severity of the escapement decline in 1994 Steering Committee endorses the initial application of these fry surveys in the analysis, as a special case.

Based on the information presented Steering Committee concludes that there are a significant number of stocks that are at risk of major loss of production and possibly at risk of extinction during 1997. Steering Committee further emphasizes that this is not a recoverable situation in the short-term because generations do not overlap in the river. Therefore, this will be a recurring problem every 3 years, which will have a significant impact on the fishery regardless of the status of other stocks.

S96-23 1997 forecasts for Johnstone Strait, Georgia Strait, and lower Fraser chum salmon

The Steering Committee supports the recommendation but notes that the forecast of 4.9 million chum may be overly optimistic and should be considered as very high for developing management strategies.

S96-24 Update on status of WCVI chum salmon stocks and forecast for 1997

The Steering Committee concurs with the Subcommittee recommendations and shares the concerns expressed.

II. SALMON SUBCOMMITTEE REPORT

1. Introduction

The Salmon Subcommittee met November 19-21, 1996, at the Pacific Biological Station, Nanaimo. Eight 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

1. Process for forecast updates: The Subcommittee noted that it is frequently the case that additional information that has a bearing on stock forecasts becomes available after a given forecast has been reviewed and accepted by PSARC but prior to the beginning of the fishing season. To provide the best advice possible, the Subcommittee has identified a need for authors to provide documented forecast updates to the Subcommittee Chair and the appropriate line managers when new information becomes available as a basis for forecast revisions prior to the fishing season.
2. Minimum standard for forecast presentations: Stock forecasts presented for review by the Subcommittee are based on data and analyses exhibiting a wide range of data quality and analytical sophistication. This is unavoidable given the diversity of data sources, personnel and time frames involved in generating a variety of regional forecasts. The Subcommittee considers it essential that some minimum analytical criteria be met by all forecasts submitted in future. Further discussion identified that the minimum standard to be met is a well described model that provides point estimates of forecasts along with a summary of the deviations of the forecasts from observed returns over the period of record as a first approximation of the level of forecast uncertainty. Identification of this minimum standard for forecasts must not be interpreted as a lessening of PSARC normal requirements for forecasts involving full retrospective analyses, consideration of alternate models and formal estimates of forecast precision at the 90, 75 and 25% levels of probability.
3. Need for ocean science staff participation: In recent years, both reviewers and science personnel, external to PSARC, have frequently recommended that PSARC make managers aware of the possibility that a variety of changes in ocean conditions are likely to result in large departures from expected returns. The implication of these comments is that PSARC advice would be improved by including such subjective commentaries. PSARC also recognizes that the frequency with which we will be requested to consider these subjective types of information will increase as our review process becomes open to greater public participation. The Subcommittee acknowledges that there could be some added value in considering the impact of suggested changes in ocean climate or other

factors on salmon recruitment variations, but emphasizes that formal consideration of such information by the Subcommittee in formulating its advice will require that documentation and analysis of the basis for such claims be made available to the Subcommittee for consideration in the review process.

As a particular example, PSARC requests a greater involvement of ocean science personnel in the preparation and review of assessment documents. The Subcommittee is disappointed by the continued absence of ocean science expertise at its meetings, although non-assessment staff have made repeated ad hoc presentations stressing the importance of ocean productivity changes in evaluating the status of stocks. Therefore, the Subcommittee reiterates its interest in: (i) receiving and reviewing documents which relate oceanographic factors to important attributes of salmon stocks and (ii) acquiring the full participation of ocean science staff in the assessment and review process. To highlight the potential value of including greater oceanographic expertise, the Subcommittee notes that some of the most reliable forecasts (e.g., Barkley Sound sockeye) routinely include oceanographic variables and that variability in ocean survival is acknowledged to be a significant source of uncertainty in many assessments.

4. Duplication of forecasts: The Subcommittee notes that parallel processes are in place to generate forecasts within DFO (e.g., Expectations packages and PSARC). Thus, more than one forecast is being produced for some stocks. These forecasts will usually differ because they are based on different methodologies.

3. Working Paper Summaries, Reviews and Discussion

S96-17 An assessment of chinook salmon (*Oncorhynchus tshawytscha*) in the Strait of Georgia. C. Walters and B. Riddell.

Working Paper Summary

The Strait of Georgia (StG) supports one of Canada's most valuable recreational fisheries, for chinook and coho salmon. Until recently, there were also substantial commercial troll and net fisheries in the Strait. Chinook stocks from Puget Sound, the Fraser River, and streams around the Strait contribute to these fisheries and to various others both inside and outside the Strait. Since 1980, chinook catches in the Strait have decreased severely, leading to suspicions that many stocks contributing to the system have been badly overfished. Assessments in the late 1970s (Argue et al. 1983) warned of the decline and urged strong conservation measures. The warnings were repeated at various times during the 1980s, yet the only major reduction in exploitation rate has been in the troll fishery. More restrictive actions in the sport fishery have not been implemented due to uncertainty about the causes of the chinook decline and effective lobbying by the sport fishing interests. For example, there is evidence, from declining marine survival rates of hatchery stocks (Cross et al. 1991; Beamish et al. 1994, Beamish et al. 1995), that marine environmental factors may have a major

impact. Stock assessment and effective advice on sustainable harvest rates has been further hampered by lack of accurate information on the naturally-spawning populations around the Strait. The assessment approach presented here attempts to avoid the problem of inadequate stock information using catch and effort in StG fisheries, and exploitation rate information from coded-wire tagged hatchery populations. We show that the available data can almost equally well be explained by a variety of hypotheses about the relative importance of fishing and environmental factors, but the results consistently indicate that the spawning runs are now low enough to represent a situation of recruitment overfishing at poor marine survival rates.

Assessment Method and Assumptions

Most Pacific salmon stock and production assessments are based on direct observation of catch and numbers of spawners by stock, permitting stock-recruitment analysis of productivity and sustainable exploitation rate. Traditional assessment approaches are not possible for chinook in the StG, because a complex of stocks contributes to the fishery, at varying rates, and there have not been accurate spawning assessments for most streams. The main data available for assessment are catches and efforts in the sport, troll, and gill net fisheries; catch distribution and exploitation rate estimates from coded-wire tagging of selected hatchery stocks; limited age composition data from the catches; and indices of spawning stock trend from Fishery Officer counts, c.p.u.e. trend in commercial fisheries where chinook are taken incidentally, and recently from some mark-recapture programs.

For this assessment, we applied an approach now widely used in other fisheries assessments. This approach is basically to fit a population dynamics model to the catch-effort data, with other data providing "auxiliary information" for the fitting. That is, we (1) define a simulation model of the population dynamics that includes key parameters for recruitment, survival, migration, and harvesting; (2) provide this model historical fishing efforts (and gill net catch removals) as "driving inputs"; (3) use the model to predict time series of catches and auxiliary observations; and (4) vary the model parameters to provide as good an agreement as possible between predicted and observed catches and auxiliary observations. Often when this assessment approach is used, a very simple surplus production model is proposed for step (2) and only the catch-effort relationship is predicted and compared to observations. For chinook, we needed a more complex model to account for at least some of the biological complications associated with age-selective harvesting at only a few ages, complete natural mortality after first spawning, migration out of the StG by a portion of recruits (and later contribution of these migrants to reproduction), and the possibility of very substantial variation in recruitment rate due to environmental factors.

There are two key advantages to using this assessment approach. First, by using an assessment model that predicts (and is fitted to) the whole history of data available, we can assure that the prediction scheme is both structurally sound (contains known lags, spatial distribution features, etc.) and does not have parameter values that would predict large cumulative divergence from the observed data over time. Second, the

assessment model can be used directly for policy analysis, simply by extending its predictions into the future with alternative future "inputs" (fishing efforts, catchabilities, etc.); the assessment results do not need to be used as inputs to a second, possibly inconsistent model for policy prediction.

The model includes far more parameters than can be estimated from catch-effort data, even with support from auxiliary data. Our strategy for dealing with over-parameterization was to set some parameters at arbitrary but biologically reasonable values; vary these parameters to define a set of assessment "scenarios" or alternative hypotheses that we judge to be equally credible on the basis of the data; and to examine options that are robust or invariant to the uncertain parameters (i.e., what can we say about management that does not depend on specific assumptions in the assessment model).

The model simulates interannual changes in abundance of age 2, 3, and 4 chinook in the StG, removing harvest and natural mortality by age each year, for the period 1960-1994. The initial population age structure and abundance can either be estimated, or assumed to be at equilibrium with respect to average harvests during the early 1960s. Abundance of 2 yr olds each year after 1960 is predicted from a stock-recruitment-environment relationship, and annual exploitation rates are predicted from observed annual sport and troll efforts. A constant proportion (0.5) of the total recruiting 2 yr olds each year is assumed to leave the Strait and be subject to constant natural and harvest mortalities (harvesting at ages 3-4 only) in outside troll and interception net fisheries. A constant proportion (0.14, see Argue et al. 1983) of these outmigrants is returned two years later to contribute to the spawning stock. Spawning (and death) is assumed to occur mainly at age 4 after ocean and river gill net harvest of upstream migrant adults is removed. In actuality, only the Fraser River component of the total spawning run is subject to significant gill net mortality; subtracting total gill net catch from the total spawning run avoids having to assess differential terminal harvest rates for the various spawning streams contributing to production.

Agreement between model predictions and data is measured by a total weighted sum of squares measure, whose sum of squares components are: the sum of squared deviations between observed and predicted sport catches of wild fish, 1960-94; the sum of squared deviations between observed and predicted commercial troll catches of wild fish, 1960-94; the sum of squared environmental effects on recruitment, 1960-92; and the sum of squared deviations between sport plus troll exploitation rates for 1979-93 and annual values estimated from coded-wire tag recoveries. The inverse variance weights for each variable were chosen to insure that the fitted model would have reasonable values of catch variation due to factors other than recruitment variation, recruitment anomalies with roughly the same variance as seen in other salmon stocks, and would not predict annual exploitation rates much higher or lower than indicated by tagging data. Minimization of the sums of squares was conducted using the Solver Tool in Microsoft Excel.

Results

Figure 17.1 shows calculated vulnerable stock size histories (age 3-4 abundance in the spring, plus 0.4 times age 2 abundance) for a range of estimation scenarios. Also shown are projections of stock size over the next 20 yrs if sport and troll efforts remain constant at 1994 values and if recruitment anomalies are near the average estimated for the late 1980s and early 1990s (if productivity per spawner averages near the estimates for that period). Figures in the Working Paper (Fig. 3 & 4) show that the agreement between simulated and observed catches is extremely good (for all estimation scenarios) and that calculated spawner-recruit relations show realistic patterns of variation. The high catchability growth scenarios ($q_{\max}/q_{\min} = 10$ or 20 in Fig. 17.1) show substantial increase in annual exploitation rate over time, while low growth scenarios indicate high exploitation rates throughout the history of the fishery. All scenarios indicate relatively stable exploitation rates after the mid 1970s. These catchability scenarios also diverge sharply in assessment of historical patterns of recruitment anomalies: high catchability growth scenarios have relatively low anomalies with little temporal pattern; low growth scenarios result in strong positive anomalies over the late 1960s to mid 1970s, then a sudden drop with persistent low or average productivity thereafter. While it is possible to concoct a variety of reasonable scenarios for how the stock changed prior to the mid 1970s, the estimation scenarios all converge to a very pessimistic picture of the current and near future situation. A key point from Fig. 17.1 is that the assessments consistently indicate current stock size to be very small (around 0.2 million fish) compared to stock sizes during the 1960s and 1970s, implying a decline of at least 80-90% in abundance. None of the estimation scenarios indicates that current low abundance can be ascribed solely to negative environmental effects on recruitment; all indicate that the stock is now also suffering recruitment overfishing. Current exploitation rates could be as much as double the optimum for long term production.

