PACIFIC STOCK ASSESSMENT REVIEW COMMITTEE (PSARC) ANNUAL REPORT FOR 1995

J. Rice, B. Leaman, L. Richards, R.J. Beamish, G.A. McFarlane, and G. Thomas (Editors)

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Nanaimo, British Columbia
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PACIFIC STOCK ASSESSMENT REVIEW COMMITTEE

(PSARC)

ANNUAL REPORT FOR 1995

by

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This report summarizes activities undertaken by the Pacific Stock Assessment Review Committee (PSARC) during 1995. During this year, 42 reviewed Working Papers and 15 unreviewed Fishery Updates and draft working papers were presented at meetings of the five PSARC Subcommittees (Salmon, Invertebrates, Groundfish, Herring and Data and Systems). In this annual report, an overview by the Chairperson of the PSARC Steering Committee is followed by 6 PSARC Advisory Documents which summarize the Working Papers, reviewers' comments, subcommittee discussions and Steering Committee comments.

RÉSUMÉ

Rice, J., B. Leaman, L. Richards, R.J. Beamish, G.A. McFarlane, et G. Thomas (Editeurs). 1996. Comité d'examen de l'évaluation des stocks du Pacifique - Rapport annuel de 1995. Can. Man. Rep. Fish. Aquat. Sci. 2383: iv + 242 p.

Ce rapport décrit les activités du Comité d'examen de l'évaluation des stocks du Pacifique (CEESP) au cours de l'année 1995. Au cours l'année, quarante-deux documents de travail (relus) et quinze rapports et documents de travail (non relus) ont été présenté aux réunions des cinq sous-comité du CEESP (Saumon, Invertebres, Demerseaux, Hareng et Informatique). Ce rapport débute par un tour d'horizon du président dur comité directeur du CEESP suivi de six documents consultatifs dans lesquels sont résumé les documents de travail, les commentaires des experts, les discussions des sous-comité et les commentaires du comité de direction du CEESP.

SECTION I - CHAIRPERSON'S REPORT FOR 1994

This is the ninth annual report of the Pacific Stock Assessment Review Committee (PSARC). The report summarises the tenth year of operation for this committee, which provides scientific advice for the management of Pacific fisheries resources. The PSARC Terms of Reference were unchanged from 1993, and are published in Humphries, et al. (1994). However, a Working Group appointed by conducted a major review of the PSARC Terms of Reference. The Working Group Report was presented to RMEC in May 1995, with draft revisions to the Terms of Reference. Action on changing the 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 operational procedures of PSARC will not be revised. The Report of the Working Group on PSARC Terms of Reference is attached as Appendix 3 of this report. However, the proposed revisions had not been adopted by the end of 1995.

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 five PSARC Subcommittees: Herring, Salmon, Invertebrate, Groundfish and Data and Systems. Generally each subcommittee holds one or more meetings annually. In 1995 the Data and Systems Subcommittee did not meet, because it was assigned no issues to address. 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.

SUMMARY OF 1995 PSARC ACTIVITIES

In 1995 eight major Subcommittee meetings were held (Table 1) resulting in the Advisory Documents contained in this Annual Report. At these meetings Working Papers, Fishery Updates, and ancillary information were presented.

At its meeting on 26-27 April, the Steering Committee reviewed the Report of the Invertebrates Subcommittee from 24-25 January 1995. The Subcommittee Report included material from eleven Working Papers. Five Working Papers addressed Red Sea Urchins, particularly the results of a series of surveys conducted jointly with aboriginal bands planning or participating in comanagement programs. Three papers addressed Geoduck stocks, again focusing primarily on results of surveys usually conducted jointly with the harvesters' association. Two papers addressed intertidal Clam surveys and resource status; one on surveys in areas considered for depuration harvests, and one for a site with a long series of calm surveys. The final paper presented an assessment and yield estimate for Dungeness crab in the Fraser River delta. Other issues addressed in the Subcommittee Report include concerns about developing explicit biological objectives to complement the work of a Shellfish Working Group initiative to set management criteria for for developing fisheries, the status of a review of stock-recruit relationship in bivalves, management issues in green sea urchins and abalone, and improving the process for linking the work of the Invertebrates Subcommittee of PSARC to requirements of shellfish fishery managers.

The Salmon Subcommittee met on 18-21 April, and Steering Committee prepared Advisory Document 94-2 following its meeting on 26-27 April. The Subcommittee reviewed 6 papers, addressing an evaluation of run size estimation methods for chum managed using the clockwork approach, trends in catches in Strait of Georgia chinook and in the marine environment, factors affecting the marine survival of coho, an assessment of the

Somass River chinook stock, an assessment of sockeye salmon in Rivers Inlet and an evaluation of freshwater production of sockeye in Babine Lake. In addition the Subcommittee conducted an intensive review of a major document on mark-selective fisheries, produced by a bi-lateral committee of the Pacific Salmon Commission. The Salmon Subcommittee report: (i) reviewed the individual recommendations of the PSC document; and (ii) provided commentary on the questions posed in the Executive Summary of the document. Steering Committee also added substantial comment to the Advisory Document, reflecting its review of that major document. Steering Committee also repeated its concerns about widespread problems in archiving and accessing important salmon data bases, and inconsistent delivery of documents to PSARC, including in this case an overview paper on 1996 salmon forecasts.

The Groundfish Subcommittee met 25-27 July, and Steering Committee prepared Advisory Document 95-3 following its review of the Subcommittee Report on 26-27 September. The Subcommittee reviewed 13 Working Papers, providing assessments of all major groundfish stocks or stock complexes in BC waters. The biological aspects of programs implemented for aggregate management of rockfish and for reduction of halibut bycatch in trawl fisheries were also reviewed. Since 1991 each major groundfish stock receives a major analytical assessment on a staggered triennial cycle, with interim assessments on other years. For 1995 major assessments were conducted for Pacific cod and sablefish. The Subcommittee and Steering Committee highlighted continuing concerns about the status of all coastal Pacific cod stocks, and uncertainty about the status of sablefish stocks, partly due to differing assessments tabled by DFO assessment staff and industry contractors. An additional meeting of the Subcommittee, on 24 November, was required to resolve differences between the two views of the status of the sablefish stock, and develop consensus advice for 1996. The Subcommittee and Steering Committee endorsed a call for full observer coverage of the groundfish trawl fishery, and expressed special concern about new estimates of levels of halibut bycatch in the fishery off the West Coast of Vancouver Island.

The Herring Subcommittee met 6-8 September, and Steering Committee prepared Advisory Document 95-4 following its review of the Subcommittee Report on 26-27 September. The Subcommittee reviewed 1 Fishery Update on the 1995 fishery, 5 Working Papers, and ancillary information on stock status provided by charter skippers and district staff. The Working Papers included analytical assessments of the 5 major herring stocks, a review of the biological basis for management of BC herring stocks, a forecast of recruitment for the West Coast of Vancouver Island stock, a simulation model for the West Coast of Vancouver Island stock, and a review of changes in spawning distribution of herring in the Strait of Georgia.

The Invertebrate Subcommittee met 12-14 September, and Steering Committee prepared Advisory Document 94-57 following its review of the Subcommittee Report on 26-27 September. The Subcommittee reviewed a Working Paper including yield estimates and a Fishery Update describing the 1995 fishery, for each of the following invertebrate species or species-complexes: intertidal clams, Green Sea Urchins, Sea Cucumbers, Red

Sea Urchins, and Geoducks. Additional Working Papers including new survey results were tabled for green sea urchins and for geoducks. Only Fishery Updates were presented for shrimp, prawn, crab, octopus, squid, horseclams, goose barnacles, scallops, abalone, and euphausiids. The Subcommittee and Steering Committee expressed particular concerns about impacts of poaching on some invertebrate stocks, the poor quality and slow delivery of catch statistics in some fisheries, potential problems associated with extracting broodstock from wild populations for use in developing aquaculture programs, and about ongoing difficulties in matching assessment results and advice to the needs of managers. A Working Group was proposed to consider both the linkages between PSARC advice and management needs, and the nature of the management approaches to invertebrate stocks and fisheries.

The Salmon Subcommittee met from 15-17 November, and Steering Committee prepared Advisory Document 94-6 following its review of the Subcommittee report on 4 December. Seven Working Papers were reviewed. The topics addressed were: biological escapement targets for Alsek River chinook, stock status and forecasts for Smith Inlet sockeye, an evaluation framework for Strait of Georgia salmon conservation measures, predation by Harbour Seals on juvenile salmon in the Puntledge River area, forecasts of Fraser River sockeye returns in 1996, assessments of recruitment forecasting methods for salmon in northern British Columbia, and a review of the forecasting performance, status, and 1996 forecasts for Barkley Sound sockeye. Steering Committee noted particular concerns about possible changes in the parasite frequencies for parasites used for stock identification in Barkley Sound sockeye and for the further deterioration of biological sampling programs for key salmon stocks along the coast. Both Steering Committee and the Salmon Subcommittee noted continued difficulties in availability of various stock assessment data in time for assessment meetings. RMEC was asked to address the scheduling problem for salmon advice, and to endorse a special workshop to review Fraser River sockeye forecasts in February 1996.

Two PSARC Subcommittees were under new chairpersons in 1995. In addition, the Chair of PSARC was on assignment in Denmark for 6 months from August 1995, and Bruce Leaman acted as Chair during that period. The contributions made by all chairpersons are gratefully acknowledged.

This document represents the efforts of the stock assessment community in the Pacific Region, especially those authors listed in Table 2. The reviewers of the Working Papers also made a major contribution. All these people are thanked for their efforts.

Table 1. Major PSARC Meetings Held During 1995.

Date	Meeting	Location
24-25 January	Invertebrate	PBS Nanaimo
18-21 April	Salmon	PBS Nanaimo
26-27 April	Steering Committee	Nanaimo
15 May	PSARC/RMEC	Vancouver
25-27 July	Groundfish	Nanaimo
6-8 September	Herring	Nanaimo
12-14 September	Invertebrate	Nanaimo
26-27 September	Steering Committee	Nanaimo
5 October	PSARC/RMEC	Vancouver
15-17 November	Salmon	Nanaimo
4 December	Steering Committee	Nanaimo
11 December	PSARC/RMEC	Vancouver

Table 2. List of PSARC Working Papers and Fishery Updates Reviewed During 1995.

GROUNDFISH SUBCOMMITTEE

Working Papers:

G95-2	Offshore lingcod stock assessment and recommended yield options for 1996. G. A. McFarlane and B.M. Leaman
G95-3	Pacific cod stock assessments for 1995 and recommended yield options for 1996. V. Haist and D. Fournier
G95-4	Flatfish. J. Fargo.
G95-5	Sablefish stock assessment for 1995 and recommended yield options for 1996. M. W. Saunders, B. M. Leaman and G. A. McFarlane.
G95-6	Pacific hake stock assessment for 1995 and recommended yield options for 1996. M. W. Saunders and G. A. McFarlane
G95-7	Spiny dogfish. B. L. Thomson
G95-8	Walleye pollock stock assessment for 1995 and recommended yield options for 1996. M.W. Saunders and W. Andrews
G95-9	Slope rockfish assessments for 1995 and recommended yield options for 1996. L.J. Richards
G95-10	Shelf rockfish assessment for 1995 and recommended yield options for 1996. R.D. Stanley
G95-11	Inshore rockfish stock assessment for 1995 and recommended yield options for 1996. K.L. Yamanaka
G95-12	Rockfish aggregate management. J. C. Rice and L. J. Richards
G95-13	Review of the Canadian bycatch reduction program for Pacific halibut. R.J. Trumble and G. H. Williams (IPHC)
G95-14	A review of the B.C. blackcod stock for 1995. R. Hilborn

Table 2. List of PSARC Working Papers... (Cont'd)

HERRING SUBCOMMITTEE

Working Papers:

H95-1 Stock assessment for British Columbia herring in 1995 and forecasts of the potential catch in 1996. J. Schweigert and C. Fort

H95-2 Review of the biological basis for British Columbia herring stock harvest rates and conservation levels. J. Schweigert and D. Ware

H95-3 Offshore herring distribution and 1996 recruitment forecast for the west coast of Vancouver Island stock assessment area. D. Ware and R. Tanasichuk

H95-4 A preliminary simulation model for the Pacific Herring (*Clupea pallasi*) population from the lower west coast of Vancouver Island. R. Tanasichuk

H95-5 Changes in herring spawn distribution in Georgia Strait: discussion, implications and recommendations. D. Hay and B. McCarter

Fishery Updates:

1. B.C. Herring Fishery Update, 1994/95. L. Hamer

INVERTEBRATE SUBCOMMITTEE

Working Papers:

I95-01 Analysis of 1994 red sea urchin surveys conducted in Haida areas. G.S. Jamieson, R. Jones, G. Martel, C.J. Schwarz, C. Taylor and R. Routledge

I95-02 Analysis of 1994 red sea urchin surveys conducted in Heiltsuk areas. G.S. Jamieson, W. Sandoval, C.J. Schwarz, C. Taylor and R. Routledge

I95-03 Analysis of 1994 red sea urchin surveys conducted in Aweena K'ola areas. G.S. Jamieson, G. Scarf, C.J. Schwarz, C. Taylor and R. Routledge

I95-04 Reanalysis of 1993 red sea urchin surveys conducted in Haida, Heiltsuk, Kitasoo and Tsimshian areas. G.S. Jamieson, K. Cripps, M. Gijssen, L. Greba, R. Jones, G. Martel, W. Sandoval, C. Schwarz, C. Taylor and R. Routledge

Table 2. List of PSARC Working Papers... (Cont'd)

I95-05	Survey protocol considerations for 1995 sea urchin surveys. G.S. Jamieson and C.J. Schwarz
I95-06	A survey of geoduck population density in Goletas Channel, 1994. A. Campbell, B. Clapp, C.M. Hand, R. Harbo, K. Hobbs, J. Hume and G. Scarf
I95-07	A survey of geoduck population density in Southeast Queen Charlotte Islands, 1994. C.M. Hand, A. Campbell, L. Lee and G. Martel
I95-08	Preliminary analysis of landed weight information for geoduck clams (*Panope abrupta*) in British Columbia, 1990-1993. L. Burger, E. Rome, A. Campbell, R. Harbo, J. Wasilewski and D. Stewart
I95-09	Intertidal clam stock estimates for depuration harvest beaches, 1994. G.E. Gillespie and G.D. Heritage
I95-10	Assessment of intertidal clam population surveys at Seal Island, British Columbia 1940-1992. B.C. Kingzett and N.F. Bourne
I95-11	Biomass assessment of Fraser River dungeness crab using change-in-ratio and index-removal methods. G.S. Jamieson and M. Joyce

Fishery Updates:

1.	Shrimp	- M. Joyce, B. Adkins
2.	Sea Cucumber	- S. Heizer, G. Thomas
3.	Geoduck	- R. Harbo, S. Heizer, G. Thomas, I. Winther, K. Hobbs
4.	Intertidal Clams	- R. Webb, K. Hobbs
5.	Crabs	- M. Joyce, S. Heizer, I. Winther
6.	Euphausiid	- J. Morrison, B. Adkins
7.	Octopus	- J. Morrison, B. Adkins
8.	Squid	- J. Morrison, B. Adkins, M Kattilakoski
9.	Horseclams	- R. Harbo, K. Hobbs
10.	Goose Barnacles	- S. Heizer
11.	Scallops	- R. Harbo, K. Hobbs
12.	Green Sea Urchins	- S. Heizer, K. Hobbs
13.	Red Sea Urchins	- S. Heizer, S. Neifer, K. Hobbs
14.	Prawns	- B. Adkins, J. Morrison, I. Winther

SALMON SUBCOMMITTEE

Working Papers:

S95-1 An evaluation of run size estimation techniques used for the clockwork chum stocks. P. Ryall and A. Cass

S95-2 Changes in chinook salmon catches in the Strait of Georgia and shifts in the marine environment. R.J. Beamish, B.L. Thomson, C. Neville, B. Riddell and Z. Zhang.

S95-3 Somass River chinook assessment and forecast for 1995 and 1996. B. Riddell, A. Tompkins, W. Luedke and S. Lehman.

S95-4 Factors affecting the marine survival of coho in the Strait of Georgia. R.J. Beamish, C. Neville, J. Rice and Z. Zhang

S95-5 Assessment of the status of Rivers Inlet sockeye salmon. D.T. Rutherford, S. M^{c}Kinnell, C. Wood, K. Hyatt, and R. Goruk

S95-6 Assessment of freshwater production of sockeye salmon in Babine Lake. C. Wood, D.T. Rutherford, K. Pitre and K. Chapman

S95-7 Biological escapement goal for Alsek River system chinook salmon. J.H. Clark, P. Etherton, S. McPherson

S95-8 Stock status and 1996 forecast of Smith Inlet (Long Lake) sockeye salmon. D.T. Rutherford and C. Wood

S95-9 Evaluation Framework and a pre-fishery assessment of harvest measures to conserve Strait of Georgia coho salmon stocks. R. Kadowaki and P. Ryall

S95-10 An assessment of harbour seal, *Phoca vitulina*, predation on outmigrating chum fry, *Oncorhynchus keta*, and coho smolts, *O. kisutch*, in the lower Puntledge River, British Columbia. P. Olesiuk, G. Horonowitsch, G.M. Ellis, T.G. Smith, L. Flostrand, and S.C. Warby

S95-11 Forecasts of Fraser River sockeye salmon for return year 1996. A. Cass and D. Blackbourn

S95-12 Assessment of recruitment forecasting methods for selected salmon stocks in northern British Columbia. C. Wood, D. Rutherford, D. Peacock, and S. Cox-Rogers

Table 2. List of PSARC Working Papers... (Cont'd)

S95-13 Review of 1988-1995 forecast performance, stock status, and 1996 forecasts of Barkley Sound sockeye. K. Hyatt and W. Luedke

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. 94	R.D. Humphreys
Aug. 1994 -	J. Rice
Aug. 1995 - Jan. 96	B. Leaman (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-	S. McFarlane

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. 1995 PSARC STEERING COMMITTEE MEMBERSHIP.

Dr. J.C. Rice, Chairperson
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APPENDIX 3. Framework for Peer Review and Provision of Scientific Information on Status and Management of Fish Stocks in Pacific Region - DFO

SUMMARY

The review and advisory process for stock assessment in the Pacific Region will be improved to address changing roles and expectations of traditional Departmental clients, and to serve new clients. Changes will also enable the Department to benefit more fully from recent organizational changes internally.

The objectives of the review and advisory process are to provide both internal and external clients with scientific information which is reliable, credible, comprehensive, and relevant. The following steps outline a process which will meet those objectives:

1. Meetings to review of data with clients. These may be relatively informal, but must precede use of data in assessments.

2. Working Papers will be prepared in advance of assessment review meetings. Working Papers should be comprehensive, analytically complete and rigorous, and address uncertainty in input data and results.

3. Internal DFO review of analytical content of Working Papers. This step screens out errors, inconsistencies, and unclear points in data and analyses, to ensure the open review process receives scientifically sound documents.

4. Revision of Working Papers in light of Step 3, with rapid turn-around of products.

5. Open scientific review of Working Papers, by professionals within and outside DFO. Ancillary information from stakeholders and clients is presented and reviewed as well.

6. Development of "consensus" on stock status among participants in Step 5. Where consensus is not achievable, the merits and short-comings of alternative interpretations of the evidence are specified.

7. Provision of scientific information on harvesting and conservation measures and finalization and release of Working Papers and Stock Status Reports follows results of Step 6.

PSARC is the current forum for steps 2-7. In future provision of advice in step 7, and some part of step 6 will be the responsibility of a conservation council or other body. Other steps would continue to be overseen by PSARC, and PSARC would continue to produce Working Papers and Stock Status reports.

WHY CHANGE?

DFO Pacific Region has new clients since PSARC Terms of Reference were developed, and roles and expectations of all clients are changing. The review and advisory process must fit into this new reality. Also, the Region has taken proactive measures to strengthen stock assessment activities, affecting planning, coordination, integration, and delivery of programmes. The initiatives in stock assessment will not yield full benefits if the Region doesn't move in a similarly decisive manner to strengthen the review and advisory process. The resource and the Department won't benefit fully from the better stock assessment activities unless the provision of scientific information is better, as well.

Objectives of the Review and Advisory Process:

An effective process serves two objectives of clients who are recipients of scientific information, and two more objectives of professionals developing or implementing the advice and information.

To recipients of scientific advice and information (within or outside DFO), the information must be:

1. Relevant - The products of the process must be the ones managers, the Minister, Advisory Committees, and Conservation Councils (if established) require.

2. Credible - Clients must understand and trust the data used in assessing stock status and provision of information on stock status. Clients must understand and trust what is done with the data. Clients must see their concerns and beliefs addressed seriously and directly.

To both those receiving and developing the scientific information, it must be:

3. Comprehensive - The assessments and information on stock status should be as multidisciplinary as possible, and must consider all the relevant data bases, all appropriate models, and all the concerns of managers and clients, prior to final decisions.

4. Reliable - Both data and models must be thoroughly and professionally reviewed; biases known, quantified, and accounted for; model assumptions known, tested (for correctness and for sensitivity); uncertainty must be explicit in as many steps as possible, and clear in the final products.

Steps in the Process Necessary to Achieve the Objectives:

1. Review of data with clients:

   (a) Should occur annually, BEFORE the data are used in analyses.

   (b) DFO must note and address client concerns when the data are used.

   (c) The review of data need not be formally structured, and is best done by the working assessment scientists (although opportunities for efficiencies in coverage of many stocks with a client group should be taken). The review must be perceived to be open to all clients.

   (d) The most conspicuous data consultations would be with fishers regarding data on fish. Less conspicuous but no less important are discussions with professionals in habitat and environmental fields (marine, freshwater, and climate) regarding these types of data and how they might be used in assessments.

2. Working Papers should be prepared in advance of the assessment review meeting. The papers should have many properties:

   (a) Must be complete in coverage of data AND model structure. Important time series should be presented annually. Reference to previous documents which include details of methods is fine; undocumented methods (including field and intermediate data processing steps), or failure to present model algorithms is NOT acceptable. To the extent possible environmental and habitat considerations should be covered, as well as "traditional" fisheries data. In many cases completeness may be better achieved through a structured series of Working Papers than through a single paper which tries address to every aspect of the biology and fisheries of a stock, and the relevant environmental considerations.

(b) Must include performance statistics of models: both retrospective performance and fit to the current parameterization data.

(c) Wherever possible must describe uncertainty in parameter estimates, forecasts, etc, especially of the properties of stocks which are the direct basis for evaluating stock status.

(d) Where there are alternative plausible models or incompatible data sets, each must be presented, with results. Selections among models usually should be made on the basis of performance (either retrospective or current goodness-of-fit / maximum likelihood), and rationales for selection should be explained clearly. If selections are based on biological arguments, the rationales should be explained fully.

(e) The Working Paper does NOT include formal advice nor recommendations on management actions, but it does include the results and numerical values which are consistent with requested management options. It must include the best estimates of uncertainty associated with these values.

(f) If managers request it, the Working Paper will contain a review of the management strategies used for the stock. If not explicitly requested, review of management strategies MAY still be addressed.

(g) Industry concerns with data or other aspects of stock status or the fishery should be addressed explicitly.

(h) If managers request only an "Interim Assessment", the document can be reduced substantially, as long as a previous assessment containing all the necessary elements can be referenced and is considered still a suitable foundation for evaluation of stock status. Even an Interim Assessment should contain full updated time series of important data sets.

(i) Often a series of Working Papers addressing different aspects of the assessment of a major stock (or a major review of a management issue) will be more useful than a single Working Paper trying to cover all points in a single document. However, a document integrating the results of other documents is still required.

3. Internal Scientific Review of Analytical Content - PSARC

(a) The initial review should be internal to DFO. If there are serious problems with data, models, or the resource, we must see them first, advise senior officials, and prepare appropriately for consequences. If there are errors, they should be corrected before our work goes public. This review step

CANNOT be done by the same individuals which prepare the assessment. If the assessment is prepared by a Working Group or Technical Committee, a separate DFO review is required. This has important implications for the handling of assessments from PSC Technical Committees.

(b) The review must cover all aspects of the assessment (or other type of activity), including:
   (i) Sampling design of all data sources.
   (ii) Intermediate data processing steps (pooling, interpolating, smoothing, weighting, "correction factors")
   (iii) Model algorithms
   (iv) Model assumptions about both processes and error structure
   (v) Estimation methods
   (vi) How uncertainty is measured and passed through successive steps in an analysis.
   (vii) Sensitivity testing of models
   (viii) Presentation of results (including uncertainty) of each plausible alternative model, and each relevant data set.

(c) The purpose of this internal review is to screen out things which are incorrect or illogical, NOT to select a preferred option from a range of plausible alternatives.

(d) PSARC may review Working Papers prepared by client groups if the group requests such a review, and the paper meets the criteria outlined in 2). Where clients participated scientifically in the conduct of work and preparation of a document (as either sole authors or as coauthors with DFO staff) the individuals may participate in the review of the document. Otherwise, this step is not open to representatives of client groups.

4. Revision of written document

(a) Very fast turn-around - target of two weeks.

(b) Revisions at this step are removal of things which are incorrect and cannot be fixed in 2 weeks, and clarification of points inadequately explained in draft document.

5. Open professional review

(a) Agenda set and distributed at close of #3.

(b) Review of revised documents (#4), available at beginning of meeting.

(c) Begins with presentation of data, models, and analytical content of revised DFO Working Paper(s).

(d) Questions and discussion of Working Paper(s).

(e) Floor open to additional Working Papers by clients (or their representatives), if any have been prepared. These alternative assessments receive full critical review as scientific documents.

(f) Floor open to ancillary information; fishermen's knowledge, traditional knowledge, etc. Critical discussion of other types of knowledge depend on the type and form of information or data tabled.

(g) These steps of meeting are run by PSARC, even if there is a Conservation Council.

6. Development of "consensus".

(a) Objective is consensus among all participants in #5. However, consensus should not be forced.

(b) Where consensus is NOT reached, merits and short-comings of each interpretation of stock status, or each option for management action should be recorded as explicitly as possible.

(c) Where failure to achieve consensus is split along sector lines (or DFO - client) each sides' views get presented in the meeting report, but identified by category of proponent.

(d) The estimated uncertainty of each option or estimate which survives this review must be included in the report.

7. Preparation and release of scientific information, advice, and documents

(a) Subcommittee reports and PSARC Advisory Documents are prepared as quickly as possible following each meeting. Release required RMEC approval. Subcommittee Chairs are responsible for preparing the Subcommittee Reports, and the Chair of PSARC is responsible for Advisory Documents.

(b) Working Papers accepted by the Subcommittee and Steering Committee must be revised within 45 working days of the Subcommittee meeting. Release requires approval by the Subcommittee Chair, and, if Steering Committee expressed concerns about a Working Paper, the Chair of PSARC.

(c) Stock status reports will be prepared for all major stocks assessed by PSARC. These reports are brief, factual, and written for an informed public audience. Subcommittee Chairs oversee preparation and collation of stock status reports, which are released through the Chair of PSARC.

(d) The relationship and overlap between PSARC Advisory Documents and the various reports of the Conservation Council cannot be delineated until the operating procedures of the Conservation Council are specified.

When a Conservation Council is established, it would assume some of the functions under item #6, and would develop the explicit conservation advice. The content of PSARC Advisory Documents would be changed, to reflect the responsibilities taken on by the Conservation Council. PSARC would retain responsibility for producing stock status reports and Working Papers, and records of Subcommittee and Steering Committee meetings. The stock status reports would reflect information and discussions conducted under items #3, #4, and #6, even if the Conservation Council produces other documents recording the activities under #6.

SECTION II - PSARC Advisory Documents

INVERTEBRATES

I. STEERING COMMITTEE REPORT

PSARC Steering Committee met 27 April, 1995 at the Pacific Biological Station, to review the Invertebrate Subcommittee report. The report was accepted. Steering Committee provided the following comments pertaining to major Subcommittee concerns, and to individual Working Papers summarized in the Subcommittee Report.

GENERAL COMMENTS

The Steering Committee felt that there should be a general discussion on the nature of the differences between the summer and winter Invertebrate Subcommittee meeting. The reports of the summer Subcommittee meetings contain many recommendations to managers which may be used in the upcoming fishing plans, whereas the reports of the winter Subcommittee meetings deal with the evaluation of the data that has been collected in the summer and will form part of the following summer's assessment. These objectives should be made clear in the Subcommittee reports. It was also noted that each Subcommittee report should have a statement at the beginning of discussion of each paper that indicates if the Subcommittee accepted or rejected the paper.

RED SEA URCHIN PAPERS I95-01,02,03,04,05

In the papers on AFS surveys it was felt that it was inappropriate to use the word Statistical Areas in the title, because the phrase DFO Statistical Area has a specific meaning which differs from the usage in these papers. The Subcommittee chair will speak to the authors and see if the titles can be changed to just "Areas".

Steering Committee stressed that the biomass and number estimates presented in the first four papers were appropriate for the purposes of the cooperative surveys. However, PSARC does not accept these estimates for management action, because the areas surveyed were not necessarily matched to management units, and because management advice requires consideration of factors not included in the survey analyses.

PSARC notes that the numbers are preliminary survey results and the data will be subject to a more intensive analysis in the summer assessment of red sea urchins.

Steering Committee still has concerns with how the low-density, large-area fishery independent survey data will be used in conjunction with the high- density, small-area fishery dependent data. However, Steering Committee is satisfied that the biases in the transect and quadrat selection found in earlier surveys have now been corrected in the new survey design.

GEODUCK PAPERS I95-06,07,10

The Steering Committee notes the clear indication of localized overfishing and agrees with the managers' strategy for dealing with these fisheries through closures and/or reduced exploitation rates in these areas.

INTERTIDAL CLAMS I95-08,09

In accepting the numbers presented in the depuration surveys, Steering Committee does not encourage direct use of these numbers to develop sustainable quota management options. Although the numbers are correct given the survey design, both the Subcommittee and Steering Committee have expressed concerns about the appropriateness of the survey design. Steering Committee acknowledges such work is underway, and supports the work strongly.

Steering Committee recommends that before going ahead with a major analysis of the Seal Island site, managers should clarify their objectives for the stocks and fisheries in the area. Steering Committee further warns that the possible goal of rebuilding stocks to the 1930 and 1940 levels is likely to be unattainable. The present recruitment levels may be the norm for this stock, and the few years of high recruitment approximately 60 years ago may have been anomalous.

CRABS I95-11

Steering Committee accepted the Subcommittee's recommendations without comment.

ADDITIONAL SUBCOMMITTEE DISCUSSIONS

New and Developing Fisheries

The Steering Committee was informed that the document on new and developing fisheries dealt primarily with economic issues and management policies, and much less with biological considerations. Steering Committee stresses that the biological issues need to be further addressed for invertebrates and other potential new and developing fisheries as well. PSARC would be an appropriate vehicle for review of this information.

Update Of Review Of Stock/Recruitment Relationships In Bivalves

The Steering Committee accepted the Subcommittee report on this topic.

MANAGEMENT ISSUES

Green Urchin

The Steering Committee accepted the subcommittee report on this topic.

Abalone

The Steering Committee accepts that DNA techniques may prove to be a very useful tool. However PSARC alerts senior management that it would be an expensive proposition to build up an appropriate data base.

Process For Linking PSARC Working Papers With Management

Steering Committee noted the importance and sensitivity of this issue, and highlighted it as a major Steering Committee concern in its minutes.

Publication of Working Papers

The Steering Committee notes some improvement in completion of revisions, but notes further progress is required. Steering Committee thanks the Subcommittee chair for his persistence in this area.

II. INVERTEBRATE SUBCOMMITTEE REPORT

1. INTRODUCTION

The invertebrate PSARC Subcommittee met on January 24 and 25, 1995 in Nanaimo. This report is a summary of advice and recommendations resulting from this meeting and provides the basis for advice to the Regional Executive Committee for development of 1995 Management Plans and stock assessment research required for some British Columbia invertebrate fisheries. The Subcommittee is scheduled to meet again in early September, 1995 to complete its reviews for 1995. A total of 11 working papers were reviewed (Appendix 1).

2. SUBCOMMITTEE MEMBERSHIP

Gordon McFarlane continued as chair of the Subcommittee. A list of participants is appended (Appendix 2).

3. SUMMARIES OF WORKING PAPERS, FISHERY UPDATES, REVIEWER'S COMMENTS AND SUBCOMMITTEE DISCUSSIONS

(a) Red Sea Urchins

Five working papers were reviewed by the Subcommittee. All were accepted with minor revisions.

I95-01,02,03 Analysis of 1994 Red Sea Urchin Surveys Conducted in Haida, Aweena K'ola and Heiltsuk Areas.

Summary

Three separate papers were presented on this topic, one for each First Nation area. However, the abstracts are similar and are therefore combined into one common abstract.

Collaborative red sea urchin surveys were conducted in 1994 by the Department of Fisheries and Oceans, the Pacific Underwater Harvesters Association (PUHA), and Aweena K'ola, Haida, and Heiltsuk First Nations. PUHA was unable to participate in the Aweena K'ola survey because of coincident fishery openings. The Haida and Aweena K'ola surveys were 'broad-brush' in design, i.e. no previous data on the distribution of red sea urchins in the areas surveyed were available, while the Heiltsuk survey was more intensive because it could be based on a survey conducted in two subareas in 1993.

The Aweena K'ola survey was conducted in Statistical Area 12 from about Robson Bight in Johnstone Strait northwards along both sides of Charlotte Strait during January to March, 1994. By Subarea, estimated densities ranged from 0.38-6.25 urchins/m^2, and the estimated total number of legal-size urchins was 48 million in 89.9 km^2.

The Haida survey occurred in Statistical Subareas 1.01, 1.02, 1.03, and 1.07 (Wiah Point westward to Fleurieu Point) in June, 1994. By Subarea, estimated densities ranged from 0.80-5.86 urchins/m^2, and the estimated total number of legal-size urchins was 94 million in 76.3 km^2.

The Heiltsuk survey occurred in Statistical Subareas 7.18 and 7.25 in August-September, 1994. By Subarea, estimated densities ranged from 2.84-3.28 urchins/m^2, and the estimated total number of legal-size urchins was 28.4 million in 27.3 km^2.

Analysis of 1994 Haida and Heiltsuk data using the revised methodology of the 1993 data, and comparing these new results with the analysis of 1994 data, indicated that the 1993 revised methodology was underestimating average densities of urchins by 20-40%.

It should be noted that estimates of total number present do not mean that this is the number of urchins available to the fishery, since only urchins in densities greater than an unknown threshold level may be economically exploited. Many legal-size urchins may be at such a low density that it may not be economically feasible to harvest them.

Reviewer's comments

The reviewer suggested that the three surveys could be combined in a single paper, to alleviate redundant reporting of background and methods of analysis. The reviewer questioned the reliability of the data collected, relevant to the analytical approach used by the authors. The reviewer also felt that the results section of the papers was much too brief. He suggested that comparisons of estimates for the different areas and different analytical approaches be included. Information from these comparisons could be used to recommend modifications to the survey design. The reviewer suggested that an estimate of the variability between transects could be used to estimate the number of transects required to provide abundance estimates within a given level of precision. Also, the standard error for the mean density was fairly low for this study. The reviewer stated that this was probably due to the fact that the transects were in close proximity. That being the case, the uncertainty in the estimates of abundance would be underestimated. The reviewer noted that the reliability of the population estimates also depends on the total area to which the means are applied. He suggested that figures be included to show what proportion of the area used in abundance estimation was actually surveyed.

I95-04 Reanalysis of 1993 Red Sea Urchin Surveys Conducted in Haida, Heiltsuk, Kitasoo and Tsimshian Areas.

The initial analyses of 1993 red sea urchin surveys included all quadrats in each transect. Survey direction was frequently switched through 180° if urchin density decreased below a minimum level so as to maximize sampling in areas of urchin occurrence. However, this biased the density estimates because areas of highest urchin density were preferentially sampled. Reanalysis of data included only those quadrats in a transect before the 180° switch, if it did occur. All subsequent quadrats which would have been located along the transect to a depth of 10 m were assumed to have zero urchins. Transect length between 0-10 m below Chart Datum was estimated from the average slope of the substrate recorded from the quadrats occurring before the transect direction switch. The estimated number of harvestable urchins (i.e. >100 mm) for Haida, Heiltsuk, Kitasoo and Tsimshian surveyed areas were 27.0, 18.5, 61.9, and 36.7 million, respectively.

Reviewer's comments

The reviewer indicated that the authors correctly identified potential sources of bias and error from 1993 surveys, but noted that the estimates produced in re-analyses were presented without a measure of uncertainty. He commented that the results section was

too brief. He suggested that examination of the variability in density between transects in a given subarea would provide a minimum measure of uncertainty in abundance estimates. This additional information could be presented to managers. He also pointed out a large discrepancy between the size of the harvestable area and the size of the area surveyed. He questioned whether the data obtained from the survey was really representative of overall abundance for the total harvestable area.

I95-05 Survey Protocol Considerations for 1995 Sea Urchin Surveys.

Logistic and analytical changes which would continue to improve both the quality and timeliness of red sea urchin surveys were presented and discussed. It was also pointed out that better definition of management objectives for red sea urchins is required so that numbers of transects allocated to potential geographic survey areas can be optimized. Assigning more transects to an area improves the precision of an estimate, but there needs to be a balance between precision required and extent and numbers of areas to be surveyed. A maximum of about 2 weeks survey time, which allows about 50 transects to be surveyed, is likely available for each First Nation territory in 1995. The optimal spatial arrangement of these potential transects can only be determined following clear definition of goals to be achieved.

Reviewer's comments

The reviewer questioned the potential bias in the estimates of abundance assuming that the area below 10m contained no urchins when it actually did, albeit low densities. He suggested that surveys of areas being exploited may provide better relative, rather than absolute, abundance indices. The reviewer agreed that a sample optimization plan may be appropriate for this fishery, given the relatively low variability around the estimates of mean density within a survey site. However, the variability in mean density among areas would be substantially higher which would make it difficult to optimize sampling over the total survey area. The reviewer also suggested that habitat-based estimators may be more cost effective in the long term than repeated surveys.