Discussion

Unless we can resolve the issue of how much catchabilities have grown over time, we cannot accurately apportion the cause for the StG chinook decline between overfishing and environmental factors. But whatever triggered the decline, it is clear that abundance is severely depressed. Even the most optimistic estimation scenarios (low catchability growth cases) predict spawning stock sizes to remain far below the optimum for natural production if fishing mortality rates remain high, even if environmental conditions are relatively favorable. Spawning stocks are now low enough that even very favorable environmental conditions would not likely result in rapid and substantial recovery (there are just not enough spawning fish to capitalize on improved productivity per fish). Two fundamental responses are possible for chinook salmon in the Strait of Georgia: (1) do nothing and hope that favorable environmental conditions will promote a "natural" recovery; or (2) act to reduce exploitation rates so as to rebuild spawning stocks to more productive levels. A third option, to try and rebuild abundance through hatchery production, has already been tried. Further, a disturbing pattern in recent years is that exploitation rate estimates from CWT data are higher than

we predict from effort and catchability growth in the population model; this suggests that there may be compensatory fishing effects due to growth in catchability with decreasing stock size, caused by efficient targeting of remaining chinook.

In the current situation, there is a fundamental tradeoff between maintaining some harvest opportunity versus rebuilding the stocks to more productive levels as quickly as possible. Reducing sport and troll exploitation rates in the Strait to the long term optimum would allow eventual recovery, but this recovery would likely take at least 20-30 yrs due the "drag" of continued harvest removals. Greater reductions in exploitation rate would speed recovery but obviously be more disruptive.

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Reviewers' Comments

Reviewer #1

Reviewer #1 believes the approach employed by the authors to be sound even though it demonstrates the ambiguity of catch and effort data without informative independent auxiliary data. The main concern of reviewer #1 is the treatment of increases in catchability over time. He states that independent estimates of the relative changes in sport and commercial catchability would help to reduce uncertainty. Reviewer #1 generally concurs with the assessment of the status of Strait of Georgia chinook salmon, but disagrees with some of the statements in the discussion and with the rationale for some of the choices of parameter values. Reviewer #1 agrees that a scenario intermediate between the low and moderate efficiency growth may be closer to reality. Despite the uncertainties, substantial reductions in fishing mortality will be necessary to restore abundance under current conditions.

Reviewer #2

Reviewer #2 believes that the authors' conclusions are largely correct and that "overharvest", not "changing or unfavorable environmental conditions", has been largely responsible for the dramatic decline in catch and presumably real abundance of StG chinook. He found the presentation of methods to be straightforward and direct, but that certain details that would have been of interest were often not mentioned and/or were not covered in sufficient detail to allow a full consideration of the merits of the approach. Similar to reviewer #1, he questioned the formulation of fishery catchability. Reviewer #2 also stated that the authors should acknowledge that their aggregated stock-recruitment function is a gross simplification of the situation in StG. In addition, reviewer #2 requested more information on how the authors treated hatchery contributions to the StG fishery as compared to those from wild fish.

Reviewer #3

Reviewer #3 again emphasizes that the use of fishery catch and effort data for stock assessment is risky because of probable but generally unquantified changes in catchability. He agrees that the simulation modelling approach used seems to be the best possible given the lack of information. Reviewer #3 concurs that chinook abundance is very low compared to the 1970s, current spawning stock size is well below the level from which high recruitment can be expected, and exploitation rates need to be reduced to rebuild spawning stocks. Reviewer #3 requested a definition of recruitment overfishing and some quantitative description of the extent of recruitment overfishing suggested by the various scenarios. He also questioned whether some populations may have been lost due to high exploitation rates. If so, he states that rebuilding of StG chinook to historical levels may be even slower than projected.

Subcommittee Discussion

The Working Paper is accepted with minor revisions to address the comments of the reviewers. The authors are also directed to review the wording of the Abstract, Results and Policy Implications very carefully, to ensure that wording is clear and consistent, and that appropriate qualifiers (such as "wild" and "under present environmental conditions") are included in all necessary places.

The Subcommittee accepts the validity of the overall model. It is acknowledged that important uncertainties remain about a number of model parameters and process formulations. Nonetheless, the number and diversity of sensitivity tests which were performed, and the general consistency of the results across the sensitivity tests, justify confidence in the major conclusions of the model, despite uncertainty in its parameters and formulations. In particular, although the true changes in catchability for the troll and sport fleets over the historic period of the fishery probably can never be known with certainty, the Subcommittee accepts that Fig. 17.1 reflects the general trajectory of the Strait of Georgia chinook stock since 1960.

Of the scenarios presented, the Subcommittee agrees with the authors that the most likely historic conditions lie between the low catchability growth and the medium catchability growth scenarios. The Subcommittee also agrees that it is impossible to identify a single "best" run, for several reasons. The differences in statistical fits of the parameterizations are fairly small (Working Paper Table 2), so identifying the best one would be difficult given the authors' concerns about data quality. Statistical goodness of fit measures are sensitive to details of weighting the fits to the various data sets, and there is insufficient justification to select one specific weighting over alternative weightings. There is also sufficient uncertainty about the data from the earlier period to justify selection of any specific set of parameters within the range bracketed by the low and medium growth in catchability scenarios. The Subcommittee does note that the low catchability growth scenario predicts too few chinook to match the pattern of chinook catches reported in the Fraser gill net fisheries, and that the medium growth scenario estimates exploitation rates in the most recent few years which are higher than independent estimates from coded wire tags. These results suggest that the true situation lies between the low and medium growth in catchability scenarios.

The Subcommittee stresses that even optimistic scenarios indicate that wild Strait of Georgia chinook stocks have declined by around 80% since the mid 1970s. Excessive exploitation and unfavourable environmental conditions have contributed to the decline. The Subcommittee agrees that the increase in catchability is plausible, caused by technological innovation in both the troll and sport fisheries, and possibly by increased effectiveness of fishers to target effort on remaining aggregations of chinook. Moreover, the Subcommittee is concerned about the declining effort in the StG sport fishery in recent years, and the potential for a large "effort response" to increases in chinook abundance. Increased abundance would be expected to attract large amounts of effective effort and raise the overall exploitation rate.

The Subcommittee accepts the projections in the Working Paper, and concludes that if exploitation is maintained at the levels of the mid 1990s, and marine survival remains at the level of the past several years, the Strait of Georgia chinook stocks will remain at their present low level, or increase only slightly. Stocks are likely to decline further if marine survival decreases or if exploitation increases (e.g., if recent constraints on outside and terminal fisheries are relaxed and those fisheries increase their exploitation of Strait of Georgia chinook stocks). If the exploitation rate in the sport fishery increases above levels estimated for the mid 1990s, the risk of stock collapse is higher.

Potential production and harvest opportunities are being sacrificed at the present stock sizes. A significant reduction in exploitation rate, relative to the rate in the early 1990s (1990-1992) will be required to achieve any noteworthy rebuilding. With a 50% reduction in exploitation rate and marine survival at current levels, it is estimated that modest rebuilding of production could be achieved in 8-10 years. However, PSARC stresses that measures taken to date which were intended to reduce harvest rates on lower Strait of Georgia stocks, particularly in sport fisheries, have not succeeded in actually limiting harvest rates in these fisheries. Rather, these assessments indicate that the dynamics of the sport fishery have changed to maintain the harvest rate.

PSARC stresses that total mortality from all sources must be considered in any conservation or rebuilding plan. For example, PSARC cautions that in evaluating consequences of management options it will be necessary to consider estimates of repeated hook-and-release mortality from non-retention fisheries. Also, PSARC expects large returns of several Fraser sockeye and pink salmon stocks in 1997. Bycatch of chinook in fisheries for these stocks will contribute to the total mortality on Strait of Georgia chinook.

PSARC further notes that enhancement activities are not considered to be an option to increase production of these wild chinook stocks because of the effort response expected as hatchery fish become vulnerable to the fishery, and because of possible ecological interactions among hatchery and wild fish.

The Subcommittee identified potential research activities associated with the model and results. Reliable estimates of changes in catchability would be highly valuable. Also, the Subcommittee noted that it is difficult to reconcile some of the results in the present Working Paper with some of the results of Working Papers S94-3 and S95-2 [Beamish and co-authors]. These Working Papers suggest that wild smolt production has not declined and that recent low escapements are a consequence of poor marine survival. By contrast, the current Working Paper suggests that wild smolt production has decreased because of overfishing. Each of the assessments indicate, however, that marine survival of chinook in the Strait of Georgia has been poor since the mid 1970s.

S96-18 An assessment of harbour seal (*Phoca vitulina*) predation on pre-spawning adult salmon (*Oncorhynchus* spp.) in Comox Harbour and the lower Puntledge River, British Columbia. P. F. Olesiuk, P. E. Cottrell and C. E. Neville

Working Paper Summary

A total of 215 hours of surface observations were made of the foraging patterns of harbour seals on pre-spawning salmon in Comox estuary and lower Puntledge River during 05 May - 30 December, 1990. During low tides, seals congregated and foraged primarily along the edge of the estuary where it dropped off to deeper water, and especially at the mouth of the river drainage channel. As tides increased, seals dispersed and began foraging over the entire tidal portion of the estuary and small numbers of seals (typically 10-30; maximum count 41) ventured into and foraged in the lower 3.5 kilometres of the Puntledge River. Although the river was only inhabited at higher tides and by a relatively small proportion (2-17%; mean 8.2%) of the total seal population, predation in the river accounted for 67% of total salmon consumption. Salmon kills in both the estuary and river generally involved groups of seals, the size of which was directly correlated with the size of prey, but the actual extent of co-operation between group members could not be established. Salmon predation rates varied seasonally in accord with the size and timing of salmon returns, and the species composition of salmon kills generally reflected

the difference in the timing of spawning of each species. Harbour seals consumed an estimated (with 95% confidence limits) 2,976 (1,548-5,194) chinook salmon, 1,806 (791-3,530) pink salmon, 3,267 (1,045-6,709) coho salmon, and 11,646 (6,708-17,479) chum salmon; which represented an estimated 36% (22-49%) of the number of chinook returning to the system, 3.3% (1.5-6.2%) of the pink return, 18% (7-31%) of the coho return, and 14% (8-19%) of the chum return. On the basis of our findings, we recommend: (1) analysis of similar existing data for Cowichan Bay; (2) telemetry studies to determine seal turnover rates in the Puntledge; and (3) engineering studies to determine the feasibility of a barrier to seals placed at the mouth of the Puntledge.

Reviewers' Comments

Reviewer #1

Reviewer #1 had concerns about the effect of small sample sizes and large expansion factors on total and species estimates of salmon killed by seals as well as concerns about the statistical methodology. Reviewer #1 did not agree that the size of feeding group and prey size are related but may have other plausible hypotheses, e.g., that the size of the prey and number of seals sharing a meal is a result of an upper limit to the size of a single meal. Reviewer #1 also questioned how effective seal predation would be in a more natural river and estuary than the highly channelized Puntledge River. Reviewer #1 supports the recommendation for further predation studies in other areas and years providing the statistical problems identified can be resolved. Reviewer #1 supports the recommendation for a study of turnover rates which could also be conducted by removal as an alternative to fitting transmitters.

Reviewer #2

Reviewer #2 concentrated on the statistical analysis used to estimate the number of salmon consumed by seals. Reviewer #2 is not convinced that the method of estimating variability is appropriate as this study seems to be an example of non-probability sampling which requires known (even or random) distribution, whereas this study does not appear to have any randomization because sites visited, times surveyed, seals observed etc. were selected in an apparent arbitrary manner. Reviewer #2 is not convinced feeding occurs at the same rate over a 24 hour period. He also believes spawning escapement estimation procedures and accuracy should be documented. The authors should elaborate on the methodology of how a seal barrier in the Puntledge might actually work.

Subcommittee Discussion

Subcommittee discussion chiefly revolved around the statistical methodology of the salmon predation estimates and the measures of variance. One member felt that because of the small sample sizes, statistical methodology used in survival analyses in epidemiology of disease may be more appropriate. Another member supported the analyses as an example of a Poisson distribution provided that the assumptions are

met. Both reviewers had concerns about the statistical analyses conducted. The Subcommittee agreed that seal predation is a major factor in reducing the severely depressed Puntledge chinook stock. The Subcommittee also discussed the applicability of the results to other areas or other years as well as the perception among our clients that seals are major predators of salmon.