Subcommittee discussion

It was suggested that examination of the cumulative distribution of the number of transects plotted against urchin density would provide valuable information to managers regarding optimal density harvest areas. Excessively high density reduces market quality of the gonads. It was suggested that fishers may consider thinning these areas to improve quality, or that these areas be removed from consideration as harvest areas.

A discussion of the history of quota allocation in the North Coast led to the recommendation, that surveys continue into unsurveyed areas to provide biological data for stock assessment, and that these data be considered along with catch data and results from specific study areas to examine growth, mortality etc.

The authors recommended continuity and control of data across all surveys be maintained by a jointly-funded (First Nations and PUHA) coordinator. The authors, while recognizing that summer surveys minimize time lost to weather and allow greater industry participation, recommended that an effort be made to assess differences in the distribution of harvestable animals between the survey period and the harvest season.

(b) Geoducks

Three working papers were reviewed by the Subcommittee. All were accepted with minor revisions.

I95-06 A Survey of Geoduck Population Density in Goletas Channel, 1994.

Summary

A survey was conducted in five areas along the northern side of Vancouver Island in Goletas Channel during 13 -21 September, 1994, to estimate the density of geoducks (*Panopea abrupta*). The paper uses the survey results with catch data from logbooks to estimate harvest rates and original biomass (B_o) of geoducks prior to the fishery. The hectares surveyed (between 5 to 20 m depth) for area 1 = 30.5, 2 = 34.8, 3 = 36.7, 4 = 19.4, 5 = 39.9 and total =161.3. Divers counted geoduck necks showing above or at the substrate surface in 5 m^2 consecutive quadrats along strip -transects 25 - 130 m long spaced 100 - 150 m apart. Overall average density (adjusted for proportion of geoducks "showing") was 1.17 geoduck / m^2 with the highest mean of 1.38 in area 1 and lowest of 0.79 in area 4. Densities increased significantly from 0.0 geoducks / m^2 in shallow (1.2 m) bedrock substrates to 1.0 - 2.0 geoducks / m^2 in deeper (12.5 - 17.5 m) waters with sand substrates.

The total geoducks removed from this area during the 1984-89 fishery, expressed as density removed, was estimated to be 0.52 geoducks / m^2 with the highest (1.23) in area 1 and the lowest (0.20) in area 5. The original total estimated density prior to 1984 was calculated at about 1.69 geoducks / m^2 with the highest (2.36) in area 1 and lowest (1.00) in area 4.

The total biomass of geoducks was estimated to be 1894 t (95% Confidence Interval CI 1467 to 2405 t) in all areas during 1994. The B_o of geoducks was estimated at about 2763.8 t (95% CI of 2336 to 3274 t) . Overall exploitation was estimated at about 31.5 % of B_o for the 6 years (1984 to 1989) with the highest (54.3 %) in area 1 and lowest (15.7 %) in area 5 which was closed in 1988 due to faecal coliform contamination.

Reviewers' comments

Editorial changes were recommended by both reviewers. One reviewer commented that a single group of plots were used to estimate show factor for the entire survey area, and questioned the assumption that show factor estimates from these plots

would be representative of the entire area. There was concern that no biological samples were collected on the survey. The recommendation to re-open certain areas on the basis of biomass estimates alone was questioned. The authors were requested to include documentation of BASIC program used for biomass estimation as an appendix.

I95-07 A Survey of Geoduck Population Density in Southeast Queen Charlotte Islands, 1994.

Summary

A survey of geoduck (*Panope abrupta*) stocks in south Juan Perez Sound, Queen Charlotte Islands, was conducted by the Haida Fisheries Program, the Pacific Underwater Harvesters Association and the Department of Fisheries and Oceans from July 7 - 18, 1994. The purpose of this survey was to estimate the density of geoducks and to back-calculate the pristine density using catch data from harvest logbooks. Transects were placed perpendicular to shore and approximately 300 m apart and SCUBA divers counted the number of geoducks in 5 m contiguous segments along both sides of the transect to a distance of one metre. The overall density of geoducks in the survey area was 1.32 geoducks/m^2 with lower and upper 95% confidence limits of 0.84 and 1.95, respectively. The estimated biomass of geoducks from the survey area was calculated, using a mean geoduck weight of 1.07 kg and a harvest area of 284.9 ha, to be 4,037 tonnes (95% C.I. 2,548-5,958 t).

The total weight of geoducks harvested from the survey area between 1984 and 1994 is 440.9 t or 0.14 geoducks/m^2. Thus the pristine density is estimated to be 1.5 geoducks/m^2 and the pristine biomass is estimated to be 4,272.7 t.

Reviewer comments

The reviewer requested clarification regarding the area of the survey relative to total geoduck habitat in the Queen Charlotte Islands, and the implied relevance of the survey estimates to the entire Queen Charlotte Islands area. The reviewer requested more detailed description regarding the calculation of standing biomass from the survey. The reviewer suggested that GIS technology be explored in estimating the survey area, and that the possibility of excluding unsuitable geoduck habitat from the survey area be explored.

Subcommittee discussion

The primary concern of the subcommittee was the relationship of fishery-dependent data (high-density/low area beds) and fishery-independent data (low-density/high area survey). It was noted that pristine biomass estimates were similar, regardless of the estimator. Concern was expressed that management using the fishery-independent estimates could lead to over-harvesting of the actual harvest areas, and that high density aggregations may be important for reproduction (fertilization). The

subcommittee suggested inclusion of individual bed quotas in the reports, and examination of the survey area and transects relative to bed boundaries from harvest log information.

The subcommittee recommended that work on large area/low density estimates be pursued, and be completed for the August assessment document.

They further recommended that the suggestion to re-open area 12-B be re-evaluated before Area 12 opens on rotation in 1997, in light of the fact that the area is ahead of scheduled exploitation, but has not exceeded maximum allowed cumulative removals of 50% of B_0.

The subcommittee recommended a review of literature related to show factor, and, if necessary, design a study of show factor, with the goal of standardizing data.

The subcommittee recommended that surveys continue to gather fishery-independent data for comparison with fishery-dependent estimates.

I95-08 Preliminary Analysis of Landed Weight Information for Geoduck Clams *Panope abrupta*) in British Columbia, 1990 - 1993.

Summary

Average weight data for geoducks, *Panope abrupta*, taken from (34) landings, is presented for the three geoduck licence areas in British Columbia: North Coast, West Coast (of Vancouver Island) and Gulf ("Inside Waters") between 1990 and (1993). The average weight of landed geoducks was (1186.16) g for the North Coast area, (1098.1) g for the West Coast and (995.8) g for the Gulf area. Average weights for specific locations within the three licence areas is given and weight frequency distributions for the three licence areas are presented. A database has been created to accommodate future weight information. Future sampling should collect weight information from index sites (i.e. locations already sampled) to provide information regarding the impact of protracted harvesting on local populations. Market samples will continue to be collected from harvest areas not previously sampled to expand the existing coastwide database of average weight information. Geographic coordinates of harvest locations must be recorded in future to allow for more accurate comparisons of average weights of samples taken from the same harvest site over time.

Reviewers' comments

The reviewer was concerned about biases in average weight determination introduced by (1) sampling the commercial catch in a non-representative fashion, and (2) inappropriate selection of broken or damaged animals. The reviewer was concerned by pooling of data that may include annual or seasonal weight variability not accounted for by the analysis. The variability in weight may, for example, be attributable to the condition

factor. An additional criticism centred on potential underestimation of geoduck landings through inclusion of damaged animals. On average, a damaged animal weighs less than a similarly sized intact animal. If quota calculations assume an average weight based on intact animals, a harvest that includes significant proportions of damaged animals could take more animals than expected.

Subcommittee discussion and recommendations

The question of whether geoduck weight loss by dehydration or damage was adjusted for in the quota computation was raised. Apparently no adjustments are applied and the prevalence of damaged animals may be attributed to fishing practices or sampling artifacts. In the north coast, problems generated by the incidence of damaged animals in the catch are ignored. It was suggested that a conversion factor to accommodate damaged animals would encourage discarding practices. Instead, a conservative quota stance was advocated. Further education of the harvesters on the market demand for live, and hence undamaged, product was encouraged.

Committee members supported the continuation of the program to gather weight data on the basis that (1) fishing effects may be measurable via the weight data; (2) these data were available relatively cheaply. The procedure for collecting biological data should be modified to ensure representative sampling. Sampling should occur as close to the fishing ground as possible to minimize weight loss due to dehydration prior to measurement. Site selection for samples should be adjusted to include only a few geographically representative sites with each site being sampled every two or three years. Increased emphasis on the collection of age structured data was suggested. The requirement for a conversion factor for "meat only" landings was noted.

(c) Intertidal Clams

Two working papers were reviewed by the subcommittee.

I95-09 Intertidal Clam Stock Estimates for Depuration Harvest Beaches, 1994.

Summary

This paper summarizes stock estimates produced for management of the depuration fishery for intertidal clams in the Strait of Georgia in 1994. Field surveys were completed at seven sites, either independently by harvesters or in cooperation with Department of Fisheries and Oceans (DFO) personnel. Area-weighted biomass estimates and associated confidence intervals were produced by DFO personnel.

The adaptation of general survey guidelines to varied survey sites requires both biological knowledge and experience in designing and carrying out clam surveys. Harvesters have knowledge of the specific sites, and are quickly able to delineate harvest

areas. Best results were obtained when DFO personnel and harvesters completed the surveys cooperatively. Some surveys were repeated, due to unsatisfactory results.

Wide confidence intervals in some surveys (e.g. Wedge Point) may have been a result of patchiness of suitable clam habitat, combined with an already contagiously distributed resource. In some cases (e.g. head of Ladysmith Harbour), only estimates of legal-sized Manila clam stocks were considered to be usable, as harvesters selected mostly legal-sized Manila clams in their samples.

Reviewers' comments

The objectives of the paper need to clearly stated. Concerns about the presentation of the survey design and methodology were noted. Point estimates were given but there was no evaluation of the survey design or biomass estimates. The reviewer made some recommendations on the statistical treatment of the results.

Subcommittee discussion and recommendations

The subcommittee accepted the paper as an initial assessment which provides important baseline data of clam populations at selected sites. Managers expressed concern that only point estimates of stock size were provided and only for some of the beaches harvested for depuration. No recommendations or yield options were presented.

The goals of these surveys need to be clearly stated. A standard design for clam surveys conducted by third parties (biological consultants, First Nation biologists) is required. It was recommended that provincial M.A.F.F. surveys be evaluated.

It was noted that ageing of the samples has not been completed and therefore estimates of production from prerecruits could not be estimated for the coming season. Further analyses of the data are required to examine prerecruit densities.

Bias was identified from surveys where the collection of biological samples were carried out by commercial harvesters without supervision by DFO or independent biologists. This will continue to be an important issue as more invertebrate surveys will be carried out in cooperation with First Nations and industry.

The subcommittee agreed that a management strategy for the harvest of clams in contaminated areas is required. An objective to manage these areas more conservatively than areas in the non-depuration fishery was identified. It is not clear if surveys and quotas are the most effective or appropriate means of achieving this goal.

It was suggested that refugia be established for intertidal clams to provide a source of brood stock. The number, size and location of these need to be examined, however

areas designated as 'prohibited' due to high level of contamination would be likely candidates and should be identified and assessed.

I95-10 Assessment of Intertidal Clam Population Surveys at Seal Island, British Columbia 1940-1992.

Summary

Population surveys were conducted at Seal Island, British Columbia (49° 37.8'N, 124° 51.8'W) from 1940 - 1992, a known area of high productivity of the Butter Clam (*Saxidomus giganteus*). Surveys attempted to determine estimates of the biomass and population structure of a single butter clam population over an extended period. A summary of the results of these surveys are presented in this study, and preliminary estimates of a yield per recruit model is determined. Beginning in 1952, records were kept of other species of bivalves found in plots dug at Seal Island, data collected for these species are presented. Previous sampling strategies and alternate sampling techniques were reviewed. Spatial dispersion of the population was examined. Previous surveys data was examined to determine optimum allocation of samples and required numbers of samples.

Clam production on Seal Island was marked by two strong year classes which were heavily exploited from 1942 to 1949 . Population trends since that time have been relatively stable at lower levels. Survey data indicate a strong selection for larger size classes in the sampling technique. Therefore, estimates of sublegal populations may be under represented in the sampling. Lack of catch data since the 1950's made estimates of natural mortality unobtainable.

Extensive morphological data for samples acquired in 1981 were fitted to Brody-Bertalanffy growth models and subsequent results were used to generate yield per recruit estimates over a range of potential mortality rates. Isopleth contours of the Beverton Holt yield per recruit relationship demonstrated that as natural mortality increased potential yields and the optimum age at first capture decreased.

Tests for population dispersion suggested that the population is contagious and that the distribution approximates a negative binomial. Analysis of population variation in previous censuses indicated that future sampling effort may be reduced by approximately half without large decreases in the precision of the estimate. Recommendations on sampling strategies for future censuses are presented.

Reviewers' comments

Both reviewers acknowledged the ambitious undertaking of compiling and analyzing the large amount of data from Seal Island clam populations. One reviewer suggested that the paper would be easier to digest if assembled into two separate papers, one dedicated to the assessment and the second to the review of survey

designs. His remarks on the analysis presented were limited to minor points, but recommended additional analysis of the data using age-structured models. This would allow the estimation of stock size and recruitment and, through forward simulations, the assessment of harvest strategies. The other reviewer outlined some problems in the statistical terminology used in the descriptions of analysis and results.

Subcommittee discussion and recommendations

There is currently a closure to the harvest of butter clams at Seal Island. No recommendation on this closure was made until further analyses and an assessment are carried out. The subcommittee supported the recommended modifications to the survey design for the 1995 survey.

Recruitment should be examined in light of the absence of a major fishery since the 1930's. There does not appear to be any rebuilding of the stocks since the closure and recruitment is generally low. The landings and CPUE in the fishery have never recovered to the levels of 1940's or earlier.

It was noted that some years of data were missing, e.g., 1977. The data series should be completed if possible.

(d) Crabs

One working paper was reviewed by the Subcommittee.

I95-11 Biomass Assessment of Fraser River Dungeness Crab using Change-In-Ratio and Index Removal Methods.

Summary

In a preliminary analysis of Fraser River delta Dungeness crab populations, both change-in-ratio and index-removal estimators, and an estimator combining both approaches, were determined. These analyses require a research survey before and after the period of catch removal, with proportions and catch rates of both legal-size and sublegal crab determined. These data, combined with known removal by number of fished crab, allow estimation of the crab biomass before the fishery and at the time of the final survey.

Results, calculated separately for both single and double-wired gear, indicated that for crab >145 mm carapace width, notch-to-notch, total population estimates were 1,215,061 and 1,665,828 crab, respectively. Abundance estimates for legal-size crab were 557,467 and 546,541 crab, respectively. Survey data from single-wired gear indicated that the proportion of legal-size crab in the population declined from 46% at the beginning of the fishery to 6% 11 weeks later, with the catch rate of legal-size crab declining from 4.13/trap to 0.37/trap, respectively. However, such data need to be treated

with some caution since possible illegal removal of sublegal crab was not accounted for. Future analyses will attempt to consider this aspect.

Reviewers' comments

The reviewer indicated general support for the estimation methodology pointing out that it provided (1) a means of evaluating prerecruit mortality, and (2) a mechanism for evaluating the effectiveness of the current size limit restriction. The reviewer requested more information on the gear, survey procedures, and spatial location of hauls. Concern was raised about the assumption of constant catchability of legals and sub-legals and about the assumption of constant natural mortality. Although estimators of exploitation rate and catchability coefficients were mentioned in the document, these estimates were not presented. The reviewer was dissatisfied with the discussion of results and wanted clarification of anomalous estimates presented.

Subcommittee discussion and recommendations

Poaching was raised as a potentially large, but unquantified, source of mortality in this fishery. Additional mortality due to handling was of concern.

The sub-committee recommended that 1995 sampling be conducted pre-fishery (April), mid-fishery (June), and post-fishery (fall) to establish baseline data. The same timing of sampling should be conducted in 1996 with the fishery closed at the mid-point (June) to determine whether a difference in sub-legal mortality can be attributed to the closure. Positive results of this management experiment suggest a management strategy that consists of fishery closure when the proportion of legal crab falls below a threshold level. Furthermore the subcommittee requests that available biological data be incorporated into future stock assessments.

4. ADDITIONAL SUBCOMMITTEE DISCUSSIONS

(i) Updated Biological Criteria for New and Developing Fisheries

A subcommittee of the Shellfish Working Group has developed a draft report focusing on policy for new fisheries but not covering biological criteria. It is felt that biological objectives will vary among each species fishery so that criteria will have to be developed separately for each fishery. The report was not presented at this meeting but is being circulated to the senior executive for approval. Discussion centred on how to proceed with policy development. It was suggested that policy should cover all species, not just shellfish, and that aquaculture should be included. It was also suggested that proponents of a new fishery should provide a literature review as a first step in the process, and that this review should be submitted to PSARC. This would provide the proponent two opportunities annually to initiate a fishery. It is recognized that some new fisheries are already underway and these should be exempted from this policy.

(ii) Update of Review of Stock/Recruitment Relationships in Bivalves

Neil Bourne provided a preliminary review of the available evidence for a S/R relationship in bivalves. At the present time it appears unlikely that experimental evidence in support of a S/R relationship is available or that an appropriate study will be initiated. However, there is some anecdotal evidence supporting the contention that brood stock level is important in sustaining populations and there is concern that minimum size limits may not be sufficient to protect a population. It was concluded that area closures, such as the present contaminated area closures, may be an appropriate precautionary measure to employ in managing bivalve fisheries. Neil recommended further work could be done on egg/recruit analysis, fecundity at length, egg viability at length, recruitment success, and mortality rates. It was also suggested that annual changes in the area of contaminated beach closures be documented, though it is recognized that their data may not be presently available.

(iii) Management Issues

Green urchin

There has been an apparent decline in south coast green urchin stocks as evidenced by a decline in CPUE in the fishery and from anecdotal information from fishermen. The fishery is presently closed. An assessment of available stock information, i.e. harvest log data, is required for this summer's PSARC meeting. Research surveys can be pursued at the cooperative research meeting to be held in February.

Abalone

The Subcommittee was requested to assess the potential for a limited abalone fishery by First Nations. The most recent survey results indicate no rebuilding of the abalone resource since the fishery closure, therefore Subcommittee does not support re-opening of the fishery for any purposes at this time. The Subcommittee also notes that even very selective openings may compromise efforts to rebuild the stocks due to the difficulty of distinguishing illegally-caught B.C. abalone from legal, imported abalone of the same species. The potential to use DNA analysis for identification of area of origin for abalone was discussed. While it was agreed that this tool could be effective, a coastwide DNA data bank would be required to eliminate alternative areas of origin for enforcement purposes. Such a data bank does not exist presently.

Process for linking PSARC working papers with management advice

To date, the objectives of many PSARC working papers have not been clearly defined and in some cases the stated objectives have not met the requests for information made by harvest managers. A process is required to ensure that: (i) Harvest Management (H.M.) communicate clearly stated management objectives to Stock

Assessment Division (S.A.D.) and (ii) stock assessment advice provided by PSARC addresses the management objectives. Working papers should contain a clear statement of objectives, the rationale for initiating the work and also contain a discussion of the management implications of the assessment advice provided. There was considerable discussion at this meeting on mechanisms for linking management objectives to the BSB work planning process and to PSARC. At present the PSARC subcommittee provides a list of working papers to BSB executive and tasks are identified through the work planning process. In November of 1994 a new process was initiated through the venue of the Shellfish Transition Working Committee that may in part meet the requirements for interaction between the two branches. At the Transition Committee meeting, harvest managers identified stock assessment issues which provided the basis for program proposals developed by the S.A.D. A list of program proposals will be circulated for review by H.M. It was suggested that management objectives cannot be developed by H.M. in isolation of S.A.D. and that an iterative process will be required to finalize objectives. In the end, an explicit list of information required is needed.

(iv) Publication of Working Papers

Working papers from the summer '94 meeting will be published shortly. If the authors of the 7 papers yet to be submitted wish to have their papers published, the papers must be submitted within the next couple of weeks. Papers presented at this meeting must be submitted by March 30.

(v) Publication of Fishery Updates

Operations Branch will publish fishery updates.

(vi) North Pacific Symposium on Invertebrate Stock Assessment and Management

Abstracts for 50 papers were submitted. A planning meeting was scheduled for the end of the week.

(vii) Next PSARC subcommittee meeting will likely be scheduled about the same dates as the previous year. The PSARC chair will circulate schedule.

APPENDIX 1. LIST OF PARTICIPANTS.

SCIENCE

Sandy McFarlane	Chairperson
Jake Rice	PBS
Jim Boutillier	PBS
Dwight Heritage	PBS
Graham Gillespie	PBS
Claudia Hand	PBS
Glen Jamieson	PBS
Alan Campbell	PBS
Anton Phillips	PBS
Rob Kronlund	PBS

FISHERIES MANAGEMENT

Rick Harbo	South Coast Division
Bruce Adkins	South Coast Division
Steve Heizer	South Coast Division
Kerry Hobbs	South Coast Division
Marilyn Joyce	Fraser River Division
Greg Thomas	North Coast Division
Ivan Winther	North Coast Division
Bill Heath	B.C. - MAFF

APPENDIX 2. WORKING PAPERS SUBMITTED TO THE PSARC INVERTEBRATE SUBCOMMITTEE, JANUARY 24-25, 1995.

I95-01 **Analysis of 1994 red sea urchin surveys conducted in Haida areas.**

Authors: G.S. Jamieson, R. Jones, G. Martel, C.J. Schwarz, C. Taylor and R. Routledge
Reviewer: J. Fargo

I95-02 **Analysis of 1994 red sea urchin surveys conducted in Heiltsuk areas.**

Authors: G.S. Jamieson, W. Sandoval, C.J. Schwarz, C. Taylor and R. Routledge
Reviewer: J. Fargo

I95-03 **Analysis of 1994 red sea urchin surveys conducted in Aweena K'ola areas.**

Authors: G.S. Jamieson, G. Scarf, C.J. Schwarz, C. Taylor and R. Routledge
Reviewer: J. Fargo

I95-04 **Reanalysis of 1993 red sea urchin surveys conducted in Haida, Heiltsuk, Kitasoo and Tsimshian areas.**

Authors: G.S. Jamieson, K. Cripps, M. Gijssen, L. Greba, R. Jones, G. Martel, W. Sandoval, C. Schwarz, C. Taylor and R. Routledge
Reviewer: J. Fargo

I95-05 **Survey protocol considerations for 1995 sea urchin surveys.**

Authors: G.S. Jamieson and C.J. Schwarz
Reviewer: J. Fargo

I95-06 **A survey of geoduck population density in Goletas Channel, 1994.**

Authors: A. Campbell, B. Clapp, C.M. Hand, R. Harbo, K. Hobbs, J. Hume and G. Scarf
Reviewers: C. Wallace
D. Hay

Appendix 2. (Cont'd)

I95-07 A **survey of geoduck population density in Southeast Queen Charlotte Islands, 1994.**

Authors: C.M. Hand, A. Campbell, L. Lee and G. Martel
Reviewer: B. Shaw

I95-08 **Preliminary analysis of landed weight information for geoduck clams (*Panope abrupta*) in British Columbia, 1990-1993.**

Authors: L. Burger, E. Rome, A. Campbell, R. Harbo, J. Wasilewski and D. Stewart
Reviewer: R. Tanasichuk

I95-09 **Intertidal clam stock estimates for depuration harvest beaches, 1994.**

Authors: G.E. Gillespie and G.D. Heritage
Reviewer: B. Leaman

I95-10 **Assessment of intertidal clam population surveys at Seal Island, British Columbia 1940-1992.**

Authors: B.C. Kingzett and N.F. Bourne
Reviewers: M. Saunders
R. Kronlund

I95-11 **Biomass assessment of Fraser River Dungeness crab using change-in-ratio and index-removal methods.**

Authors: G.S. Jamieson and M. Joyce
Reviewer: C. Hand

BIOLOGICAL ADVICE ON PACIFIC SALMON

I. STEERING COMMITTEE REPORT

PSARC Steering Committee met April 26 1995, at the Pacific Biological Station, Nanaimo, to review the Salmon Subcommittee report. The report was accepted. Steering Committee provided the following comments pertaining to major Subcommittee concerns, and to individual Working Papers summarized in the Subcommittee Report.

MAJOR SUBCOMMITTEE CONCERNS AND GENERAL SUBCOMMITTEE RECOMMENDATIONS

Stock Assessment Data

Steering Committee noted that this issue reappears regularly, yet significant improvements seem not to occur. Steering Committee noted RMEC's strong endorsement of the salmon FMISST initiative, and RMEC's direction that Branch Directors should ensure all staff cooperate with the FMISST Team. Steering Committee directed the Chair of PSARC to send a memo to the Regional Informatics Coordinator highlighting the relevant material in the PSARC/RMEC minutes, and giving PSARC's support to effective implementation of those directions.

1996 Forecasts

Steering Committee noted the apparent breakdown in line communications, resulting in the failure to notify the Stock Assessment Section Heads of the need to prepare this document. The prospects for salmon returns in 1996 remain poor, and PSARC reiterates the need for the overview document. This issue will be raised again with RMEC.

Selective Fishery Evaluation

See comments under Major Steering Committee concerns.

General Recommendations

Steering Committee discussed this issue at length. It was agreed that although in principle it was desirable to have a disk with relevant data archived with each Working Paper, there could be practical and security problems, and overlap with FMISST initiatives. Steering Committee requests that this aspect of archiving PSARC materials be addressed in the revision of the protocol for archiving PSARC documents (See Steering Committee minutes 27 April, 1995). Furthermore Steering Committee asks Subcommittee Chairs to ensure more complete tabular and appendicular documentation of data, directly in draft Working Papers. Working Paper authors are to make data available to reviewers on request, to assist in full review, subject to the provisions of the Science Branch Guidelines for Access to data. Finally, Steering Committee notes that

FMISST is an appropriate vehicle for ensuring the proper archival of data used in stock assessments, and encourages FMISST to address this need within their mandate.

COMMENTS ON WORKING PAPERS

S95-1 An evaluation of run size estimation techniques used for the clockwork chum stocks.

The recommendations of the Salmon Subcommittee were accepted. A major concern was that the methodology does not take into account interannual variation in run timing, which could lead to errors in run size estimation. Steering Committee also suggested that the data used in the analyses should be readily available and that the clockwork approach may be useful in other fisheries.

S95-2 Changes in chinook salmon catches in the Strait of Georgia and shifts in the marine environment.

Steering Committee agreed with the Subcommittee observation that, due to data limitations, it may not be possible to determine if the major influences on chinook survival in the Strait of Georgia were density dependent or density independent. However, Steering Committee concurred there was clear evidence that chinook survival had declined.

Part of the Steering Committee discussion focused on what constitutes burden of proof for PSARC Working Papers and whether this working paper was dealt with fairly. Steering Committee does not disagree with the Salmon Sub-committee's decision that it was not willing to recommend large scale reductions in chinook hatchery production based on possible, but unproven, density dependent limitations to production. However, Steering Committee agrees with the authors that it may be possible to examine the density dependence hypotheses through massive manipulation in hatchery production.

Steering Committee supports the Subcommittee's continued interested in any future analyses or experimental work that clarifies the role of the environment and density dependent interactions in controlling the survival rates in chinook salmon.

S95-3 Somass River chinook assessment and forecast for 1995 and 1996.

Steering Committee concurred with the Subcommittee discussion of this assessment, and noted the importance of the results. Steering Committee cautions that hatchery stocks may rebuild faster than wild stocks and that it will be necessary to avoid increasing harvest rates in mixed wild and hatchery stock fisheries prior to rebuilding wild stocks

Steering Committee stresses that there are biological considerations associated with proposals to increase enhancement efforts to help these stocks through the next few

years. Any proposals to increase the rate of stock rebuilding through the use of high technology enhancement methods such as rearing to maturity should be reviewed at the fall 1995 Salmon Subcommittee meeting

Steering Committee notes that WCVI chinook will require several cycles to rebuild and that rebuilding could be set back if unfavourable environmental/biological conditions recur. It also notes that the long-term production capacity of these stocks may have changed, or might in future change, and that targets may have to be re-assessed. A dismissal of the current problem as due solely to mackerel predation may be inappropriate and misleading.

Steering Committee is also concerned, based on undocumented observations in 1994, that other species of salmon on the WCVI may be a serious conservation concern during the near future. Assessments and formulation of advice for management planning is recommended for coho salmon and for sockeye stocks outside Barkley Sound.

S95-4 Factors affecting the marine survival of coho in the Strait of Georgia.

This is a revision of previously submitted Working Paper S94-14, and was accepted by the Subcommittee subject to major revision. Steering Committee endorses the Subcommittee discussion of this paper. Steering Committee notes that the Subcommittee did not accept the authors' conclusion that there is a higher rate of marine mortality for wild coho than for hatchery coho, because differential outmigration of wild smolts could also produce the observed decline in percent of wild smolts in successive samples. Steering Committee also notes that revision of Working Paper will clarify the alternative interpretations consistent with the observations. Most important, Steering Committee concurs that the advice in Advisory Document S94-9 should still be the scientific basis for Strait of Georgia coho conservation and rebuilding measures.

S95-5 Assessment of the status of Rivers Inlet sockeye salmon.

Steering Committee notes that Rivers Inlet sockeye previously supported one of the major sockeye fisheries in BC, and the current status of the stock is a serious concern. The cause of collapse of this stock remains unknown and should be thoroughly investigated.

Steering Committee supports the Subcommittee's acceptance of the Working Paper subject to major revision, specifically inclusion of fishery CPUE and clear-water tributary escapement data. It is unfortunate that escapement data are inadequate to permit complete analysis of stock recruit parameters that could contribute substantially to the development of biological advice. Recommendations to improve escapement estimates are supported.

Steering Committee agrees with Reviewer 1 that habitat degradation may be a significant causal factor in the decline of Rivers Inlet sockeye. Habitat status should be assessed and efforts to restore habitat should be implemented where necessary.

Steering Committee recommends a risk-averse management regime. In discussion concern was raised that the current harvest regime, although characterized as "conservative" by the Subcommittee, may be over-exploiting the stock at its present apparent low productivity. Steering Committee recommends that modification of the "test fishery" to further reduce harvest should be considered.

S95-6 Assessment of freshwater production of sockeye salmon in Babine Lake

Steering Committee endorses the Subcommittee decision and discussion. This document is a first step towards a comprehensive assessment of Babine Lake sockeye. Steering Committee notes that work necessary to provide a full assessment is in progress but is behind schedule. It is recommended that completion be expedited and that a full assessment be submitted to PSARC as soon as possible.

The Steering Committee notes the serious discrepancy in smolt estimates for Babine sockeye and that this problem is not unique to Babine. A review of procedures used to enumerate sockeye smolts at sites throughout B.C. is recommended to ensure data accuracy and reliability.

Pacific Salmon Commission (PSC) Selective Fishery Evaluation Document

Steering Committee reviewed the Subcommittee's report on the PSC Selective Fishery Evaluation. Steering Committee expressed its gratitude to the Subcommittee for the work put into their detailed commentary on this document. The implications of this document to the conduct and management of future fisheries, and to the generation of stock assessment data, are profound. The Steering Committee therefore spent considerable time evaluating the Subcommittee's report on this document.

Steering Committee notes that the PSC Working Group was not tasked to review alternatives to Selective Fishery Programmes. However, consideration of alternatives is a fundamental component of future decision making about these programs, and must be undertaken. Steering Committee draws attention to the following from the Subcommittee report:

> "Ultimately, decisions about selective fisheries will rest upon value judgements contrasting wild stock conservation and fishing opportunities against the loss of information for management and the financial costs of implementation. While selective fisheries may prove to be a useful tool in achieving certain management objectives, alternative means exist which may be less costly to implement and pose less risk to assessment and management capabilities; e.g. time and area

closures, catch ceilings, bag limits, etc. These alternatives should be fully considered and evaluated when considering implementation of selective fisheries."

The Salmon Subcommittee report: (i) reviewed the individual recommendations of the PSC document; and (ii) provided commentary on the questions posed in the Executive Summary of the document. Steering Committee discussion on these elements, by section, are:

1. Steering Committee comments on the Salmon Subcommittee's review of the PSC Selective Fishery Evaluation recommendations:

(i) **Selective fisheries should not be considered for chinook at this time.**

Steering Committee endorsed the Subcommittee recommendation supporting this conclusion.

(ii) **The adipose fin should be used as the mass mark for hatchery coho if selective fisheries are implemented.**

Steering Committee endorsed this recommendation, noting: (i) the need for electronic monitoring of both wild and hatchery escapement, as well as catches from all fisheries, to locate CWT fish; and (ii) that implementation of the selective fishery program will automatically require an additional new program to estimate exploitation effects on wild stocks. The latter is a fundamental requirement because the uniqueness of the adipose clip to CWT fish will be lost (see point 3 below) and information on hatchery fish will not permit estimation of total mortality (including catch and release mortality) of wild fish.

(iii) **Research should be undertaken to provide improved estimates of mark induced mortality and marked recognition error rates for adipose-clipped fish.**

Steering Committee endorsed the recommendation and noted that the Washington Department of Fish and Wildlife studies currently underway to estimate these effects should be reviewed by PSARC.

(iv) **Implement double index tagging of marked (ad-clip + CWT) and unmarked (CWT only) hatchery groups.**

Steering Committee endorsed this recommendation, noting the need to tag additional fish for each indicator stock. Steering Committee also notes that such a program mandates electronic monitoring of escapements and catches.

(v) **Employ electronic detection of CWTs and random sampling of all fisheries and the spawning escapement. CWTs of 1-1/2 length should be used to increase the reliability of electronic detection.**

Steering Committee endorsed the recommendations as modified by Subcommittee concerning potential installation problems for electronic equipment.

(vi) **Maintain *adequate* levels of tagging and recovery sampling.**

Steering Committee endorsed the Subcommittee's review and support for this recommendation. Steering Committee notes that sampling of many fisheries and escapements is currently ***inadequate.***

(vii) **Ensure extensive interagency cooperation and coordination of mass marking, CWT recovery programs, and selective fishing.**

Steering Committee endorsed the Subcommittee's review and support for this recommendation.

(viii) **Associate wild tagging programs with a representative hatchery marking program within the same production area for stocks that are significantly impacted by selective fisheries.**

Steering Committee notes the lack of hatchery-wild pairing in many areas, and even a difficulty in finding adequate paired wild stocks that could be used as surrogates for hatchery-wild pairs. Steering Committee regards this lack as a significant shortcoming of the proposal. Steering Committee recommends that PSARC review additional analyses of the adequacy of paired wild-hatchery stocks for interpretations of survival and exploitation, prior to evaluating the impact of selective fishery programs. Credible escapement monitoring programs are also fundamental to implementation.

(ix) **Selective fishery programs should not be implemented without specific, measurable criteria to provide an objective basis for performance evaluation.**

Steering Committee endorsed the Subcommittee's review and support for this recommendation. Steering Committee notes that a large number of elements will need to be monitored accurately in order to evaluate such fishery programs. This could require substantial additional resources to provide estimates of sufficient precision, particularly concerning changes in the distribution of fishing effort resulting from the program. The adequacy of the performance evaluation depend on the commitment to these monitoring programs. Basic assessment programs will be required, in addition to new and perhaps expensive programs on fisheries or stocks not presently monitored adequately.

(x) **Differences in exploitation or escapement rates between paired replicate, double index tag groups should be the primary means of evaluating the impact of selective fishery regimes on individual stocks.**

Steering Committee endorsed the Subcommittee's review and support for this recommendation.

(xi) **Establish and adopt a protocol for selective fishery proposals to provide for effective review and concurrence of all jurisdictions that would be substantially impacted.**

Steering Committee notes that if any jurisdiction implements such a program, it will significantly impact stock assessment programs for all other jurisdictions where joint harvest occurs. This will require that ***all*** agencies establish the necessary programs and equipment to effect monitoring of selective fisheries for stocks marked in other jurisdictions.

(xii) **A minimum lead time of two years prior to implementation of selective fisheries should be provided for interagency coordination and installation of necessary changes in catch sampling technology and monitoring programs.**

Steering Committee endorses the Subcommittee's revision of this recommendation, noting the imperative to complete a number of tasks which are fundamental information needs for the decision on whether to initiate Selective Fisheries.

(xiii) **Mass marking of hatchery fish by removing adipose fins should not be permitted until interagency coordination has occurred and assurances are received from affected jurisdictions that the capability to recovery CWTs through electronic sampling will be in place.**

Steering Committee notes that unilateral implementation of marking for selective fisheries by one agency will automatically oblige all agencies to implement monitoring programs, even if they do not implement marking and selective harvest programs. These obligatory monitoring programs must be implemented to avoid destruction of our own ability to use CWT data for assessment and evaluation purposes.

2. Commentary on Questions in the Executive Summary

Qs 3, 4, and 5.

Steering Committee endorsed the concerns expressed by the Subcommittee concerning effort responses, compliance, release mortality, wild escapement monitoring, and acquisition of broodstock for some hatcheries. Steering Committee highlights the

potential need for a public education program to supplement any enforcement programs implemented. Steering Committee also stresses that compliance for particular measures is generally a function of perceived and continuous benefits.

The document does not make clear that it is necessary to remove from consideration for marking and harvesting all hatchery production that is intended to address needs to rebuild depressed stocks in some areas. These costs are not presently factored into simulations of selective fishery programs. We will also lose ability to switch hatchery production for other needs in future because of the need to maintain hatchery-based catches in fisheries.

Q6. Can the viability of the CWT program be maintained?

Steering Committee endorsed the comments made by the Subcommittee in particular, the second paragraph of their comments under Q6. Steering Committee stresses in particular the impacts of the selective fishery on such items as the estimation of interception rates for international negotiations.

Steering Committee notes that many of the benefits identified in the document are not uniquely associated with selective fishery programs and could be gained through independent implementation of such elements as electronic monitoring at hatcheries.

Q7. What are the costs associated with implementing selective fishery programs?

Steering Committee endorses the Subcommittee's concerns about the additional costs of selective fishery programs that have not been accounted for in the document. Even the estimation of these costs will require significant Regional resources. However, Steering Committee notes that costs of the *status quo* are also not estimated in the document, nor are those for programs currently under consideration by DFO for other purposes. Clearly, more information is required to conduct a thorough benefit:cost analysis of such proposals.

Q9. Where to from here?

The Steering Committee endorses the Subcommittee's view that the impacts of Selective Fishery Programmes are profound and such programs should not be implemented without extensive additional evaluation, incorporating the specific characteristics and concerns of fisheries in British Columbia. Some Steering Committee members did note that elements of selective fisheries have been implemented in other jurisdictions although they may have distinctly different objectives from those proposed in the PSC document. Although the consequences of selective fisheries elsewhere were not reviewed, implementation of selective fisheries appears not to have ensured rebuilding of wild stocks.

II. SALMON SUBCOMMITTEE REPORT

1. INTRODUCTION

The Subcommittee met April 18-21, 1995, at the Pacific Biological Station in Nanaimo. Six working papers were presented to the Subcommittee. In addition, the Subcommittee reviewed the Pacific Salmon Commission report on Selective Fishery Evaluation. Meeting participants and reviewers of Working Papers are listed in Appendices 1 and 2, respectively.

2. MAJOR SUBCOMMITTEE CONCERNS

Stock Assessment Data

As stressed in previous Subcommittee reports, data-related problems were noted in several Working Papers. Many salmon data sets potentially useful for stock assessment are not systematically stored or archived. The Subcommittee **recommends** that a high priority be assigned to the management of stock assessment data. Furthermore, the Subcommittee recognizes the need for allocation of resources to data management.

1996 Forecasts

The Subcommittee **recommends** that the low catch anticipated and the conservation issues for a number of stocks in 1996 should be documented by PSARC and reviewed as soon as possible. The magnitude of these concerns should be identified to the user groups and accounted for during management planning. At the November 1994 meeting, the Subcommittee recommended that such a discussion paper be prepared for senior managers and industry. The Subcommittee agrees that the problem is urgent and that the recommendation should be re-instated.

Selective Fishery Evaluation

The Subcommittee reviewed the PSC document evaluating the potential impacts of establishing selective fisheries for hatchery fish. The authors of the document are complimented on the production of a detailed analysis that will form the basis for further investigations of this concept. The Subcommittee acknowledged that the document examines many of the costs and benefits of selective fisheries in generic fishing scenarios. While the document concludes that, in theory, harvest rates on wild stocks can be reduced by selective fisheries, the Subcommittee believes that the projected benefits are less and the costs are more than the document indicates. Further, the Subcommittee has concerns about the threat that selective fisheries pose to our current capability to assess and manage coho stocks, based on traditional methods. Even with substantial infusion of new resources, we will lose ability to directly monitor total fishing mortality rates and estimate fishery-specific exploitation rates under selective fishing.

Further analysis of these concepts is warranted, including a full explanation of the potential costs and benefits.

3. GENERAL SUBCOMMITTEE RECOMMENDATIONS

The Subcommittee notes that many data sets which support analyses in Working Papers are maintained by individual users in a variety of formats. Analyses based on these data sets cannot be independently verified by the Subcommittee or by reviewers of Working Papers. Therefore, the Subcommittee **recommends** that these data sets be submitted and archived electronically with the Working Papers. A DFO standard database format would be appropriate for these data.

4. WORKING PAPER SUMMARIES, REVIEWS AND DISCUSSION

S95-1: **An evaluation of run size estimation techniques used for the clockwork chum stocks. Ryall and Cass.** ** Accepted with **minor** revision**

Working Paper Summary

Management of the Johnstone Strait fisheries is determined by the Clockwork Management plan. The area of coverage for this plan is represented by statistical areas 11-19, 28 and 29. The Clockwork Management plan was introduced in 1983. The plan provided a framework for the objectives and strategy by which the Johnstone Strait and Fraser River commercial fisheries would be operated. The primary objective was to achieve the maximum potential of the resource. Additional objectives were to: (1) Rebuild the wild escapement to 2.5 million. This initially included a minimum escapement goal for the Fraser River of 700,000 wild chums. An interim wild escapement goal of 1.8 million chums was set for the period 1983-86. (2) Reach the escapement goal target of 2.5 million in 3-4 cycles. It was planned to increase this goal every four years. Currently we are at an escapement goal of 2.0 million wild spawners. (3) Learn as much as possible about the productivity of the stocks. (4) Allow limited fishing at low stock sizes. (5) Stabilize the annual catch.

The approach taken to achieve the above objectives was to limit fishing through the use of a stepped harvest rate. The harvest rate is set according to the size of the chum run, with a threshold stock size below which commercial fishing would not occur. The clockwork harvest rate schedule is outlined in the table below.

Wild Stock	Total Stock	Harvest Rate
0 - 2.0 million	0 - 3.0 million	10%
2.0 - 2.9	3.0 - 3.9	20%
3.0 - 4.2	4.0 - 5.2	30%
over 4.2	over 5.2	40%

The paper documents the current methodology used to predict in-season estimates of the returning Clockwork run size and presents a case study of the 1993 season. Also, a comparison of in-season estimates to post-season harvest rate estimates is provided in order to assess whether the harvest rate goals are being met.

In-season estimates of run size are derived from regression analyses of catch and CPUE data from seine test fisheries and commercial fisheries occurring in Johnstone Strait. Regressions are based upon the log-linear model:

$$\mathrm{Log}R_t = \alpha_w + \beta_w \mathrm{Log}U_{tw}$$

which is applied to historical data on run size (R_t) and catch or catch per effort (U_{tw}) to estimate the regression coefficients (α_w and β_w). Regression coefficients are calculated for each week *w* of test fishing or commercial fishery. As the weekly estimates of run size depend upon independent CPUE or catch measures for each week *w*, they can be combined to provide an overall estimate from the set of available weekly estimates. The weekly run size estimates are combined in an inverse proportion to their associated variances.

As the Clockwork chum run starts to migrate through Johnstone Strait in early September, test fishing provides the first indication of returning run size strength. However, it is not until late September that the regression analyses are statistically significant. The regression calculated from test fishing data derived from the third week of September is not significant (P=0.67) and for the fourth week of September while significant (P=0.01) only has an R^2 of 0.39. This is in comparison to the commercial "Assessment Fishery" run in the 3-4 week of September which has an R^2 of 0.67 to 0.75 depending upon the data used in the calculation. There is currently a request to eliminate the "Assessment Fishery" from the Sport Fish Advisory Board (SFAB). It is our recommendation that the "Assessment Fishery" is a necessary tool at this time for estimating chum run size early in the season and should not be eliminated. The assessment fishery could be modified to address the SFAB request of reducing chinook, coho and steelhead catches.

The current methodology does not take into account variability in the run timing of the chum stocks. As the stock can vary by as much as 2 weeks in return timing, this would appear to be an important variable to take into account in order to improve the current methodology. Finally, reconstruction of historical run sizes is dependent upon estimates of catch and escapement. Catch estimates are fairly well determined from sale slips and other sources, however, estimation of escapement is much more uncertain.

Also, the estimation of escapement has deteriorated over the years. A review of techniques used for estimating Clockwork escapements is needed.

Reviewer's comments

Reviewer #1

Reviewer #1 stated that the Working Paper has short comings in its current presentation. The in-season procedure is dependant on post-season historic bench marks. The bench marks are mainly the sums of catch and escapement. An understanding of measurement errors in the components which yield the bench mark post-season run sizes is required. This is important in that 90% to 60% of the run escaping the Johnstone Strait fishery goes to subsequent catch and escapement. Likely, the measurement error in catch is less then that of escapement. Also likely and more important, the measurement error in escapement over the historic years has been variable in magnitude and direction.

The assessment and recommendation regarding the September week 3 and 4 test fishery as poorer predictors than the assessment fishery is supported. The replacement methodology is likely to include improved escapement estimates either in index consistency or absolute value.

The run timing has varied by more than two weeks. This may be a change in the run timing but it also could be a change in the component stock production. For example, a late stock component of the run could be more productive in a particular year. The timing curve for the total run for that particular year, would be shifted to the right. The point to be made is that the question may not be one of run timing but of changes in population productivity.

Reviewer #2

This paper provides a valuable update on the Clockwork Management plan for operating the Johnstone Strait and Fraser River commercial chum fisheries. Although it has some limitations, clockwork chum management constitutes a rational scheme for operating a salmon fishery. The data requirements are fully identified, along with methods for incorporating data into the decision analysis. Furthermore, the stakeholders have been openly included in the management process.

Reviewer #2 added three recommendations to the existing four recommendations from the authors:

1. Consolidate all historical data used for clockwork chum management, particularly the data from test fisheries, into a corporate data base that can readily be used by researchers in diverse components of the DFO organization. Review and identify potential data weaknesses, particularly those in the escapement data.

2. Design, document, and implement a synthetic statistical model for clockwork management. The design phase should include a study of the existing historical data to detect the potential predictive value of data not previously utilized, such as sex and age ratios in the returning run of chum salmon. The historical record should also be used to test proposed new methods against the benchmark of methods employed in the past.

3. Take advantage of lessons learned from clockwork chum management in establishing rational schemes for managing other salmon fisheries.

Subcommittee discussion

The Subcommittee accepted this working paper, following minor revisions, as a preliminary step towards a more complete analysis of the Clockwork process for in-season decisions on chum salmon fisheries. For example, the Subcommittee accepted the authors' first recommendation that the "assessment" fishery not be eliminated but noted that alternatives to the current assessment fishery methodology should be explored. These could include implementing non-possession and non-retention of chinook, coho, and steelhead by purse seine and reducing the fleet size participating in the commercial assessment fishery. The Subcommittee also agreed that the present assessment procedures should continue and that the incorporation of run timing information should improve the predictive regressions used for the Clockwork process. The latter, however, must be considered in the broader context of a full evaluation of the statistical procedures. The Subcommittee noted the need for more stock-specific information, and the potential for serious limitations to the predictive models due to the weakness in the spawning escapement data. The Subcommittee notes the need to design, document, and implement a synthetic statistical model for clockwork management, and that this type of model may be used as a model for other salmon management situations. The design phase should include a study of the existing data to detect the potential predictive value of data not presently utilized, such as sex and age ratios in the returning chum salmon. Further, given the availability of marked enhanced production in these fisheries and the age structure of chum salmon, the Subcommittee suggested that examination of pre-season forecasts may aid in the early season assessment of run strengths. These pre-season forecasts can be incorporated with the in-season monitoring programs to possibly improve the management decisions in the early season.

The Subcommittee particularly noted the difficulty of developing predictive models of total return when over 50% of this return is accounted for in the spawning escapement. The authors noted the recent decline in the number of streams being assessed for chum escapement and the variability in the quality of escapement surveys. Further, the Subcommittee noted a concern that escapements to the more southerly stocks were increasing but that the escapements in the more northerly areas, which are more proximal to the major fishing area, appear seriously depressed. Given the multiple stock nature of

the Johnstone Strait chum fishery and these variations in spawning escapements, the Subcommittee also **recommends** that the status of these Study Area chum salmon be reviewed. Once our ability to assess these stocks (both by stock and within season) are better understood, the Subcommittee would be better able to advise on the management of this chum salmon resource. The Subcommittee notes, however, that greater accuracy in determination of spawning escapements is likely to be necessary given the low sustainable exploitation rate for chum salmon.

The Subcommittee further **recommends** the consolidation of all historical data used for chum clockwork management, particularly the data from the test fisheries and stock composition programs. Incorporation into a centralized database would improve accessibility and facilitate longer term maintenance of this data as it accumulates.

S95-2: Changes in chinook salmon catches in the Strait of Georgia and shifts in the marine environment. Beamish, Thomson, Neville, Riddell and Zhang. *Accepted with **major** revision**

Working Paper Summary

When the abundance of salmon declines over time, the management action is frequently to increase the number of spawners. The goal is to restore abundances to a past higher level of production, implicitly assuming that the capacity of the environment has not changed. However, if the capacity of the environment to sustain the historical abundance had declined, then rebuilding to those higher levels may not be possible regardless of the increased number of spawners. Over-fishing could have contributed to the decline in production if exploitation rates had not been adjusted for declining productivity of the stocks. Reducing exploitation rates during a period of reduced productivity (i.e., survival in freshwater and/or the marine environment) would be appropriate for sustaining the stock and what surplus yield remains, but a management goal of restoring historical harvest levels may not be attainable until the environmental conditions also reverse.

In this paper, we examine the association between changes in the marine environment and the decline in production of chinook salmon in the Strait of Georgia. Chinook catches in the Strait increased in the 1970s and reached maximum levels from 1976 to 1978 (Fig. 2.1). Catches then declined steadily until the mid-1980s and stabilized at levels approximately one quarter of the maximum levels. Between 1987 and 1991, catch levels averaged 168,000 chinook reflecting changes in production and regulation since the mid-1970s. The timing of the decline, however, was synchronous with other changes observed in the late 1970s: an increase in the mean temperature of the Strait of Georgia, a reduced average annual daily discharge from the Fraser River, and an abrupt decrease in the marine survival of Canadian hatchery chinook released into the Strait of Georgia. It is noteworthy that the decline in survival of these hatchery chinook occurred before the major increase in the numbers of hatchery chinook released.

Estimates of the numbers of chinook smolts in the Strait of Georgia were compared for the mid-1970 period and for recent years. Estimates for the 1970 period were based on run reconstruction based on catch, spawning escapements, and hatchery production. Applying a range of monthly natural mortality rates and proportions of the smolts from U.S. origins, resulted in a possible range of smolt abundance from 22 to 35 million smolts, 14 to 22 million of which would have been from natural production in Canada. Direct sampling of chinook smolts in the Strait of Georgia during 1992 and 1993 was used to estimate an abundance in these recent years. Smolts were classified as hatchery or wild based on otolith patterns. Approximately one half of the smolts were of hatchery origin. These data and the total numbers of hatchery chinook released into the Strait of Georgia, including an allowance for Puget Sound hatchery chinook, suggest that approximately 82 million chinook smolts entered the Strait in 1992. This comparison would indicate that the number of smolts in 1992 was more than twice the average number in the mid-1970s, including the numbers of wild smolts. The relationship between the number of Canadian hatchery chinook released into the Strait of Georgia, since the 1973 brood year, and the subsequent production (catch plus spawners) from each brood suggests strong density dependence.

We conclude that there was a change in the carrying capacity for chinook in the Strait of Georgia in the late 1970s that contributed to the decline in abundance of chinook salmon. We cannot prove that the decline in chinook production results directly from these environmental changes but suggest that there is strong circumstantial evidence. However, due to the confounding of the trend in hatchery releases and the changes in the environmental variables over this time, we can not determine how chinook production in the Strait is being limited. We suggest though, based on other larger scale changes in the north Pacific, that the change in chinook abundance could be linked to large scale climate-ocean interactions. Rebuilding of chinook production to previous higher levels is unlikely until the carrying capacity for chinook in the Strait of Georgia increases, either naturally or through manipulation.

Reviewer's comments

Reviewer #1

Reviewer #1 considered the authors' presentation to be an interesting hypothesis for the declines in chinook survival in the Strait of Georgia and one worthy of additional research. The science of identifying hatchery from wild fish is developing along similar lines for other species (steelhead, Atlantic salmon). The method proposed will likely be a useful technique for estimating mixtures of hatchery and wild fish providing that sampling designs are adequate.

The reviewer believed the authors' estimates of chinook abundance in the Strait to be the weakest part of the work. If temporal/spatial stratification in the Strait is important (which it certainly is for chinook adults) the estimates could be quite wrong. If the authors' hypothesis is true, then there could be a density-dependent effect on juvenile growth

given the substantial decreases in chinook survival. The authors should have collected juvenile chinook size data and other data are likely available. These data should be examined for density-dependent effects on juvenile growth. Finally, the mechanism for the decline in survival is unknown. The causes of mortality might be disease (not considered by the authors), starvation, predation or a combination of the three.

Reviewer #2

This paper proposes that there is a finite carrying capacity to the Georgia Strait for the production of salmon, and that carrying capacity has been reduced by oceanographic or climatic changes that occurred in the mid-1970s. Obviously if these ideas are true, then there are some serious management issues to address concerning the protection of wild stocks, the value of increased enhancement activities, and the development of fishing plans. Reviewer #2 agrees that there is a finite limit to fish production in the Strait, and that the limit (or the productivity) can change on decadal scales with climatic factors. However, the analysis of data supporting these hypotheses is not simple because of the potential for confounding and spurious effects.

Reviewer #2 points to two somewhat interrelated issues. First, since hatchery contribution to catch was small during the peak and decline of catch, it would seem these trends are related primarily to changes in wild fish production. To support that contention, escapement trends should be presented so that the reader can better relate the changes in catch to total abundance. The second issue is the decline in survival of hatchery releases in the most recent years. A formal statistical analysis is required to allow a more objective assessment of the four alternative hypotheses presented in the paper. However, even after this analysis, it will not be possible to distinguish between (1) lower survival of hatchery fish in recent years from density-dependent mortality, and (2) a decrease over time in density-independent survival. This is because there are strong time trends in both the fish and environmental data. If the productivity of the Strait has declined over time (or perhaps the population of predators has increased over time), then survival could be declining independently of density. These hypotheses directly affect the appropriate management advice. Unfortunately, discrimination among competing hypotheses will require more variation in SEP release levels or direct mechanistic evidence on the causes of mortality of young chinook.

Subcommittee discussion

This Working Paper, reviewed previously in Advisory Document 94-4 as Working Paper S94-3, has been revised and resubmitted as requested. The authors examine the association of changes in the marine environment and the declines in the chinook catches in the Strait of Georgia. The timing of the decline was synchronous with an increase in the mean water temperature of the Strait of Georgia, a decline in the annual Fraser River flows, and an abrupt decrease in the marine survival of hatchery-reared chinook smolts.

The reviewers noted the general scientific interest in establishing a working hypothesis for the changes. The weakest parts of the work identified by the reviewers are the estimates of abundance in the Strait and the development of a mechanism relating environmental changes and catch. The concept of a finite carrying capacity to the Strait is acceptable. Production could be changed through changes in carrying capacity, changes in survival rates at densities below the carrying capacity, or through both processes.

The Subcommittee acknowledged the declining survivals and a change in the environment that would potentially reduce production. The Subcommittee noted, however, that due to limitations in the available data, it would probably not be possible to determine whether the environmental shift changed the carrying capacity or changed the survival rates. The key point is that there have been changes. There is a need determine whether survival rates are density dependant or independent. The analysis in the paper is uncertain and will likely remain uncertain because data for years with large releases do not exist prior to 1978. Evidence for higher carrying capacity during the period of high catches and survival rates of hatchery chinook is therefore not available, and the existence of a regime shift in carrying capacity can not be directly tested. Evidence for a regime shift in the environment of the Strait of Georgia is taken from a large body of literature outside of PSARC.

S95-3: **Somass River chinook assessment and forecast for 1995 and 1996. Riddell, Tompkins, Luedke and Lehman** **Accepted with **minor** revision**

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. Their contributions have increased as the hatchery expanded and, in 1991, the total catch of this stock was 430,000 chinook and total production, accounting for incidental mortalities, exceeded 500,000. However, the production is highly variable depending on marine survival conditions. Loss of this production reduces the abundance of chinook available to ocean fisheries and generates allocation conflicts in the terminal area. Unfortunately, reduced survival rates have been observed for the 1991 and 1992 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 1995 and 1996 terminal runs to Barkley Sound are projected to be substantially less than the spawning escapement goal for the Somass system.

Following the procedures accepted by PSARC in 1994 (WP S94-7A), this Working Paper completed a review of all the escapement data since 1985, incorporated the 1994 data and procedures for examining uncertainty in the forecasts, and developed forecasts of terminal run size (to Barkley Sound) for 1995 and 1996. 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 the 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).

Results

Terminal runs of Somass chinook have varied by a factor of almost 4 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 67.3% over this period (Table 3.1). Consequently, omitting tag recoveries from these spawners has under-estimated survival values and significantly over-estimated exploitation rates.

The 1995 forecasts of ocean abundance resulting from production models Prod2 and Prod3 are summarized in Table 3.2. The forecasts of ocean abundance include expansions for the unassociated and/or natural production. The projected ocean abundances differ by 7600 fish but this difference becomes much smaller in the expected terminal run. This results from different ocean exploitation rates by age and the differences in the forecasted age structure in the ocean abundance. Terminal runs to Barkley Sound in 1995 are only projected to be about 32-33,000 chinook, assuming no change in ocean exploitation patterns.

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. Example outcomes of the Prod2 and Prod3 forecasts of total terminal run to Barkley Sound are presented in Table 3.3. These results assume that the ocean management actions taken in 1995 are maintained in 1996 but other scenarios can be examined. Forecasts for the 1995 terminal run (total Somass production) range from 32,100 to 56,000 depending on the model and ocean management actions. The 1996 forecasts show a similar range but the major difference between the 1995 and 1996 returns are the expected numbers of females in the terminal runs. Whereas in 1995, the numbers of females may vary between 20,100 and 37,200; the numbers of females in 1996 will be seriously reduced to between only 5,800 to 11,950.

Estimation of forecasting error

The average prediction error varied between 26% and 47% (over the three sibling regression models) of the known data value for the Prod2, and 15% to 43% 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 3.1 compares the annual deviations from observed total terminal runs and the average deviation for the Prod2 and Prod3 models. The Prod3 model had lower average error and was estimated to be 11% (average absolute deviation) of the observed values. The range in the error, however, is from 4 to 28% for Prod3 and 5 to 40% for Prod2.

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 1995 and 1996 are 26,500 and 104,000 chinook (target number of females 14,300 and 13,400) respectively.

These goals are consistent with the minimum 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 73,000 chinook, based on a requirement for 11,260 females. Even in the absence of directed chinook fisheries in 1995 and 1996, the forecasted terminal run of females in 1996 is expected to be less than either goal.

Working Paper Recommendations

1. The recommended forecast for the total terminal run of chinook (age 3,4, and 5) to Barkley Sound in 1995 is 33,400±11% and for 1996 is 37,600±11%. These values are based on the Prod2 and Prod3 models and assume no change from recent ocean harvest rates in ocean fisheries from S.E. Alaska down to the west coast of Vancouver Island.

2. Recommended spawning targets for the Robertson Creek Hatchery and Stamp River in 1995 and 1996 are 26,465 spawners (14,300 females) and 72,932 spawners (11,258 females), respectively. The escapement goal for 1996 presumes that enhanced production can be increased by 2 million smolts (by rearing an additional 2.3 million eggs). This increased rearing may require increased funds at Robertson Creek and priorization of available rearing space.

3. The forecasted 1995 and 1996 returns to Barkley Sound will require reduced ocean harvest impacts in order to provide terminal fishing in 1995 and to conserve spawning stock for 1996. The major issue in the Somass stock will be lost production from the 1996 brood but more serious conservation problems are likely for natural chinook populations along the west coast of Vancouver Island. These natural populations will not have the resilience of the enhanced Somass River chinook and will likely become a longer term conservation problem if steps are not

taken to minimize their reduction in population sizes. It would be prudent to substantially reduce fishing mortalities in 1995 and 1996 in order to increasing spawning of the age 5 cohort in 1995 and minimize the loss of spawners for 1996.

Reviewer's comments

Reviewer #1

This is a sound assessment of an important chinook stock. The manuscript gives clear explanations of where the data came from, and how they were manipulated prior to the final analyses. There are clearly problems with some of the data, particularly the jack estimates in some years. The final treatments of the problematic data series seem reasonable, but in some cases it is unclear if the present treatment is consistent with how similar problematic data were handled in past assessments. It is important to indicate clearly whether we are consistent or inconsistent with past handling of the data, so any differences in final results (compared to past assessments) can be attributed to either changes in how we treat past information, or in what the stock actually is doing. Some of the historic inconsistencies in the data series should be resolved to ensure that work is conducted with the best (and a stable set of) data.

The conclusions are clear - returns are low for 1995, and VERY low for 1996 - regardless of which forecasting and cohort models are used. Differences among models are unimportant, compared to the overall message, and PSARC advice should reflect that strongly. Most of the conclusions are supported by the data and analyses. The exception is the advice on wild stocks in the same area, where no data or references to past documents are provided. This is particularly unfortunate, because the message on the threat to small, wild chinook stocks is a very important one. If references or data can be added to the final document, they should be, so PSARC has the evidence to support a clear statement on this important issue.

Reviewer #2

This report is a thorough and detailed presentation of the data, methodology and assessment for predicting chinook run size in 1995 and 1996 for the Somass River system (hatchery plus wild). However, reviewer #2 found the methods section difficult to read (particularly the section on age 2 (jack) estimation methods), and tables in the results section confusing and sometimes contradictory. Reviewer #2 noted that the spreadsheet model does not account for sequential catches of maturing chinook, which would reduce the gains to terminal runs that are expected from ocean harvest rate reductions in individual fisheries.

Reviewer #2 agreed with recommendations one and two. With respect to recommendation three, he agreed in concept with the concern expressed for 1995/1996 returns to small WCVI natural stocks. However, the report presented no data that would justify this concern.

Subcommittee discussion

The Subcommittee accepted the Working Paper with minor revisions. The authors are to be commended for identifying and correcting inconsistencies in historical data and for a sound use of the data. The Subcommittee agreed that the data are of sufficiently quality to become the definitive Somass-Robertson data set. The authors indicated that the best repository of the data set is the MRP data base.

The Subcommittee endorsed all three recommendations of the Working Paper with the caveat that recommendation 3 needs to be supported by data or references which identify west coast Vancouver chinook stocks as a serious conservation issue. Summaries of the recommendations are as follows:

1. The recommended forecast for the total terminal run of chinook (age 3,4 and 5) to Barkley Sound in 1995 is 33,400±11% and for 1996 is 37,600±11%. These values accept the ocean abundance forecast in this Working Paper and assume ocean exploitation rates at recent average levels.

2. Recommended spawning targets for the Robertson Creek Hatchery and Stamp River in 1995 and 1996 are 26,465 spawners (14,300 females) and 72,932 spawners (11,258 females), respectively.

3. The forecasted 1995 and 1995 returns to Barkley Sound will require reduced ocean harvest impacts in order to meet the 1995 spawning escapement goal plus an obligated requirement for Native catch and to conserve spawning stock for 1996. The major issue in the Somass stock will be lost production from the 1996 brood but more serious conservation problems are likely for natural west coast Vancouver Island stocks.

The Subcommittee noted that variations in run timing distributions of west coast Vancouver Island stocks are such that these runs are present through much of the ocean fishery. The Subcommittee concluded that to achieve desired ocean harvest reductions, concerted management action must be expended to ensure that gains in sequential ocean fisheries through conservation measures are not lost in aggressive down stream fisheries. If management actions are not distributed equally in all ocean fisheries, then the desired harvest reductions may not be achieved and resource re-allocation issues among various users may result.

S95-4: Factors affecting the marine survival of Coho in the Strait of Georgia. Beamish, Neville, Rice and Zhang **Accepted with **major** revision**

Working Paper Summary

Juvenile coho of the 1990 and 1991 brood years were sampled several times in the Strait of Georgia, for a few weeks to several months after entering the sea. Fish were classed as hatchery or wild in origin, based on the otolith microstructure. Canadian and US hatcheries produced an estimated 10-11 million smolts during these years. Using the individual samples as replicates, the mark ratio method estimates wild smolt production to be 6.5 (SE=1.1) and 4.5 (SE=0.8) million for the 1990 and 1991 brood years. However, there is a significant decline in successive estimates over time within each brood year.

The pattern of change over time for both brood years is fit well by a model with an exponential decline in the individual production estimates over the entire period of sampling. This decline is consistent with a differential (lower) survivorship of wild coho relative to hatchery coho, but could also be explained by a constant differential rate of outmigration of wild smolts from the Strait of Georgia to outside waters. The intercept of the model with 15 May as the origin date for wild smolts entering the sea, gives estimates of 18.5 (SE=3.2) and 12.3 (SE=1.4) million wild smolt production in the Strait of Georgia.

Estimates of wild smolt production from 1977 to 1979, based on records of catch, escapement and hatchery survivorship levels, are 11-12 million wild smolts per year, with approximately 3 million hatchery smolts also produced. Regardless of the interpretation of current estimates of wild smolt production, total smolt production in the Strait of Georgia in the early 1990s is much higher than in the late 1970s. Catches have had no trend over that period, whereas escapements have declined. Two effects are necessary to balance these figures. The first factor is a large compensatory response in the freshwater life history of coho, so freshwater production has increased or remained stable over a period of declining escapements. The second factor is a large decline in marine survivorship; from around 15% prior to the 1978 brood year to values half that level. This drop in marine survivorship coincided with major changes in the physical and biological oceanography in the Strait of Georgia and greater North Pacific, starting in 1978. These changes resulted in lower ocean productivity, and possibly density dependent marine processes influencing marine survivorship. Such density dependent processes would mean that large numbers of smolts would experience lower survivorship than smaller numbers of smolts. In that case high levels of hatchery production might be acting to depress the survivorship of wild smolts.

Reviewer's comments

Reviewer #1

This is an interesting paper presenting important results from the Strait of Georgia sampling program. Results provide insight into potential differences in marine survival between hatchery produced coho smolts and other coho residing in the Strait. Reviewer #1 supports the need for work in the marine environment to better understand factors governing survival and distribution of coho. He agrees that the Strait of Georgia has a

finite carrying capacity that is not constant. However, a lack of information on the sources of information used to arrive at some conclusions reached in the paper, and concerns about the method used to estimate numbers of wild coho make it difficult to support the main conclusion: an interaction between wild and hatchery coho results in a higher rate of marine mortality of wild coho than hatchery coho.

The authors should define what they mean by wild coho. Outplanting of fed fry to streams is common in many streams draining into the Strait of Georgia. Presumably, the early growth patterns of these fish would be similar to hatchery fish and the later freshwater growth patterns similar to wild fish. What ramifications does the presence of these "semi-enhanced" fish have on this assessment?

Reviewer #1 has serious concerns regarding the approach used to estimate the number of wild smolt releases. The ratio estimator used assumes that marked (hatchery) and unmarked ("wild") animals have the same probability of being caught in the second and subsequent samples. Depending on the location and timing of sampling, there may have been incomplete mixing of hatchery and wild fish. Another assumption is that the survival rate of both marked and unmarked fish is the same. Because this is not true, it would not appear to be valid to use the set of samples within a brood year as replicates. Although reviewer #1 is not convinced that sample sizes are adequate to examine patterns over time, he thinks this is a very important pattern to examine. He suggests that the authors obtain catches through MRP for the commercial troll and sport fishery and partition these into hatchery and wild fish.

Reviewer #2

The factors affecting the marine survival and the carrying capacity of Strait of Georgia are very important and reviewer #2 feels that this paper adds to the discussion on this topic. However, the lack of information associated with the data make the paper difficult to understand. Reviewer #2 believed that the following information should have been included to substantiate the analysis: (1) actual sample locations and dates; (2) total numbers in a sample; (3) stocks and fisheries used in figure 3; (4) hatcheries combined to calculate quantities such as survival and distribution; (5) calculation of hatchery survivals; and (6) CWT tag codes recovered, numbers of each tag, and hatchery of origin.

Reviewer #2 supports the need for work on marine survival of coho salmon. He agrees that the carrying capacity of the Strait of Georgia is finite. At current hatchery production levels, both hatchery and wild smolt survival may be compromised. More work is needed on the interaction between hatchery and wild fish. Given the information presented in the paper, the conclusion that there is a higher rate of marine mortality of wild coho than of hatchery coho is not supported.

Subcommittee discussion

Subcommittee members exhibited broad agreement with the comments presented by the two reviewers of this paper and accordingly suggest acceptance of the paper subject to major revisions as follows: (1) provide better documentation of data sources along with their strengths and weaknesses; (2) provide better documentation of the methods used by the authors to generate their own observations; and (3) revise the presentation of results and discussion to compare and contrast two alternative interpretations of the data, i.e. that different trends in hatchery versus "wild" coho juveniles are either evidence for (a) differential migration and residence patterns by hatchery versus wild fish or (b) differential survival of hatchery versus wild fish.

Subcommittee members did not accept the major conclusion as currently stated (i.e., that high hatchery production could depress the survivorship of wild smolts) and stressed that future management advice from S95-4 will vary in important ways dependent on which alternative interpretation is regarded as more parsimonious. For example, recommendations for future study requirements as well as for modification of enhancement operating procedures depend critically on determining whether the differences between patterns observed for hatchery versus wild fish are a likely consequence of differential mortality in the Strait of Georgia or of differential residence patterns in the Strait of Georgia.

Having considered the contents of S95-4 carefully, the Subcommittee does not recommend any departures from previous recommendations on Strait of Georgia coho conservation and rebuilding.

Given its potential importance, continued evaluation of evidence for size-dependent mortality should be an integral part of any future coho conservation initiatives.

S95-5: Assessment of the status of Rivers Inlet sockeye salmon. Rutherford, M^{c}Kinnell, Wood, Hyatt, and Goruk. **Accepted with **major** revision**

Working Paper Summary

This paper provides a comprehensive review of the status of the Area 9 (Rivers Inlet) sockeye salmon stock. Adult catch and escapement data and a limited time series of in lake juvenile data have been used in this assessment. Based on catch and escapement data, total stock size and catch have been decreasing since 1948. During this same time period, escapements have been increasing; however, the estimated 1994 escapement is one of the lowest on record (Fig. 5.1). Stock recruitment analysis suggests a regime shift occurred around the 1974 brood year (Fig. 5.2). Available juvenile and adult data were analyzed to determine if this shift occurred in the freshwater or marine phase. Results were inconclusive as no change was detected in either phase. The authors mention several events that occurred around the 1974 brood year that could be responsible for this apparent regime shift. These include (i) the adaptive management

experiment initiated in the 1979 return year; (ii) warmer spring sea surface temperatures in Queen Charlotte Sound; (iii) the onset of fertilization of neighbouring Long Lake (Area 10); and (iv) noisy data.

Relationships exist between (i) juvenile in-lake density and juvenile weight; (ii) juvenile density and presmolt weight; (iii) juvenile density and freshwater scale growth. Relationships are weak between adult escapements and resulting juvenile recruitment. High uncertainty is associated with escapement estimates, because the majority of spawning occurs in the glacial streams of Owikeno Lake and the techniques and methodology used to enumerate spawners are not documented and therefore can not be evaluated.

The paper concludes that the reliability of escapement estimates is unknown and escapement appears not to be indexing abundance. Continuing with the current catch and adult enumeration program alone will not provide reliable data for determining factors limiting sockeye production from Area 9. Implementation of new programs to collect data necessary for stock assessment needs to be considered.

Reviewer's comments

Reviewer #1

This assessment of Rivers Inlet sockeye is the first to examine the time series of in-lake juvenile data and present them to PSARC. The time series of escapement and returns (catch+escapement) and residuals from the escapement-return relationship are used by the authors to demonstrate a decline in stock productivity during brood years 1974-94 compared to 1948-73. The time series of residuals from the stock-recruit relationship gives compelling evidence of a decline in productivity beginning in the mid-1970s and extending to the present. Several hypotheses to explain the decline in productivity are put foreword. Two additional hypotheses are perhaps worthy of consideration: (1) Cyclic interactions among year classes are principal mechanisms controlling the population dynamics; and (2) Habitat degradation in Owikeno Lake and/or spawning tributaries has increased freshwater mortality.

The authors and reviewer #1 support the continuation of the present adaptive management policy. The biggest impediment to improving assessment capabilities in Rivers Inlet is the potential for large measurement errors in the escapement data. Certainly, the time required to detect a response from a particular management action will be much longer if escapement errors mask all but the most drastic management actions. Escapement estimation is obviously a regional issue affecting all stocks. Immediate improvements to the Owikeno escapement estimates should be recognized as a high priority.

Estimates of smolt abundance are needed to separate freshwater from ocean events. Reviewer #1 agrees that the feasibility of smolt estimation should be assessed. It

important to realize that to be useful, a smolt estimation program requires long term funding.

Reviewer #2

Although some useful data are presented in this paper, the information will be of very limited use to fishery managers given the management policy that has been adopted. In part, this is due to the general nature of the request for advice given to the authors by PSARC (i.e. provide an assessment of Rivers Inlet sockeye salmon). There are also, however, significant problems with the basic data (such as escapement) and the serious lack of documentation both in the area of data collection and in the pre-season and in-season methods used to manage this fishery.

Previous assessments of this stock (or aggregate of stocks) have included forecasts of run size as well as other information on stock status. Given the policy adopted by fisheries managers, such forecasts (along with appropriate qualifiers and levels of precision) would have been useful additions to this Working Paper. Presumably, some form of pre-season forecast (even if this consists of the mean of recent returns) is required to develop fishing plans. Reviewer #2 assumes that test fishing information is used to update run strength (and timing) forecasts in-season. When the in-season procedures are documented, some assessment of their validity should be done. In addition, procedures to improve in-season advice should be evaluated and implemented.

The authors suggest recent declines in catch appear to have a basis in both biology and management. While these may be contributing factors, there are some indications that other factors (i.e. change in the April sea surface temperature at Pine Island, the artificial fertilization of Long Lake) have also impacted this stock (perhaps not in a linear fashion). Some further assessment of these factors should be considered to determine if they can be used to help predict either trends in returns or refine pre-season or in-season predictions of run strength and timing.