The Subcommittee agrees that the spring 1996 recommendation for further documentation of seal predation on adult Puntledge chinook salmon has been met. The Subcommittee accepts the Working Paper with revisions based on receiving further statistical advice, re-analysis of the data, addition of data tables in the Working Paper, and other minor revisions. The Subcommittee agrees that seals are major predators of salmon in the Puntledge River and estuary, although further statistical analyses are required to validate the point estimates and confidence limits. Decisions about cost effective mitigation measures would depend on further studies of seal turnover rate in the Puntledge. Because of the widespread perception of our clients that seals are major salmon predators, the Subcommittee supports the collection and documentation of additional data of seal predation on salmon in other streams, e.g., the Cowichan.

**S96-19 Forecasts of Fraser River sockeye and pink salmon for return year 1997.
A. Cass and D. Blackburn**

Working Paper Summary

Record high spawning escapements in 1993 (age-4 returns in 1997) affect forecast reliability for the major sockeye runs returning in 1997. Estimates of escapements to the Early Stuart, Late Stuart and Quesnel systems accounted for 84% of the all-Fraser sockeye escapements in 1993. For Early Stuart sockeye, the preliminary escapement estimate in 1993 is 887,000 fish (Fig. 19.1). This is 130% above the previous record escapement of 385,000 fish in 1989. The estimate of spawning escapement to the Late Stuart system in 1993 was 1.8 million or three times the previous record escapement of 576,000 sockeye in 1989 (Fig. 19.2). The escapement of Quesnel Lake sockeye in 1993 was 2.62 million or 40% higher than the brood year escapement (Fig. 19.3).

The effect of the record high sockeye escapements on density-dependent survival and hence on forecast reliability of age-4 Stuart and Quesnel sockeye cannot be evaluated based solely on escapements. Unfortunately, sibling abundance estimates for these stocks (age-3 jacks) collected in 1996 are poorly determined. Therefore, jack abundance data are likely to be poor predictors of age-4 abundance in 1997. Except for in-lake hydroacoustic estimates of sockeye fry in Quesnel Lake, we have no ability to assess potentially density dependent effects on freshwater survival of dominant runs of Fraser sockeye in 1997. It is clear that our ability to develop defensible numeric sockeye forecasts for the early and late Stuart stocks in 1997 are severely compromised and that they are very uncertain. For pre-season management purposes, it would be prudent not to plan for returns to the Stuart system beyond historical limits. The Fraser sockeye forecast for 1997 at a 50% probability (50% chance of being less

than or greater than the forecast) is 29 million fish and at a 75% probability is 12 million fish. The forecast for Fraser pink salmon is 11 million (50% probability) and 7.5 million (75% probability) (Table 19.1).

An index of survival using the $\log_e$ transformed recruits-per-spawner was computed for major stocks (brood years 1948-1991) to assess correlations in survival among major stocks (early Stuart, late Stuart, Stellako, Quesnel, Chilko, Birkenhead and Late Shuswap). Correlations among stocks were all positive and low ranging from 0.06-0.57. Although survivals among stocks are positive, the potential for adjusting forecasts of late-timed stocks in-season based on observed survivals of early-time stocks is likely to be very low given the low correlations among stocks. The fact that the trends in survivals are positive indicates that extreme changes in survivals of early runs may signal changes in other stocks (i.e., high mortality occurred in all runs in 1995).

Reviewers' Comments

Reviewer #1

Reviewer #1 accepts the recommendations in the Working Paper. Although he makes several technical comments, he does not believe that these would materially change the outcome of the analysis. For example, reviewer #1 questions the method used by the authors to compute the variance for aggregate forecasts and suggests an alternative approach. He also questions the approach used to model among stock correlations.

Reviewer #2

Reviewer #2 suggests that we have more reason to expect medium to high returns in 1997 than low returns. In his view, Quesnel Lake has seen escapements which exceeded those observed in 1993 and, given the right conditions, has the potential to produce substantial returns. He concurs with the authors' concerns regarding extrapolation of forecasts beyond the range of observed data. Given this problem, reviewer #2 suggests that qualitative rather than quantitative estimates be presented.

Subcommittee Discussion

The Subcommittee noted that the methodologies for forecasts of Fraser sockeye and pink salmon returns were previously reviewed and accepted by PSARC in 1994 and 1995. The authors considered five regression models in the computation of forecasts of individual sockeye stocks and four models for an aggregate pink salmon forecast that represents returns of all pink salmon stocks in the Fraser River system. Forecasts from models with the lowest root mean square error were selected. Efforts were also undertaken to incorporate anecdotal and qualitative information from sources other than the Fraser sockeye and pink production data used in the modeling exercise. The authors concluded, and the Subcommittee agreed that the information presented was insufficient to warrant amendments of the model results. Forecast run sizes are shown

in Table 19.1 at probabilities of 90, 75, and 50 that the actual return will be larger than the forecast.

The Subcommittee recognized the authors' emphasis that an extremely high level of uncertainty is associated with the 1997 return estimates. Uncertainty exists because, in general, the models and available data used to generate the sockeye and pink forecasts produce imprecise and unreliable results. Based on retrospective analyses, the mean absolute percent error (MAPE) of the forecasts for major sockeye stocks on the 1997 cycle ranged from 42% to over 300% (Chilko 42%, early Stuart 81%, late Stuart 261%, Quesnel 320%). Even greater uncertainty exists for the 1997 sockeye forecasts for several reasons. First, brood year spawning escapements in 1993 for two major contributing stocks on the cycle, early and late Stuart sockeye, were high and far beyond the range of historical observations (Figs. 19.1 and 19.2). Since escapement was the explanatory variable in the regression models, forecasts were based on extrapolations to levels well outside the range of observed returns. Second, the in-lake acoustic estimates of Quesnel Lake fry, upon which the Quesnel stock forecast is based, are uncertain as indicated in a previous PSARC review; alternative data for the Quesnel stock, 1993 brood year escapement, was also high and far beyond the range of historical levels.

Despite the inherent uncertainty in the forecasts, the Subcommittee generally agreed that large brood year escapements such as those in 1993 (the largest since 1909) should produce larger returns. Density dependent effects on freshwater and marine survival are currently unknown, however, and will limit production at some high but yet unobserved level of abundance. Preseason plans should accommodate the large uncertainties in the forecasts and also consider sockeye run sizes to the Stuart River that are within the range of historical returns.

Subcommittee Recommendations

The Working Paper was accepted with the following minor revisions:

1. The appendix containing the description of the anecdotal and qualitative information should be removed from the Working Paper and documented in a memorandum to the StAD Head. The Working Paper should include a reference to the memorandum and a brief summary of the information presented.
2. Table 2, showing the forecasts by stock and probability level, should be amended to standardize the format for forecasts by: (a) removing the 80% and 95% probability levels; and (b) identifying the early and late Stuart forecasts separately from the rest of the stocks with a footnote to indicate the extreme uncertainty in the estimates.
3. The recommendation section should be revised as follows:
 - (i) Forecasts for the early and late Stuart stocks are extremely uncertain because the brood year spawning escapements used to produce the forecasts are high

and well beyond the range of observations. As a result, the forecasts are outside the range of observed returns and unreliable.

- (ii) For Quesnel sockeye, historically the largest run on the 1997 cycle, the forecast relies on in-lake acoustic estimates of fry that themselves are uncertain. Coupled with uncertain freshwater and marine survivals and unknown density-dependent effects, forecasts of this stock are very unreliable.
- (iii) Preseason plans should accommodate the large uncertainties in the forecasts. Run size estimates should rely on more informative in-season estimates of actual returns.

S96-20 Preseason 1997 Run Size Forecasts For Major Sockeye, Pink, And Chum Salmon Stocks In Northern British Columbia. C. Wood, D. Rutherford, D. Peacock and S. Cox-Rogers

Working Paper Summary

This Working Paper includes preseason 1997 run size forecasts for nine sockeye, five pink, and five chum salmon stocks or stock groupings in northern British Columbia, statistical areas 1-10. The recommended forecasts (see Table 20.1) are based on simple models reviewed in a previous working paper, and procedures that follow three guiding principles:

- *Forecasts of run size are only meaningful for stocks or stock-groupings whose run sizes can actually be measured.* Forecasts were not developed for stock-groupings in some statistical areas where total stock size could not be reconstructed with reasonable accuracy.
- *A forecast should specify the probability of all possible run sizes.* Full cumulative probability distributions for the forecasts are plotted in comparison with historical stock sizes in the Working Paper. The cumulative probability plot for Skeena River sockeye salmon is included here as an example (Fig. 20.1).
- *Forecasting methods should be selected for their predictive power (measured in retrospective analyses), not on how well the underlying models fit historical data.* All forecasts in Table 20.1 are based on a procedure that performed best for that species in a retrospective analysis in which identical procedures were followed to forecast stock size in previous years using only the data that would have been available at the time.

Following previous recommendations endorsed by PSARC (Working Paper S95-12), the recent 5-yr average stock size (5YAVG CY) model with log-normal error structure was used to forecast 1997 sockeye salmon runs, whereas brood year escapement data and the non-linear Ricker stock-recruitment model (NLSRESC) were used to forecast pink

salmon returns. These models and two others, the long-term average model (AVGCY) and the average rate of return from escapement model (LSRESC), were evaluated in the Working Paper by retrospective analysis for Area 8 chum salmon. The long-term average model performed as well or better than competing models, and accordingly, was used to develop 1997 pre-season run size forecasts for all chum salmon stocks.

Reviewers' Comments

Reviewer #1

Reviewer #1 recommends acceptance of the Working Paper and that PSARC clarify the need to provide run forecasts for stocks or stock groupings where the data collected to date are unreliable. Reviewer #1 notes that the significant correlations in stock size among some adjacent stocks provide additional strong support for the regime theory developed by ocean science staff. In particular, ocean conditions in northern BC and Alaska may remain favorable for salmon while conditions in south-central BC may remain unfavorable.

Reviewer #2

Reviewer #2 agrees with the authors that it is a waste of analytical effort to forecast stock sizes that cannot be estimated reliably. He suggests that analytical methods less sensitive to numerical uncertainty might be more appropriate (e.g., expressing data and forecasts as ranks or categories). Reviewer #2 agrees that incorporating environmental variables into forecasts might be useful and should be investigated further. In the interim, however, the precautionary management approach would require very conservative pre-season fishing plans.

Subcommittee Discussion

The Working Paper was accepted with minor revisions, specifically, inclusion of escapement goals for the stocks with forecasts and standardization (with other Working Papers) of how the probability of forecasted run sizes are expressed. Probabilities of run sizes were expressed as the probability of the true run being less than the forecasts, whereas probabilities in the Fraser River forecasts were expressed as the probabilities of exceeding the predicted run sizes. The Subcommittee has chosen to standardize on the latter for a range (50%, 75%, and 90%) of probable run sizes. The Subcommittee agreed with the authors that the use of these simple forecasting models (i.e., recent year averages) will not predict major changes in annual run sizes, but they are "useful on average, whether over a number of different stocks, or over a series of years within a stock." Consequently, extreme changes in returns due to changes in marine production or other factors (e.g., recent disease problems affecting juvenile Babine sockeye abundance in the Skeena River) will not be predicted (e.g., averaging effect), but could influence subsequent predictions unless the type of forecasting model was changed.

The Subcommittee identified two points for the authors consideration: (i) enhanced Area 8 chum stocks were included in the forecasts of Area 8 total production, but could be partitioned and forecasts prepared for hatchery and wild chum salmon; (ii) patterns in correlations between stocks could reflect mis-allocation of catch between some adjacent stocks and may not then be indicative of common environmental effects on the stocks; this could be tested by examining correlations in escapements. These issues will be considered in future forecasting work.

The Subcommittee notes that if more accurate short-term forecasts are necessary for management, then greater investments in data quality (accuracy of catch and escapement data by stocks, and particularly, in biological sampling for age structures) will be required. Further, longer term shifts in environmental conditions probably affect salmon production in ways that alter the parameters for forecasting such that long term forecasts will be biased and imprecise. It follows that an understanding of long-term cycles in environmental conditions that affect salmon survival and growth may be the only hope for developing forecasts that will be useful in predicting long term average stock sizes.