The evidence provided does suggest Area 9 sockeye stocks are depressed and reviewer #2 supports the author's recommendation that managers adopt a risk averse policy. Unfortunately, there is not enough information to specify what the exact state of the resource is at the current time and what would be the consequence of a change in the current management policy.

Subcommittee discussion

The Subcommittee accepted the Working Paper subject to major revision to include assessment fishery CPUE and escapement trends in clear-water tributaries.

The Subcommittee concluded that total sockeye abundance is highly uncertain because of the quality of the escapement data. Fundamentally, there is nothing wrong with the adaptive management policy of the Rivers Inlet sockeye fishery, but without

reliable escapement data, the effects of the management policy cannot be adequately monitored. The Subcommittee suggested exploring different approaches to abundance estimation: (1) improvement of escapement data collection perhaps through the use of river hydroacoustics (a costly option); and (2) the use of juvenile surveys (cost-effective method). A document outlining benefits and costs for improving Rivers Inlet sockeye abundance estimates could be the first step in the process.

There is an assessment fishery in place to gauge run size in-season. This fishery is an in-season check of the run size and is an integral part of the adaptive management regime. The Subcommittee suggests exploring the relationship between the commercial assessment fishery CPUE and the total stock size (catch plus escapement) estimates.

The Subcommittee concluded that there is a potential conservation problem with Rivers Inlet sockeye, possibly related to habitat degradation. Recent declines in catch provide a clear signal. Declines in returns and a run of negative residuals from the stock/recruit relationship in recent years suggest a conservation problem but could also be reflective of the poor escapement data. The Subcommittee further concludes that given the present information, there should be no departure from the current conservative management regime for Rivers Inlet sockeye.

S95-6: Assessment of freshwater production of sockeye salmon in Babine Lake. Wood, Rutherford, Pitre and Chapman **Accepted with **minor** revision**

Working Paper summary

This Working Paper is intended as a first step towards a comprehensive assessment of the status of sockeye salmon in Babine Lake, the largest sockeye-producing lake in the Skeena River. The primary objectives are to assess the status of freshwater production of sockeye in the main basin of Babine Lake, to revise escapement data in light of new information about the significance of lake spawning in Babine Lake, and to provide updated summaries of smolt production data. Smolt enumeration and sampling programs have been conducted since the 1950s but data collected after 1984 had not been interpreted or summarized for analysis. These data will be used to assess marine survival and overall stock-recruitment relationships in a subsequent working paper pending completion (under contract to DFO) and PSARC review of a sophisticated run reconstruction model to estimate catch by stock in mixed-stock fisheries of northern British Columbia and Southeast Alaska.

Accounting for unidentified fish

Overall, escapements to Babine Lake are known accurately from fence counts in the Lower Babine River since the 1940s, but these data require careful interpretation because of enhancement activities and puzzling discrepancies between the overall fence count and summed estimates of escapement to individual spawning sites. In the past

these "unidentified fish" were attributed to an uncensused lake spawning population although there was no evidence that lake spawning occurred to any significant extent within Babine Lake. Three alternative explanations for the discrepancies were evaluated in the Working Paper: (1) fish spawn in unsurveyed areas (e.g., lake spawning in Babine Lake); (2) visual estimates of spawning escapements generally underestimate actual abundance; and (3) surplus returns to enhancement facilities at Fulton River and Pinkut Creek are not enumerated reliably because they are denied access to upstream spawning sites. Visual estimates of abundance indicate that many fish attempt to spawn in gravel below the main counting fences but an unknown proportion remain in the lake.

Lake spawning

Empirical data from surveys of lake spawning habitat do not support the lake spawning explanation. All evidence to date suggests that lake spawning occurs in Babine Lake but accounts for a negligible proportion of the unidentified fish and contributes little to fry recruitment. Suitable lake spawning habitat is rare and most occurs in very shallow water such that any significant concentration of spawning activity would have been observed from the surface. The distribution of lake spawning activity strongly suggests that lake spawning sockeye are mostly if not entirely surplus escapements to Pinkut Creek and to a lesser extent Fulton River. Survival of eggs in most shoreline redds is expected to be poor because of generally poor dissolved oxygen concentrations at depths >1 m and damage from dewatering, freezing, and ice scouring at depths <1 m. It seems improbable that other important tributary spawning sites have been overlooked given the extent of survey effort since the 1940s.

Enumeration error

Prior to 1970, all sockeye returning to Babine Lake resulted from natural reproduction. Having dismissed the lake spawning explanation, unidentified fish during this period probably reflect enumeration errors. True escapements were determined to be about 20% higher than recorded by regressing the Babine fence count (less the small aboriginal harvest at or above the fence and fence counts to Fulton and Pinkut after 1965) on the summed estimates of escapement to individual spawning sites (excluding fence counts). This regression equation was then used to correct visual estimates of escapement to unenhanced spawning sites after 1970. Because enumeration effort in unenhanced streams has generally declined since the pre-enhancement period, the corrected escapements to these streams may still underestimate true levels in recent years.

Surplus enhanced production

Parallel increasing trends in the number of unidentified fish and returns to enhancement facilities suggest that unidentified fish are of enhanced origin. Visual estimates of escapements below the counting fences exceeded desired levels for the first time in 1975 in Fulton River and in 1981 in Pinkut Creek. These fish are called "surplus"

because they are assumed to contribute negligibly to fry production given overcrowded conditions in the streams below the fences and previous conclusions about the limited occurrence and poor reproductive success of surplus fish spawning in Babine Lake or neighbouring streams. Although the visual estimates of surplus are considered uncertain, they account for up to 79% of the unidentified fish after ruling out lake spawning and correcting estimates of escapement to unenhanced spawning sites. Best estimates of total enhanced surplus have increased dramatically since enhancement began (Fig. 6.1) and have averaged 30% (range 19-63%) of the total enhanced run counted through the Babine fence.

Interactions between enhanced and wild runs

Corrected escapements to unenhanced spawning sites declined between 1970 and 1985 but have since rebuilt to their former abundance (Fig. 6.1). The fact that wild escapements begin to decline immediately after the first enhanced sockeye return suggests that increased exploitation rates on enhanced returns caused the decline. This conclusion is supported by the fact that early-timing escapements were least affected whereas wild mid-timing escapements were most affected (Fig. 6.2). Furthermore, late-timing escapements increased following the implementation of more conservative management policies whereas mid-timing runs that overlap the enhanced runs completely did not. Since 1985, the wild mid-timing run has averaged less than 60% of pre-enhancement levels.

Fry and smolt production

Average fry recruitment to the main basin has increased over threefold following enhancement and smolt production from the main basin has increased correspondingly (Fig. 6.3). This trend of increasing juvenile density in Babine Lake is associated with a steady decrease in average size because smolt size is negatively correlated both with fry and smolt abundance for the corresponding brood year. Even so, the average weight of yearling smolts resulting from brood years of maximum fry recruitment or smolt abundance remains between 4-5 g; these smolts are large in comparison to those from other productive sockeye lakes such as Shuswap Lake on a dominant year cycle. Fry-to-smolt survival has not decreased with increasing juvenile densities indicating that additional fry recruitment to the main basin would probably further increase smolt abundance. An analysis of adult returns is required to determine the optimal tradeoff between smolt size (because of its influence on marine survival) and smolt abundance.

Reviewer's comments

Reviewer #1

Reviewer #1 found the document to be well-conceived and well-written, with little need for much revision. Objectives, methods and assumptions are clearly described and results and conclusions are reasonable and defensible.

No indication of the precision of the fry and smolt estimates is presented other than a comment that imprecision in the estimates caused unrealistically high survival rates in some years. The very low survivals in other years may be due to the same cause. It would be interesting to know how the coefficient of variation for both fry and smolts relates to years of unrealistically high or low survival rates. More emphasis should be placed on this, because it suggests problems with what is considered the best long-term data set on juvenile sockeye production in B.C. Survival rates in some years strongly suggest that either or both estimates of fry recruitment and smolt output were considerably in error. For one brood year (1992) with apparently very high (83%) fry-to-smolt survival, reviewer #1 carried out a hydroacoustic survey. They estimated a fall fry population of 56 million, far lower than the smolt estimate of 190 million obtained the following spring. While the hydroacoustic survey may have underestimated sockeye abundance because of surface or shore-orientation, it is highly unlikely that it underestimated sockeye abundance by about 4-fold. This suggests that for the 1992 brood year and perhaps for other years, smolt numbers were overestimated.

Reviewer #1 agrees that Babine Lake provides an excellent opportunity for investigating effects of consecutive years of high recruitment/heavy grazing pressure. While changing cyclic patterns (i.e. increasing sub- and non-dominant escapements to near dominant levels) to B.C. lakes may have substantial economic benefit, there still may be substantial risk, and effects of changes should be very carefully monitored.

Two additional points could be more explicitly stated: (1) Mid-timing escapements to Babine (with the exception of Morrison sockeye) are usually higher than needed to use all available spawning areas. Feasibility of increased harvest rates at a terminal fishery should be explored. (2) Morrison sockeye are the only major sockeye stock on Babine which appear to be adversely affected by Fulton and Pinkut returns. SEP's proposed spawning channel on the Morrison River should be mentioned and commented on in light of data presented here.

Reviewer #2

For the most part, the conclusions suggested by the authors are consistent with the data presented in this paper. Of the areas surveyed for lake spawners, it seems evident that lake spawners make an insignificant contribution to fry production. Because the Morrison and North arms of Babine Lake have not been surveyed recently however, a blanket statement about lake spawners may be inappropriate.

The regression adjustment procedure for underestimation of escapement prior to 1970 is also supported by the data. For data after 1970, however, the regression adjustment procedure warrants additional work. This procedure affects subsequent calculations of surplus enhanced fish and fry to smolt survival rates. Hence, the recommendation to use corrected escapements after 1970 should not be approved until it is clear there is no reason to use a different factor.

Unenhanced spawning escapements did decline significantly between 1970 and 1985 as the authors suggest and have subsequently recovered. However, the data do not substantiate the statement that this recovery was in the Upper and Lower Babine rivers. The Lower Babine river continues to have well below historical escapements, even with a 20% adjustment factor applied.

The final conclusion regarding smolt size and survival data indicating under utilization of rearing capacity is consistent with the data presented in this paper. Reviewer #2 also agrees that the information from the limnological study currently underway is critical before decisions are made as to whether fry production should be increased in the Babine system.

Subcommittee discussion

The Subcommittee accepted the Working Paper with minor revisions, i.e., accounting for the reviewers' concerns and suggestions, such as the use of other methods to estimate the 1992 adult return to the Babine Fence.

The Subcommittee agrees with the conclusions of the paper, summarised as:

1. A very limited capacity in Babine Lake for lake spawners, resulting in a negligible contribution to fry production in the main basin.

2. A probable underestimate (by about 20%) of the escapement to unenhanced stocks, both before and after enhancement, thus accounting for at least 12% on average of the discrepancy between the fence count and the summed estimates of individual escapements.

3. The remaining 88% of the discrepancy between the fence counts and summed individual estimates is attributed to an underestimation of surplus enhanced fish below fences at Fulton River and Pinkut Creek.

4. Total escapements to unenhanced spawning areas declined between 1970 and 1985 but have since rebuilt to their former abundance with the exception of the unenhanced component of the mid-timing run (Morrison and Tahlo Creek). This is not surprising as the mid-timing return includes the enhanced stocks.

The Subcommittee also agrees with the recommendation in the paper that the corrected estimates of total escapements by early-, mid-, and late-timing runs be used to estimate wild fry production and as input to future run reconstruction analyses. The Subcommittee cautions that this recommendation applies only to the aggregated escapements and would not suggest systematic change (i.e. by 20%) of individual tributary escapement counts in DFO databases.

The Subcommittee notes that results from this Working Paper suggest that increased harvest of enhanced stocks would be warranted. However, coincidental timing of enhanced fish and unenhanced fish in the mid-timing run at the Babine Fence would require either additional enhancement efforts on the currently unenhanced group (Morrison Arm stock primarily) or harvesting sites being limited to the areas of Fulton River and Pinkut Creek.

5. PACIFIC SALMON COMMISSION SELECTIVE FISHERY EVALUATION: AD-HOC SELECTIVE FISHERY EVALUATION COMMITTEE

Executive Summary

Conservation concerns for wild salmon have increased interest in exploring alternative management approaches that permit harvest while reducing impacts on stocks needing protection. One such approach is the implementation of selective fisheries which would allow retention of marked hatchery fish while requiring release of unmarked fish. Although conceptually attractive, little is known about the potential impacts of selective fisheries on wild stocks or current management tools. Because of the importance of conservation and potential implications of selective fisheries for the coastwide coded-wire-tag (CWT) system, the Pacific Salmon Commission (PSC) established an ad-hoc committee in October, 1993, to complete an assessment of selective fisheries. The assessment focused on two general questions: (1) Can selective fishery regulations reduce harvest rates on unmarked salmon and can total exploitation rates be reduced and spawning escapements increase as a result? and (2) Can the viability of the existing coastwide CWT program for stock assessment and management planning be maintained if selective fisheries are implemented?

More specific questions related to the two general questions and other potential, selective fishery implementation issues are used to frame the information presented in this Executive Summary.

1. Can selective fisheries be applied to both chinook and coho salmon?

At this time, selective fisheries are only considered feasible for coho salmon. The logistics of marking chinook salmon are more difficult than for coho because of the large numbers of juvenile chinook salmon that would have to be marked, the smaller size of fish at release, the limited time for marking, and the necessity of handling the fish shortly before release. The complex life history of chinook, involving migration over multiple seasons and extensive geographic areas, greatly increases the difficulty of selective fishery assessment. Further, impacts of selective fisheries on chinook salmon would likely extend coastwide, increasing both costs and the difficulty of coordinating implementation. Because of these factors, our assessment focuses on evaluation of selective fisheries for coho salmon.

Recommendation

(a) **Selective fisheries should not be considered for chinook salmon at this time.**

2. What external mark should be used to identify a hatchery fish?

Under selective fisheries, fish that can be retained must be easily distinguished from fish that are to be released. The adipose fin clip and ventral fin clip were evaluated as the two most feasible mass marks for selective removal on the basis of five criteria: ease of application; cost of application; ease of recognition by an untrained observer; mark induced mortality; and stability over the life of the fish. The adipose fin is superior across all criteria.

A Selective Fishery Model (SFM), was developed and used to evaluate the effectiveness of various selective fishing scenarios involving stocks with different patterns of exploitation. Based on assumed lower mark induced mortality and marked recognition error rates, escapements of unmarked fish and catch levels were higher with adipose clips than with ventral clips. Also, biases in CWT-based cohort analysis were lower for adipose clips than for ventral clips for the same reasons.

Recommendations

(b) **The adipose fin should be used as the mass mark for hatchery coho if selective fisheries are implemented.**

(c) **Research should be undertaken to provide improved estimates of mark induced mortality and marked recognition error rates for adipose-clipped fish.** Definitive data are not yet available to enable reliable estimation of these critical factors.

3. Can a selective fishery reduce harvest rates on unmarked stocks?

A fishery harvest rate is defined as the proportion of a total population available to a fishery that is killed by that fishery, whether as landed catch or incidental mortality. Harvest rates are assumed to be identical for all groups of fish available to the fishery.

Results from the SFM indicate that harvest rates on unmarked fish in selective fisheries can be substantially reduced. However, the magnitude of the reduction was variable, ranging from 10% to 80% and increased as release mortality of the gear decreased. Recreational gear, traps, and beach seines are believed to have the lowest release mortality rates. Gillnets and purse seine fisheries in which a large number of fish are caught per set are believed to have the highest release mortality rates. Troll and purse seine fisheries in which a small number of fish are caught per set are believed to have intermediate release mortality rates. The size of harvest rate reductions also

depends to a lesser degree on the encounter rate of unmarked fish, marked recognition error (the probability that a marked fish will be inadvertently released), and the probability of multiple recapture of released fish.

4. Can the reduced mortality of unmarked stocks in a selective fishery be translated into reductions in total stock exploitation rates and increases in escapement?

A total stock exploitation rate is defined as the proportion of the initial cohort size that is killed by fishing, whether through landed catch or incidental harvest. The effectiveness of selective fisheries in reducing total stock exploitation rates and increasing escapements of unmarked fish varies depending upon the exploitation pattern of individual stocks as well as the regulations, placement, and size of the selective fishery.

Compared to the current situation where no fisheries are selective, we estimate that total stock exploitation rates of most unmarked stocks can be expected to be reduced by less than 5% under scenarios involving only a single selective fishery. If all fisheries were to operate under selective regulations, total stock exploitation rates of unmarked fish can be expected to be reduced from 20% to 60%.

Changes in wild salmon spawning escapements were found to depend upon the proportion of a stock available to the selective fishery, the harvest rate reduction in the selective fishery, and the harvest of unmarked fish in nonselective fisheries.

5. How would the catches and incidental mortality in the fisheries be affected?

In our assessment, landed catch declined significantly in all cases for selective fisheries, compared to nonselective regulation. Across the range of selective fisheries simulated, landed catches in the selective fisheries were reduced by between 30% and 70%. Declines in catch levels varied with the proportion marked, the degree of marked recognition error, reduced abundance of marked fish due to mark induced mortality, and the proportion of the harvested population that is marked. The total catch in nonselective fisheries generally increased. This results from the reduced harvest rate on the unmarked fish and the marked recognition error in the selective fishery which creates greater abundance in subsequent fisheries. Incidental mortalities due to release mortality increased significantly (100% to 400%) in all selective fishery scenarios examined.

6. Can the viability of the CWT program be maintained?

Because the CWT is central to management of chinook and coho salmon, the viability of the CWT program is of vital concern. For this assessment, the viability of the CWT system is defined as (1) The ability to use CWT data for assessment and management of wild stocks of coho and chinook salmon; (2) Maintaining the program such that the uncertainty in stock and fishery assessments and their applications does not unacceptably increase management risk; and (3) The ability to estimate stock-specific exploitation rates by fishery and age.

Based upon our analysis, it is apparent that the viability of the CWT program will be impaired if selective fisheries are implemented on a broad scale. Substantial changes to tagging and recovery programs will be needed to minimize the potential loss of management information. Interagency coordination in research and management methods must be increased to reduce the risk to the CWT system. Further, during transition periods when selective fisheries are either implemented or terminated, there is a higher risk that management capabilities would be degraded.

To minimize the loss of information if selective fisheries are implemented, the CWT program should be modified as follows:

Recommendations

(d) **Implement double index tagging (DIT) of marked (ad-clip + CWT) and unmarked (CWT only) hatchery groups.** Double index tagging involving the use of paired replicates will be required regardless of which mass mark type is finally chosen. This will approximately double the numbers of tags released for indicator stocks.

(e) **Employ electronic detection of CWTs and random sampling of all fisheries and the spawning escapement. CWTs of 1-1/2 length should be used to increase the reliability of electronic detection.** Voluntary recovery of tags in recreational fisheries based on visual identification would no longer be possible so random sampling of recreational fisheries would be required.

(f) **Maintain "adequate" levels of tagging and recovery sampling.** Our ability to generate useful estimates from the CWT system depends upon the recovery of a sufficient number of CWTs. Specific levels of tagging and sampling will depend upon the objectives of the CWT program and selective fisheries.

(g) **Ensure extensive interagency cooperation and coordination of mass marking, CWT recovery programs, and selective fishing.** Unilateral implementation would affect multiple jurisdictions and severely disrupt the

viability of the CWT program. The viability of the CWT program can be a matter of concern to managers who do not conduct selective fisheries within their own jurisdictions because tagging studies that produce fish that enter the fishery may be significantly impacted.

(h) **Associate wild fish tagging programs with a representative hatchery marking program within the same production area for stocks that are significantly impacted by selective fisheries.** Wild fish survivals and production cannot be evaluated without paired CWT experiments.

Even with these efforts, however, some information and aspects of the present CWT program will be compromised or lost. The independence of tag groups, particularly of wild tagging programs will be lost. Unmarked hatchery and wild tag groups must be associated with marked and tagged hatchery groups in order to maintain all the present information. Uncertainty in our estimates and assessments based on CWT's will increase due to a requirement for additional assumptions. We will not be able to correctly allocate incidental mortalities when multiple selective fisheries occur. This loss would become increasingly important for assessment of wild stocks, fisheries management, and allocation as incidental mortalities increase. Our ability to estimate catch compositions and interceptions may be compromised. The size of the problem would be directly related to the scale of the marking program and selective fisheries.

On the other hand, in some ways, selective fisheries can improve the basis for fisheries management. For example, electronic detection of CWTs and random sampling of recreational catch could improve the precision of estimates that currently rely on voluntary tag recoveries. In addition, the marking of all hatchery fish would increase the accuracy of accounting for this production in fisheries or in escapement.

7. What are the costs associated with implementing a selective fishery program?

The monetary costs of selective fisheries are substantial. The estimated, minimum annual cost for implementing selective fisheries in the Strait of Georgia and Puget Sound are $0.9 million and $0.8 million (U.S. $'s), respectively. In addition, there are up front capital equipment costs of $1.2 million and $1.5 million for Canada and the U.S., respectively. These costs represent the minimum for establishment of a selective fishery for coho in the Southern Panel area. Cost estimates do not include expenses associated with evaluation, or implementation in other areas of the U.S. whose stocks or recovery programs may be affected, or revisions to analytical tools and management models.

The implementation cost for establishing the first selective fishery would be high since major changes to the sampling programs and management would be required. The costs of implementing additional selective fisheries would be lower since the major modifications would already be in place.

There are also costs associated with reduced catches, the loss of fish due to mark induced mortalities and increased incidental mortalities during selective fisheries. These costs could be large, depending on the selection of mass mark, the gear, the scale of the selective fisheries, and the ratio of marked to unmarked fish in the fishery.

8. How should selective fisheries be evaluated?

Considerable uncertainty exists around the outcomes predicted by our assessment, due to our limited experience with selective fisheries and the inherent variability in the many factors and processes defining selective fisheries. Given the uncertainty of expected outcomes, assessment of the effectiveness of any selective fishery implemented will rely heavily on observation and measurement of actual outcomes. Spawning escapement, total fishing mortality, exploitation rate, fishery opportunity and economic benefits and costs, are outcomes that can be monitored and used to assess the effectiveness of management programs involving selective fisheries.

Recommendation

(i) **Selective fishery programs should not be implemented without specific, measurable criteria to provide an objective basis for performance evaluation.**

(j) **Differences in exploitation or escapement rates between paired replicate, double index tag groups should be the primary means of evaluating the impact of selective fishery regimes on individual stocks.**

9. Where to from here?

Ultimately, decisions about selective fisheries will rest upon value judgements contrasting wild stock conservation and fishing opportunities against the loss of information essential for management and the financial costs of implementation. While selective fisheries may prove to be a useful tool in achieving certain management objectives, alternative means exist which would be less costly to implement and pose less risk to management capabilities; e.g. time and area closures, catch ceilings, bag limits, etc.. These alternatives should be fully considered and evaluated when considering implementation of selective fisheries.

To implement selective fisheries while maintaining a viable CWT program will require a full and coordinated effort by all marking and affected sampling agencies,

allocation of funds for new equipment and sampling programs, and modification of management models to incorporate selective fisheries.

Recommendations

(k) **Establish and adopt a protocol for selective fishery proposals to provide for effective review and concurrence of all jurisdictions that would be substantially impacted.**

(l) **A minimum lead time of two years prior to implementation of selective fisheries should be provided for interagency coordination and installation of necessary changes in catch sampling technology and monitoring programs.**

(m) **Mass marking of hatchery fish by removing adipose fins should not be permitted until interagency coordination has occurred and assurances are received from affected jurisdictions that the capability to recovery CWTs through electronic sampling will be in place.** If poorly implemented, selective fisheries could incur high costs while producing few benefits to fisheries and, at least temporarily, the loss of management capabilities.

Reviewer's comments

Reviewer #1

Reviewer #1 congratulates the committee for the hard work they put into this analysis. However, he has very serious concerns about the conclusions derived from the analysis. He believes that several unstated, but key assumptions, led the evaluation committee to overestimate the effectiveness of the selective fishery. First, fishing effort is assumed to be independent of the number of fish available to be caught. In all other stocks that reviewer #1 has examined, fishing effort goes up as a stock declines. He strongly recommends that this crucial assumption be investigated before a selective fishery program proceed. This could probably be done by examining historic data. Second, it was assumed that the cost of the project would not result in a decrease in the production of hatchery salmon. Reviewer #1 finds this assumption unlikely. Third, it is assumed that all hatchery fish will be marked. There is an obvious advantage for any hatchery in not marking their hatchery production, because they will get more returns. Reviewer #1 suggests that the project is not stable to cheating. Fourth, several of the key parameters have not been directly investigated, e.g. marking mortality. More effort should be applied to these problems.

Reviewer #1 concludes that the effectiveness of the project has been overestimated by the Selective Fishery Evaluation Committee. The most important

assumption in the model that was not investigated is that fishermen will not change their behaviour, e.g. they will not increase fishing effort as the fish available to be caught decreases. This assumption is completely unreasonable. This assumption was key to the collapse of several marine populations. It is folly to model such a fisheries system without an attempt to include the behaviour of the fishermen.

The first paragraph of section 9 in the executive summary clearly states that alternative management strategies may yield better results for a lower price. Unfortunately, this paragraph is at odds with the rest of the report. Reviewer #1 believes that alternatives to selective fisheries are almost certainly better, and that the whole selective fisheries approach in the marine environment is misguided.

Reviewer #2

In general the conclusions and recommendations presented in the manuscript are consistent with the information and analyses presented in the document. Specific concerns are:

The conclusions suggest that total stock exploitation rates for most unmarked stocks would be reduced by less that 5% under scenarios involving only a single selective fishery. An exception to this result (Case 4, inside recreational fishery), where the total exploitation rate was reduced by over 30% and escapement of wild coho stocks increased by almost 80%, warrants further discussion in the document.

The estimated increase in incidental mortalities (100-400%) is based on consideration of only dropoff mortality in the base case. Incidental mortality prior to age 3 (i.e. release of sub-legal size fish) is not included in the baseline estimate and would make the proportional increases smaller.

The Selective Fisheries Model (SFM) runs are conducted assuming the same effort under the selective fisheries and non-selective fisheries scenarios. However, implicit in the concept of selective fisheries is a need to reduce exploitation rates on wild coho stocks and the idea that selective fisheries might reduce these rates while maintaining or increasing exploitation rates on other hatchery stocks. Simulation analyses comparing selective versus non-selective fisheries strategies within a framework of specific management targets (i.e. increased wild escapement) would be more useful for evaluating selective fisheries than the constant effort approach used here.

The range of recreational fishery release mortality rates assumed in the SFM are based on estimates for adult coho and legal-size chinook, however, the model is intended to simulate coho dynamics whose average release mortality is somewhat lower than that for chinook.

Results from two sets of analyses conducted with the Stock Composition Model (SCM) provide inconsistent results when applied to Double Index Tagging (DIT) type

data. The first analysis, based on output from the SFM, suggests that Double Index Tagging (DIT) can provide unbiased estimates of stock composition. The second analyses, based on modified CWT data, suggest significant biases in stock composition estimates with DIT. It is not clear why the two approaches to generating data for input to the SCM produce such divergent results.

Subcommittee discussion

The Subcommittee provided the following comments on recommendations 1-13 in the PSC report:

Subcommittee comments on recommendations

1. **Selective fisheries should not be considered for chinook at this time.**

Endorsed for the technical reasons provided.

2. **The adipose fin should be used as the mass mark for hatchery coho if selective fisheries are implemented.**

Endorsed from a technical standpoint. The adipose fin clip mark is cheap to apply, easy to recognize, familiar to user groups, causes little mortality (<5%), and is reliable (<8% unrecognizable marks). However, any decision to use the adipose mark as a selective fishery mark will preclude its current use to indicate the presence of a coded-wire tag in coho and chinook, and thus, will have serious implications for stock assessment of these species.

3. **Research should be undertaken to provide improved estimates of mark induced mortality and marked recognition error rates for adipose-clipped fish.**

Endorsed. These critical factors cannot be estimated reliably with the data available. The Subcommittee understands that the Washington Department of Fisheries and Wildlife is currently conducting such studies.

4. **Implement double index tagging of marked (ad-clip + CWT) and unmarked (CWT only) hatchery groups.**

Endorsed if the adipose mark is used as the mass mark. Double index tagging (DIT) will be required to minimize the loss of present assessment capabilities and will approximately double the number of tags released for hatchery indicator stocks.

5. **Employ electronic detection of CWTs and random sampling of all fisheries and the spawning escapement. CWTs of 1-1/2 length should be used to increase the reliability of electronic detection.**

Not endorsed as stated. Given recommendation (4), it will be necessary to detect coded-wire tags electronically in random samples of all fisheries and spawning escapements *where coded-wire tags are expected*. Existing sampling programs will not be adequate to implement selective fisheries. Electronic detection and increased random sampling offer important benefits over existing programs, but costs will increase accordingly. For example, random sampling in sport creel surveys will have to be extended to the west coast of Vancouver Island and augmented throughout southern B.C. to achieve representative coverage and a sampling rate of at least 10%. These additional costs have not been considered fully in the Selective Fishery Evaluation document and need to be examined more carefully. Although the Subcommittee endorses the need for electronic detection, it cannot comment on the feasibility of implementation since this has not yet been demonstrated. Longer (1.5-length) tags may be required to detect coded-wire tags reliably and studies of the potential biological consequences of 1.5-length tags should be continued. New detectors and associated procedures will be required to detect tags in processing plants and in spawning escapements. The Subcommittee recommends that Industry be involved in the design and testing of electronic detection procedures. The Subcommittee also acknowledges that recommendations for developing and testing electronic detection procedures in commercial sampling programs were provided to the Strait of Georgia Coho Rebuilding Committee by the Ad-hoc Selective Fishery Evaluation Committee.

6. **Maintain *adequate* levels of tagging and recovery sampling.**

Endorsed in principal but noted that *adequate* can only be determined after specific goals for the program have been established. It was noted that sampling is currently *inadequate* in many fisheries and escapements under the existing mark sampling program. Improvements in tag recovery rates may be obtained as electronic sampling for tags is implemented for commercial fisheries.

7. **Ensure extensive interagency cooperation and coordination of mass marking, CWT recovery programs, and selective fishing.**

Not endorsed as worded. Extensive interagency cooperation alone is not sufficient. Without an explicit commitment by all agencies and jurisdictions involved, there is little value in embarking on the program.

8. **Associate wild tagging programs with a representative hatchery marking program within the same production area for stocks that are significantly impacted by selective fisheries.**

Endorsed, subject to additional evaluation. The Subcommittee was unable to assess the degree to which pairings of B.C. hatchery and wild stocks have similar distributions and exploitation rates. The immediate implementation of selective fisheries would preclude testing this assumption. The recommendation, as written, will not provide

assessment information for wild stocks that cannot be associated with hatchery stocks. Assessment of wild stocks without associated hatcheries requires double index tagging of wild fish. Only the largest coho stocks with high levels of smolt production could potentially be assessed because at least 60,000 tagged smolts must be released per stock, and half of the marked wild population would be subject to the exploitation rates of hatchery stocks. The risks to wild coho stocks assessed with this technique will need to be evaluated.

9. **Selective fishery programs should not be implemented without specific, measurable criteria to provide an objective basis for performance evaluation.**

Endorsed. The Subcommittee noted that a parenthetical statement on the types of evaluation criteria should be included in the recommendation. The costs associated with various evaluation criteria vary.

10. **Differences in exploitation or escapement rates between paired replicate, double index tag groups should be the primary means of evaluating the impact of selective fishery regimes on individual stocks.**

Endorsed.

11. **Establish and adopt a protocol for selective fishery proposals to provide for effective review and concurrence of all jurisdictions that would be substantially impacted.**

Endorsed the concept. The Subcommittee was advised that a draft protocol has been developed.

12. **A minimum lead time of two years prior to implementation of selective fisheries should be provided for interagency coordination and installation of necessary changes in catch sampling technology and monitoring programs.**

Not endorsed as written. Implementation and evaluation of a selective fishery will require more lead time than the existing recommendation would suggest. A number of tasks must be completed to provide the information needed to make a decision about whether to mass mark for a selective fishery. Once the information is available, additional time will be required to establish the interagency framework.

13. **Mass marking of hatchery fish by removing adipose fins should not be permitted until interagency coordination has occurred and assurances are received from affected jurisdictions that the capability to recovery CWTs through electronic sampling will be in place.**

Endorsed (see comments on recommendation 7).

Subcommittee commentary on questions in the executive summary

Questions 1,2, and 8 in the executive summary are addressed under Comments on Recommendations above.

Q3 - Can a selective fishery reduce harvest rates on unmarked stocks?
Q4 - Can the reduced mortality of unmarked stocks in a selective fishery be translated into reductions in total stock exploitation rates and increases in escapements?
Q5 - How would the catches and incidental mortality in the fisheries be affected?

The Subcommittee addressed these three questions together, because many issues are interrelated.

With regard to Question 3, the answer is yes, harvest rates of unmarked stocks can be reduced under specific conditions. Many of the conditions are identified clearly in the document. Effects of selective fisheries on catches, harvest rates, exploitation rates, and escapements are gear dependent but can be very large if most fisheries are selective. For example, for the theoretical stock similar to Strait of Georgia coho, the reductions in exploitation rate are estimated to be up to 34% if all marine recreational fisheries are selective, and up to 60% in the unlikely event that all recreational and commercial fisheries become selective. However, the fisheries in the selective fisheries model are reasonably generic, and another phase of assessment is necessary, where specific characteristics of Canadian fisheries and stocks of concern are represented accurately. There is still significant uncertainty about the real-world consequences of selective fisheries; some due to uncertainty about model formulations and parameters, some due to implementation uncertainty (meta-responses of those things we are trying to manage).

Other subcommittee concerns include:

Effort response: Reviewers and some Subcommittee members felt an effort response in selective fisheries would occur. This should be modelled, but it is likely that the benefits (lower exploitation rates and higher escapements) would be diminished if an increase in effort occurred. There may be an effort increase simply from changes in demographics of the BC population, and this possibility is not addressed in the models. It was noted that the recreational harvest rate on chinook has increased despite a more restrictive bag limit. Fishers may also choose to fish longer because of the release of unmarked fish. Any effort response is going to be a very complex phenomenon, and may have complex impacts on the costs and benefits of selective fisheries. These concerns suggest it will be necessary to monitor the dynamics of selective fisheries themselves, as well as dynamics of the catches (and releases) of those fisheries.

Compliance: Some Subcommittee members thought that assumptions about levels of compliance were optimistic, particularly after the programme had been in place

for a few years. Reductions in levels of compliance have been seen in other fisheries, after restrictive measures have been in place for some time. Enforcement efforts can be used to ensure high compliance, but the levels of enforcement would have to be high, and committed for the duration of the selective fishery.

Release mortality: Release mortality goes up in many fisheries when bycatch is high, due to factors such as increased time on deck and less careful handling. When all unmarked fish are bycatch, mortalities may be higher than are currently documented and higher than are assumed in the models.

The Subcommittee has some concerns about multiple capture and release of wild fish. The document assumes that mortality is constant, i.e. that each capture event is independent. If there is any synergistic effect of multiple capture and release the effect is likely to be complex. However, it will result in model estimates of incidental mortalities being low and benefits being optimistic.

Wild escapement monitoring: Evaluation of selective fisheries requires the existence of a credible escapement monitoring programme in each major wild stock area for three reasons. First, representative escapement monitoring is essential for each area where DIT is applied. Second, because of uncertainty about estimation of exploitation rates and the need to calibrate DIT to Single Index Tagging (SIT), at least in early years, the Department may not be able to provide convincing evidence of reduction in exploitation rate. Data on escapements will provide additional information about the consequences of the programme. Moreover, the objective of selective fisheries is to increase wild escapement, not simply to reduce exploitation rate. Direct, credible measures of these increases is the ultimate indicator that selective fisheries are delivering the objective.

Hatchery production: Given the expected increase in exploitation of hatchery stocks in selective fisheries, at low levels of ocean survival, acquisition of broodstock at some hatcheries may be a concern.

The implementation of DIT would require making 3-5% of the production in the affected hatcheries unavailable to selective fisheries. This is a small reduction, but is not factored into the catch estimates produced by the selective fishery model. The impact of this factor is that the catches in selective fisheries are overestimated by a small amount (the exact value depending on the exploitation rate).

Q6 - Can the viability of the CWT programme be maintained?

Although the Subcommittee has some uncertainties about Q3-Q5, there are serious reservations about Q6, the ability to maintain the viability of the coded-wire tagging programme (CWT).

Overall, it will be very likely that the Department will lose some capability to manage fisheries, and we will lose information needed to provide scientific advice on stock status and stock forecasts. We will have to spend much more money, and invest significantly more staff time, to provide less advice of greater uncertainty. We cannot say by how much management risk will be increased, beyond noting that the level of increase in risk depends on new programmes which will be implemented, and how effective they turn out to be. Key concerns include the loss of independence of tag groups, and loss of our ability to monitor wild stocks directly using CWT programmes. This is a step backward, and would be the single largest change in stock assessment of coho and chinook salmon since establishment of the CWT programme.

Other limitations to the viability of the CWT programme are not resolved in the document. For example, with multiple selective fisheries it appears that it will NOT be possible to directly estimate exploitation rates on wild stocks in specific fisheries, or to estimate incidental mortalities in successive selective fisheries. This has important implications for Canada-US information needs. Evidence is unclear regarding the ability to estimate stock composition of (and interceptions by) mixed stock fisheries.

Many of the potential benefits to stock assessment are technological measures which are actually independent of the selective fisheries. Examples are the electronic detection of tags and improved representative sampling of recreational fisheries. The total marking of hatchery production would benefit some aspects of stock assessment advice, but only the need for an external mark, as opposed to alternatives such as thermal marks, is intrinsic to selective fisheries.

Q7 - What are the costs associated with implementing a selective fisheries programme?