S96-21 An update on 1996 stock status and 1997 forecasts of Barkley Sound sockeye. K.D. Hyatt and W. Luedke

Working Paper Summary

Recent year returns of Barkley Sound sockeye have declined precipitously from 1.8 million fish in 1991 to only 200,000 fish in 1995. Although dramatic, these declines were anticipated by two independent forecasting procedures first developed in 1987 and applied annually since 1988 to predict return variations of Barkley Sound and West Coast Vancouver Island (WCVI) sockeye. Given the magnitude of the stock declines in recent years, no commercial fisheries were anticipated or carried out in either 1995 or 1996. Recent year stock declines represent a continuation of a pattern of predictable variations in ocean climate states that lead to both steep increases and pronounced "crashes" in WCVI sockeye returns. The absence of any surplus for commercial catch in recent years is directly attributable to the combined effects of: (i) a shift of conditions in the marine environment that dictated average to below average survival of sockeye smolts migrating seaward between 1993 and 1996 and (ii) management to protect escapement as a basis for increases in future year returns.

Over the past 8 years four independent techniques have been tested annually for their utility in generating reliable pre-season forecasts of Barkley Sound sockeye returns for harvest managers. The four techniques are known as the Salinity Survival Method (SSM), the Survival Stanza Method (SSM), the Sibling Age Class Method (SACM), and the Salmon Enhancement Program Biostandard Method (SEPB). Updates on the performance of three of these techniques to 1996 are as follows:

- (1) The SStM forecast exhibits the best overall performance with a mean absolute percent error (MAPE) value of approximately 27% over the most recent 9 years of forecasting. Further, SStM forecasts account for the majority of variations in returns if the extreme observation associated with the 1991 return year is omitted from the analysis.
- (2) The SSM forecast exhibits the next best performance with a MAPE value of 36% over the most recent 9 years of forecasting. SSM forecasts also exhibit a statistically significant association with returns if the 1991 return year is omitted from the analysis.
- (3) SEPB forecasts have performed well over some return intervals but not others. During the 1988-1996 testing interval SEPB forecasts exhibited a substantially higher MAPE value (59%) than that displayed by both SSM and SStM forecasts (27-36%). Large magnitude deviations between SEPB forecasts and actual returns tend to occur in consecutive years which seriously erodes the confidence of harvest managers as well as the fishing industry in their utility.

All forecasts for 1997 indicate that returns of Barkley Sound sockeye will remain below the 20 year average (880,000) in 1997 but returns are likely to represent an improvement over both the 1995 and 1996 years of return. Given the management (and escapement) benchmarks established in 1995, returns adhering to any of the 1997 forecasts will allow for some harvest. However, under the variable harvest rate strategy adopted in 1996, harvest projections range from a total allowable catch (TAC) of 80,000 given an SStM return of 357,000 to a TAC of 300,000 given a SEPB return of 715,000.

Comparative performance of the various forecast options along with DFO's recent pursuit of a more risk averse approach to management recommends the SStM forecast range of 259,896 to 454,104 sockeye as the preferred, pre-season forecast for 1997. Returns adhering to the SStM forecast will generate surpluses of between 39,000 and 114,000 sockeye for allocation to harvest in Area 23.

Reviewer's Comments

Reviewer #1 could not endorse or refute recommended 1997 forecasts for Barkley Sound sockeye because of the lack of technical information presented. He noted that past PSARC reviews have been highly critical of the authors' methodology, focusing on the need to develop statistical measures of uncertainty about the point estimates, and the need to assess the accuracy of the forecast methods by comparing them to more conventional techniques (i.e., average return, average return rate per spawner, stock-recruit functions, etc.). Although the Working Paper did not address previous technical concerns as directed, reviewer #1 thought that the forecasts were reasonable for practical management purposes, based on the apparent recent performance of the forecast techniques.

Subcommittee Discussion

The Subcommittee accepted the Working Paper with minor revisions. The Subcommittee endorsed a 1997 forecast using the SSM methodology for which a probability profile could easily be developed for this report (forecast at the 50%, 75% and 90% levels). Given the magnitude of smolt releases and salinity conditions in 1994 and 1995, the SSM forecast is for returns of 693,000 (50% level) sockeye to Barkley Sound in 1997. The Subcommittee did not endorse the SStM forecasts because the SStM method does not allow for the variance calculations necessary to report probability profiles (see Major Subcommittee Concerns). The authors were encouraged to develop methods for computing probability distributions for the SStM model for future application.

The Subcommittee was informed by the authors that work investigating the use of an alternative stock identification methodology is underway. The use of DNA to discriminate Barkley Sound sockeye stocks appears to be a feasible replacement to the earlier use of parasite factors. However, the DNA investigation is currently not funded and it is estimated that a minimum of \$30 thousand would be required to complete the reanalysis of Barkley Sound sockeye. Once catch composition can be identified into the three Barkley Sound sockeye stocks the authors can undertake the hindcasting analysis of their forecast models to examine the uncertainty and forecasting error in each model (SStM and SSM).

The authors have presented an index correlation between Hobiton River sockeye returns and Barkley Sound sockeye returns that could be applied in 1997. Hobiton River sockeye have an earlier return timing than the Barkley Sound sockeye. They also point out that age structure for 1997 as predicted by the SSM model is a ratio of 2 to 1 age four to five-year-old-sockeye. Thus, the use of both the Hobiton River index and deviation from the predicted age structure should prove useful for managers to determine whether the actual return is deviating from the forecasted return.

S96-22 Forecast of 1997 return of coho to west Vancouver Island with comments on the implications of the poor brood year (1994) escapement. B. Holtby and R. Kadowaki

Working Paper Summary

In 1997, the progeny of the extremely low WCVI coho escapement in 1994 will enter the fishery. The 1991 brood (1994 return) suffered smolt-to-adult survivals of less than 1% in both WCVI populations for which we have estimates (Carnation Creek (wild): 0.6%); Robertson Creek (hatchery): 0.05%). This preliminary 1997 forecast was prompted by obvious concerns over the ability of WCVI coho stocks to sustain fishing in 1997. The forecasts in this Working Paper are based on preliminary escapement figures for Robertson Creek and on as yet incomplete escapement to Carnation Creek. Total escapement to Carnation Creek was estimated using historical run timing.

1997 Forecasts of Smolt to Adult Survival Rate

Based on a sibling regression model (SRM), the forecast of the smolt-to-adult survival rate for Robertson Creek hatchery coho returning in 1997 is 0.036 (75th percentile: 0.025; 90th percentile: 0.015). The SRM has performed adequately at Robertson Creek. The SRM forecast of smolt-to-adult survival rates for Carnation Creek is 0.369 (75th percentile: 0.307; 90th percentile: 0.253). With the added uncertainties that are due to the projecting of total returns, the forecast smolt-to-adult survival could be as high as 0.436 (95th percentile of run timing projection). These forecast survivals are significantly greater than the highest survivals seen between 1971 and 1996 ($t_{22df} = 3.73$, $P < 0.002$). The average fork lengths (FL) of smolts leaving Carnation Creek in 1996 (age-1: 103.1 mm; age-2: 113.3 mm) were significantly larger than the maxima observed between 1971 and 1995 (age-1: 92.9 mm; age-2: 112.4 mm). Because the jacking rate is strongly dependent on smolt size and the smolts in 1996 were well outside the range encompassed by the SRM model, we doubt the reliability of the SRM forecast. We recommend the adoption of the forecast of smolt-to-adult survival generated with the sea-surface salinity model (SSSM), which has performed nearly as well as the SRM at Carnation Creek. The SSSM forecast for smolt-to-adult survival is 0.090 (75th percentile: 0.053; 90th percentile: 0.019) and does not depend on smolt size.

Evaluation of Potential Fishery Impacts in 1997

Based on coded-wire tag based measurements on Robertson Creek hatchery coho, the long-term average exploitation rate on WCVI coho stocks is believed to be in the 65% to 70% range. Data are not yet available to confirm the 1996 exploitation rate, but it will likely be close to 50%.

We describe an approach for generating advice on exploitation rates from forecasts of smolt-to-adult survival and measured (or estimated) smolt production. The approach is premised on the determination of a "Limit Reference Point Escapement" (LRP_e). The probability (in this case a "risk") of escapement falling below the LRP_e should be explicitly controlled by management of the fisheries. We present values for the LRP_e which range from 1 to 13 females/km. We suggest that the risk of escapement falling below 1 female/km should be set near zero for most, or perhaps all, populations. An escapement of 13 females/km is probably close to the MSY escapement for Carnation Creek (although below the median escapement to Carnation Creek between 1971 and 1995, exclusive of 1994 of 18.2 females/km (range 7.1 to 57.1)), while 9 and 3 females/km are LRP_e s that represent progressively greater risks of compromising future production. We recommend 9 females/km as a suitable LRP_e for WCVI coho populations based upon our understanding of Carnation Creek production dynamics. Some risk of escapement falling below a LRP_e of 9 females/km is likely acceptable. The following table shows the exploitation rates that would produce the four LRP_e s at Carnation Creek using the SSSM forecast smolt-to-adult survivals applied to the observed smolt production of 892 (age-1 and age-2) in 1996. For comparison, the

exploitation rates that would produce the LRP_e s given the recent 3-yr smolt production (1,323) are shown in brackets.

LRPE (females/km)	exploitation rates to achieve LRP_e with forecast smolt-adult survivals (with % of values $\geq$ indicated survival)					
	50%=0.090		75%=0.053		90%=0.019	
13	0	(0.74)	0	(0.56)	0	(0)
9	0.19	(0.82)	0	(0.70)	0	(0.14)
3	0.73	(0.94)	0.54	(0.90)	0	(0.71)
1	0.91	(0.99)	0.85	(0.97)	0.56	(0.90)

At the mean predicted survival of 0.090, the LRP_e of 13 females/km would not be achieved even without fishing. An exploitation rate of 50% (preliminary estimate of exploitation rate in 1996) would allow an escapement of 6, 3, and 1 female/km at the 50%, 75% and 90% smolt-to-adult survival probabilities, respectively. All of those escapement levels are below the recommended LRP_e of 9 females/km. For comparison, in an average year, current harvest rates (50-65%) would insure that even the highest LRP_e would be achieved under all but the most pessimistic marine survival scenario.

Using a model detailed in the Working Paper, age-1 smolt production per kilometer of stream was estimated for 45 WCVI streams (Port Renfrew to Cape Scott) for which we had estimates of juvenile densities and fork length (FL) from the fall of 1995 (1994 brood year). This represents a minimum (pessimistic) estimate of smolt production since there is likely a small age-2 component from the 1993 brood year for many of the surveyed populations. Age-1 juvenile coho (those that produce age-2 smolts the following spring) are often under-estimated in surveys of the type employed in these WCVI streams. Consequently, direct estimation of this age-2 smolt component is not possible. We believe that Carnation Creek produces more age-2 smolts than most other WCVI populations, so the addition of the most recent 3-year average of age-2 smolt production/km from Carnation Creek (72) to the estimated age-1 production in the surveyed populations should estimate a maximum (optimistic) potential smolt production. Estimated smolt production (both age-1 only and age-1 and age-2 combined) was converted to numbers of recruiting females by applying the SSSM forecast smolt-to-adult survival for Carnation Creek and the long-term sex ratio observed at Carnation Creek (0.426 female). We then calculated the exploitation rates required to escape the four LRP_e s, and plotted the results as frequency distributions.

No juvenile coho were detected in six of the 45 surveyed streams, and a substantial proportion of WCVI streams will produce fewer than 100 age-1 smolts/km (Fig. 22.1A). Carnation Creek production was likely in the lower 25% of surveyed streams (Fig. 22.1). Even with the addition of 72 age-2 smolts/km over 20% of WCVI streams will produce fewer than 200 smolts/km (Fig. 22.1B).