The Subcommittee does acknowledge the costs listed in the document are a reasonable accounting of many of the major capital costs of implementing a selective fishery in the Strait of Georgia and Puget Sound, but notes these are incremental costs, and not the total costs for even these portions of the programmes. Moreover, the Subcommittee notes that the costs are not actually the minimum costs of a selective fishery, because many significant costs would be incurred that are not included in the totals presented in the document (approx. 1.67 million $Can Capital and 1.23 million $Can Annual Operation).

The document does list some costs which are not included in their cost figures, including: public information, enforcement, and modification of management models. The Subcommittee notes that the costs of these factors may be high. Particularly significant are the costs of modification of management and assessment models. In many cases, we will actually require starting from fundamentals to build completely new models and theoretical frameworks. Developing, testing, and reviewing these models will consume a number of person-years of time of highly specialized staff who are already in short supply in the Department and heavily committed to priority problems. These new models MUST

be prepared and tested prior to prosecution of selective fisheries, and their development will seriously disrupt delivery of other tasks expected of these staff.

Other major costs which are not listed in the document include:

(a) Expansion of annual creel surveys to freshwater recreational fisheries and on the West Coast of Vancouver Island and in Johnstone Strait. (In fact, the existing creel survey in the Strait of Georgia may have to be expanded significantly to ensure adequately representative sampling.)
(b) Sampling aboriginal fisheries for CWT's. (This cost is not only associated with selective fisheries.)
(c) Expansion of wild escapement monitoring programmes, particularly in areas where there are no matching hatcheries, and anywhere that DIT programmes are in place.
(d) Re-engineering in processing plants for installing and operating the electronic detectors.
(e) Adjustments to the management of chinook fisheries if the selective fisheries for coho alter the fishing patterns of chinook fisheries.

There are additional indirect costs which must be considered in the overall decision to implement selective fisheries. One example is the likelihood that when fisheries are made selective, effort will be redirected to other stocks which cannot support increased (or even existing) harvest rates (for example the Strait of Georgia recreational fishers may increase harvest of lingcod and rockfish). It is not desirable to address conservation problems in one species by creating or aggravating conservation problems in other species. A second example is the likelihood of demands for selective fisheries for other species as an alternative to other less costly conservation options.

Quantifying these indirect costs will be complex, and the issue is not addressed in the document. Nonetheless, the costs and concerns are real, and must be addressed as part of the overall decision regarding selective fisheries.

Q9 - Where to from here?

The Subcommittee feels the technical and biological risks have to be re-evaluated. There are potential benefits for reducing harvest rates on wild stocks, but the costs could be significant. There are alternatives to selective fisheries as measures to improve the status of wild stocks, and the document does not address the comparative costs and benefits of alternatives. Further analysis of these alternatives is warranted, including a full explanation of the potential costs and benefits.

The Subcommittee notes that even proceeding with an in depth evaluation of selective fisheries in Canada will require significant resources, particularly of staff time. Moreover, the Subcommittee notes that in the face of conservation concerns with wild coho stocks, the concept of selective fisheries may be criticized as inconsistent with the

renewed commitment to risk- averse management and putting conservation first. Selective fisheries require taking the risk of reliance on an uncertain and unproven technology in order to maintain current levels of effort.

6. OTHER BUSINESS

Schedule of Subcommittee meetings

The fall meeting of the PSARC Salmon Subcommittee is scheduled for November 14-17, 1995, in Nanaimo.

APPENDIX 1. PARTICIPANTS AT THE APRIL 18-21, 1995 MEETING OF THE PSARC SALMON SUBCOMMITTEE.

SUBCOMMITTEE CHAIR: **L. Richards**

SUBCOMMITTEE MEMBERS	AUTHORS/REVIEWERS	OBSERVERS
D. Anderson	R. Bailey	D. Blackbourn
S. Argue	D. Beamish	B. Leaman
A. Cass	L. Blankenship (WDFW)	M. Henderson
C. Cross	M. Bradford	B. Shaw
K. Hyatt	J. Irvine	
S. McKinnell	R. Kadowaki	
D. Meerburg	L. Lapi	
J. Rice (PSARC Chair)	R. Moore (WDFW)	
B. Riddell	G. Morishima (QMC)	
M. Stocker	C. Neville	
A. Tautz	D. Rutherford	
P. Ryall	J. Schnute	
C. Wood		

APPENDIX 2. REVIEWERS OF WORKING PAPERS SUBMITTED TO THE FALL 1994 MEETING OF THE PSARC SALMON SUBCOMMITTEE.

Working Paper	Reviewer #1	Reviewer #2
S95-1	Anderson	Schnute
S95-2	McKinnell	Bradford
S95-3	Rice	Argue
S95-4	Irvine	Lapi
S95-5	Cass	Noakes
S95-6	Shortreed/Hume	Jantz
PSC	Myers (Nfld)	Haist

Table 3.1. Terminal run (catch or spawners) to the Somass system for Robertson Creek hatchery chinook and natural production by fishery or spawning site.

A) Total production from Somass system:										
Return year:	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Sport catch	1368	1332	2036	2488	3155	3788	6374	2712	4145	2655
Comm. nets	176	87	15	1423	3933	2960	6117	351	2371	67
Native catch	1017	1975	1220	1068	1349	997	3514	3177	3263	1631
River spawners	7494	2930	1545	6263	5099	8184	9690	11998	7764	4749
Hatchery	1907	1393	3869	1459	2892	4584	3535	2512	2041	1113
Total	119,65	77,19	86,87	127,03	164,30	205,15	292,33	207,52	195,85	102,17
B) Total returns from Hatchery production only:										
Sport catch	1148	1113	1357	1255	2993	2222	3940	1782	2847	2236
Comm. nets	90	14		804	3442	2453	4063	9	1693	4
Native catch	692	919	698	656	1073	769	2545	2336	2333	1479
In-River returns	5404	1026	670	4246	3316	6696	7054	8768	5397	2351
Hatchery	810	512	2236	868	2217	3628	3215	2206	1754	863
Total	81,46	35,85	49,61	78,31	130,44	157,70	208,18	151,03	140,25	69,35
% hatchery	0.6	0.4	0.5	0.6	0.7	0.7	0.7	0.7	0.7	0.6

Table 3.2. Comparison of model forecasts for 1995 ocean abundance by age, and the expected total terminal run assuming no change in ocean exploitation rates, relative to ocean exploitation rates since 1985.

Age	Prod 2 - Total Ocean Abundance	Prod 2 - Total Terminal Run	Prod 3 - Total Ocean Abundance	Prod 3 - Total Terminal Run
3	24429	3227	7157	945
4	19368	7231	29445	10994
5	41362	21651	40942	21431
Total	85159	32109	77544	33370

Table 3.3. Summary of Terminal run size by age (numbers of chinook) resulting from reductions in harvest rates (hr) in Ocean fisheries. Terminal run includes the total return to the Somass system, including hatchery and wild production. Values in brackets below the totals are the numbers of females expected in the total terminal run.

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

	Harvest Scenarios			
1995	Base: 1984-1990 Brood Averaged Ocean hr; WCVI troll hr limited to pre-1992 values.	Scenario 1: Cdn. ocean hr rates - 50%, all fisheries reduced equally	Scenario 2: Scenario 1 plus Alaskan fisheries reduced equally	Scenario 3: No directed ocean chinook fisheries in Alaska or Cdn
Age 3	3227	3411	3480	3663
Age 4	7231	8506	9280	10774
Age 5	21651	27527	31506	38966
Totals	32109 (20079)	39444 (25137)	44266 (28513)	53403 (34868)
1996				
Age 3	32361	34209	34905	36735
Age 4	5341	6641	7393	9034
Age 5	2418	3616	4516	6484
Totals	40120 (6749)	44467 (8428)	46814 (9527)	52253 (11951)

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

	Harvest Scenarios			
1995	Base: 1984-1990 Brood Averaged Ocean hr; WCVI troll hr limited to pre-1992 values.	Scenario 1: Cdn. ocean hr rates - 50%, all fisheries reduced equally	Scenario 2: Scenario 1 plus Alaskan fisheries reduced equally	Scenario 3: No directed ocean chinook fisheries in Alaska or Cdn
Age 3	945	999	1020	1073
Age 4	10994	12931	14107	16379
Age 5	21431	27248	31186	38570
Totals	33370 (21636)	41178 (26971)	46313 (30515)	56022 (37192)
1996				
Age 3	32361	34209	34905	36735
Age 4	1565	1946	2166	2647
Age 5	3676	5498	6865	9857
Totals	37602 (5805)	41652 (7491)	43936 (8675)	49239 (11288)

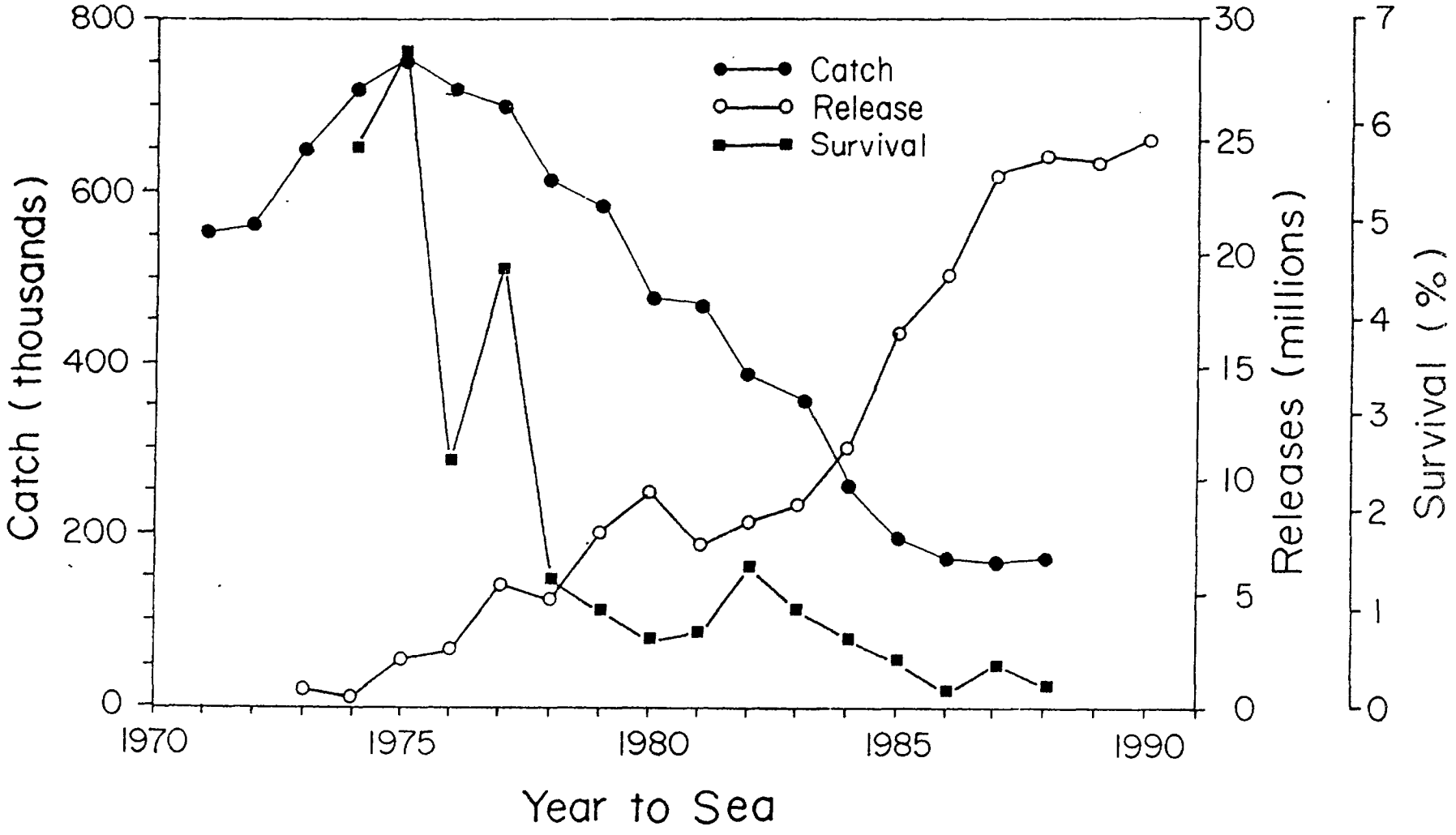

Fig. 2.1. Strait of Georgia commercial and sport chinook catch and releases into the Strait of Georgia and Fraser River. Note that as hatchery releases has increased, hatchery survival has decreased.

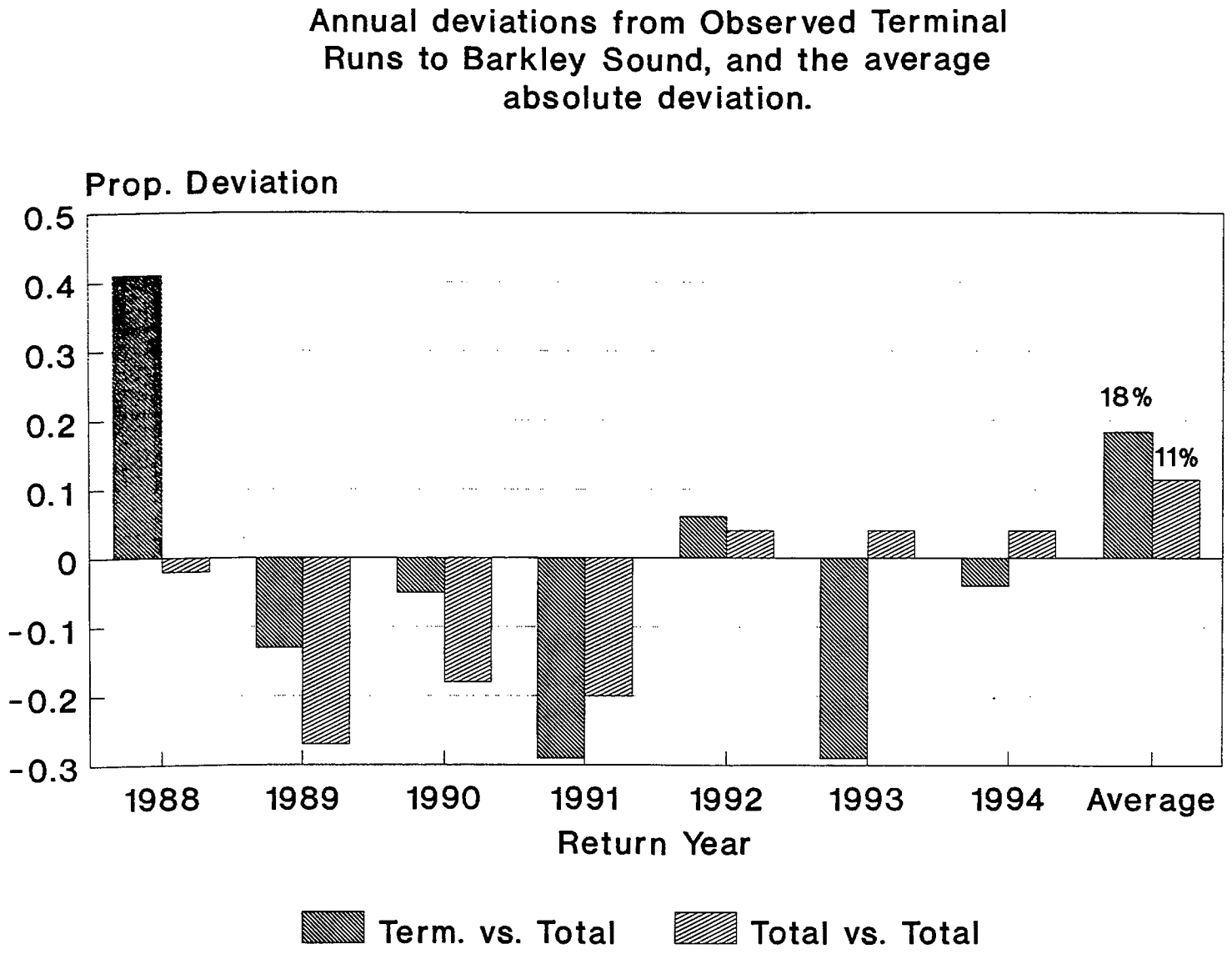

Fig. 3.1 Annual deviations from observed terminal runs to Barkley Sound, and the average absolute deviation.

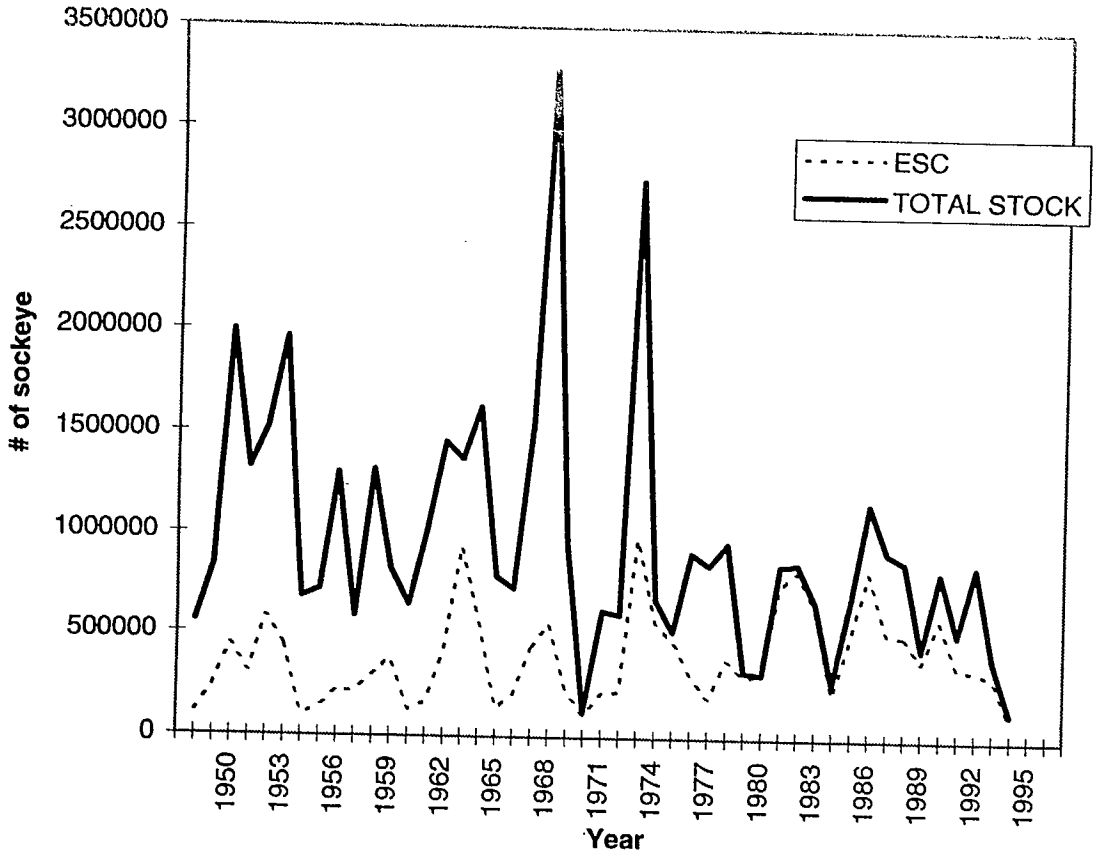

Fig. 5.1 Total stock and escapements for Area 9, 1948-1994.

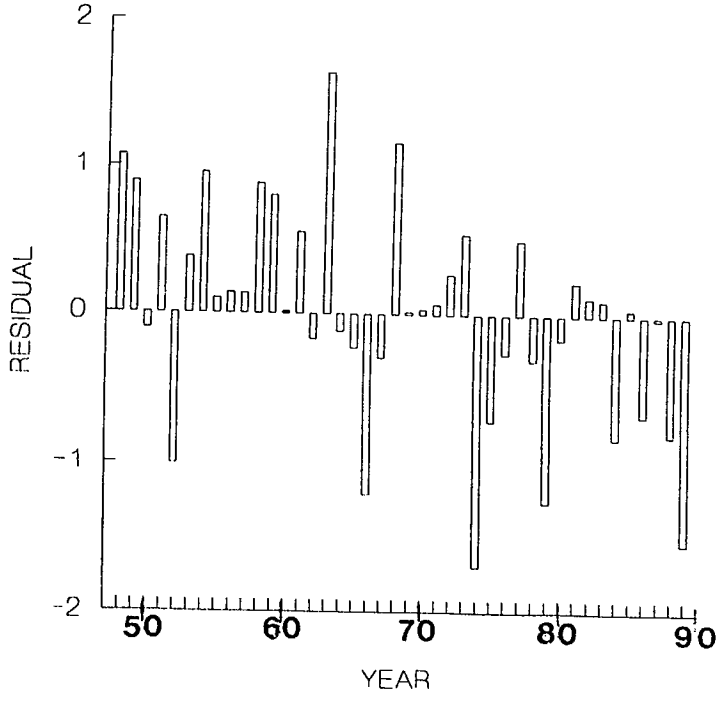

Fig. 5.2 Trend in residuals from Ricker stock-recruitment model fitted to adult escapements and total returns.

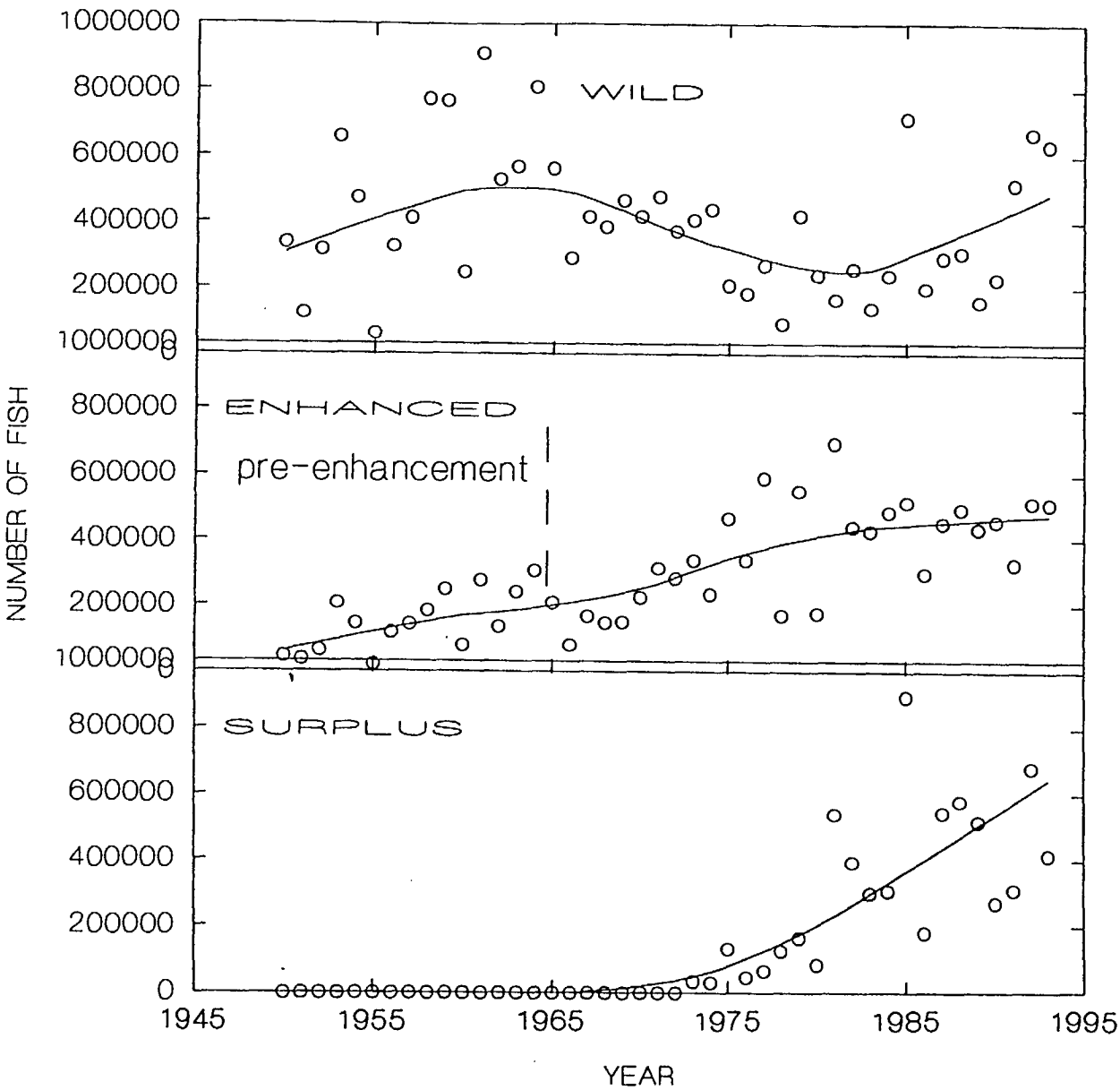

Fig. 6.1 Trends in corrected total wild and enhanced escapements and surplus enhanced escapements. Lines fitted by LOWESS (F=0.5)

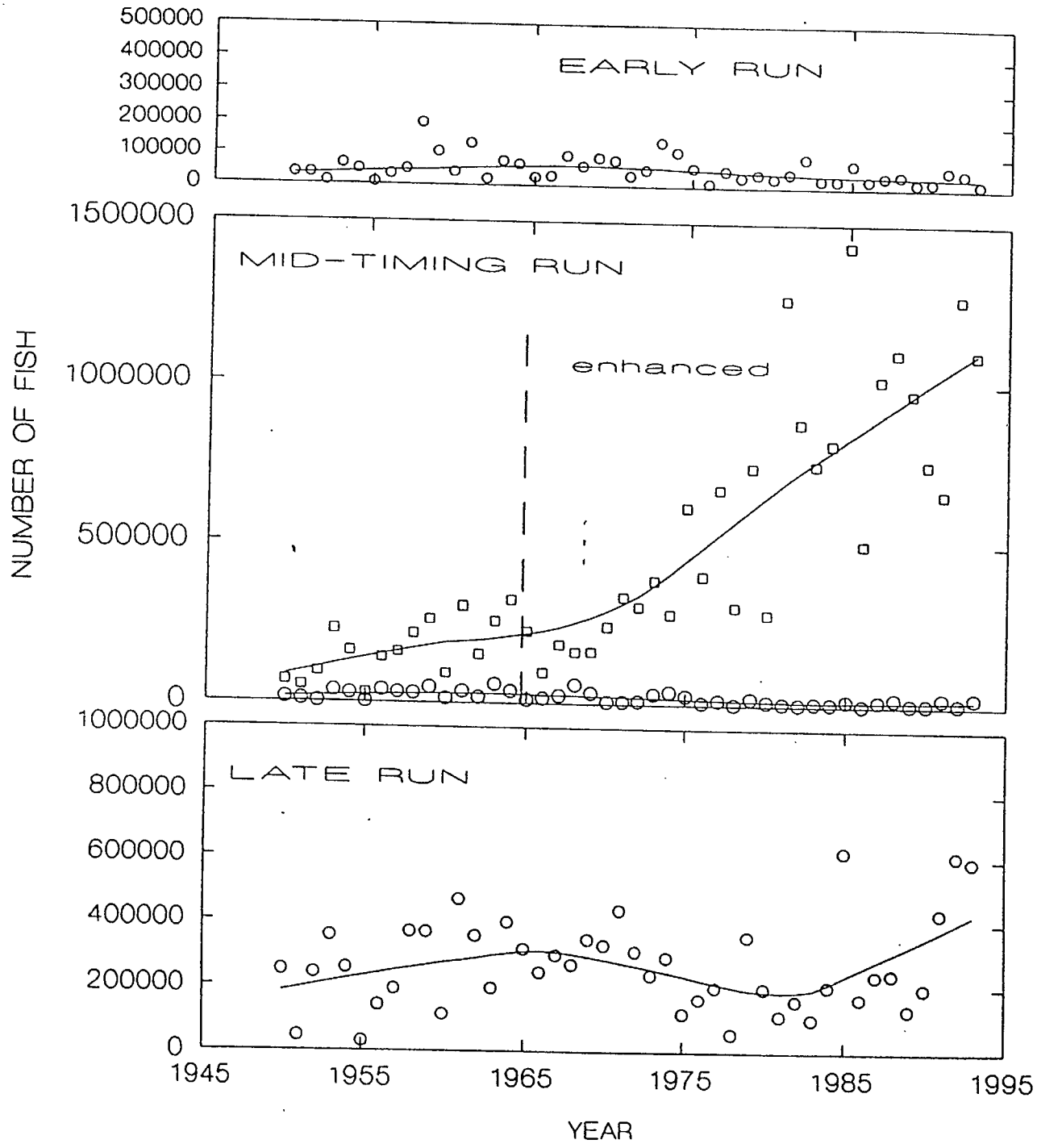

Fig. 6.2 Trends in corrected escapements by run timing group. Circles represent unenhanced spawning sites, squares enhanced sites. Lines fitted by LOWESS (F=0.5).

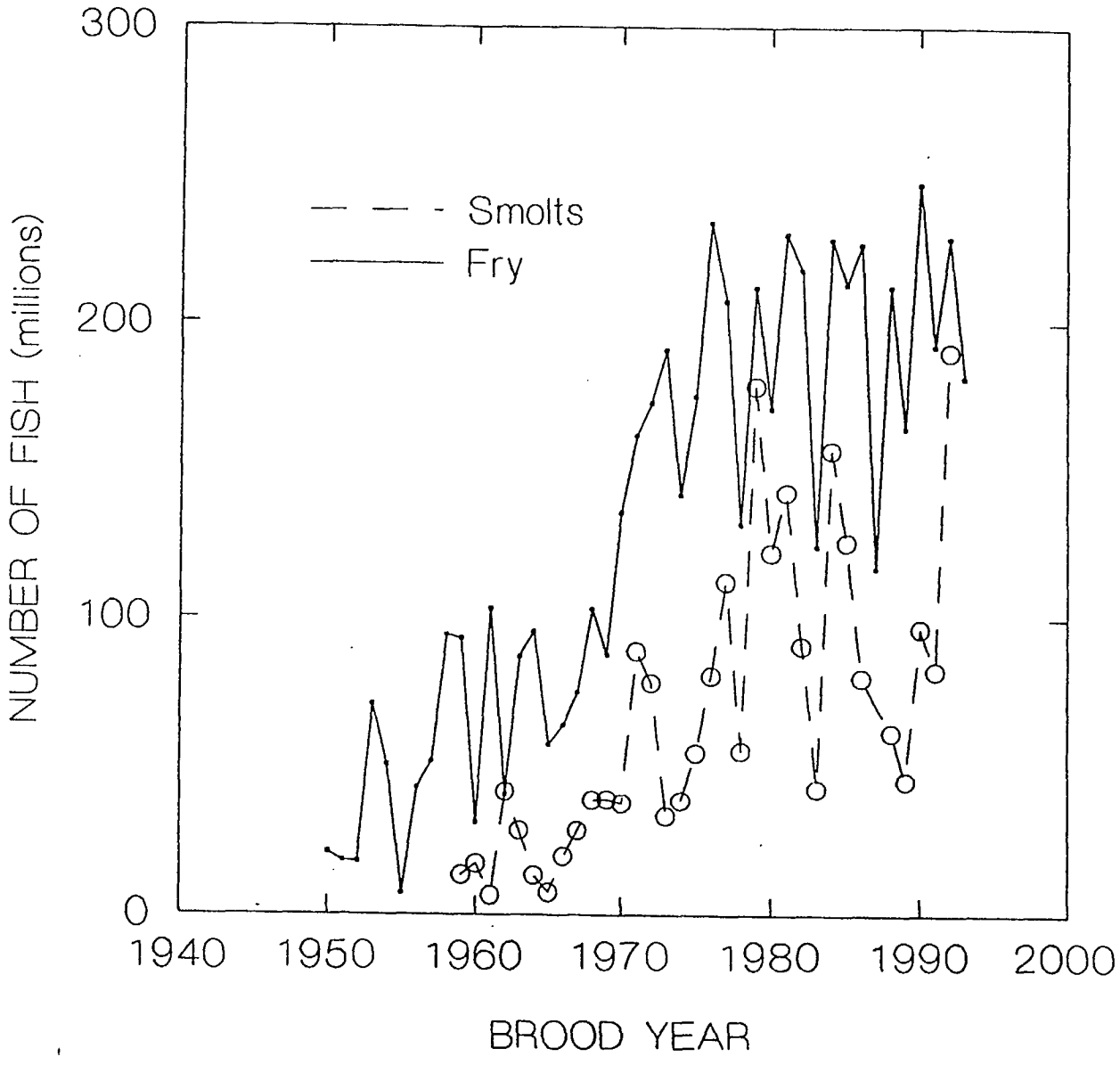

Fig. 6.3 Trends in emergent fry and smolt abundance rearing in the main basin of Babine Lake by brood year.

GROUNDFISH

I. STEERING COMMITTEE REPORT

The PSARC Steering Committee met September 26-27, 1995, at the Pacific Biological Station to review the Groundfish Subcommittee report. The report was accepted, noting that portions of the report for some species are not yet complete. Steering Committee recognizes that these sections are in review by the Subcommittee and urges the Subcommittee to complete these sections in a timely manner, so that their contents can be considered in the generation of fishery management plans. Steering Committee provided the following advice and recommendations on the Major Concerns in the Subcommittee report.

PACIFIC COD

Steering Committee notes that the Pacific cod stock in Hecate Strait is at low abundance. Steering Committee notes that the stock has been declining for several years and that fishing effort on the stock has not declined in proportion to the biomass, as in previous years. The recommendation of the Subcommittee for closure of the fishery is endorsed. Steering Committee notes that management of other groundfish fisheries will have to accommodate the need for conservation through curtailment of incidental catches of Pacific cod. Managers, industry, and stock assessment biologists will need to develop management plans that avoid dissipating positive conservation actions through bycatch in other fisheries.

For the west coast of Vancouver Island, Steering Committee supports the no directed fishery option for Pacific cod but notes that the analysis suggests there will be more flexibility in allowing incidental catches in other fisheries off the west coast of Vancouver Island compared to Hecate Strait. Steering Committee notes that the Queen Charlotte Sound cod stock may be in a similar depressed state, although no detailed analysis for this stock is available.

SABLEFISH

Steering Committee notes that the Subcommittee has not yet completed its consideration of this species. An additional Working Paper was received after the July Subcommittee meeting and review of it is not yet finished. The two working papers provide alternative views of the status of B.C. sablefish and do not agree on the estimate of absolute abundance. However, there is agreement on the declining biomass and increasing exploitation rate trends for this species. The Subcommittee will provide a recommendation on sablefish to the Steering Committee prior to its November meeting.

HALIBUT BYCATCH

Steering Committee acknowledges Canada's commitment to the reduction of bycatch mortality in B.C. trawl fisheries in the forum of the International Pacific Halibut Commission. The Committee notes that bottom-trawl fisheries may require increasingly

restrictive measures in the near future to meet this domestic commitment. Steering Committee supports the development of a paper that includes the methodology used to estimate by-catch mortality as well as mortality estimates, and the annual review by PSARC of the halibut bycatch mortality in Canadian fisheries.

AGGREGATE MANAGEMENT

Problems with some aspects of the aggregate rockfish management program were noted in the Subcommittee report, in particular that catches of some species exceed the high risk level under the aggregate framework. We are in year two of this program and there is a need to develop evaluation criteria for the management objectives of this program and for rockfish stocks, as well as the associated data collection programs. Steering Committee notes initiatives have already been taken to bring appropriate staff together to discuss future groundfish management.

OBSERVERS

Steering Committee supports recommendation for full observer coverage in the groundfish fleet, for the reasons noted in the Subcommittee report.

Concerning the individual Working Papers the Steering Committee provided the following comments and recommendations.

LINGCOD - STRAIT OF GEORGIA

Steering Committee supports continued recommendations for zero removals and the recommendation put forward in the 1994/95 report concerning the formation of the working group to address measures to rebuild lingcod in the Strait of Georgia.

OFFSHORE LINGCOD

Steering Committee endorses recommended yield options as presented by the Subcommittee.

FLATFISH

Steering Committee endorses the revised recommended yield options, subject to review and approval by the full Subcommittee.

PACIFIC HAKE - STRAIT OF GEORGIA

Steering Committee recognizes current yields are fully subscribed but notes additional survey work could confirm whether the biomass is present to support higher yields.

PACIFIC HAKE - WEST COAST

Steering Committee endorses yield options as presented. However the Committee notes the scheduled review of 1995 survey work this fall and will provide further commentary following the Subcommittee review of this work. RMEC is advised that yields could range from similar to 1995 levels to considerably lower.

DOGFISH

Steering Committee endorses the Subcommittee recommendations.

WALLEYE POLLOCK

Steering Committee endorses the Subcommittee recommendations.

SLOPE ROCKFISH

Steering Committee endorses the Subcommittee recommendations.

SHELF ROCKFISH

Steering Committee endorses the Subcommittee recommendations.

INSHORE ROCKFISH

Steering Committee endorses the Subcommittee recommendations, including the formation of a Working Group to develop recommendations on alternative assessment and management strategies to address the problems of localized overfishing.

II. GROUNDFISH SUBCOMMITTEE REPORT

1. BIOLOGICAL ADVICE ON MANAGEMENT OF B.C. GROUNDFISH FOR 1996

This document contains synopses of stock conditions and management recommendations for the major groundfish stocks off British Columbia. It also contains an assessment of the rockfish aggregate management program and the halibut bycatch reduction program. The report is based on working papers and reviews of these papers and includes summaries of both the papers and the reviews.

In 1991, the 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, triennial 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 1995 major assessments were conducted for sablefish and Pacific cod.

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 assessment revisions 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, any outside reviewers. 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 1995 meeting is appended to this report.

2. 1995 WORKING PAPERS AND AUTHORS

McFarlane, G. A. and B.M. Leaman. 1995. Offshore lingcod stock assessment and recommended yield options for 1996. G95-2: 22 p.