The scenarios depicted in Fig. 22.2 through Fig. 22.4 are associated with increasing levels of risk aversion, with the "A" panels more risk averse than the "B" panels. With mean smolt-to-adult survivals, 25% (Fig. 22.2B) to 50% (Fig. 22.2A) of the streams will receive an escapement less than the 9 females/km, even in the absence of fishing. With poor (90th percentile) smolt-to-adult survivals and no fishing, between 15% (Fig. 22.4B) and 25% (Fig. 22.4A) of the streams would not get even 1 female/km, less than 45% of the streams would get 3 females/km, and only a couple of streams would get more than 9 females/km (Fig. 22.4). Results for 75th percentile of the smolt-to-adult survival are intermediate to those two predictions (Fig. 22.3). Even at the mean survival forecast and assuming a substantial age 2 component, the majority of systems would be expected to receive less than 13 females/km, and approximately 25% would have escapement below 9 females/km (Fig. 22.2B). At intermediate levels of uncertainty about the marine environment (Fig. 22.3) any level of fishing would mean that at least 58% of the populations would not see escapements over 9 females/km, at least 19% of the populations would not achieve 3 females/km and perhaps as many as 15% would not achieve 1 female/km.

We conclude that maintaining the exploitation rate at current levels (50-65%) would be risk prone and that very substantial reductions in exploitation rate will be required to insure even low levels of escapement to WCVI streams in 1997.

Reviewers' Comments

Reviewer #1

Reviewer #1 stated that the methods used by the authors follow the current "best" practice for these stocks. However, he could not fully assess the methods because they were not described in sufficient detail in the Working Paper. For the 1997 forecast, reviewer #1 concurs with the authors' conclusion that the results from the SRM model for Carnation Creek are suspect and probably too optimistic, due to the unusual circumstances this year. In reviewer #1's opinion, the authors do not provide sufficient rationale or justification for their recommendation that the SRM forecast of survival rate of 0.0356 be adopted for the Robertson Creek coho return in 1997. Reviewer #1 concurs with the authors that a recommended harvest rate of between 19% and 44% for Carnation Creek coho in 1997 is warranted under the current DFO policy of risk averse harvest, given the many uncertainties in the forecasted returns. He is not convinced by the author's arguments, however, that this same level of harvest extended to the entire WCVI is necessarily also appropriate and will result in optimal harvest and adequate escapement of all these other WCVI coho stocks. Additional information is clearly required on the productivity of other WCVI stocks, compared to the Carnation Creek and Robertson Creek hatchery stocks.

Reviewer #2

According to reviewer #2, the Working Paper provided a convincing analysis of recent survival rates for two coho salmon populations. However, reviewer #2 criticized the authors for not treating uncertainty explicitly. Although the authors developed confidence intervals, they did not explain their methods. Reviewer #2 had the impression that uncertainty was considered in fitting regression lines in the forecasting models, but not in calculating survival rates for the most recent jack and adult returns, required as input data for the 1997 forecasts. Reviewer #2 stated that standard deviations for the proportions of jack and adult runs returning by 29 October should be calculated from the historical data and incorporated, along with uncertainty about exploitation rates, in calculating a plausible range for the expected number in the 1996 escapement.

Subcommittee Discussion

The Subcommittee evaluated information presented at the meeting to select among competing models used to forecast survival and exploitation rates. Three models considered were a sibling regression model (SSR), a sea surface salinity model (SSSM) and a cycle average model (CAM). The SSR model is based on a correlation between jack and adult abundance. This model fits historical data better than the other models, although none of the models have been evaluated through retrospective analysis. The use of the SSR model is suspect for 1997 because jacking rate and smolt size are strongly correlated and because mean smolt size of the 1997 brood was well beyond historical range. Furthermore, the SSR model predicts a high coho survival rate at Carnation Creek that is inconsistent with the low survival rate prediction at Robertson Creek given the previous strong correlation between Robertson Creek and Carnation Creek annual survivals. Thus, the SSR model for Carnation Creek was considered too risky and was rejected. The CAM model was eliminated because it performed more poorly than the SSSM and historical averages would fail to predict outliers. The SSSM was accepted as the preferred model and predicts a mean survival rate of 0.090 (risk averse 75th percentile: 0.053, 90th percentile: 0.019).

The Subcommittee noted that even under a 'no fishing' policy in 1997 and assuming the mean survival (risk neutral) from the SSSM (0.090), approximately 13% of the stocks would attain escapements of less than 3 females/km and approximately 25% would attain escapements of less than 9 females/km. A risk averse scenario that assumes a survival rate at a 75% probability level (0.053) results in about 19% of stocks with escapements of less than 3 females/km or 58% with escapements less than 9 females/km under no fishing. Applying an exploitation rate in 1997 similar to that in 1996 of 50% and a survival rate of 0.053, results in approximately 38% of stocks achieving escapements of less than 3 females/km and 88% of stocks achieving escapements of less than 9 females/km.

The authors have proposed 9 females/km as a Limit Reference Point (LRP) or minimum escapement below which full production would be compromised (see also Working

Paper S96-11). The LRP is smaller than the target escapement desired for maximum production. For this reason, it is important to be particularly cautious in 1997 and understand the implications of overestimating the LRP for these stocks.

The Subcommittee noted that the LRP of 9 females/km has not been reviewed explicitly by PSARC (although it was included in a previous Working Paper on Strait of Georgia coho) and, as noted by the authors, evidence supporting its validity is not documented. Given the low expectations in 1997, uncertainties in harvest management, genetic diversity concerns, and the fact that there is no in-season mechanism for forecasting abundance, the implications of an appropriate LRP are critical. Policy questions regarding application of risk averse measures to coho (e.g., appropriate risk level) were discussed but could not be resolved without further analysis and direction from senior management.

The Subcommittee accepts the paper subject to major revisions that include incorporation of the information presented at the meeting. The Subcommittee agreed that the significant reduction in harvest needed in 1997 is a short-term remedial requirement to rebuild stock levels. The Subcommittee notes that no evidence was presented requiring modification of previous advice on the long-term exploitation rates on this stock aggregate (60-65%).

Subcommittee Recommendations

1. The Subcommittee recommends that significant reductions in exploitation rate from recent levels are required in 1997 to ensure the conservation of WCVI coho populations. The magnitude of reductions involves an evaluation of trade-offs between current fishery values and the risk of not maintaining a full suite of viable and productive coho populations.
2. A Working Paper is required at the next Salmon Subcommittee meeting to document the evidence for an appropriate Limit Reference Point for WCVI coho spawning escapement.

S96-23 1997 Forecasts for Johnstone Strait, Georgia Strait, and Lower Fraser chum salmon. P. Ryall, D. Bailey and N. Schubert

Working Paper Summary

Wild returns for both the Fraser and non-Fraser groups were forecast from the 1992-1994 brood year escapements, the average return per spawner, and the average age at return. The average returns per spawner and average age at return estimates were based on: for Fraser stocks, 1976-1986 brood year returns for both even and odd years combined; for non-Fraser stocks, the most recent 15 years of data. The total enhanced return to inside waters including the Fraser River is estimated preseason by applying average fry

to adult survival rates for each major facility and stage at release to brood year actual fry releases and average brood year age composition by facility. These estimates are currently based on the simple averages of the last complete ten years of data (1979 to 1988 broods). For minor production, a production area biostandard based on major facility data is computed and used with actual releases by stage from these facilities to estimate production. Habitat restoration is based on habitat capacity assuming full utilization by adult spawners, average egg to fry survivals of 20% based on actual data, and area biostandards of fry to adult survival and age composition. Habitat restoration and community program production is included in wild production based on the return per spawner ratios of return. Alternate enhanced forecasts for age 4 and age 5 returns based on average age composition and actual numerical returns for the brood in the previous year are not possible at this time as 1996 enhanced return data are not available until at least the summer of 1997.

The 1997 total expected return of Johnstone Strait, Georgia Strait and lower Fraser River chum salmon is:

Stock Type	Age 3	Age 4	Age 5	Total
Fraser River wild	396,000	1,027,100	109,600	1,532,700
Fraser River enhanced	50,000	245,500	29,200	324,700
Non-Fraser River wild	341,000	1,703,000	251,000	2,295,000
Non-Fraser River enhanced	92,900	505,600	114,000	712,500
Total	879,900	3,481,200	503,800	4,864,900
Percent	18%	72%	10%	-

Reviewer's Comments

Reviewer #1 indicated that it was not possible to evaluate the accuracy or precision of the forecast for 1997 because there was no evaluation of alternative forecast models and no indication of past performance of the simple model used. Furthermore, there was no indication of uncertainty around the forecast presented. Reviewer #1 recommended that alternative forecasting models such as historical averages, fry-adult returns, sibling models and escapement-recruitment relationships be developed and evaluated using retrospective analysis.

Subcommittee Discussion

The Subcommittee agreed with the reviewer's recommendations but recognized that such analyses will take significant effort and that fisheries managers need pre-season forecasts to discuss with industry in the near future. The authors presented some recent additional analysis which showed that the model (average returns per spawner) used had historically performed quite well (27% mean absolute percent error (MAPE), 1988-94) at least for some components of the forecast and that pre-season forecasts were not dissimilar from some of the in-season management abundance estimates

(except in 1996, see below). The Subcommittee also noted that the median of historical return/spawner (R/S) estimates rather than the mean should be used in future assessments as the R/S values are not expected to be normally distributed, nor have they been historically.

The Subcommittee noted that the forecast model used was previously accepted by PSARC in 1988 and accordingly could be supported presently. However, there has been significant progress in recent years for other stocks in both forecast models and ways to present their results. The Subcommittee encourages the authors to incorporate these concepts into a more detailed analysis for presentation to PSARC at the earliest possible opportunity.

In the interim, the Subcommittee accepts the Working Paper, with revision to include the use of past model performance as a measure of uncertainty in the forecast. The forecast for 1997, therefore, is for a return of approximately 4.9 million chum salmon. The Subcommittee noted that the R/S model performed poorly in 1995 (when the forecast was for 4.2 million chum to return when 1.9 million chum actually returned). Inclusion of 1995 data in the calculation of MAPE above increased the error from 27% to 39%.

The Subcommittee notes that the uncertainty about the forecast, using past model performance, will not be analogous to confidence statements being made for other stock forecasts such as Fraser sockeye and such differences should be clearly indicated.

S96-24 Update on status of WCVI chum salmon stocks and forecast for 1997.
W. Luedke and D. Bailey

Working Paper Summary

WCVI chum salmon populations have been reported in more than 220 WCVI river systems. Two areas (Nitinat and Nootka) have significant enhancement, while the other areas have virtually all wild production. In total, WCVI chum returns have ranged between 250,000 and 2.6 million since 1953. However, since 1984 when the first major hatchery returns were realized, the mean total return has averaged almost 1.5 million, compared to a 650,000 average in the previous three decades. In general, chum salmon production appears to be widely distributed in many systems, extremely variable between years, and exhibits poor correlation between rivers. This latter point may be a result of local influences in the freshwater and/or estuarine environments. There is no apparent trend in escapements in any of the areas without enhancement, however, escapements have been substantially below current escapement goals. Since 1983, there has been significantly lower production in southern areas with no enhancement (Area 23 and Area 24), whereas more northerly areas appear to be within long term ranges of production. In recent years, only Nitinat (Area 22) and Nootka (Area 25) have had surpluses to escapement requirements. Due to limitations in the

preseason forecasts, as well as inability to provide in-season forecasts of total stock or total allowable catches, simplified harvest strategies have been formulated to address these limitations. At Nitinat, duration of weekly fishing opportunities are determined by escapement levels into Nitinat Lake. At Nootka, a fixed effort pattern has been developed in the approach areas to provide an overall exploitation rate of 25% or less. Forecasts for the WCVI chum are presented. At Nitinat, we recommend a forecast of 1.2 million total return with a harvestable surplus of approximately 900,000 chum. At Nootka, we recommend a forecast of 330,000 total return which should provide a harvestable surplus in the order of 20,000 chum. Other areas of the WCVI are not expected to meet current escapement targets.