Haist, V. and D. Fournier. 1995. Pacific cod stock assessments for 1995 and recommended yield options for 1996. G95-3: 61 p.

Fargo, J. 1995. Flatfish. PSARC Working Paper. G95-4: 34 p.

Saunders, M. W., B. M. Leaman and G. A. McFarlane. 1995. Sablefish stock assessment for 1995 and recommended yield options for 1996. G95-5: 59 p.

Saunders, M. W. and G. A. McFarlane. 1995. Pacific hake stock assessment for 1995 and recommended yield options for 1996. G95-6: 49 p.

Thomson, B. L. 1995. Spiny dogfish. G95-7: 17 p.

Saunders, M. W and W. Andrews. 1995. Walleye pollock stock assessment for 1995 and recommended yield options for 1996. G95-8: 19 p.

Richards, L. J. 1995. Slope rockfish assessments for 1995 and recommended yield options for 1996. G95-9: 36 p.

Stanley, R. D. 1995. Shelf rockfish assessment for 1995 and recommended yield options for 1996. G95-10: 70 p.

Yamanaka, K. L. 1995. Inshore rockfish stock assessment for 1995 and recommended yield options for 1996. G95-11: 44 p.

Rice, J. C. and L. J. Richards. 1995. Rockfish aggregate management. G95-12: 16 p.

Trumble, R. J. and G. H. Williams. (IPHC) 1995. Review of the Canadian bycatch reduction program for Pacific halibut. G95-13: 6p.

Hilborn, R. 1995. A review of the B.C. blackcod stock for 1995. G95-14: 31 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
Strait of Georgia lingcod	Very low
Offshore lingcod	Average
Pacific cod	Very low
Petrale sole	Very low
Rock sole, English sole, and Dover sole	Average to high*
Sablefish	Average to low**
Pacific hake	Average
Spiny dogfish	Average to high*
Walleye pollock	Low to average*
Slope rockfish	Low to average*
Shelf rockfish	Low to average*
Inshore rockfish	Low to average*

* depending on specific stock.
** may change in the final report

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. At present, these analyses have been performed for only a few stocks.

5. MAJOR SUBCOMMITTEE CONCERNS

Pacific Cod

This year's analysis indicated that Pacific cod stocks in Hecate Strait and off the west coast of Vancouver Island are at very low abundance. The estimates of low abundance are consistent with the observations from the fishery for the past two years that indicated that fishermen were unable to catch the recommended quotas. Catches of Pacific cod have a history of cyclic fluctuations of low and high abundance with some synchrony in the trends of the Hecate Strait and west coast of Vancouver Island stocks. The current low abundance may be part of this natural cycle. However, fishing effort has not declined as it did under similar circumstances in the past causing the Subcommittee to be concerned that a fishery could impair the ability of the stocks to rebuild in the future.

Sablefish

There was a major assessment of sablefish stocks this year. The Subcommittee agreed that the abundance of the coastwide stock is declining and that the analysis indicated that the stock could not continue to support the current harvest levels. The Subcommittee and the authors identified several difficulties with the analysis such as problems with the precision of age estimates, difficulties with estimating recruitment, and the effect of large shifts in CPUE. Despite these difficulties, the Subcommittee recommended lower yield options for 1996.

Halibut Bycatch

Halibut in the Canadian fishery spend part of their juvenile period in waters off Alaska. Alaskan fisheries kill large numbers of juvenile halibut as bycatch and Canada and the International Pacific Halibut Commission have expressed concern that the high bycatch mortality is both unnecessary and has a major impact on the quotas in the Canadian zone. In order to reduce halibut bycatch, Canada and the United States signed a bycatch reduction agreement in 1991. As part of the Canadian halibut bycatch reduction plan, Canada agreed that PSARC would review the estimates of halibut bycatch mortality that are submitted each year at the annual meeting of the International Pacific Halibut Commission meeting.

The first review at this Subcommittee meeting identified several concerns, the most serious being the bycatch estimates off the west coast of Vancouver Island. The

analysis, which is still incomplete, indicates that bycatch estimates may triple from about 300,000 lbs to 900,000 lbs. An increase of 600,000 lbs could cause a major setback in the Canadian program to reduce the bycatch mortality to one million pounds by 1997 and may require harvest restrictions that relate specifically to bycatch targets rather than stock conditions.

Aggregate Management

The rockfish aggregate management program was the subject of considerable discussion. A number of problems were identified such as the overharvest of some species, excessive discarding of others and changes in the species composition of aggregates. However, the Subcommittee recognized that single species management also had its own set of problems. Managers were very concerned about the implementation of aggregate management in 1995 and were concerned about the future impacts on stocks unless some of the problems were resolved quickly. There was discussion about the continuation of aggregate management. It was agreed to continue the discussions about the program and that there is an urgent need to address the implementation problems, possibly in association with Industry. In addition, there is an immediate need to evaluate aggregate management in relation to the impact on stocks. It was clear that some changes in the implementation of this program are required for 1996.

Observers

The Subcommittee noted that management issues and stock assessments have become sufficiently complex that it is now important that all Groundfish vessels have observers. Observers are needed to verify catch, monitor discards, and to assist in the collection of data and samples. The Subcommittee noted that it is an appropriate time for full coverage in the Groundfish fleet.

IMPORTANT UNRESOLVED ISSUES FROM THE 1994 SUBCOMMITTEE MEETING

Strait of Georgia Lingcod

1. The Subcommittee reviewed the need for the formation of the working team recommended in last year's report (not established in 1994/95). It was agreed last year that the working team was required to (a) review the potential of various strategies for increasing stock biomass; (b) examine the use of area closures for exploring the feasibility of stock rebuilding; (c) review the various methods for deriving abundance indices and recommend the best direction for future monitoring of the inshore lingcod stock; (d) examine the value of increasing the effort directed towards sampling and ageing specimens from this fishery, and recommend the optimal sampling design; and (e) make recommendations on biological research which will assist future assessment analyses.

The Subcommittee repeated the need for this group and agreed that the working group might be expanded to consider other issues relating to recent problems with rockfish stocks in the Strait of Georgia.

2. The requirement to have more discussions on the management objectives associated with aggregate management emphasized in last year's report are re-emphasized in this report.

3. The recommendation to place more emphasis on walleye pollock was not met. Although the need to redirect effort to carry out more work on pollock remains, the Subcommittee felt that the lower catches in 1994 were an indication that the concern expressed in last year's report is not as great this year.

6. SUMMARIES OF ASSESSMENTS, REVIEWERS' COMMENTS AND SUBCOMMITTEE DISCUSSIONS

Offshore Lingcod (G95-2)

This document presents an interim assessment for offshore (non-Strait of Georgia) lingcod stocks. Yield options remain unchanged from those in McFarlane and Leaman (1995). Catch and effort data for 1994 have been included.

Offshore lingcod stocks were examined for the northwest and southwest coasts of Vancouver Island, Queen Charlotte Sound, Hecate Strait and the east 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) recent CPUE data suggest stocks are decreasing in abundance, however no new biological information is available to support this suggestion. CPUE off northwest Vancouver Island (Area 3D) suggests stock abundance is average, however catches have been above the quota for the last two years. Recent declines in CPUE in Queen Charlotte Sound (Areas 5A-5B) may indicate stocks are slightly below the long-term average abundance level. Recommended low to high risk yield levels range from 1,400-2,800 t, 400-800 t, and 1,100-2,200 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 1,000 t is provided out of concern for the sensitivity of the species to exploitation and the rapid expansion of the fishery.

The reviewer commented that this is an interim assessment and no new analyses have been conducted. The reviewer stated that in addition to fish abundance, other factors influence CPUE; fishery factors, regulations, fish density (catchability) etc., and some of these should be discussed. The reviewer commented that problems with age data have been stated in the past and the progress on age resolution or alternate analyses should be included in the document. Reasons for using the particular CPUE series used in the assessment should also be incorporated into the document.

The Subcommittee stated that there have been concerns from industry over fishing during the spawning period. The Subcommittee notes that a spawning closure could be instituted as a conservative approach to management because of the vulnerability and availability of the males during nest guarding.

Pacific Cod (G94-3)

Major, new Pacific cod stock assessments are presented for two areas. There was no analysis of the Strait of Georgia stocks and the Queen Charlotte Sound stocks. In Canadian waters, Pacific cod is close to the southern limit of its commercial abundance and exhibits rapid growth and a short life span. Pacific cod were not aged using hardparts, but ages have been inferred from length-frequency analysis.

The area off the west coast of Vancouver Island (Area 3C) has historically produced approximately 90%, and Area 3D, 10% of the total landings. However, since 1991, the proportion of landings from Area 3D has increased to an average of 23%. Within 3C, the fishery occurs on Amphitrite Bank, where over the last 5 years over 50% of the total catch occurs during January-March on aggregations of spawning Pacific cod, and on Big Bank and Swiftsure Bank, where 25% of the total catch occurs during April-September on feeding cod. The trawl fishery targeting spawning cod began about 1961, assumed considerable importance after 1971, and was subject to various conservation regulations between 1978 and 1988.

Catch quotas were first introduced to regulate Pacific Cod fisheries on the west coast of Vancouver Island in 1994, although the quotas applied only to Area 3C catch (1994-1995; 2,170 t; 1,300 t). In 1994 the Area 3C quota was not achieved and landings to date suggest that the 1995 quota will also not be achieved.

The probability that the 1996 spawning stock biomass will be below the specified minimum level (2,700 i.e. 25% of the average unfished spawning stock size) is 0.094. The low risk option for the west coast Vancouver Island Pacific cod stock is, therefore, for no fishery. The average risk option, obtained from the median stock projection, is for a 694 t quota. The high risk option, based on the 75 percentile point of the stock projections, is for a 916 t fishery.

In Hecate Strait, the stock of Pacific cod was historically the largest off the west coast of Canada, producing approximately 50% of the coastwide catch. As with other Canadian Pacific cod stocks, recruitment and subsequently total biomass, fluctuates widely.

Catch quotas have been used to regulate the Hecate Strait Pacific cod fishery since 1992. The quotas declined in 1993 and 1994 (1992-1995: 3,400 t; 5,100 t; 3,850 t; 1,850 t). Fishermen were unable to catch these reduced quotas in 1993 and 1994, and preliminary indications suggest the quotas will not be achieved in 1995.

There is a need to specify minimum spawning stock biomass for Pacific cod stocks. During previous cycles, when Pacific cod stock abundance decreased due to a few years of poor recruitment, fishing effort decreased as well. Thus, fishing mortality rates did not escalate and drive the populations to extremely low levels. During the current cycle of stock declines there is little evidence that effort is decreasing so other measures need to be implemented to ensure maintenance of adequate spawning stocks. In the absence of a detailed evaluation of harvest strategies, we recommend that no fisheries occur if the forecast spawning stock biomass is less that 25% of the unfished median spawning stock biomass. This recommendation and the target F of 0.30 are intended only as interim harvest policies, pending a more detailed evaluation. The probability that the 1996 spawning stock biomass will be below the specified minimum level (5,015 t) is 0.78. Therefore, any fishery for Pacific cod in Hecate Strait is considered a high risk.

The Queen Charlotte Sound region has yielded an average of 16% of the coast-wide Pacific cod catch. This proportion has ranged from a low of 6% in 1987 to a high of 51% in 1971. Although a detailed assessment has not been conducted for this stock, cursory examination of the CPUE data suggests that it may be at very low levels. Annual landings and CPUE indices for the Queen Charlotte Sound region are significantly correlated with those for Hecate Strait and the west coast of Vancouver Island. Thus, this stock is potentially as seriously depressed as the Hecate Strait and the west coast Vancouver Island stocks.

Reviewer number 1 agreed that use of Multifan was a reasonable approach. However, the identification of cohorts is more complex in a length-based analysis than in an age-based analysis. More details on sampling design for length-frequency data would be useful. Additionally, changes in fishing strategy could affect the size composition of the samples and alter the model interpretation of fishing mortality or growth. The use of median CPUE did not seem to add robustness to the analysis. The qualification level for CPUE could also bias the apparent trend because of low stock levels in some years. The flat surface of the likelihood function again complicates the model interpretation. Details of the stock projection are unclear. The use of the long time series of recruitments (with high historic levels) could overestimate forecasted recruitments. An autoregressive time series approach may be appropriate.

Reviewer number 2 stated that the technical basis of the assessment appeared sound, but noted that similar statements had been made for previous assessments which had reached different conclusions. However, more severe restrictions are warranted with past catches and quotas on a declining trend. All PSARC documents should include a retrospective analysis and summaries of past management action; performance for Pacific cod stocks has been consistently poorer than forecasted. This poor performance is itself cause for concern and suggests highly conservative management is presently required. A comparative study of past assessment methods should be conducted.

The terminology was inconsistent for certain calculated values such as nominal and calculated effort. Furthermore, different values appear in different documents for supposedly the same quantity. Where values change from year to year, Working Papers should provide an explanation for the change.

Reviewer number 2 believed the continued reliance on CPUE data to be particularly problematical. This issue is compounded by the use of qualification levels. The proportion of catches that meet the qualification level should be included for discussion. The Strait of Georgia stock should be re-examined from this point of view; this stock has not been reviewed since 1987. The interpretation of the Multifan analysis is also of concern because of the high dimensionality of the model and the flat likelihood surface. Thus, a good model fit may not relate to biological reality. More detailed examination of model performance should be conducted.

The Subcommittee notes that Pacific cod stocks periodically undergo large fluctuations in biomass and that the stocks appear to be at a cyclical low. Historically, effort tended to change with abundance. However, effort in the recent period has not declined with catch.

The Subcommittee accepts the authors' recommendation that any Pacific cod catch in Hecate Strait is a high risk to the maintenance of minimum spawning stock biomass. The Subcommittee notes that Pacific cod are caught in both directed and incidental fisheries. Thus, restrictions on Pacific cod catch could impact other fisheries, particularly those for flatfish. Analyses of existing data from observer programs might identify where area/time closures would be most effective. If closures are implemented, objective criteria for re-opening the fishery should be specified and discussed with industry. Minimum spawning stock biomass levels could provide an objective criterion.

The Subcommittee also accepts the author's conclusions for the west coast of Vancouver Island and recommends that the stock should be managed at the low risk option of zero yield. Stock projections indicate that the stock is at low levels; the fishery has been unable to catch past quotas in spite of high effort. There are technical concerns with the analysis for this stock, however. Inclusion of environmental factors may provide better stock projections.

Because of the importance of this Working Paper, the revised document will be circulated for comment to Subcommittee members prior to final approval.

The Subcommittee discussed the need for an analysis of the Pacific cod stocks in Queen Charlotte Sound and in the Strait of Georgia for next year's Subcommittee meeting, but no decision was made.

Flatfish (G-95-4)

This year interim assessments have been prepared for all flatfish stocks except for stocks in the Strait of Georgia. Standardized catch and effort statistics have been updated to include information from the 1994 fishery. The assessment for Dover sole in Area 3CD incorporates information from the February 1995 biomass survey. Catch-age analysis has been updated for Hecate Strait English sole and rock sole and estimates of the 1994 biomass levels are contained in those assessments. The yield options presented for rock sole and English sole in last year's assessment (Fargo 1995) reflected an above average recruitment/abundance scenario for those stocks. Current results from catch-age analysis for rock sole indicate that recruitment is diminishing for rock sole and landings are declining. Recruitment for English sole remains high. Dover sole stocks are near average levels while those of Petrale sole remain low.

The reviewer agreed with the yield recommendations presented for flatfish with the exception of Hecate Strait English sole and Rock sole. For rock sole updated catch-age analysis using both CPUE from the surveys and CPUE from the commercial fishery show that biomass is declining. Updated yields from the catch-age analysis are 550 t and 1,200 t for low and high risk respectively. For English sole the catch-age analysis indicated a 14% increase in biomass and surveys a 78% decrease. Since survey design was similar between the two surveys, this information should not be discounted when developing yield options.

The Subcommittee agreed with the reviewers' comments and recommended the author rerun the catch-age analysis for English sole using the survey CPUE data to tune the model. The Subcommittee agreed to review the new analysis prior to the completion of the Subcommittee report. The Subcommittee endorsed the lower yield options for Hecate Strait rock sole generated from the updated catch-age analysis for this stock. The Subcommittee also endorsed the other yield recommendations in the document. The Subcommittee noted the declines in CPUE for the southern Petrale sole stock. These declines coupled with the lack of any indication of strong recruitment in recent years are a matter of concern.

The revised assessments used the results of research trawl surveys to tune the catch at age analysis. As a result, the original recommended yield levels for rock sole and English sole for Area 5C-D have been lowered by approximately 50%. These new estimates which have not been reviewed by the Subcommittee, need to be reviewed and discussed with managers. This will form an addendum to the Subcommittee report when finished.

Addendum - added December 6, 1995

The Subcommittee during its third meeting reviewed the revised flatfish assessments for rock sole and English sole in Hecate Strait. The Subcommittee agreed that the revised assessment should be expanded to explain in more detail the

incorporation of the survey data into the analysis. The Subcommittee noted that the lower end of the yield range may be too low because considerable uncertainty still exists with the use of the survey data as the sole determinant of biomass.

Sablefish (G95-5)

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. A separable catch-at-age model (Synthesis) was used to estimate the current status of each stock. Biomass in the south and north was estimated to be 8,200 t and 15,800 t, respectively. The range of estimates for all examinations was approximately 4,500-10,000 t for the northern stock and 9,300-15,800 t for the southern stock. Overall, both stocks are estimated to be in decline, a result of low recruitment during the late 1980s and early 1990s. Yields ranging from 225 to 1,000 t were presented as low to high-risk yield options for the south stock and from 465-1,580 t for the north. Coastwide low to high-risk yield options are presented as 690-2,580 t. In the absence of a substantial increase in recruitment, the stock is projected to continue to decline at present harvest rates.

Reviewer number 1 noted the lack of a reliable time series of abundance indices as a major problem with the assessment. This may result in a poor estimate of absolute abundance although it is possible the recent declining trend is better estimated. Biomass estimates can become quite unstable when changes in catchability are modelled as in this assessment. Finer-scale spatial analysis of logbook data might help improve the quality of CPUE indices; focusing this on "background" areas where fish are not abundant might be a good approach. Pooling over age classes might help deal with the sparsity of age data and ageing errors. Modelling age-dependent migration may be a possible approach. Evaluating the uncertainty in the assessment would be useful in providing guidance to managers; several possible approaches are suggested although some of these are still in development. Dealing with selectivity separately for longline and trap fisheries should be considered. Using a decreasing M value to represent emigration is a good approach, but it was not clear how values were chosen.

Reviewer number 2 noted the progress made since the last assessment especially in beginning to look at the hypothesis of depletion of local pools of fish. The reviewer noted that the key question regarding the changed conclusions from last year's assessment is whether the whole series has been rescaled or whether the slope of the recent decline in stock size increased. Analyses on a finer spatial scale should be conducted. More detail should have been provided to back up the recommendation that northern and southern components be assessed separately. A time series of longline CPUE should be developed. Are trip by trip CPUE estimates as representative as overall average catch divided by effort? It appears that changes in CPUE corresponded closely to changes in management strategy. The technique of standardising lengths to weights might be misleading in exploring the hypothesis of successive depletion of local pools of

fish; also length-weight information is a decade old. An explicit partial recruitment vector should be included. More information is needed on converting lengths to ages. The assessment should be consistent about whether the big changes in CPUE were due to management changes or environmental effects. The trends since the mid-1960s in age 2 recruits and spawning stock biomass are alarming, showing that large yearclasses were unable to maintain the stock size. Ageing error should be dealt with explicitly in the modelling exercise.

The following Subcommittee comments occurred before the review of some late submissions and will be modified as a result of these submissions.

The Subcommittee noted that the assessment had advanced considerably since the previous meeting. The main differences from last year's assessment are that more information has been included (in particular more age data) and the model fits are more stable due to use of a more parsimonious, straightforward model. Additional new data are to be incorporated in future (notably a longline data series).

A key question is whether the recent decline in CPUE reliably indicates a decline in stock size. Possible explanations for a decline in CPUE other than declining abundance were raised: fishing for quality not quantity (no indications from the fishery of changed strategies); retirement of some skilled skippers (preliminary analysis suggests that the trend is independent of changes in skippers); using less bait. Some aspects of the form of the CPUE series suggest that factors other than abundance may be operating. There have been changes in depth distribution of fishing over the years which might help to explain CPUE changes, but depth distribution of fishing is difficult to evaluate since sets are from shallower to deeper areas. In any case de-emphasizing CPUE data results in little change to the conclusions of the assessment.

Could tagging information be used to strengthen the assessment? A Petersen estimate of abundance based on tagging is in preparation. This will be affected by the usual problems with tag-recapture estimates, but it will provide an independent estimate of abundance.

The justification for the 51° 15' line to separate north and south areas was questioned. This line is not necessarily absolute, but is in an oceanographic transition zone which could reasonably be expected to separate two recruitment pools.

January-March CPUE data were not used in the analysis to ensure consistency of the CPUE time series. Often there was no fishery in the first quarter.

If recent CPUEs are comparable with those in the late 1970s and most of the 1980s (and above the long-term average), when annual catches of 4,000-5,000 t were taken, why are we recommending severe restrictions on catch? It was noted that the catches of 4,000-5,000 t/yr may have been based on fishing accumulated biomass, and that changes in fishing practices may mean that CPUEs are not strictly comparable.

The Subcommittee endorsed the yield recommendations in the document and concluded that although there is considerable uncertainty in interpreting data in the assessment (especially available CPUE data), biomass is declining. The Subcommittee noted that the high risk yield or greater has been taken from this stock in recent years (except 1994) and concluded that harvesting had probably been at a non-sustainable level over this period. Recent recruitment has been comparable to the long-term average and there are no signs of strong yearclasses which might lead to increased abundance in the near future. The actual level of biomass in recent years is more uncertain, but the assessment provides the best estimate available.

The Subcommittee accepted the separation of the northern and southern areas, pending review of the appropriate documents. Separate management of these components was recognized as operationally more complex than managing as a single unit. The Subcommittee requested that the information supporting the separation of the two units be tabled and reviewed at the next meeting.

Discards and bycatch in other fisheries should be examined as a source of non-fishing mortality. This could be done using data from the observer program.

A copy of the sablefish assessment was sent to the Pacific Coast Blackcod Fisherman's Association. This association issued a contract with Triton Environmental Consultants Ltd. for a review of the document. The Triton review recommended a second assessment be undertaken by an independent contractor, Dr. Ray Hilborn. The "Hilborn" review was discussed at a meeting of Groundfish staff and sablefish fishermen, then reviewed by two staff and submitted to the Groundfish Subcommittee. The Subcommittee considered the "Hilborn" review and the comments of the two reviewers at a special subcommittee meeting. Results of this review were not available for this draft and will be included in the final subcommittee report.

The Subcommittee agreed that the Hilborn review would be a working paper (G95-14) and included in a later addendum to the Subcommittee report, with the reviews. At this time the Subcommittee has not finalized its review of all the sablefish documents and reviews. Once all documents have been distributed and reviewed, the Subcommittee will reconvene to finalize the recommended yield options.

ADDENDA TO SUBCOMMITTEE REPORT

The second meeting of the Groundfish Subcommittee occurred on September 22, 1995. The following report was approved by the Subcommittee but will be modified as a result of decisions made at the third meeting of the Subcommittee. The report of this third meeting follows this addendum.

Addendum

An additional submission to the Subcommittee was received after the July meetings. This submission was made by the major user group in the sablefish fishery (Pacific Coast Blackcod Fishermen's Association) and was an assessment of the sablefish resource based, in part, on Working Paper G95-5 but also included additional analyses. This submission has been assigned as Groundfish Subcommittee Working Paper G95-14 and was reviewed by the Subcommittee and the author on September 22, 1995 in Nanaimo. The following summary will be included in the final Subcommittee report under section 6., Sablefish (G95-5, G95-14). Subcommittee members participating were as follows: Vancouver - G. Buechler, B. Turris; Nanaimo -R. Beamish, G. McFarlane, M. Saunders, B. Leaman, J. Schweigert and V. Haist.

Working Paper G95-14: A review of the B.C. black cod stock - 1995.
Ray Hilborn (University of Washington, Seattle).

Summary

A number of different analyses were applied to the data on the B.C. blackcod stock including: (1) yield-per-recruit and spawning stock-per-recruit; (2) equilibrium total yield allowing for spawner-recruit relationships; (3) long-term age-structured models fitted to age distribution data; and (4) STOCK SYNTHESIS (SSMOD) runs. Analyses under (1) suggest that the combination of maturity preceding vulnerability to the fishery allows higher exploitation rates than the relatively low natural mortality rate would suggest. A 15% exploitation rate would be achieved using the $F_{40\%}$ reference point while use of the $F_{30\%}$ reference point would lead to an optimal exploitation rate of 25%.

Long-term fits to age-structured models aggregating all data into a single stock suggest that the spawning stock is now about 57,000 t of vulnerable biomass and at about 50% of the unexploited level. Use of SSMOD on data for two stock units in B.C. gave results very similar to the analyses presented in Working Paper G95-5, a vulnerable biomass of approximately 24,000 t coastwide. However, the 24,000 t biomass estimate presented in G95-5 was viewed as the high end of the biomass range, whereas the analysis in Working Paper G95-14 presents the 24,000 t as near the middle of the range of available biomass. In addition, the Working Paper obtained an opposite sensitivity of estimated biomass to effort emphasis than presented in G95-5. The choice of a single stock or two stocks for the B.C. coast governs the estimation of present total mortality rates; a single-stock hypothesis suggests total mortality is presently about 0.20, whereas a two-stock hypothesis suggests total mortality rates of approximately 0.35 and 0.25 in the north and south, respectively.

The author or working paper G95-14 concludes that two hypotheses may be considered for the status of the sablefish stock: (1) the stock is extremely healthy and potentially underexploited; or, (2) it may be harvested at near the MSY level. If hypothesis (2) is accepted, the paper suggests that the F=M reference point used in

Working Paper G95-5 to estimate available yield is excessively conservative and that an exploitation rate of even 15% is conservative. The author makes several suggestions for future data collection and analysis initiatives to improve our ability to assess this stock. They include the continuation of current data collection efforts, analysis of tagging data to determine exploitation rates, and the development of an alternative index with which to tune age-structured estimations.

Reviewers' comments

Reviewer #1

The first reviewer appreciated the attempts to apply several analyses to what was viewed as a poor data set. Some suggestions on improvements to the presentation were suggested in order to reference specific analyses and conclusions. The reviewer agreed that the effort data were unlikely to provide much insight to the stock status. The reviewer noted that evidence from the analyses did not support either a single or split-stock hypothesis convincingly, rather there was some support for both. The reviewer agreed with the historical estimate of Z contained in the working paper and the resultant estimate of exploitation rate of about 10% in recent years. While the status of the stock was not regarded as well established the reviewer noted that the decline in spawning biomass should be a source of concern.

The reviewer concluded that the optimal exploitation rate calculations were uncertain but that the declining spawning biomass indicated that current harvest levels should be reduced. Examination of reference points for yield calculations by the reviewer suggested that even a level of $F_{45\%}$ might be more appropriate if there is serial correlation in recruitment and long-term cycles in environmental variables affecting recruitment.

This reviewer noted the need for examining alternative analyses and suggested that a simulation model of the population, to generate data conforming to specific hypotheses, would be a valuable adjunct for future analyses. The reviewer questioned whether the steepness parameter of 0.8 was indeed conservative for a species with the life history of sablefish. It was also suggested that the R_0 value of 6,000 used in G95-14 might be overly optimistic given recent increases in mortality rates. Lastly, the reviewer cautioned that high recruitment in the 1980s does not appear to have been sustained and subsequent weaker cohorts may increase the rate of decline of the stock at current harvest levels

Reviewer #2

Reviewer 2 estimated mortality rates as approximately equal for northern and southern stocks, rather than the differential rates suggested in both G95-5 and G95-14. This reviewer believed a two-stock hypothesis was more appropriate for B.C. waters, based on the tagging information contained in G95-5, and added that the most appropriate northern stock unit might be in combination with sablefish in the southeastern

Gulf of Alaska. The conclusion that the major difference in present biomass estimates was associated with the choice of alternative stock hypotheses was questioned by the reviewer because of the different analytic models used for the two cases in G95-5 and G95-14. Using a similar model for both hypotheses, the reviewer concluded that the differences in stock status were not driven primarily by the stock hypothesis, rather were associated with other features of the data.

The reviewer conducted both split-stock and single-stock analyses for the data set and concluded that the data set was largely uninformative about the present level of biomass. Confidence limits on estimated biomass for both stock hypotheses were extremely wide. Analyses of split stocks estimated generally higher levels of exploitable biomass in both northern and southern areas than G95-5 but lower estimates of single-stock coastwide biomass than obtained in G95-14.

The reviewer believes it is not possible to evaluate the probability distributions of biomass generated with SSMOD because the variance of individual components is set arbitrarily. The conclusion in G95-14 that an exploitation rate of 15% is conservative is supported by the analysis in that working paper. However, the reviewer noted that this conclusion is inconsistent with the performance of the stock in recent years when some analyses suggest the exploitation rate may have been below 15%. The reviewer concluded that it would be prudent to reduce harvest rate under the assumption that the apparent decline in the stock results from fishing mortality being too high.

Subcommittee discussion

The Subcommittee, including Dr. Hilborn held an extensive discussion of this working paper and its conclusions relative to those in G95-5. It is apparent that the data set available for analysis presently is relatively uninformative about the absolute level of stock biomass in 1995. The precision of some data used in all analyses is low and the effort data set is of little or no value as a tuning index for the catch-at-age estimations. The Subcommittee examined the basis for the differences in the analyses conducted in the two working papers. It is clear that the uninformative data set available renders the analyses quite susceptible to even small changes in underlying assumptions. The authors of both working papers and the reviewers agreed that additional data being prepared for inclusion in the analyses, in the form of exploitation rates derived independently (e.g. tagging data) and other effort time-series (e.g. longline gear), would provide the only major improvement to assessment using the current model. While the Subcommittee identified some elements of the various analyses that required further investigation to resolve differences, it was agreed that major increments in understanding based on analysis of the data in the working papers were unlikely. The Subcommittee recommended that the authors conduct such investigations for inclusion in the next assessment. The Subcommittee also recommended that the appropriate scientists develop an assessment plan that would include these new data sources. In addition, it was agreed that consultation with appropriate scientists employed by user groups as reviewers of the assessment should be undertaken early in the assessment cycle, in

order to improve the review process and the integration of views expressed such user groups.

The Subcommittee then addressed the problem of advice on yield options for managers, in the face of the substantial uncertainty about the absolute level of stock biomass in 1995. Authors and reviewers of both working papers agreed on the trajectories of stock biomass and exploitation rate. It was agreed that there was a declining trend in the exploitable biomass and a rising exploitation rate. The relative contributions of fishing mortality and recruitment changes to these trajectories are not well established. However, the Subcommittee concluded that it was very important to reverse the trajectory of exploitation rate. This will require a decrease in the removals from the stock(s). The absolute amount by which the quota should be decreased could not be determined with certainty. Some members of the Subcommittee believed that a major decrement was required to establish a sufficient signal in the exploitation rate trajectory. Others argued that smaller changes should create detectable change.

The Subcommittee concluded that an alternative approach to stock management could provide the appropriate mechanism to improve our knowledge of stock status. The Subcommittee recommends that a more moderate approach to reducing the quota be adopted, in conjunction with a division of the coast into two management units and an intensification of the tagging program in each area. The majority of the reduction should be visited in only one of the stock areas so that the increased effort in the other area will provide sufficient tag returns to establish the exploitation rate. The Subcommittee recommends the majority of the quota therefore be assigned to the southern stock unit, which has received lower fishing effort in recent years. This measure will increase fishing effort in the south and decrease it in the north, thereby generating changes in exploitation rates in both areas. The Subcommittee recommends that Operations and Science staff meet quickly to design this program for the 1996 fishing year.

Addendum

The Groundfish Subcommittee had its third meeting Friday, November 24 from 9:00 to 12:30. The primary purpose of this meeting was to reach a consensus on the sablefish yield and management recommendations for 1996.

The Subcommittee had previously reviewed and discussed two assessments. One assessment produced by DFO staff indicated that the exploitable biomass was in the range of 24,000 t and that if previous quotas were maintained, the annual exploitation rate would be approximately 30%. The DFO assessment concluded that this exploitation rate was too high and that quotas should be reduced. The second assessment was contracted to Dr. Ray Hilborn by the sablefish industry. His analysis produced an exploitable biomass estimate in the range of 55,000 t, which would indicate that the current quotas are exploiting the stock at a rate of approximately 10% or less.

The Subcommittee noted that both analyses indicated a declining trend in exploitable biomass in recent years due to low recruitment. The Subcommittee further noted that the differences in absolute abundance presented in the assessments would not be resolved at this meeting on the basis of technical refinements of the models.

In previous discussions, it was agreed that an analysis of tagging data could produce additional measures of exploitation rates. If the rates were closer to 10% then the stock biomass would be higher and the higher quotas would be appropriate. If the exploitation rates were in the range of 30%, then the biomass was lower and lower quotas would be recommended. A tagging analysis had been carried out under contract but the Subcommittee did not review this tagging document as a PSARC submission as it required additional analysis. External reviews of the tagging analysis were tabled at the meeting but because of their preliminary nature, the Subcommittee did not include the reviews in this report. With these qualifications, the Subcommittee reported that the preliminary analysis appears to support the lower exploitation rates.

After an extensive discussion, there was a consensus that the recommended yield for 1996 should not exceed the quota in 1995 of 4200 t and that a reduction in yield would be conducive to changing the recent trend of a decreasing biomass and an increasing exploitation rate. The Subcommittee noted that if subsequent data analysis indicates that if the reduction in 1996 was not necessary, the reduced yield in 1996 would not be lost to the fishery because sablefish are a long-lived fish. The Subcommittee also recommended that the management plan for 1996 encourage the redirection of effort to the south in order to reduce the exploitation rate of the northern stock and improve tagging returns in the south.

Pacific Hake (G95-6)

The fishery in the Strait of Georgia increased in 1994 to 9,631 t from 4,368 t in 1993 and in 1995 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 March 1993 that found a total of 245,000 t throughout the Strait of Georgia. This estimate is higher than that from previous surveys conducted during 1981 and 1988, although problems with the survey may have caused an overestimation of stock size. The survey had a strong showing of 1 and 2 year-olds which have continued to show in fishery samples through 1995. The yield options for the Strait of Georgia remain unchanged from the previous assessment conducted using Virtual Population Analysis (VPA) and a forward simulation model that indicated that yields up to 14,000 t may be sustainable. Detailed survey and analytical effort are warranted for future assessments given the size of the fishery and uncertainty associated with the current assessment.

Since 1968, more Pacific hake have been landed from the offshore stock than from any other species in the groundfish fishery on Canada's west coast. The combined Canada and United States catch of Pacific hake increased from 200,000 t in 1993 to 359,000 t in 1994 as a result of increased biomass found during the 1992 triennial survey.

The increase was due to the expansion of the survey offshore of previous designs and not due to increased recruitment. The presence of hake on selected offshore U.S. and Canadian transects was verified during a cruise during July 1994. The catch in the Canadian zone was 106,172 t in 1994, up from 58,783 t in 1993.

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. The deterministic modelling of recruitment in short-term projections using median recruitment was replaced with a more realistic stochastic model that uses the existing recruitment time series. Overall abundance as indicated by stock synthesis runs, is declining as the strong 1980 and 1984 year classes move through the fishery and because of poor recruitment since the moderately strong 1990 year class. Yield options for two assumptions regarding the strength of the 1994 year class, three possible fishing strategies and three risk levels are presented, with available total Canada and United States yields for 1996 ranging from 79,000 t to 200,000 t which are lower than 1995 yield options. Yields beyond 1996 are projected to fall below 100,000 t in the absence of a strong year class. It is anticipated that results of the 1995 triennial survey will be available by January 1996 and managers should consider modifying fishing plans if results vary substantially from the status of the stock reported here.

The Subcommittee and the first reviewer noted the high survey biomass estimate of 245,000 t for the Strait of Georgia and commented that additional survey work may indicate significantly higher recommended yields for this stock. The reviewers requested that in the subsequent assessment the authors explore the impact of assuming constant recruitment and elaborate on their confidence in the absolute value of the biomass estimate.

For the west coast stock, reviewers recommended and the Subcommittee endorsed that future assessments include more background information on the joint work that is conducted by Canadian and U.S. scientific staff. Future documents should also include more complete summaries of the analyses, in particular, the results of the various simulations.

Reviewer number 1 commented on the overwhelming influence of the high 1992 biomass estimate on the overall assessment. The Subcommittee requested more elaboration of the analyses which explored the impact on the assessments of reducing the weighting of this point biomass estimate.

Reviewer number 1 commented on the tendency for strong age classes to maintain their prominent modes over time and suggested that the degree of ageing imprecision was exaggerated in the model. The reviewer recommended a detailed examination of this assumption in the next assessment.

Reviewer number 2 suggested greater elaboration of the "Percentile" rule and its role in the calculation of the yield recommendation. The same reviewer suggested that the impact of varying F on the model output should be shown in tabular or graphical form. The Subcommittee suggested including the various quota allocations of 1995 and suggested that references to "sustainable" yield be removed from the document.

The Subcommittee commented that the document included comments on the presence of young hake in new regions in 1994. The Subcommittee suggested that the authors might enhance the discussion about the overall distribution of young hake in 1994, in particular if they were absent from regions where they had been seen in previous years.

The Subcommittee accepted the yield recommendation for the west coast hake stock of 79,000 t to 200,000 t for Canada and United States as proposed, but noted the continued period of poor recruitment. These are coastwide yield estimates that have not been separated into Canada and U.S. allocations as the two governments are presently involved in negotiations on the percentage of yield to be taken by each country. The Subcommittee commented that the continued failure to resolve the allocation issue between Canada and the United States may interfere with attempts to constrain the catches within the recommended yield range.