Reviewers' Comments

Reviewer #1

Reviewer #1 agreed with the authors that pre-season forecasts were generally inaccurate and were of little use to in-season management. However, reviewer #1 noted that this assertion was poorly documented. The paper lacked data in some cases and did not present a retrospective analysis of alternative forecast models. More rationale for selection of the environmental scalar variables would also have been desirable. Despite these concerns, reviewer #1 could find no reason to reject the forecasts provided. Given the limited role of forecasts in managing these stocks, reviewer #1 questioned the need for further work on improving them. He suggested instead that the authors' recommendation to improve estimates of stock composition and to evaluate escapement targets should be the focus of future work.

Reviewer #2

Reviewer #2 shared the concerns of reviewer #1 with respect to the lack of a retrospective analysis and consideration of alternative forecast models. In addition, he pointed out that confidence intervals around the point estimates should be provided, so that an evaluation of the utility of the forecasts could be made. Reviewer #2 was also critical of sections 2, 3 and 5 which describe WCVI chum fisheries, assessment methods and recommendations for assessment and research, respectively. He noted that many of the assertions made in these sections were not supported by data or analysis and suggested that these sections be removed if proper documentation was not provided.

Subcommittee Discussion

The Working Paper was accepted with revisions. The authors are to address the reviewers' comments and the direction provided by the Subcommittee in making these revisions.

There was disagreement by some Subcommittee members with reviewer #2 over the inclusion of sections 2 and 3 in the Working Paper which they found useful in providing

a context for the forecasts. Because of the qualitative nature of these sections, the Subcommittee decided that they should be condensed and included as part of the introduction to the Working Paper.

The Subcommittee agreed with both reviewers that a statistically rigorous methodology had not been applied to the development of 1997 forecasts of WCVI chum salmon. They were concerned about the wide range in format and quality of forecasts provided by PSARC which may create confusion among fishery managers on how to use the forecasts. It was agreed that in the long-term, all forecasts should be expressed as probability distributions rather than point estimates and that retrospective analyses be used to choose among alternative forecast models as in Working Papers S96-19 and S96-20. In the interim, the Subcommittee decided to accept these forecasts with the caveat that an assessment of the past performance of the specific model being used must be included with the forecast. Mean absolute deviation (MAD) and mean absolute percent error (MAPE) should be the statistic used in this assessment. Similar to the discussion of Working Paper S96-23, the Subcommittee was concerned that forecasts are likely biased too high (risk prone) because they were based on average returns per spawner (R/S) instead of the median R/S, given that the distribution of R/S is likely skewed (lognormal).

Subcommittee Recommendations

1. The Subcommittee supports the chum forecasts for Nitinat Lake (1,200,000 chum) and Nootka Sound (328,000 chum). There are commercially harvestable surpluses in both of these areas. The authors are to provide an evaluation of forecast performance for past years using the same methodology.
2. The Subcommittee could not comment on the expected status of other WCVI chum stocks in 1997 given the lack of detailed analyses for these stocks. However, the authors' expectation of no surpluses given recent run sizes is prudent advice in the absence of more information.

Appendix 1 Participants at the November 19-21, 1996, meeting of the Salmon PSARC Subcommittee

Subcommittee chair: L. Richards
PSARC Chair: J. C. Rice

Subcommittee members:

C. Wood	P. Ryall
A. MacDonald	S. McKinnell
R. Kadowaki	B. Holtby
D. Meerburg	A. Cass
D. Bailey	L. Jantz
B. Riddell	W. Saito
K. Hyatt	S. Argue
M. Stocker	D. Anderson

Authors/Reviewers:

R. McNicol	D. Blackbourn
C. Walters	S. Cox-Rogers
R. Kronlund	

Observers:

E. Lochbaum
M. Henderson
N. L. Hopwo

Appendix 2 Reviewers of Working Papers

Working Paper	Reviewer #1	Reviewer #2	Reviewer #3
S96-17	R. Kope	D. Hankin	D. Swain
S96-18	B. Holtby	J. Irvine	
S96-19	R. Kronlund	S. McKinnell	
S96-20	D. Welch	R. Kadowaki	
S96-21	S. Cox-Rogers		
S96-22	B. Hargreaves	C. Wood	
S96-23	A. Cass		
S96-24	S. Argue	R. McNicol	

Figures and Tables

Table 19.1. Fraser River sockeye run size forecasts by stock and timing group (bolded) for 1997.

STOCK/TIMING	Forecasts for reference probabilities ^a			
	25%	50%	75%	90%
<u>SOCKEYE^b</u>				
Early Stuart ^c	3,022,000	1,874,000	1,162,000	751,000
Early Summer	874,000	456,000	238,000	132,000
Fennell	89,000	47,000	25,000	14,000
Bowron	76,000	37,000	18,000	9,000
Raft	36,000	20,000	11,000	6,000
Gates	361,000	195,000	105,000	60,000
Nadina	24,000	15,000	10,000	6,000
Pitt	117,000	62,000	33,000	18,000
Seymour	45,000	30,000	20,000	14,000
Scotch	126,000	50,000	20,000	9,000
Mid Summer	66,606,000	25,639,000	9,869,000	4,125,000
Chilko	3,155,000	1,992,000	1,258,000	826,000
Quesnel	27,613,000	8,200,000	2,435,000	804,000
Stellako	723,000	471,000	307,000	207,000
Late Stuart ^c	34,959,000	14,976,000	6,415,000	2,957,000
Birkenhead	1,201,000	689,000	395,000	238,000
Late Summer	1,212,000	590,000	287,000	148,000
Late Shuswap	29,000	10,000	4,000	1,000
Cultus	104,000	56,000	30,000	17,000
Portage	173,000	84,000	41,000	21,000
Weaver	905,000	440,000	214,000	110,000
TOTAL	73,048,000	29,249,000	11,711,000	5,075,000
PINK	17,212,000	11,387,000	7,533,000	5,104,000

^a probability that the actual run size will exceed the specified forecast

^b Except for 50% probability levels the pooled forecasts by run timing group were computed using a weighted sum of the variance (weighted by the forecast). Therefore, sums of individual stocks within a particular group do not necessarily equal the totals listed (bold).

^c Early and Late Stuart sockeye forecasts are based on extrapolations well beyond the historical range. It would be prudent not to plan for run sizes beyond the historical maximum, that is, 1.4 million early Stuart sockeye and 5.8 million late Stuart sockeye.

Table 20.1 Summary of pre-season run size forecasts for 1997 for north and central coast sockeye, pink, and chum stocks.

Species	Statistical Area	River or Lake	Escapement Target	Forecasts for reference probabilities ^a			% increase or decrease ^b
				50%	75%	90%	
Sockeye	1	Yakoun	^c	7,300	5,000	3,300	-36.29
	2	Skidegate	9,525	12,000	7,000	4,000	-35.74
	3	Nass	245,700	1,100,000	800,000	580,000	6.84
	4	Skeena	1,159,011	4,500,000	3,500,000	2,700,000	-34.70
	6	Kitlope	20,000	40,000	29,000	21,000	-24.71
	8	Atnarko	75,000	60,000	40,000	26,000	-28.26
		Kimsquit	30,000	25,000	15,000	8,500	-50.00
	9	Owikeno	200,000 ^d	200,000	94,000	41,000	207.69
	10	Long	200,000	200,000	83,000	30,000	223.01
Pink	2E	all	720,909	6,100	1,900	660	-21.02
	6	all	1,447,200	1,100,000	500,000	300,000	-9.22
	8	all	1,475,400	2,200,000	1,100,000	590,000	49.27
	9	all	342,450	84,000	30,000	12,000	129.32
	10	all	65,600	46,000	24,000	13,000	-13.50
Chum	2E	all	453,025	320,000	190,000	130,000	73.85
	6	all	518,350	260,000	160,000	100,000	-31.49
	8	all	267,450	430,000	280,000	200,000	-41.64
	9	all	150,700	46,000	26,000	20,000	9.14
	10	all	98,500	44,000	28,000	20,000	-6.51

^a probability that the actual run size will exceed the specified forecast

^b percentage change calculated as [median (50%) forecast - last observed return] * 100/last observed return where last observed return is 1996 for sockeye salmon and 1995 for odd-year pink salmon and chum salmon.

^c 5000-10000 (under review)

^d minimum; target increases with run size according to management plan.

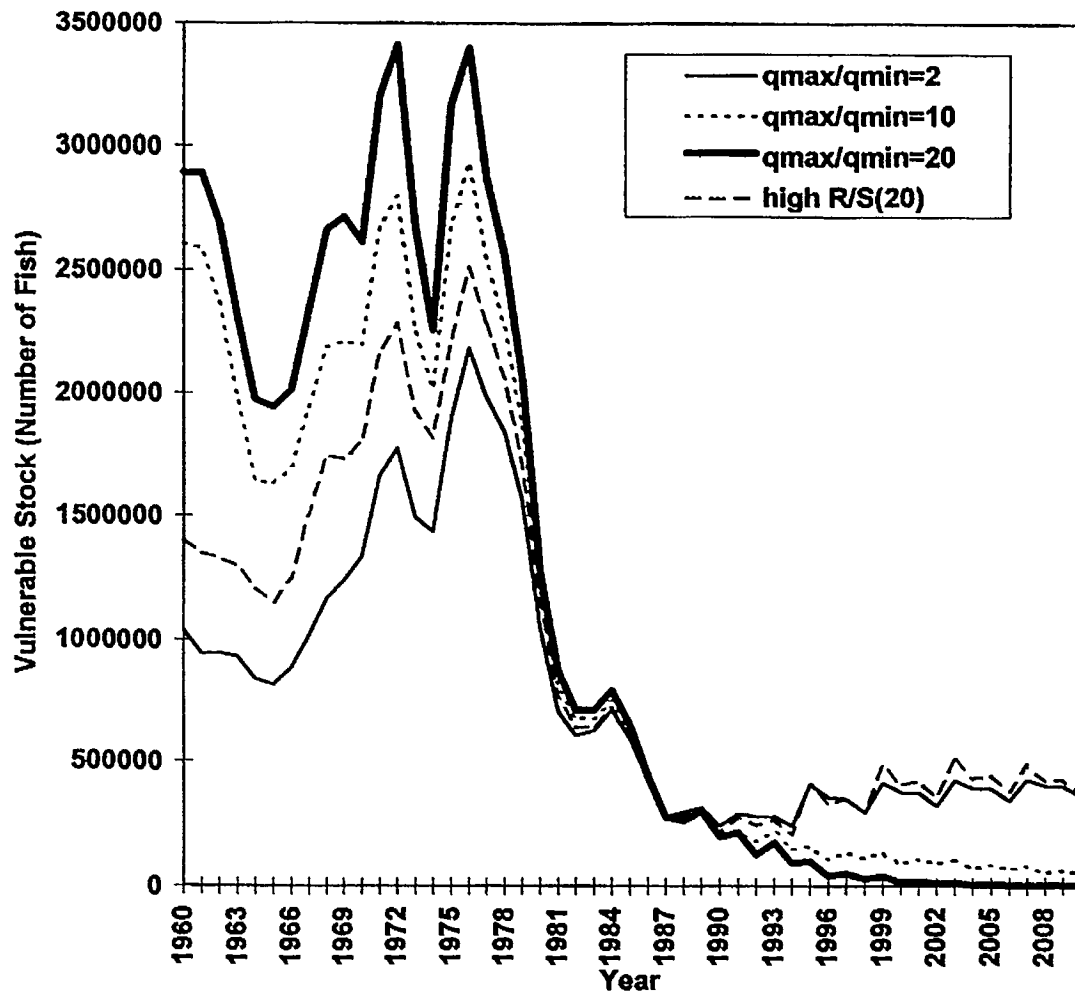


Fig. 17.1. Alternative scenarios for historical and future abundance of chinook salmon in the Georgia Strait. The range of estimates arises from uncertainty about growth in efficiency of sport and troll gear (q , catchability) since 1960, and about maximum recruits (R) per spawner (S) at low spawning stock sizes.

EARLY STUART (all tributaries)

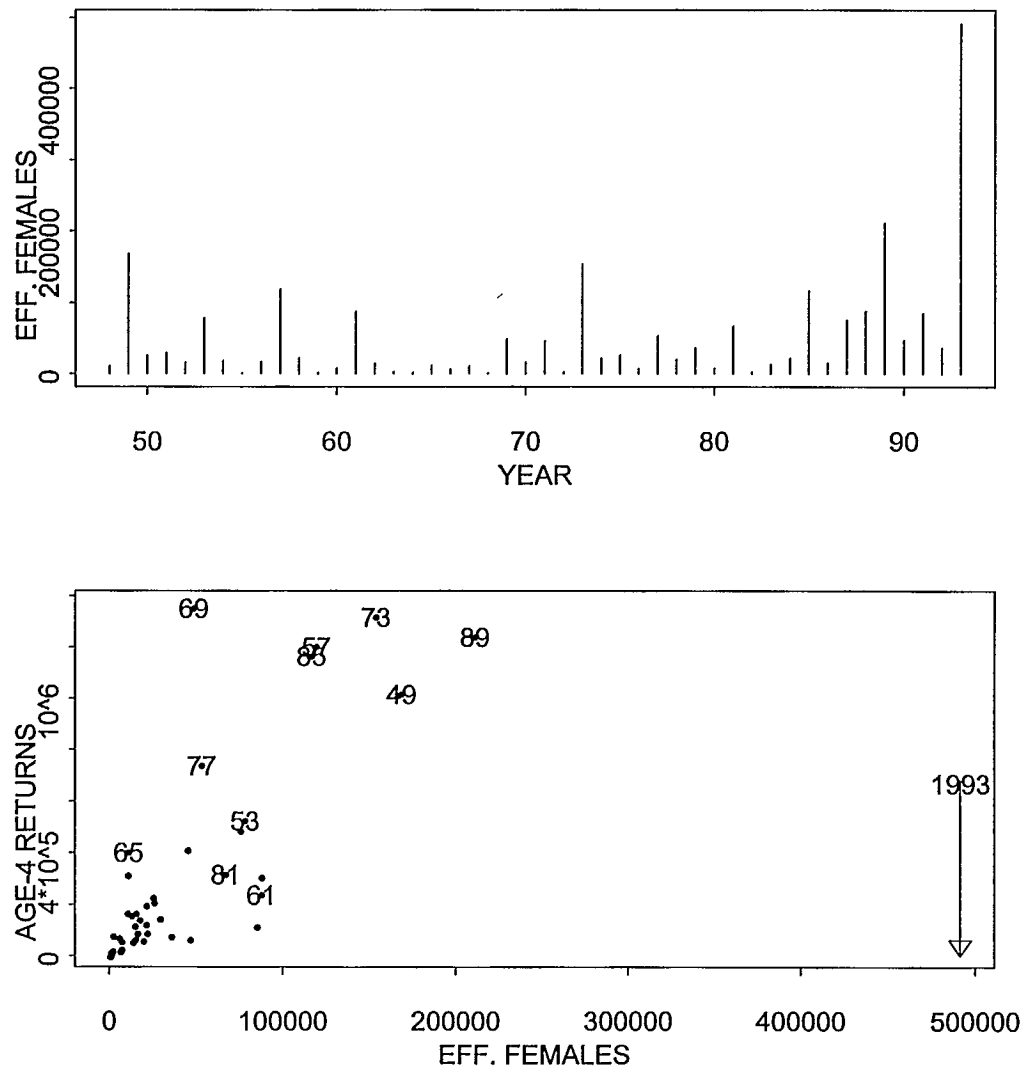


Fig. 19.1. Time series of spawning escapement estimates for sockeye measured in effective females (adult females weighted by egg deposition) (Upper) and relationship between escapement and age-4 progeny (Lower). The arrow indicates escapement in 1993 (1997 brood of age-4 sockeye). Data labels are 1997 cycle line year.

LATE STUART

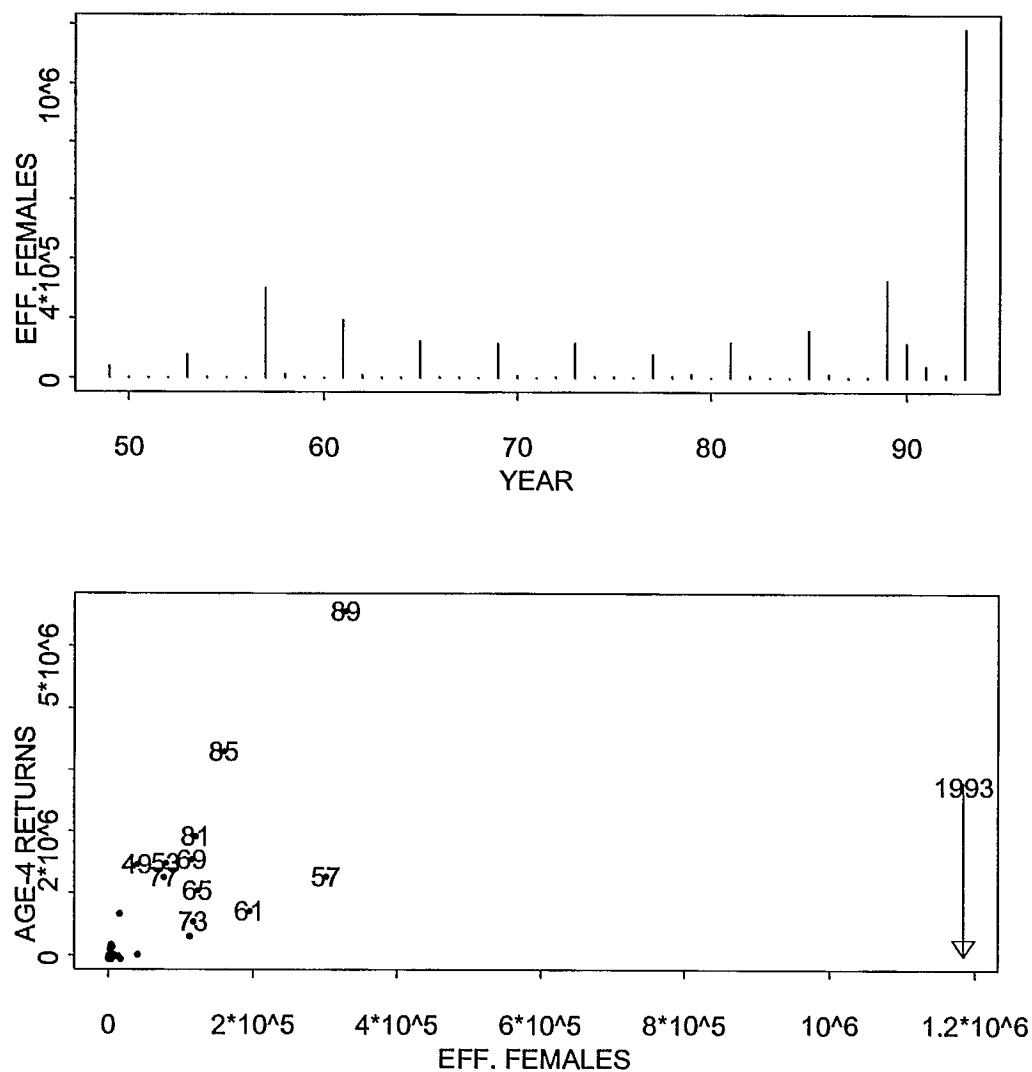


Fig. 19.2. Time series of spawning escapement estimates for sockeye measured in effective females (adult females weighted by egg deposition) (Upper) and relationship between escapement and age-4 progeny (Lower). The arrow indicates escapement in 1993 (1997 brood of age-4 sockeye). Data labels are 1997 cycle line years.

QUESNEL

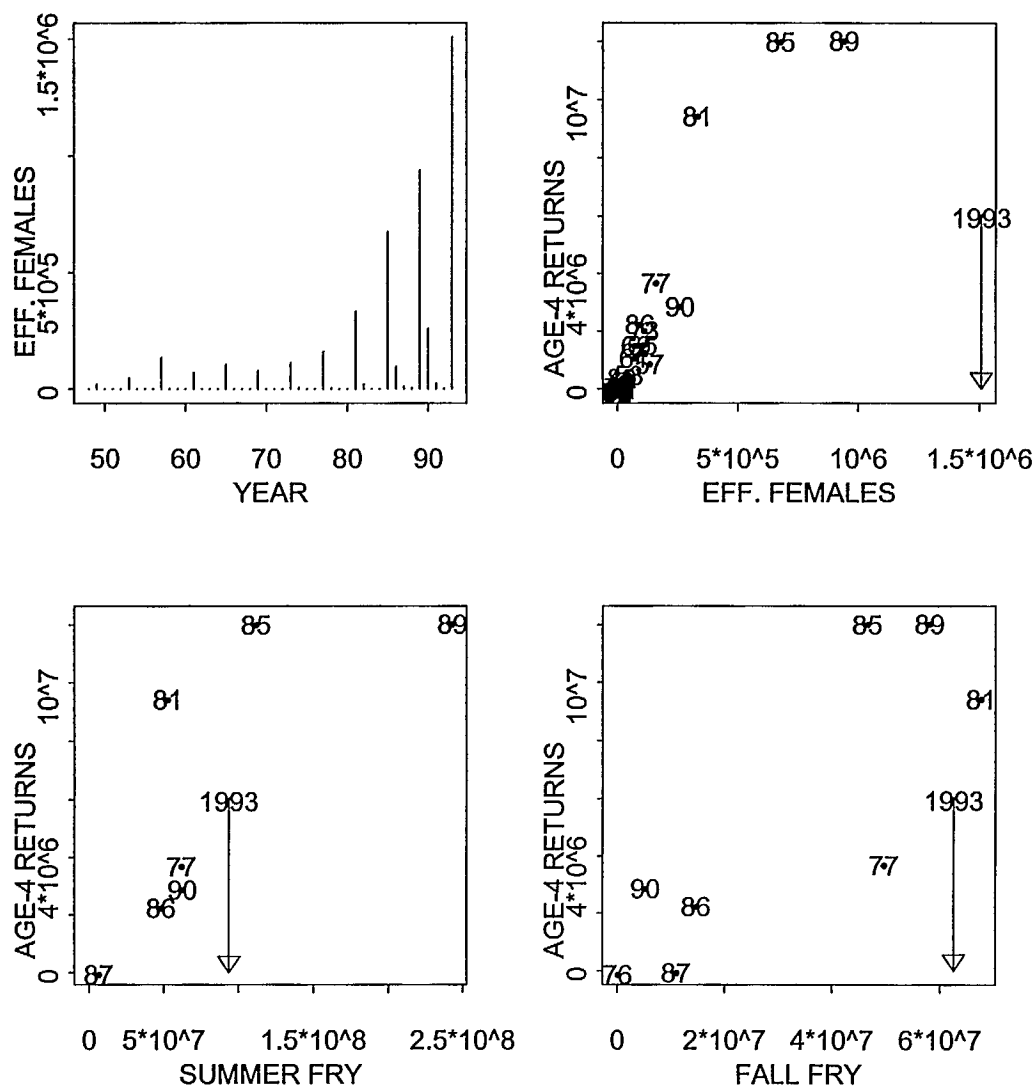
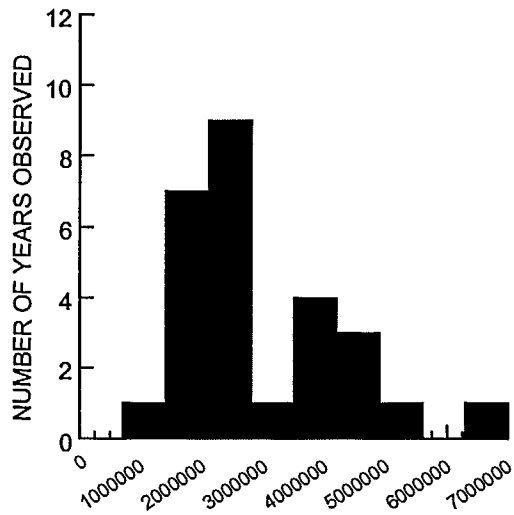


Fig. 19.3. Time series of spawning escapement estimates for sockeye measured in effective females (adult females weighted by egg deposition) (Upper-Left); relationship between escapement and age-4 progeny (Upper-Right); relationship between hydroacoustic summer (Lower-Left) and fall (Lower-Right) fry estimates. The arrow indicates escapement in 1993 (1997 brood of age-4 sockeye). Data labels are 1997 cycle line years.