Spiny Dogfish (G95-7)

The spiny dogfish fishery is a marginal fishery that is primarily driven by market value and production costs. The primary processors are in Puget sound. The offshore dogfish stock is considered to be a single group extending from Alaska to California, excluding the stock complex found in the Strait of Georgia-Puget Sound area (Saunders 1985). In this report, catch statistics for this stock are compiled for fisheries off British Columbia and Washington State. Spiny dogfish remain unexploited off Oregon and California. The stock assessment of spiny dogfish is based on a deterministic age-structured model developed by Wood et al. (1979).

A summary of fishery statistics has been provided showing catch and effort patterns for B.C. and Washington fisheries for the years 1979-1994. Directed effort towards spiny dogfish remains market dependent as the economics of the fishery is considered to be marginal. Catch in B.C. fisheries in 1994 was 87% of the 1979-1993 catch average while total B.C.-Washington state catch was 7% greater than the 1979-1993 catch average. Yield options developed using a deterministic age-structured model are unchanged from recent years at 9,000-15,000 t for the offshore stock and 4,000-6,000 t for the Strait of Georgia-Puget Sound stock. Catch levels in both areas remain below the low-risk harvest levels.

The reviewer agreed with the recommendations and agreed that, provided landings did not change significantly, the Department should continue to monitor the

fishery as in the past. The reviewer recommended that the criterion for the yield range be inserted.

The Subcommittee also considered that these yield estimates will not change until more detailed data relating to stock structure and catch composition become available. A document is not recommended for next year.

Walleye Pollock (G95-8)

This is an interim assessment for walleye pollock. Catch tables have been updated to monitor changes in the fishery which continues to be active in particular in Minor Area 12 (Queen Charlotte Strait) and in Hecate Strait/Dixon Entrance. The demand for pollock as foodfish appears to be linked inversely to availability of more desirable species like Pacific cod and lingcod. Since 1981, landings of pollock were highest in 1987-88 and 1992-94 (Table 8.1), coincident with documented periods of low abundance of Pacific cod stocks off the west coast of Vancouver Island. The current groundfish management plan also affects demand. Most available species are regulated by trip limits, and since pollock in most areas are not quota or trip limited, they attract effort once limits of other species are reached. The walleye pollock fishery in the North Pacific and the Bering Sea is one of the largest fisheries in the world, thus there is a persistent international market for walleye pollock.

The coastwide catch of walleye pollock decreased substantially from 8,709 t in 1993 to 4,230 t in 1994 due to decreased demand. The 1994 incidental catch in the joint-venture hake fishery decreased to 130 t from 552 t in 1993. The range of sustainable yield options based on Gullands (1983) MSY model is 630 to 2,350 t for the Strait of Georgia (excluding Area 12) and 440 to 1,760 t for Dixon Entrance /Hecate Strait. A precautionary quota of 2,450 t or less 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.

The reviewer suggested that an estimate of 0.3 for M would be more appropriate for a coastal stock of pollock. The Subcommittee recommended that, while the author's assumptions about M being less than 0.2 may be accurate, the impact of an estimate of 0.3 should be explored in the next analysis. Furthermore, the Subcommittee suggested that for the next assessment the author explore the possibility of estimating M from published studies on the relationship of M/K.

The reviewer suggested that information on length frequency samples should be included. This suggestion was endorsed by the Subcommittee. The Subcommittee also requested that biomass trends in Alaskan fisheries, particularly that for S. E. Alaska be monitored and documented in the next assessment.

While the reviewer suggested harvest quotas be based on recent annual landings, the Subcommittee agreed with the author that it would be inappropriate to base recommended yields on recent harvests. With respect to recommended yields for the new fishery which had developed in the south coast, the Subcommittee recommended a yield range of 1,000-2,450 t. The upper limit is similar to recent landings. The Subcommittee suggested the lower limit to emphasize the concern over the limited area assumed to be responsible for productivity of this stock. The Subcommittee and the reviewer commented that this assessment cannot be expected to provide any greater resolution in future years without directed research such as surveys.

The Subcommittee accepted the remaining pollock yield recommendations as proposed for other areas.

Slope Rockfish (G95-9)

Slope rockfish as defined in previous assessments include Pacific ocean perch, redstripe rockfish, yellowmouth rockfish, and rougheye rockfish. Because of increased targeting by the trawl fishery on other rockfish species, preliminary information is added to this assessment for shortraker rockfish (*Sebastes borealis*) and thornyheads (genus *Sebastolobos*). As this is an interim assessment, there are no changes to recommended yields, which were based primarily on catch histories. However, catch caps determined from the mean of the 1993-94 catch are recommended for both shortraker rockfish and thornyheads. No assessment was conducted for Area 5E-N, pending a review of the experimental closure. Coastwide catches of Pacific ocean perch and yellowmouth rockfish increased 21% and 8% in 1994, respectively, while coastwide catches of redstripe rockfish and rougheye rockfish decreased 28% and 32%, respectively, reflecting the combined effects of rockfish aggregate management and port monitoring introduced in 1994. Overall, effort increased 6% in 1994, resulting in the highest values recorded, while the number of rockfish trips dropped by 22%.

The most recent major assessment was completed in 1993, including catch-age analyses of Pacific ocean perch in Goose Island Gully from 1963-92 and in Moresby Gully from 1978-92. These analyses identified large uncertainties in the estimates of current biomass and potential yield. New data were included in this assessment from a survey conducted in Goose Island Gully in 1994; the updated catch-age analysis resulted in a survey biomass estimate of 25,200 t, with corresponding yields as specified in previous assessments of 350 t to 1,800 t. Although this analysis suggests that yields at the higher end of the previous risk range (350-1,800 t) may be sustainable, caution is advised. For example, a different vessel was used in the 1994 survey and vessel effects alone could account for the higher measured abundance of Pacific ocean perch. Another survey is planned for 1995 to investigate vessel effects. In addition, levels of dumping and/or discarding are unknown, but could be high.

The reviewer felt that the document in general, incorrectly emphasized the likelihood of significant rebuilding of Pacific ocean perch stocks in Queen Charlotte

Sound. Specifically, there was concern over the interpretation of (1) prominent modes in age compositions and (2) research survey biomass estimates. In isolation, prominent modes in age compositions cannot be equated with strong year-classes. In a detailed treatment of the survey estimates, the reviewer concluded that biomass estimates from the two surveys conducted using commercial vessels, provide no evidence of an increase in biomass from 1984 to 1994.

The reviewer noted that this document, and in fact all PSARC assessments, should include a table documenting historic records of quotas and corresponding catches. The reviewer in attempting to do this reported that the harvests of Pacific ocean perch in 3C and Goose and Mitchell's gullies were well in excess of any yield recommendations and suggests that this should be discussed in this or some other PSARC document (i.e. Aggregate Management Review).

The Subcommittee agreed that there was no evidence of an increase or decline in Pacific ocean perch Goose Island Gully stock abundance from the 1994 survey since 1984, and that the document should be rewritten to reflect this. New stock reconstruction results using a q determined by surveys conducted by the G.B. Reed and the Eastward Ho in 1984, indicated that the current range of yield options were appropriate. The committee adopted the yield options presented. It was noted that due to discarding and non-reporting , the level of catch may have been large enough to limit rebuilding.

A survey is planned for September for this stock and it was suggested that September was not the most appropriate month for the survey due to changing sex ratios. Summer months would be the best.

The Subcommittee agreed that the average of 1994 and 1993 catches be used to set quotas for thornyhead and shortraker rockfish. The reviewer cautioned managers that since there are two species of thornyheads, there will be an increase in attempts to report thornyhead landings as longspine thornyhead. It was further suggested that the quota be implemented as a generic thornyhead quota until port sampling provides evidence that two species are being landed.

In light of considerable uncertainty due to the past mis-reporting of species, the managers are urged to adopt a conservative approach with redstripe rockfish quotas.

Shelf Rockfish (G95-10)

Shelf rockfish include widow, canary, silvergray and yellowtail. Originally a full assessment was scheduled for the current PSARC review cycle, but this is an interim assessment. In this report biological data are updated for the widow, canary, and silvergray rockfish and there is a catch-at-age analysis for the coastal stock of yellowtail rockfish.

An assessment of widow rockfish is included for one coastwide stock. Yellowtail rockfish are treated as two stocks. The "coastal" stock covers central Vancouver Island to the Alaska border. The "boundary" stock combines southern Vancouver Island (PMFC Area 3C) with northern Washington. Canary rockfish are treated as two stocks, west coast Vancouver Island (PMFC Areas 3C and 3D) and Queen Charlotte Sound (PMFC Areas 5A and 5B, excluding Moresby Gully). Canary rockfish fisheries are insignificant in northern B.C. Silvergray rockfish is treated as three stocks, the south and central stocks being similar to the canary rockfish stock definition, while the fishery of Moresby Gully plus Hecate Strait is treated separately.

Revised assessments for eight shelf rockfish stocks are presented. The yield range for silvergray rockfish in PMFC Areas 3C+3D (Vancouver Island) remains the same at 150-425 t. The range for silvergray rockfish in 5A+5B (Queen Charlotte Sound) is changed from 375-725 to 350-700 t, and the 5C+5D (Hecate Strait) range for silvergray rockfish is lowered from 150-425 to 125-400 t. Recommended yield ranges for the canary rockfish stock of Area 3C+3D is 350-525 t, up from 200-375 t. Under aggregate management, silvergray rockfish and canary rockfish landings were 213% and 145% respectively of the sum of the high-risk yields. The recommended coastwide yield range for widow rockfish is unchanged at 1,100-3,000 t. The yield recommendations for the yellowtail rockfish stock of PMFC Area 3C fishery (south Vancouver Island) is combined with the northern Washington fishery (PMFC Areas 3C-U.S. and 3B). The range is unchanged at 1,000-2,000 t for the combined U.S. and Canadian fishery. The yield recommendation for the remaining yellowtail rockfish fishery (PMFC Areas 3D-5E) is raised slightly from 2,500-4,900 t to 2,750-5,100 t. A total of 374 t of yellowtail rockfish was captured in Area 3D as bycatch during the offshore hake fishery in 1994. This is the first time that bycatch in this fishery has been significant for this stock.

The Subcommittee was concerned that quotas may not be sufficiently restrictive. The Subcommittee also noted that it was necessary to quantify discards. More biological samples are needed if the accuracy of assessments is to improve, but it was realized that the costs of sampling the smaller stocks will be high. There was an indication of overages and underages in the past year resulting from aggregate management but the author has not found evidence of overfishing that would be large enough to require a reduction in yields. The Subcommittee and the author considered that the CPUE analysis may be affected by the movement of fisheries but noted that there are problems with dividing the data finer. Also, the search time associated with most species is limited so looking at it from this level is not practical. A question was raised about the reduced abundance of older females of canary and yellowtail rockfish and whether they have moved out of fishing areas or whether they have higher mortality. There is no indication that there is any movement out of the fishing areas and no aggregations of older females are observed elsewhere. Recommended yield options are generally the same as in the past.

Inshore Rockfish (G95-11)

A detailed assessment of inshore rockfish was presented in 1991 . In addition to table updates, changes presented in this document include 1994 fish slip information by species, 1994 'Zn' logbook summaries and the presentation of length and age data from biological samples taken from the commercial fishery. This assessment includes the issues pertinent to the entire coastwide fishery as well as a discussion of the fisheries inside and outside the Strait of Georgia. Limited entry licensing has reduced the 'Zn' fleet size from over 2183 licences in 1991 (592 inside, 1,591 outside) to 257 licences (74 inside, 183 outside).

Coastwide commercial hook and line rockfish catch was 1956 t in 1993 and preliminary figures for 1994 are 1942 t. In 1994 catches declined off the west coast of Vancouver Island and the north coast areas and increased in the Strait of Georgia and off the Queen Charlotte Islands, relative to 1993. In general, the stock condition is poor in the Strait of Georgia, and unknown in other areas. Yield levels (tonnes) for each statistical area were determined, as in the past, by multiplying ratios of catch to habitat (tonnes per km^2) by the size of the rockfish habitat within each statistical area (km^2).

The reviewers' comments were primarily editorial. The Subcommittee requested that the 1994 and 1995 quotas be presented in tabular form with the proposed 1996 quotas. Grouped quotas should not be presented in the document because the biological basis for grouping quotas was unclear. The Subcommittee requested that documentation of the Area 7 rotational fishery be included in the next discussion.

The Subcommittee discussed the appropriateness of current assessment and management strategies for inshore rockfish. They noted the localized nature of stocks and that in some localities catches were above the high risk quotas. Concern was expressed that data requirements to conduct traditional assessments were large and expectations for acquiring these data were poor. Given the increased pressure on these stocks and the Department's limited ability to assess and manage stocks at a localized level, the Subcommittee recommends that a special working group be established to develop recommendations for alternative assessment and management strategies to address the developing problem of localized overfishing. Examples of possible solutions include but are not limited to the establishment of marine protected areas and rotational closures. The Subcommittee noted that this special working group could be combined with the group that will review the state of the lingcod stocks relative to the biological objectives proposed in the Biological Objections Working Group Report and examine the potential of using closed areas to rebuild stocks.

Aggregate Management (G95-12)

In this report the term aggregate management rather than assemblage management is used.

Starting in 1994 the Region began to manage rockfish on the basis of species aggregates rather than on an individual species basis. This Working Paper reviews the conceptual basis for aggregate management and the reasons why this approach to rockfish management was adopted. The paper also reviews the performance of the fishery between 1993 and 1994.

Single species fisheries management generally attempts to maintain yield from each species at some optimal sustainable level of production. Aggregate management attempts to maintain yield from a group of species at some optimal sustainable level, recognizing that individual species will contribute in varying amounts to the aggregate yield. Each approach requires different assumptions about the effectiveness of management actions, environmental forcing, and the existence of long-term equilibria.

Under single species management, Pacific Region rockfish trawl fisheries were characterized by technological inability to harvest individual species selectively. The mixed species catches led to a number of biological and economic problems. Biological problems included large quota overages, significant dumping and discarding, misreporting, and poor quality information. Economic problems included irregular supply of fish, poor quality, and inefficiencies in harvesting.

The authors of the working paper concluded that aggregate management appears to have reduced overages, dumping and discarding. However, the combined effects of aggregate management and the new port monitoring program which was introduced at the same time cannot readily be separated. Overall, quality of information has improved and misreporting may also be lower. Some individual species appear to be overfished substantially, relative to their single-species contributions to the aggregate quotas, however biological evidence of this overfishing was not presented in other working papers during the Subcommittee review. Other species were harvested at or below this level.

With the improvements in data quality, past estimates of production and target harvest must be reassessed. Changing prices may also affect the performance of the aggregate fishery. Both these concerns should be explored further as part of a fuller evaluation of the aggregate management program.

Reviewer number 1 noted that the data collection programs necessary to evaluate the program (e.g. mandatory on-board observers) did not appear to have been in place either before or after implementation. The reviewer therefore believed that it was not possible to evaluate the success of the management initiative at this time.

Reviewer number 2 noted that data availability and limitations precluded definitive statements concerning the success or failure of this initiative, but felt that aggregate management had not performed significantly worse than single species management. The reviewer also noted that aggregate management did not appear to have created significant conservation concerns, although a longer data series would be required to determine if the species harvested above their sustainable yield levels during assemblage

management were in serious decline. The reviewer recognized the need for evaluation of the status of individual species within the aggregates and potential adjustments of the aggregate compositions, particularly if price differentials among species influence removals.

Reviewer number 3 believed that evaluation of the success or failure of this program is premature, particularly in view of unsatisfactory results of the aggregate management program during 1995. The reviewer expressed strong concerns about the negative impacts of overages by species and stocks, area concentration of fishing effort, and discarding. Discarding to meet aggregate limits and high-grading at sea in response to price differentials is reported to be increasing. Relinquishments, as an index of mismatches in the composition of the catches compared to the aggregate definitions, are also increasing. The reviewer believed that the program has failed to achieve the intended goals of reducing discarding or optimizing harvest among species or stock groups. The reviewer further stated that there are significant concerns that assessing, managing, and harvesting an assemblage of species will inevitably result in depletions of some stocks and/or species.

The Subcommittee held an extensive discussion about the conceptual basis for the aggregate management program. The shortcomings of the initiative to date concerning overages and discarding were acknowledged. The shift in aggregate definitions and price differentials among species have complicated the situation in 1995, resulting in increased reports of discarding. Area concentration of effort has been a particular concern. It is also unclear whether the underlying biological basis of the initiative in terms of continuing yield from rockfishes at the stock level has been clearly articulated. The Subcommittee noted that we do not have a rigorous method for evaluation of the success of such programs, compared with those that we apply to stock assessment results. The influence of economics on the distribution and magnitude of fishing effort by species and areas is significant but we do not appear to have implemented measures that mitigate these effects on the performance of the management program. The Subcommittee noted that in other jurisdictions measures have been put in place to provide such tools (e.g. observer coverage, on-board camera/GPS systems, etc.) to allow evaluation of new management measures, and that they should be applied in the case of aggregate management.

Subcommittee members questioned the basis used in the document for evaluating the success of the program, noting that species and stock overages relative to estimated yields are a serious concern. Systematic estimation of discarding is not in place and precludes use of one of the measures identified as an evaluation criterion. Similarly, no rigorous methodology has been applied to relate economic performance and management measures. The Subcommittee notes that economic, management, and stock assessment evaluations of such programs require notably different data and evaluation criteria. PSARC's concern should be the biological performance of the stocks and appropriate criteria must be identified and data collection programs initiated. The Subcommittee also noted that the persistent requests from industry for revised species

compositions of the assemblages indicates that industry does not have a clear understanding of the basis and impacts of this initiative.

The Subcommittee expressed concern about the overexploitation of individual stocks. In addition, while it was agreed that aggregate management could limit the simultaneous overexploitation of stocks, measures to prevent sequential overexploitation of stocks were not incorporated into the plan. In particular, the development of coastwide comprehensive observer programs was identified as a major component of improving our ability to evaluate any such management program. The Subcommittee notes that alternative frameworks for the implementation of aggregate management, concerning the advisability of summing individual quotas to arrive at assemblage totals and measures to avoid area-specific concentration of fishing effort, need to be developed. The Subcommittee recommends that a Working Group, including Operations and Science staff, be formed to develop explicit criteria for the evaluation of this and any such management measures, and to identify the data collection programs that are fundamental to using such criteria. The Subcommittee also notes a further need for the Region to develop management objectives for rockfish stocks and the associated evaluation criteria.

The Subcommittee accepted the document subject to major revisions and further review concerning statements about the performance of the program.

Halibut Bycatch (95-13)

The Canadian Halibut bycatch reduction plan that was submitted at the 1994 Annual Meeting of the International Pacific Halibut Commission (IPHC) included a requirement for PSARC to review halibut bycatch mortality estimates. For this Subcommittee meeting documentation of the halibut bycatch in Canadian groundfish fisheries was sent to the staff of IPHC for review.

The reviewer was unable to evaluate bycatch estimates based on observer data from the west coast of Vancouver Island, as none was available due to insufficient data. Some halibut-to-groundfish catch ratios and the halibut CPUE for WCVI seemed higher from preliminary observer data than from previous estimates, which could indicate that bycatch may be higher than currently estimated. More comprehensive observer data in the near future, should help to resolve this.

The reviewer noted that the Canadian plan to reduce bycatch mortality of Pacific halibut by 50% from 1991 levels to 1 million pounds by 1997 represents a significant commitment to bycatch reduction. Real bycatch mortality savings will be realized through the program if the bycatch mortality is reduced as indicated. The Observer Program implemented in 1991 has provided substantially less information than anticipated, but has potential to be valuable. At its present level of coverage, the Observer Program will not be useful in directly monitoring the halibut bycatch mortality limit. Initial reduction in bycatch mortality of 21% reported through 1994 resulted primarily from changes in estimation procedures, especially reductions in discard mortality rates, rather than from

actual reductions. Some bycatch reduction resulted from lower Pacific cod quotas, but the reviewer could not evaluate the effectiveness with the data provided. It also was impossible with the information at hand to determine the degree of actual bycatch mortality reduction that has occurred since 1991.

The Subcommittee discussed the Canadian plan to reduce halibut bycatch mortality in the domestic trawl fishery. In summary, DFO committed to a 50% reduction from the 1991 halibut bycatch mortality level to 1 million pounds by 1997. The DFO bycatch reduction program implements a bycatch mortality limit, and reduces the limit over time. Under this approach, there is a need to find ways to harvest groundfish with less halibut bycatch mortality, or decrease the groundfish harvest when the halibut bycatch limits are reached.

The Subcommittee discussed aspects of the program including optimum levels of observer coverage required, and potential impacts on other groundfish fisheries. The Subcommittee recommended that a document be prepared and submitted to the next review meeting which includes the methodology used to estimate bycatch mortality as well as the mortality estimates.

7. ADDITIONAL SUBCOMMITTEE DISCUSSIONS

(a) All PSARC assessments should include a table documenting historic records of quotas and corresponding catches.

(b) Major assessments should include a review of sampling.

(c) The Subcommittee chair will arrange a meeting with the Head of the Stock Assessment Division to arrange a meeting with L. Richards, G. McFarlane, B. Leaman, R. Beamish and B. Ackerman to consider the most appropriate manner to address the resource conservation issues in the Strait of Georgia which include the resource issues of rockfish and lingcod and bring forward a recommendation to the Steering Committee.

Table 1. Recommended Yield Option Summary

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

AREA	SPECIES	1995 YIELD OPTIONS	1996 YIELD OPTIONS
4B	Lingcod	Zero yield	Zero yield (no options proposed)
Minor Area 12	Lingcod	Winter closure 65 cm size limit	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
3D	Lingcod	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
5C/D	Lingcod	Low risk yield 1000 t	Low risk yield 1000 t
4B	Pacific cod	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
5A/B	Pacific cod	No options proposed	No options proposed
5C/D	Pacific cod	Low risk yield 1870 t Sustainable yield 3040 t High risk yield 5520 t	No fishery No fishery No fishery
5E	Pacific cod	No options proposed	No options proposed
Coastwide	Petrale sole	No options proposed	No options proposed
4B	Flatfish	No options proposed	No options proposed
3C/D	Dover sole	Low risk yield 1300 t High risk yield 2000 t	Low risk yield 1300 t High risk yield 2000 t
5A	Rock sole	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
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)

Table 1 (Cont'd)

AREA	SPECIES	1995 YIELD OPTIONS	1996 YIELD OPTIONS
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)
5C-5E	Dover sole	Low risk yield 800 t High risk yield 1200 t	Low risk yield 800 t High risk yield 1200 t
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
South Stock North Stock	Sablefish	No options proposed No options proposed	Low risk yield 275 t High risk yield 1000 t 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
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
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
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
4B	Walleye pollock	Low risk yield 1300 t High risk yield 2700 t	Low risk yield 630 t High risk yield 2350 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
Area 12	Walleye pollock	No yield options are proposed	Low risk yield 1000 t High risk yield 2450 t
Coastwide (Area 3C to 5E-S)	Pacific ocean perch	Low risk yield 3400 t High risk yield 5700 t	Low risk yield 3400 t High risk yield 5700 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
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

able 1 (Cont'd)

AREA	SPECIES	1995 YIELD OPTIONS	1996 YIELD OPTIONS
Coastwide (Area 3C to 5E-S)	Redstripe rockfish	Low risk yield 950 t High risk yield 2570 t	Low risk yield 950 t High risk yield 2570 t
Coastwide (Area 3C to 5E-S)	Yellowmouth rockfish	Low risk yield 1100 t High risk yield 1850 t	Low risk yield 1100 t High risk yield 1850 t
Coastwide (Area 3C to 5E-S)	Rougheye rockfish	Low risk yield 500 t High risk yield 900 t	Low risk yield 500 t High risk yield 900 t
Area 3C to 5E-S	Shortraker rockfish	No options proposed	Average of 1993 and 1994 catches
Area 3C to 5E-S	Thornyhead rockfish	No options proposed	Average of 1993 and 1994 catches
5E(N)	Pacific ocean perch	Experimental fishing area	Experimental fishing area
5E(N)	Yellowmouth rockfish	Experimental fishing area	Experimental fishing area
5E(N)	Rougheye rockfish	Experimental fishing area	Experimental fishing area
5E(N)	Redstripe rockfish	Experimental fishing area	Experimental fishing area
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
3D-5E	Yellowtail rockfish	Low risk yield 2500 t High risk yield 4900 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
3C/D	Silvergray rockfish	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
5C/D	Silvergray rockfish	Low risk yield 150 t High risk yield 425 t	Low risk yield 125 t High risk yield 400 t
5E(S)	Silvergray rockfish	No options proposed	No options proposed
3C/D	Canary rockfish	Low risk yield 175 t High risk yield 550 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

Table 2A. 1996 recommended yield options (t) by statistical area for red snapper.

Statistical Area	1995		1996	
	Low	High	Low	High
Strait of Georgia				
12	22	33	22	33
13	7	11	7	11
14	12	18	12	18
15	6	9	6	9
16	6	8	6	8
17	3	5	3	5
18	5	7	5	7
19	7	11	7	11
20	11	16	11	16
28	3	4	3	4
29	9	12	9	14
Grouped quota	25	38	-	-
West Coast				
11,111	166	222	166	222
21,121	27	36	27	36
23,123	117	157	117	157
24,124	96	128	96	128
25,125	61	82	61	82
26,126	42	56	42	56
27,127	85	113	85	113
Grouped Quota	188	251	-	-
Queen Charlotte Islands				
1,101	88	118	88	118
2,102,130,142	154	205		
2, 102			125	166
142			17	23
30, 130			12	16
Grouped Quota	242	323	-	-
North Coast				
3,103	6	8	6	8
4,104	19	27	19	27
5,105	23	31	23	31
Grouped Quota	48	66	-	-

Table 2A (cont'd)

Statistical Area	1995		1996	
	Low	High	Low	High
Central Coast				
6,106	99	133	99	133
7,107	83	112	83	112
8,108	63	85	63	85
9,109	16	22	16	22
10,110	25	33	25	33
Grouped Quota	99	133	-	-

Table 2B. 1996 recommended yield options (t) by statistical area for rockfish.

Statistical Area	1995		1996	
	Low	High	Low	High
Strait of Georgia				
12	68	103	68	103
13	29	44	29	44
14	27	40	27	40
15	16	25	16	25
16	16	24	16	24
17	23	36	23	36
18	16	24	16	24
19	24	37	24	37
20	14	21	14	21
28	11	17	11	17
29	22	34	22	34
Grouped Quota	176	269	-	-
West Coast Vancouver Island				
11,111	49	66	49	66
21,121	11	15	11	15
23,123	35	46	35	46
24,124	50	67	50	67
25,125	25	33	25	33
26,126	26	35	26	35
27,127	25	33	25	33
Grouped Quota	125	167	-	-
Queen Charlotte Islands				
1,101	16	21	16	21
2,102,130,142	49	66		
2, 102			48	64
142			1	1
30, 130			0	1
Grouped Quota	65	87	-	-
North Coast				
3,103	4	5	4	5
4,104	34	46	34	46
5,105	48	64	48	64

Table 2B (Cont'd)

Statistical Area	1995		1996	
	Low	High	Low	High
Grouped Quota	52	69	-	-
Central Coast				
6,106	50	67	50	67
7,107	34	45	34	45
8,108	74	99	74	99
9,109	6	7	6	7
10,110	15	20	15	20
Grouped Quota	84	112	-	-

Table 3. Total Canadian groundfish landings (t) by species, 1984-1994

Species	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1984-93	1994[b]
English sole	812	692	452	755	879	1,041	1,266	1,171	1,319	1,770	1,016	1,298
Rock sole	525	430	454	887	1,960	2,066	2,264	3,414	3,094	3,014	1,811	2,209
Petrale sole	417	336	416	445	790	952	1,066	793	603	579	640	483
Dover sole	1,148	963	1,167	633	1,281	2,149	2,382	2,217	2,763	3,957	1,866	3,917
Rex sole	219	205	87	83	145	140	134	59	93	240	141	272
Starry flounder	170	66	54	65	110	123	143	146	145	105	113	101
Turbot	369	764	895	1,193	375	609	2,635	2,286	3,573	4,020	1,672	4,038
Other flatfish	141	161	215	232	147	50	51	87	225	252	156	227
Pacific cod	3,465	2,342	3,650	13,917	11,015	9,149	6,463	11,914	10,321	8,096	8,033	3,538
Lingcod	3,688	5,668	3,827	3,591	3,462	3,980	5,219	5,385	4,370	5,236	4,443	4,475
Sablefish[c]	3,855	4,275	4,668	4,719	5,563	5,493	5,038	5,531	5,008	5,108	4,926	5,096
Pollock	800	1,895	577	1,270	1,111	443	939	2,597	3,426	7,974	2,103	4,224
Hake	4,600	6,055	6,802	13,275	6,054	8,682	10,609	23,175	27,956	15,959	12,317	33,293
Ocean perch	6,698	6,069	5,914	6,335	6,929	6,004	5,761	4,331	4,056	4,565	5,666	5,626
Other rockfish	8,512	11,709	19,040	18,177	20,399	18,437	22,885	19,428	22,248	20,403	18,124	17,683
Misc. species	175	192	245	344	353	172	122	143	203	190	214	286
Hagfish	-	-	-	-	66	829	213	23	60	-	119	-
Dogfish	2,510	2,815	3,289	3,801	5,483	2,780	4,194	3,126	2,335	722	3,106	1,760
Animal food	161	309	255	188	130	127	17	tr.	tr.	149	134	-
Reduction	244	214	175	210	581	353	210	380	1,003	770	414	72
Total	38,509	45,160	52,182	70,120	66,833	63,579	71,611	86,206	92,801	83,109	67,011	88,598

[a] Does not include catches from joint-venture fisheries, see Table 4.

[b] Preliminary data.

[c] Sablefish catches from 1992 - 1994 do not include catches for special permit fisheries to offshore seamounts. This amounted to an additional 325 t in 1992, 52 t in 1993 and 107 t in 1994. Previous years may include trips to offshore seamounts.

Table 4. Joint-venture catches of groundfish off B.C. in 1994

Nation	Species	Quota (t)	Catch (t)
Poland	Hake	48,500	47,715
China	Hake	23,500	22,456
Russia	Hake	14,000	13,983
Total[b]	Hake	86,000	84,154
	Pollock	incidental	166
	Pacific ocean perch	incidental	3
	Other rockfish	incidental	1,291
	Other species	incidental	184

[a] Catches (converted from processed weights) are reported by foreign processing vessels and cannot be verified by weight tallies.

[b] Catches for incidental species are not available by nation for 1994.

APPENDIX 1. PARTICIPANTS AT THE GROUNDFISH SUBCOMMITTEE MEETING, JULY 25-27, 1995.

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

NAME	AFFILIATION
Internal (DFO)	
B. Ackerman	Operations Branch, RHQ Vancouver
J. Fargo	Stock Assessment Division, PBS
V. Haist	Stock Assessment Division, PBS
M. Henderson	Stock Assessment Division, RHQ Vancouver
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
K. Rutherford	Stock Assessment Division, PBS
M. Saunders	Stock Assessment Division, PBS
R. Stanley	Stock Assessment Division, PBS
B. Thomson	Stock Assessment Division, PBS
L. Yamanaka	Stock Assessment Division, PBS
External	
P. Sullivan	International Pacific Halibut Commission, Seattle
B. Trumble	International Pacific Halibut Commission

APPENDIX 2. LIST OF REVIEWERS OF WORKING PAPERS PRESENTED AT THE GROUNDFISH SUBCOMMITTEE MEETING, JULY 25-27, 1995.

REVIEWERS:

Internal (DFO):

G. Buechler	Offshore Division, Vancouver
J. Fargo	Stock Assessment Division, PBS, Nanaimo
V. Haist	Stock Assessment Division, PBS, Nanaimo
B. Holtby	Stock Assessment Division, PBS, Nanaimo
R. Kronlund	Stock Assessment Division, PBS, Nanaimo
S. McFarlane	Stock Assessment Division, PBS, Nanaimo
D. Noakes	Aquaculture Division, PBS, Nanaimo
J. Rice	Stock Assessment Division, PBS, Nanaimo
M. Saunders	Stock Assessment Division, PBS, Nanaimo
R. Stanley	Stock Assessment Division, PBS, Nanaimo
J. Schweigert	Stock Assessment Division, PBS, Nanaimo
B. Thomson	Stock Assessment Division, PBS, Nanaimo
D. Welch	Ocean Science and Productivity Division, PBS, Nanaimo
L. Yamanaka	Stock Assessment Division, PBS, Nanaimo

External:

R. Hilborn	University of Washington, Seattle, Washington
A. Parma	International Pacific Halibut Commission, Seattle
G. Stauffer	National Marine Fisheries Service, Seattle, Washington
P. Sullivan	International Pacific Halibut Commission, Seattle
R. Trumble	International Pacific Halibut Commission, Seattle
Consultants	Triton Environmental, Vancouver

PACIFIC HERRING

I. STEERING COMMITTEE REPORT

The Steering Committee met September 26-27, 1995 at the Pacific Biological Station to review the Subcommittee report. The Report was accepted, with the following comments and recommendations.

STOCK STATUS AND YIELD RECOMMENDATIONS

Major herring stocks are managed by a fixed harvest rate policy in conjunction with a CUTOFF level. CUTOFF levels are set at 25% of unfished average biomass. Catch levels are set at 20% of forecast biomass unless forecast is close to or below CUTOFF levels. Assessments of major stocks are conducted using both age-structured (AS) and escapement (ESC) models.

Queen Charlotte Islands

Steering Committee concurred with the estimation of stock status and forecast for poor recruitment in 1996, and endorsed the Subcommittee's recommendation for zero catch. It was noted that reporting of Section 35 catches was incomplete for 1995, similar to the previous year. Steering Committee advises that the absence of data on removals by all fisheries compromises our ability to assess and manage the stock.

Prince Rupert District

Steering Committee concurred with the stock status, forecast for average recruitment and recommended yield option of 4230 t. Steering Committee notes that the recommendation is based solely on the ESC model. However, the Subcommittee did continue its efforts to resolve the differences in stock status between the AS and ESC models for this area, by changing weighting and partitioning some of the data for the Kitkatla area. Steering Committee recommends that the Subcommittee add information on historical biomass used to calculate quotas for previous years, in future reports.

Central Coast

Steering Committee agreed with the Subcommittee prediction of average recruitment and the recommended yield option of 5150 t for 1996. Steering Committee notes that there has been poor recruitment in two of the last three years and the concern of the Subcommittee that, if 1994 year class is poor, the stock will be at or near CUTOFF. This concern will be exacerbated if the 1993 cohort also recruits in below average numbers, so that the stock could be at or near CUTOFF for the 1997 fishery.

Strait of Georgia

Steering Committee concurred with stock status estimates and the recommended yield option for the Strait of Georgia. Both assessment models indicate a decline in

abundance in Strait of Georgia since 1993, however the stock is still healthy with 1995 abundance at or slightly below abundance of 1994. Based on average recruitment the recommended yield is 12,670 t.

In terms of forecasting, a juvenile survey indicated that recruitment in 1995 may be below average but the relationship of juvenile abundance in surveys and subsequent recruitment is not yet established. Steering Committee notes the opportunity and need to integrate information from all survey work that captures larval or juvenile herring into the evaluation of this relationship.

West Coast Vancouver Island

Steering Committee concurred with the assessment of stock status and agreed that recruitment is likely to be poor for 1996. The Steering Committee endorsed the Subcommittee's conservative recommended yield option of 2040 t. This conservative recommendation also recognizes the Subcommittee's concern that the stock is in a low phase of productivity, and that data are insufficient to recommend an increase in the quota above the 1995 level. Steering Committee advises further that harvest control procedures need to be implemented to prevent quota overruns for this stock.

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 following major Subcommittee recommendations:

- that further work on recruitment forecasting be carried out
- that appropriate steps are taken to ensure accurate and timely catch data is submitted by all users
- that herring fisheries in 1996 be managed to minimize quota overruns, particularly in areas of low stock abundance (such as the west coast of Vancouver Island).

The remaining recommendations in Appendix 4 of the Subcommittee report are referred back to the Subcommittee for consolidation and delivery in order of importance. Steering Committee requested that future Subcommittee reports limit the Recommendation section to items upon which the Subcommittee requests advice from, or action by, the Steering Committee or the Regional Management Executive Committee.

II. PSARC HERRING SUBCOMMITTEE REPORT

The Subcommittee met on September 6-8, 1995 to derive a consensus on the status of herring stocks in 1995 and to forecast abundance and potential catch levels for 1996. 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 1994 recommendations (Appendix 5); and summaries, reviews, and Subcommittee discussions of working papers (Appendix 6) are attached.

The objectives of the meeting were to:

1. Review the stock assessment source documents and other pertinent stock assessment information contained in the working papers, discuss stock status in 1994/1995, forecasts of abundance in 1995/96, and recommend 1996 catch levels for consideration by the PSARC Steering Committee.

2. Identify areas where further assessment work is most needed for management purposes and develop recommendations regarding these areas (Appendix 4).

3. Develop proposals for Industry funded herring research.

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.
- Quota recommendation.

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.

1. 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 minimize 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.

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.