A. Historical distribution of stock sizes



B. Forecast of stock size

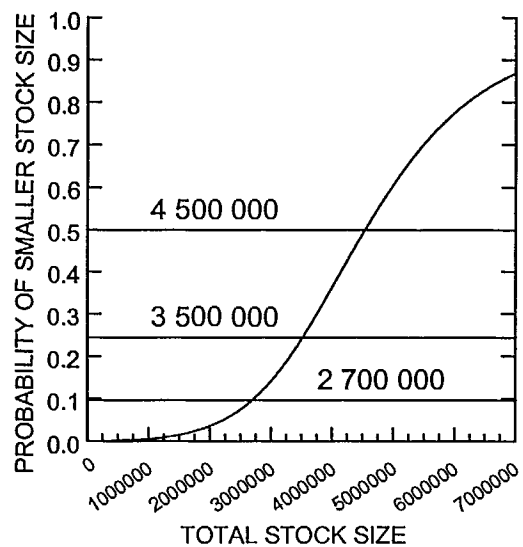


Fig. 20.1. The forecasted cumulative probability distribution for total stock size in 1997 for Skeena River sockeye salmon as compared with the historical distribution of total stock size.

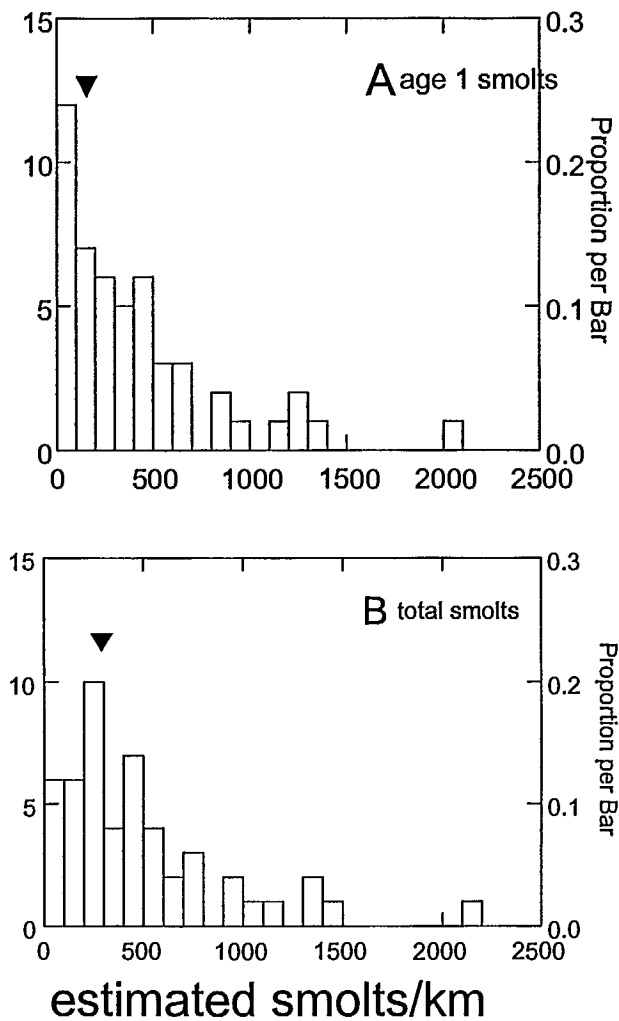


Fig. 22.1. Frequency distributions of estimated smolt production for surveyed WCVI streams for (A) 1+ smolts only. (B) total smolt production. The triangles indicate measured smolt production at Carnation Creek in 1996.

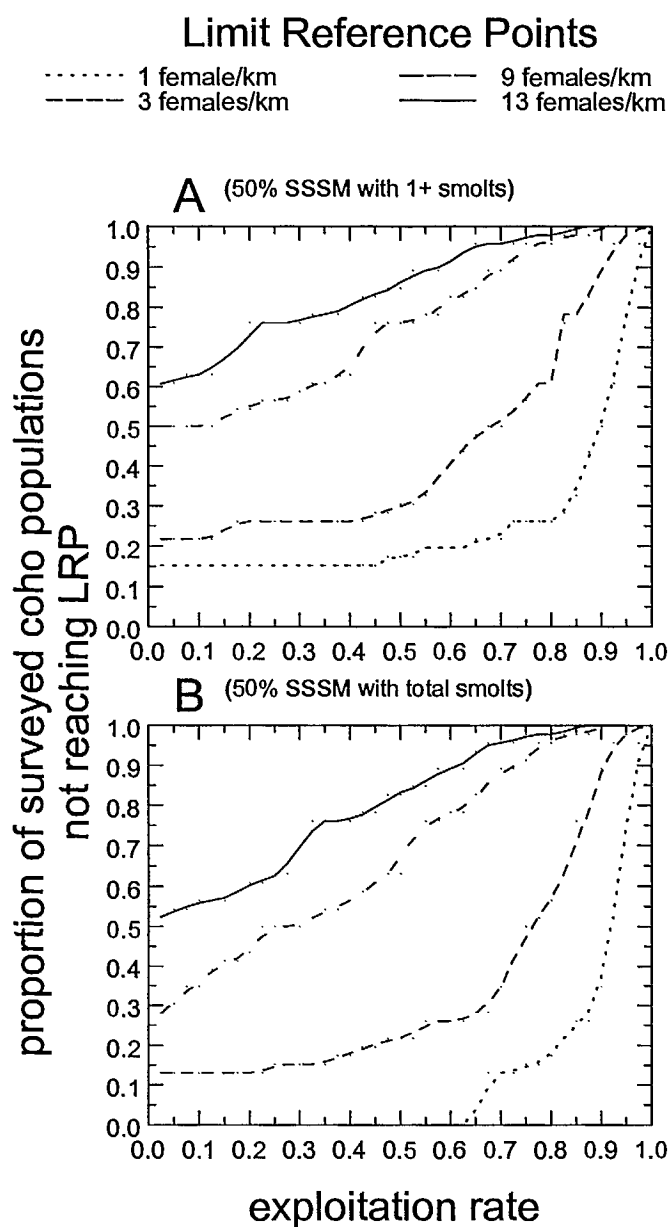


Fig. 22.2. Probability distributions for achieving LRP_es as functions of applied exploitation rate for mean predicted smolt-to-adult survival (0.090 SSSM). (A) 1+ smolts only. (B) total smolts.

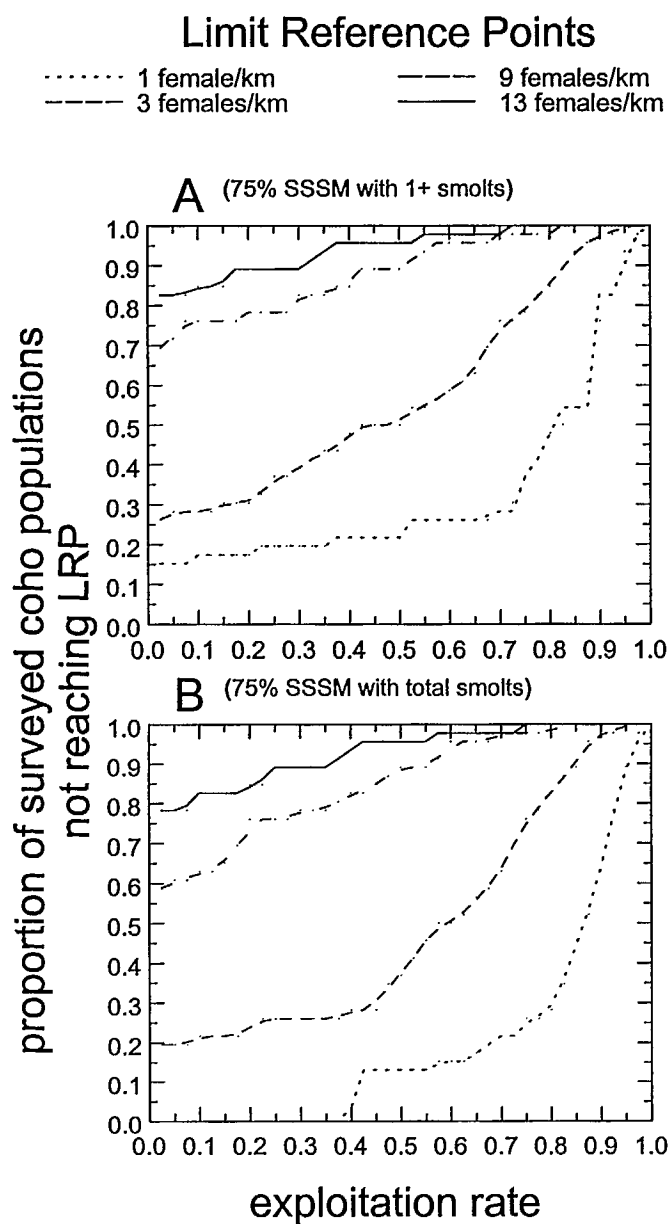


Fig. 22.3. Probability distributions for achieving LRP_es as functions of applied exploitation rate for 75th percentile predicted smolt-to-adult survival (0.053 SSSM). (A) 1+ smolts only. (B) total smolts.

Limit Reference Points

..... 1 female/km --- 9 females/km
 - - - 3 females/km — 13 females/km

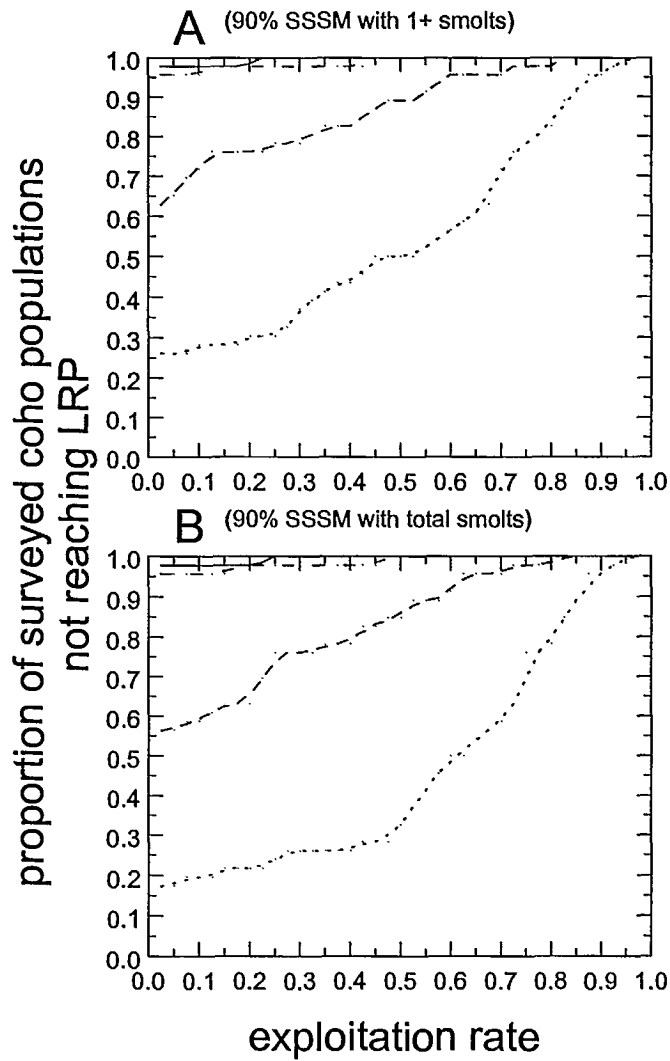


Fig. 22.4. Probability distributions for achieving LRP_es as functions of applied exploitation rate for 90th percentile predicted smolt-to-adult survival (0.019 SSSM). (A) 1+ smolts only. (B) total smolts.

SH 223 F55 no.2447 c.1

Rice, J.

Pacific Stock Assessment

Review Committee (PSARC)...

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