2. 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. Evaluation of the impact of fishing on the spawning beds is incomplete. In 1995 the number of eligible seine and gillnet licences were 252 and 1319 respectively. Of these, only 180 seines and 864 gillnets were fished because a substantial number of licences were inactivated for double licence fisheries and for SOK. Total roe landings have averaged 35,600 t over the last five years. The total landed value of the commercial roe herring catch in 1994 was $70 million, and for the spawn-on-kelp fishery was $17 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, and roe catches (thousands of tonnes) since 1983 are listed below:

		1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995[d]
QCI	PSARC[c]					2.2	0.0	2.7	7.1	4.6	3.6	3.5	1.0	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
	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
PRD	PSARC[c]					6.4	8.7	8.5	4.7	3.9	6.1	11.0	6.8	4.4
	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
	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
C.C.	PSARC[c]					4.6	4.8	9.7	8.6	7.6	7.5	14.0	14.0	10.9
	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
	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
GULF	PSARC[c]					10.6	9.3	9.9	11.0	14.0	11.8	18.3	19.5	13.9
	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
	Catch	16.4	10.2	6.2	0.2[a]	9.1	7.5	8.4	8.1	10.5	11.6	13.1	16.7	12.1
WCVI	PSARC[c]					9.7	7.9	10.5	7.2	6.8	5.8	3.4[e]	7.3	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
	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
PSARC	Total[c]					33.5	30.7	41.3	38.6	36.9	34.8	50.2	48.6	31.2
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
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

* 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-roe fisheries;
[d] 1995 catch data are hail estimates only.
[e] Catch recommended not to exceed that for 1992.

3. STOCK STATUS AND FORECASTS FOR MAJOR ASSESSMENT REGIONS

For northern B.C., the stock assessment regions used for the 1995 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 1995 and forecast abundance for 1996, 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 1951-95 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:

Catch = Weighted run - 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 structure model only. The current year's assessment was further refined by providing a weighted Cutoff as determined from simulations of the age structure and escapement models populations reconstructions. However, the Subcommittee has agreed to retain the 1995 Cutoffs, rather than using the revised estimates, in deriving quotas for 1996. This was done to provide some stability to assessment procedures. A more extensive review of the Cutoff levels is anticipated for the 1996 assessments.

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. Annual catches by the roe fishery declined from 7800 t in 1990 to 2700 t in 1993. In 1994, a small quota was provided for Section 35 and SOK fisheries only because forecast abundance was close to the Cutoff level. In 1995, forecast abundance was below Cutoff so fishing was limited to Section 35 harvest only.

In general, the quality of the data available for the Queen Charlotte Islands in 1995 is good. All major spawns were surveyed by SCUBA methods; however, biological samples were limited to a small number acquired by the seine test vessel in the area.

The Subcommittee notes that no record of Section 35 harvest has been submitted for this area in 1994 and 1995. Catch data is an important component of assessment models which provide the basis for advice on herring stock status. It is crucial that all sources of catch be documented.

Both the age-structured and escapement Models suggest that the spawning stock biomass in the Queen Charlotte Islands has been declining since 1990 and remains below the Cutoff level. Spawn indices generally support the declining trend though there was a slight increase in 1995.

Estimates of year class strength from the two analytical models indicate that the 1989 year class is still dominant as age 5+ fish. However, the three most recent year classes are poor and five of the last seven year classes have been poor. Though the showing of age 1+ fish in 1995 provides some optimism for stronger recruitment in 1996, the Subcommittee recommends that the poor recruitment option be selected because of low stock productivity demonstrated in recent years.

To forecast stock abundance for 1996, the Subcommittee adopted a 50:50 weighting of the forecasts from the two analytical models. Assuming poor recruitment (1993 year class), the forecast pre-fishery biomass in 1996 is 6,690 t. Since the Cutoff level is 10,700 t ***the recommended catch is zero.***

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 not exceeded 9,000 t, and in 1983 no roe-herring catch was taken from this area. For the past five years, annual roe harvests have been approximately 4,300 t.

All major spawns in the Prince Rupert District were surveyed by SCUBA methods, and it is believed that no significant spawns were missed. Sales slip catch data appears to be complete; some of Section 35 catch has been reported, and the level of reporting is better than last year. Biological sampling coverage was thorough in Area 5 but a limited number of seine test samples were obtained from Areas 3/4. There was a lack of consistency in age composition between Areas 3/4 and Area 5, possibly resulting from low sampling effort in Areas 3/4.

The escapement and age structure models both indicate stock abundance has been declining since 1993 as the strong 1988 and 1989 year classes decrease in the population. The two models do not agree on the absolute value of herring abundance with the age structure estimate almost double the estimate by the escapement model. Abundance estimates by the age structure model are considered to be unreasonably high. An attempt was made to obtain more plausible estimates by providing greater weight to spawn data in the model and by down-weighting age data from Kitkatla. Revised age structure estimates agree more closely with the escapement model but further analysis is required to identify the source of bias. The Subcommittee recommends applying 100% weighting to the escapement model estimate of abundance (18,800 t) in 1995.

The declining trend in herring abundance is supported in part by spawn indices which declined between 1992 and 1994, and remained stable in 1995. It is the perception of fishery managers that observed abundance in Area 3/4 was similar to 1994, but there is concern that abundance in Area 5 is at low levels.

An analysis of age composition of the stock indicates the 1990 and 1992 year classes were of average strength and the 1991 year class was poor. The Subcommittee had no evidence on which to select a recruitment assumption other than average. The forecast abundance for 1996 based entirely on the escapement model is 21,160 t. At a harvest rate of 20%, the recommended fishery catch is 4,230 t.

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 not exceeded 15,000 t. Recent catches increased to a peak of 12,400 t in 1994, then declined to 10,000 t. Over the last five years catches have averaged 9,700 t.

Data quality in 1995 is considered to be good. All major spawns were surveyed, the majority by dive survey, with the exception of the Kwakshua Channel area. Sampling intensity for age composition was similar to the levels obtained in recent years. There has generally been good agreement between age structure and escapement model estimates of abundance in the Central coast. Both models indicate the stock is declining from an historic high level.

The trend of declining abundance is supported by observed declines in peak soundings. Spawn indices have declined as well between 1992 and 1994 but increased in 1995.

Assuming average recruitment (1993 year-class), the forecast pre-fishery biomass in 1995 is 25,770 t. At a harvest rate of 20%, the recommended catch for 1996 is 5,150 t.

The Subcommittee notes that year class strength in two of last three years has been poor, resulting in the observed population decline. Another year of poor recruitment (1994 year class) will likely leave the central coast stock at or near Cutoff level.

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). Since 1972 herring catches have generally ranged between 8,000 and 18,000 t. The area was closed to roe-herring fisheries in 1986, due to stock conservation concerns. The stock rebuilt rapidly after the closure to record high levels in 1992 and 1993. Roe herring harvests have increased from 8,100 t in 1990 to a peak of 16,700 t in 1994, then declined to 12,100 t in 1995. Over the last five years landings have averaged 12,800 t.

All the catch data were reported, and all major spawns were surveyed in 1995. Biological sampling was thorough and the age-compositions were consistent throughout the Strait of Georgia.

Both assessment models indicate abundance has declined in the St. of Georgia from a record high in 1993. All stock abundance indicators depict 1995 abundance at or slightly below the abundance of the previous year. Fisheries managers and charter skippers agree that the stock is still healthy.

The strength of recruiting year classes were average in 1993 and 1994, but poor in 1995. A Strait of Georgia juvenile survey indicates that recruitment in 1996 will not be good; however, there is not yet a sufficient time series to accurately correlate juvenile abundance with subsequent recruitment.

The Subcommittee adopted an equal weighting of the two analytical models to obtain a stock forecast for the Strait of Georgia. Based on an assumption of average recruitment the forecast pre-fishery stock biomass is 63,350 t, which yields a potential catch of 12,670 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 concerns about stock abundance. 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; for the last five years the catch has averaged 5,100 t. In 1995, the recommended harvest was less than the 20% level because the forecast biomass was near Cutoff. As well, special management measures were instituted to control catch in the fishery.

Data quality was good in 1995. All major spawns were surveyed by diving and sampling for age composition was adequate.

Both assessment models indicate a decline in abundance from a peak in 1989, although the escapement model indicates a slight increase in 1995. The age structure model indicates that 1995 abundance is below the Cutoff level. The present biomass level is the lowest in the roe fishery time series and can be attributed to poor recruitments in six out of the last seven years. The last strong year-class in this stock assessment region

occurred in 1985 and this age class is now at negligible levels in the stock. Spawn indices indicate abundance in 1995 is similar to the previous year.

Recruitment forecasts based on data from an offshore trawl survey and from an analysis of environmental risk factors indicate there is a high probability of poor recruitment in 1996. Both recruitment indicators have proven to be reliable forecasting tools. The forecast abundance for 1996 based on a 50:50 weighting of model estimates and an assumption of poor recruitment is 21,440 t. Since the forecast level of abundance is close to Cuttoff (18,800 t), the harvestable surplus in 1996 is calculated as the difference between forecast abundance and Cutoff (2,640 t). However, the Subcommittee has chosen to recommend a more conservative harvest level. The reasons for adopting a conservative harvest cap include: (1) the stock is in a low productivity phase as a result of recent warm water events, therefore, sustainable harvest levels are lower than the long term average; (2) one of the assessment models (age structure) forecasts abundance for 1996 below the 18,800 t cutoff level; (3) all indicators show abundance in 1995 at levels similar to the previous year. The Subcommittee therefore recommends **harvest levels in 1996 not exceed the recommended level in 1995 of 2,040 t.**

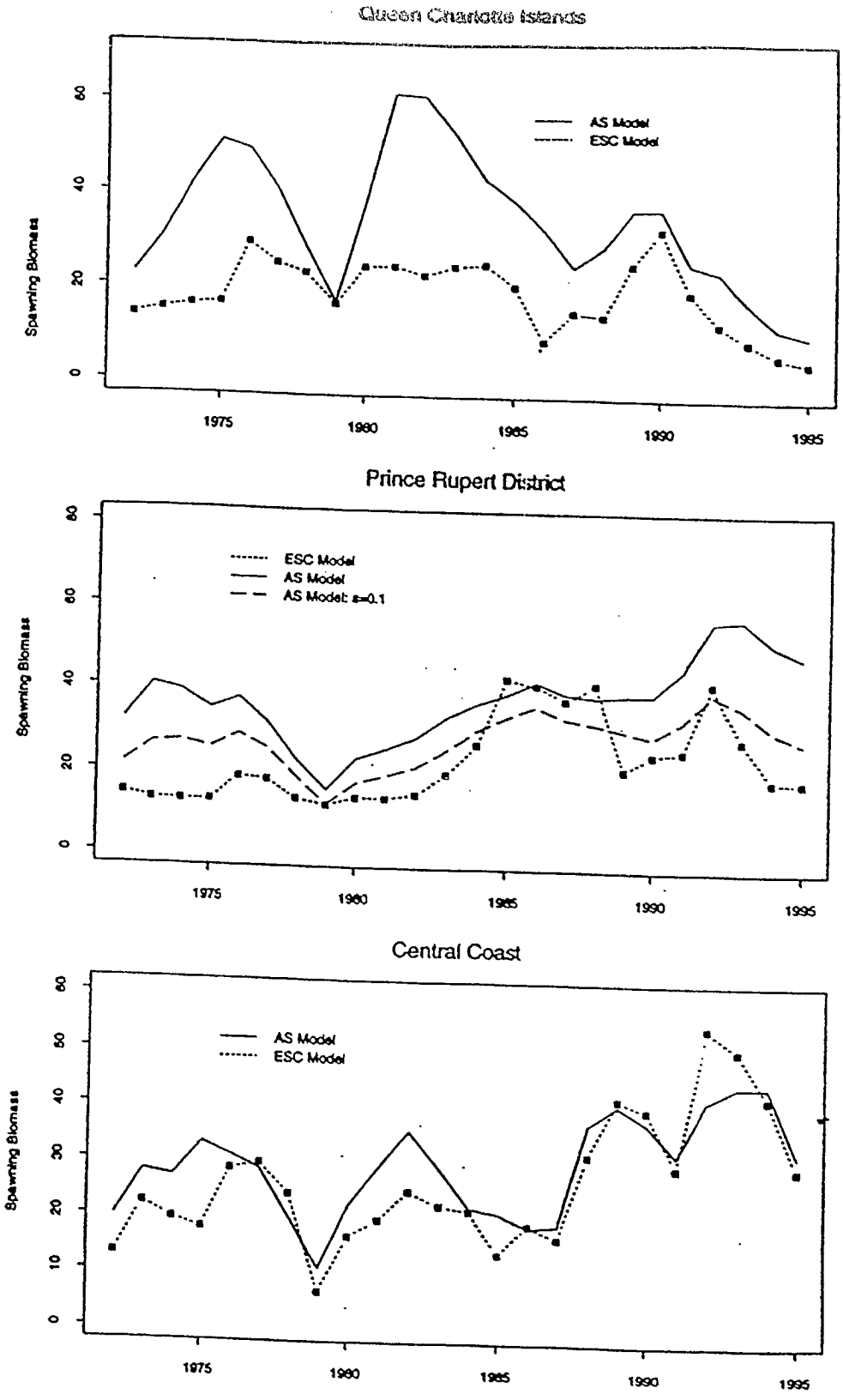

Fig. 1. Estimates of spawning stock biomass (tonnes x 1000) from age-structured and escapement model analyses for northern B.C. herring stock assessment regions, 1972-1995

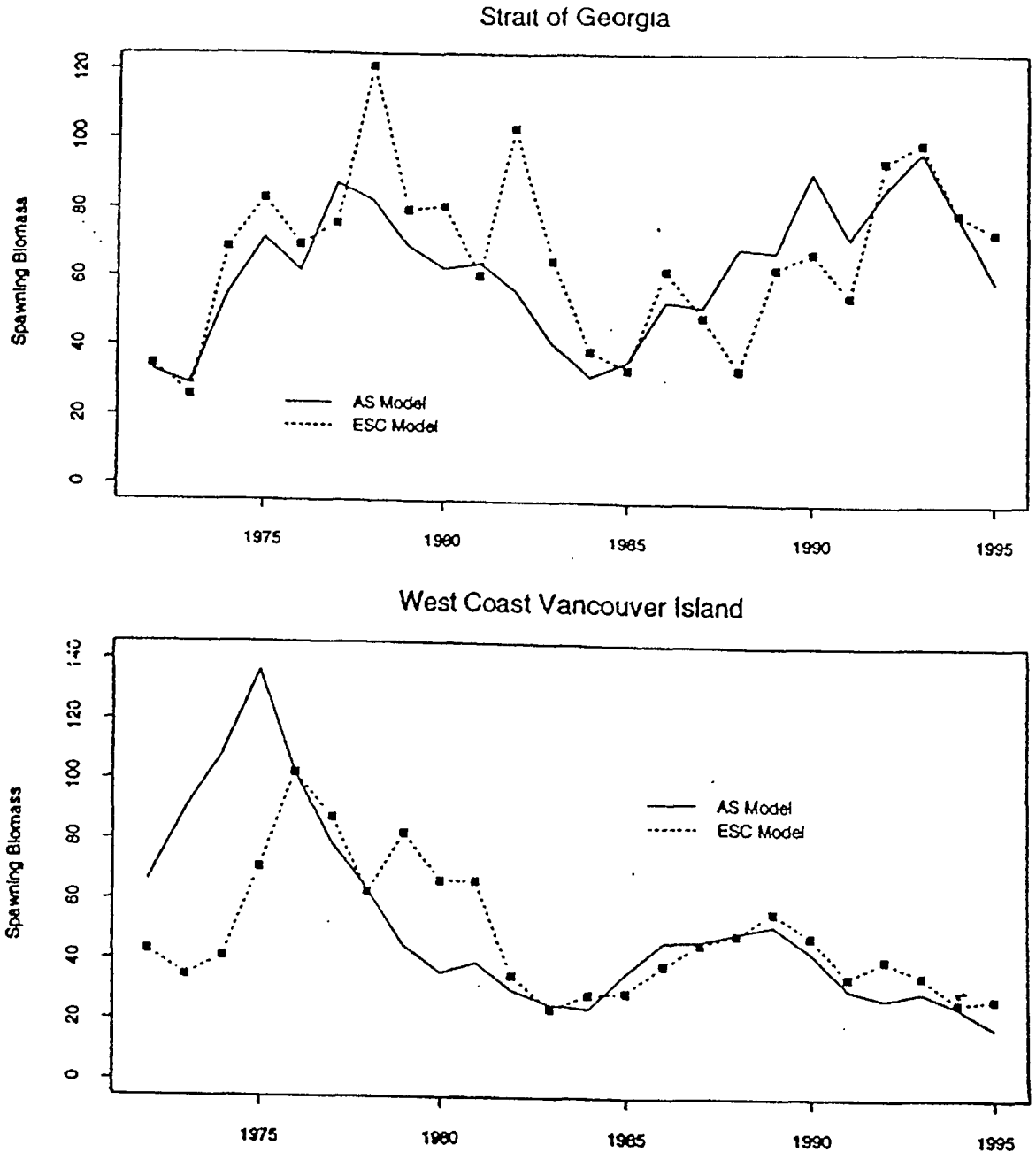

Fig. 2. Estimates of spawning stock biomass (tonnes x 1000 from age-structured and escapement model analyses for southern B.C. herring stock assessment regions.

4. RECOMMENDED COASTWIDE 1996 HARVEST

For each major stock, the recruitment assumption, the corresponding 1996 pre-fishery biomass forecasts, and the recommended catches (in tonnes) are summarized below (also see Appendix 3). The Subcommittee notes that because of declining stock trends in four of the five stock assessment regions, the recommended closure of the Queen Charlotte Islands stock assessment region, and the poor recruitment prospects for the west coast of Vancouver Island region, the recommended quota is less than the 1995 quota. The quota recommended for 1996 is the second lowest in the last decade and well below the decade average (27,900 t).

Stock Assessment Region	Cutoff Biomass	Recruitment Assumption	Forecast	Recommended Harvest
Queen Charlotte Islands	10,700	poor	6,690	zero
Prince Rupert District	12,100	average	21,160	4,230
Central Coast	18,800	average	25,770	5,150
Strait of Georgia	21,200	average	63,350	12,670
West Coast Vancouver Island	18,800	poor	21,440	2,040*
TOTAL			138,410	24,090

*** Quota based on previous year's quota.**

5. 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 minimize stock recovery time, which is critical for stocks in a low productivity regime (e.g., Queen Charlotte Islands). We are presently unable to monitor effects of 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.

6. 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.

7. PARTNERSHIPS WITH CLIENTS

In 1994 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. A Biological Review Meeting will be held again in 1995 and is scheduled for September 28 in Vancouver. As in the previous year client participation will include representatives from each client group: Fisheries Council, Seine sector, Gillnet sector, U.F.A.W.U., Spawn-on-Kelp, and one Native Band member from each major stock area.

APPENDIX 1. 1995 PSARC HERRING SUBCOMMITTEE WORKING PAPERS.

No.	Title	Authors	Reviewers
H95-1	Stock assessment for British Columbia herring in 1995 and forecasts of the potential catch in 1996.	J. Schweigert C. Fort	F. Funk D. Hay
H95-2	Review of the biological basis for British Columbia herring stock harvest rates and conservation levels.	J. Schweigert D. Ware	R. Stanley R. Tanasichuk
H95-3	Offshore herring distribution and 1996 recruitment forecast for the west coast of Vancouver Island stock assessment area.	D. Ware R. Tanasichuk	J. Fargo J. Schweigert
H95-4	A preliminary simulation model for the Pacific Herring (Clupea pallasi) population from the lower west coast of Vancouver Island.	R. Tanasichuk	C. Wood C. Fort
H95-5	Changes in herring spawn distribution in Georgia Strait: discussion, implications and recommendations.	D. Hay B. McCarter	D. Chalmers R. Higgins
Fishery Update	B.C. Herring Fishery Update, 1994/95.	L. Hamer	N/A

APPENDIX 2. LIST OF PARTICIPANTS

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**** (Acting PSARC Chair)**

Note: Fritz Funk (ADFG, Juneau) attended the first day of the meeting as a reviewer and observer.

APPENDIX 3.1. CRITERIA USED IN THE ASSESSMENT OF STOCK STATUS FOR THE QUEEN CHARLOTTE ISLANDS STOCK ASSESSMENT REGION IN 1995.

CRITERIA	STATUS
1. Data Quality	
(a) all catch reported	(a) No.
(b) all spawn surveyed	(b) All major spawns surveyed.
(c) consistent age composition	(c) Juan Perez 40% age 1+;Skincuttle and Selwyn 40% age 5+; Test seiner collected only 7 samples.
2. Spawn and stock trends	
(a) age-structured model	(a) Declining trend continues, stock below cutoff level; lowest biomass since 1972.
(b) escapement model	(b) Declining trend continues, stock below cutoff level; lowest biomass since 1972.
(c) spawn indices	(c) Declined 1990-94; increased in 1995
(d) in-season echo- soundings	(d) Declining since 1989.
(e) consistent trend info	(e) Yes
3. Perception of stock status	
(a) charter skippers comments	(a) Encouraged by young fish in Juan Perez Sound.
(b) management staff	(b) No comment.
4. Recruitment trends	
(a) age-structured model	(a) Poor 1990-92; 5 of last 7 years poor.
(b) escapement model	(b) Similar
5. Cutoff	10,700 t
6. Forecast weighted run size	
(a) weighting	(a) 50:50 (AS:ES)
(b) recruitment assumption	(b)
• **poor**	• **6,690 t**
• average	• 8,900 t
• good	• 15,200 t
7. Additional information	
8. Quota recommendation	**Stock below cutoff; recommend no harvest**

APPENDIX 3.2. CRITERIA USED IN THE ASSESSMENT OF STOCK STATUS FOR THE PRINCE RUPERT DISTRICT STOCK ASSESSMENT REGION IN 1995.

CRITERIA	STATUS
1. Data quality	
(a) all catch reported	(a) No reports of Section 35 catch.
(b) all spawn surveyed	(b) Some small peripheral spawns missed.
(c) consistent age composition	(c) Kitkatla 50% age 5+; Areas 3-4 dominated by ages 2+ and 6+; only 9 seine samples collected in Areas 3-4 and 26 test and 12 roe fishery samples from Area 5.
2. Spawn and stock trends	
(a) age-structured model	(a) Not considered.
(b) escapement model	(b) Declining since 1992.
(c) spawn indices	(c) Declined from 1992-94; 1995 similar to 1994.
(d) in-season echo-soundings	(d) Similar to 1994; lower than 1993.
(e) consistent trend info	(e) Yes.
3. Perception of stock status	
(a) charter skippers comments	(a) Lower stock in Port Simpson; no comment for Kitkatla.
(b) management staff	(b) Big Bay similar to 1994; Kitkatla is low.
4. Recruitment trends	
(a) age-structured model	(a) No good recruitment since 1988 and 89 year-classes; 1990 and 1992 year-classes are average.
(b) escapement model	(b) Average.
5. Cutoff	12,100 t
6. Forecast weighted run size	
(a) weighting	(a) 0:100 (AS:ES)
(b) recruitment assumptions	(b)
• poor	• 18,250 t
• **average**	• **21,160 t**
• good	• 31,380 t
7. Additional information	
8. Quota Recommendation	**4,230 tonnes**

APPENDIX 3.3. CRITERIA USED IN THE ASSESSMENT OF STOCK STATUS FOR THE CENTRAL COAST STOCK ASSESSMENT REGION IN 1995.

CRITERIA	STATUS
1. Data quality	
(a) all catch reported	(a) Yes
(b) all spawn surveyed	(b) Yes, except for Kwakshua.
(c) consistent age composition	(c) Yes
2. Spawn and stock trends	
(a) age-structured model	(a) Declining since 1994.
(b) escapement model	(b) Declining since 1992.
(c) spawn indices	(c) Declined 1992-94; slight increase in 1995.
(d) in-season echo-soundings	(d) Maximum down to 25,000 t from 29,000 in 1994.
(e) consistent trend info	(e) Yes
3. Perception of stock status	
(a) charter skippers comments	(a) Fairly abundant
(b) management staff	(b) Stocks down from 1994.
4. Recruitment trends	
(a) age-structured model	(a) 1990 and 1992 year-classes poor; 1991 is average; 1989 year- class was last good recruitment.
(b) escapement model	(b) Similar.
5. Cutoff	18,800 t
6. Forecast weighted run size	
(a) weighting	(a) 50:50 (AS:ES)
(b) recruitment assumption	(b)
• poor	• 22,930 t
• **average**	• **25,770 t**
• good	• 35,890 t
7. Additional information	
8. Quota recommendation	**5,150 tonnes**

APPENDIX 3.4. CRITERIA USED IN THE ASSESSMENT OF STOCK STATUS FOR THE STRAIT OF GEORGIA STOCK ASSESSMENT REGION IN 1995.

CRITERIA	STATUS
1. Data quality	
(a) all catch reported	(a) Yes
(b) all spawn surveyed	(b) Yes
(c) consistent age composition	(c) Yes
2. Spawn and stock trends	
(a) age-structured model	(a) Declining trend since 1993 high.
(b) escapement model	(b) Declining trend since 1993 high.
(c) spawn indices	(c) Declined from 1993 to 1994; 1995 similar to 1994.
(d) in-season echo-soundings	(d) 57,800 t maximum soundings.
(e) consistent trend info	(e) Yes.
3. Perception of stock status	
(a) charter skippers comments	(a) Healthy stocks; Area 15 poor.
(b) management staff	(b) No concerns.
4. Recruitment trends	
(a) age-structured model	(a) Average 1993 and 1994; poor in 1995.
(b) escapement model	(b) Average.
5. Cutoff	21,200 t
6. Forecast weighted run size	
(a) weighting	(a) 50:50 (AS:ES)
(b) recruitment assumptions	(b)
• poor	• 48,800 t
• **average**	• **63,350 t**
• good	• 85,620 t
7. Additional information	Strait of Georgia juvenile survey indicates recruitment will not be good.
8. Quota recommendation	**12,670 tonnes**

APPENDIX 3.5. CRITERIA USED IN THE ASSESSMENT OF STOCK STATUS FOR THE WEST COAST OF VANCOUVER ISLAND STOCK ASSESSMENT REGION IN 1995.

CRITERIA	STATUS
1. Data quality	
(a) all catch reported	(a) Yes.
(b) all spawn surveyed	(b) All major spawns surveyed; some small spawns (Vernon Bay, Hesquiat Peninsula) missed.
(c) consistent age composition	(c) Higher percentage of age 3+ in Nootka and Esperanza; overall 13% age 2+.
2. Spawn and stock trends	
(a) age-structured model	(a) Declining.
(b) escapement model	(b) Same as last year; possible slight improvement.
(c) spawn indices	(c) Declining trend; slight increase since last year.
(d) in-season echo-soundings	(d) 21,000 t maximum Barkley; 4,000 t maximum Sydney; Nootka poorer; Esperanza improved.
(e) consistent trend info	(e) Most evidence indicates a declining trend.
3. Perception of stock status	
(a) charter skippers comments	(a) Area 23 soundings all in one place; no fish in lower Clayoquot; Nootka and Esperanza similar to 1994.
(b) management staff	(b) Spawn looked down; anticipated only spawn-on-kelp fishery in 1996.
4. Recruitment trends	
(a) age-structured model	(a) 1985 year-class good; 1989 year-class average; the remaining recent year-classes are poor.
(b) escapement model	(b) Poor.
5. Cutoff	18,800 t
6. Forecast weighted run size	
(a) weighting	(a) 50:50 (AS:EM)
(b) recruitment assumption	(b)
• **poor**	• **21,440 t**
• average	• 28,120 t
• good	• 44,540 t
7. Additional information	Models suggest increased catch with no sign of stock improvement. AS model estimate is below cutoff. HWG will be informed AS model below cutoff. Offshore recruit forecast is poor.
8. Quota recommendation	**The 1996 quota should not exceed the 1995 quota, 2040 tonnes.**

APPENDIX 4. 1995 RECOMMENDATIONS FOR STOCK ASSESSMENT AND RELATED ACTIVITIES.

1. The absence of reliable removals data (Section 35, Roe, S-O-K and Food and Bait fisheries) jeopardizes conservation efforts for herring stocks. All fishery participants must ensure that accurate and timely catch data are submitted.

2. The Subcommittee continues to be concerned about the potential for quota overruns in many fisheries. These concerns are particularly strong regarding 1996 fisheries where overruns of advised harvest would place some of the stocks below Cutoff levels. The Subcommittee recommends 1996 harvest management plans be designed and implemented to prevent overruns of target catches in these areas, particularly the west coast of Vancouver Island.

3. There has been a recent reduction in coverage of herring spawns occurring outside major stock assessment areas. The Subcommittee reiterates the importance of spawn information, 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. Mechanisms should be explored to carry out spawn surveys in peripheral areas.

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 risk factors on west coast Vancouver Island herring recruitment be continued, and extended to the other major stocks. The intent is to derive a probabilistic recruitment forecast that can be used in estimating harvests.

5. Preliminary results from the juvenile herring surveys in the Strait of Georgia show promise for providing forecasts of incoming recruitment to this stock. The Subcommittee recommends these surveys and associated analyses be continued. The Subcommittee notes, however, that the ability of the surveys to forecast recruiting year-class strength cannot be evaluated fully until they have been conducted over a period of years where there has been substantial contrast in the strengths of year-classes produced by the stock. It is recommended that a paper be presented at the 1996 meeting correlating forecasts of juvenile recruitment with observed recruitments in the St. of Georgia.

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.

7. A longstanding problem exists with diverging population estimates from the ES and AS models for the Prince Rupert stock assessment area. Attempts have been made to resolve this with an increased emphasis on escapement data and by removing some Area 5 sampling data from the AS analysis. Problems with AS assessments may arise from sampling bias. Work should continue to identify appropriate data inputs.

8. It is recommended that work documenting changes in spawn distribution continue. As well, hypotheses (for example, colonization/extinction) explaining the observed changes should be developed and tested.

9. The Subcommittee is concerned that there are significant discrepancies between the quantity of herring allocated and used by S-O-K operations. Cost recovery programs should be established to monitor the total catch and mortality in S-O-K impoundments. Additionally, potential local habitat destruction due to "dumping" of dead herring should also be monitored and assessed. A paper documenting all records of herring mortalities from S-O-K operations and a standard method of surveying ponds should be given at the next PSARC meeting.

10. A long term strategy is required for the development and re-evaluation of harvest rates and Cutoffs. Industry should be consulted to determine their requirements in developing appropriate harvesting strategies. The proposed Conservation Council would be the appropriate body to consult on this issue.

11. There are several areas where additional information would be beneficial to herring PSARC. It is recommended that proposals be developed within Science Branch for appropriate studies; including recruitment mechanisms and spawn distributions.

12. The Subcommittee is concerned by the low representation by harvest managers at this meeting and encourages their attendance in the future.

APPENDIX 5. PROGRESS REPORT ON RECOMMENDATIONS MADE IN 1994.

1. In 1995, overages in roe fisheries were minimized, in part, because of increased effort control in the fisheries.

2. Transition of responsibility for spawn surveys from Operations Branch to Science Branch went relatively smoothly, though some problems with program coordination were experienced. Several significant spawns were missed because of cutbacks in resources, including spawns in Kwakshua Ch. area, Rivers In., and Knights In..

3. Work on environmental risk factors used to forecast recruitment continued for the WCVI stock and similar studies are being extended to other stocks.

4. Juvenile surveys were not done in the St. of Georgia in 1995, which deprived PSARC of a potentially valuable forecasting tool.

5. Winter hydroacoustic surveys were not reinstated in 1994 and it is not clear that these surveys provide useful assessment information. When hydroacoustic data is incorporated in the age structure model, results are equivocal.

6. Analyses which will provide error distributions in abundance estimates from spawn data have been initiated.

7. Work has been initiated to resolve problems with AS analyses of abundance for the Prince Rupert region.

8. The Subcommittee continues to apply a conservative harvest policy for minor stocks.

9. A paper describing changes in spawn distribution in the St. of Georgia has been reviewed, and further work suggested.

10. Some of the ponds used by 22 of the 39 S-O-K operations were surveyed by dive teams in 1995, and herring mortalities are summarized in the fishery update. Discussions have been initiated with licence holders regarding industry funded monitoring in the S-O-K fishery.

APPENDIX 6. SUMMARY OF WORKING PAPERS REVIEWERS' COMMENTS AND SUBCOMMITTEE DISCUSSIONS.

H95-1 Stock assessment for British Columbia herring in 1995 and forecasts of the potential catch in 1996. J.F. Schweigert, C. Fort and L. Hamer.

This document describes two analytical models used to assess B.C. herring stocks; presents estimates of current and past stock abundances since the 1950/51 season; and forecasts stock levels for the 1996 fishing season. There were no major changes in methodology for estimating stock abundance from those used in the previous year. Preliminary results of analyses for the Prince Rupert District using different relative weightings of spawn survey and age structure information, and based on a subset of the sampling data, are presented. Some insights into the disagreement between the age-structured and escapement models were obtained but further work is required. Abundance levels continued to decline in the Queen Charlotte Islands resulting in a forecast level of abundance again below the CUTOFF levels for permitting harvest. Stock abundance also declined from 1994 levels in all other areas. Stock declines are largely the result of below average strength of the recruiting 1992 year-class.

Summary of Reviews and Subcommittee Discussions

In their initial written comments both reviewers concluded that the stock assessment procedures were appropriate for the task, but both made a number of comments that requested clarification and revision. Also, both made recommendations for refined analyses and reporting for future years. Specifically it was recommended that for application of the age structure model:

(1) Authors should consider truncation of the data series by considering a shorter time span that concentrates on the most recent data which may be of higher quality;
(2) Authors also should consider elimination of parameter 'q' to reduce a potential risk of overparamaterization;
(3) Authors might consider using alternate weighting schemes for the 3 data sources (age, catch, spawn), independent of the ratio of relative errors.

Throughout the document there are some differences in the abundance trends between the escapement and age-structure models. In the PRD the escapement model seems to be the most appropriate. In the assessment document the alternative analyses that excluded the Kitkatla data provided a better fit to the age data (i.e. compare the residuals in years 1990-present -see Appendix Tables 3.2 - 3.7 in H95-1), but showed a different stock trend. Further exploration of model sensitivity to data inputs should be explored in future.

It was requested by a reviewer that methodology used for the escapement model analysis be documented in more detail. As well, time trends in the spawn index should be examined.

Both reviewers noted that there may be impending problems in the central coast. The trends are for declining biomass and this might have been more strongly stated in the document.

The Subcommittee accepted this document conditional on the revisions and clarifications requested by the reviewers and specific points raised by the Subcommittee.

H95-2 Review of the Biological Basis for B.C. Herring Stock Harvest Rates and Conservation Levels. J.F. Schweigert and D. Ware

The biological basis for the fixed 20% harvest rate and threshold minimum biomass conservation levels for managing the major B.C. herring stocks is reviewed. Computer simulation studies of Alaska and B.C. herring populations indicate 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. It is recommended that additional studies, incorporating more realistic recruitment processes, be conducted to determine if the fixed 20% harvest rate is appropriate for both productive and less productive stocks, under the observed range of natural climate variability.

Summary of Reviews and Subcommittee Discussions

The two reviewers agreed that the paper adequately describes the rational for the harvest rate (20% of forecast biomass) and conservation levels (25% of average unfished biomass) used in the management of B.C. herring fisheries. The Subcommittee agreed that consideration should be given to adopting stock specific harvest rates and suggested additional work to be done to assess methodologies. The paper was accepted with minor revisions suggested by reviewers.

H95-3 Offshore Herring Distribution and 1996 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 southwest coast of Vancouver Island was conducted between August 1-8, 1995. Twenty-two 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 fairly typical this year, but the average densities were considerably lower than last year. Seven tows targeted on herring. Analysis of length compositions indicate that 26% of the west coast of Vancouver Island herring spawning stock will consist of age 2+ recruits in March 1996. From age-structured model projections of the biomass of surviving repeat spawners, we estimate that the recruiting 1993 year-class

will be "poor". Age 1+ fish (1994 year-class) were quite abundant, and there was a reasonable showing of young-of-the-year herring (1995 year-class) in Barkley Sound. Our research in the west coast of Vancouver Island stock assessment area indicates that herring recruitment tends to be poor when oceanic conditions are warmer than normal, and the summer biomass of migratory hake (an important herring predator) in the region is high. The state of both risk factors, which were unfavourable during the formation of the 1993 year-class, suggests that there is a 62% chance that it will be "poor". This forecast is consistent with the results of the offshore assessment survey.

Summary of Reviews and Subcommittee Discussions

Both reviewers agreed that the paper was timely and that the results were useful for the WCVI stock assessment, but noted that results of the trawl survey were based on a very small sample (4 tows). Reviewer 1 noted that concerns from last year's meeting had been addressed; noted that bootstrapping 4 values was unlikely to provide reliable confidence limits; and suggested that classifying past recruitment levels to low/average/high should be done on a combination of age structure model and escapement model results, not just on the AS. Reviewer 2 suggested that some indication of how the results are used in the assessment process should be included in the paper. The Subcommittee noted that midwater trawl CPUE was a very rough indication of herring abundance and recommended that this be clarified in the paper. The Subcommittee also recommended that the estimate of 1996 recruitment (3,300 t) be included in the paper but without a confidence interval. The paper was accepted with minor revisions.

H-95-4 A preliminary simulation model for the Pacific Herring (Clupea pallasi) population from the lower west coast of Vancouver Island. R. Tanasichuk.

This paper presented preliminary work on a simulation model for B.C. herring stocks. The Subcommittee suggested, and the author agreed, that further work was required and that the paper should be withdrawn. It was also agreed that work on the model should be continued, after consultation, and another paper describing the model be submitted to PSARC in 1996.

H95-5 Changes in Herring spawn distribution in Georgia Strait: discussion, implications and recommendations. D.E. Hay and P.B. McCarter.

Evidence for the changes in spawn distribution are shown. The historical spawn data show a change in the distribution with a decline in the spawn deposition in the southern Georgia Strait, particularly on the eastern (mainland) side. This change supports the contention that there has been a "shift" in spawn distribution, but there are a number of explanations. These include possible changes in the stock structure, or changes associated with environmental or habitat changes, or even changes in the spawn surveys. We examine these and other issues. We tentatively conclude that the

changes we have observed are probably within the range of normal variation, over a temporal scale of decades and a spatial scale of from 10-100 km. Therefore, we expect to see continued changes in distribution and at present there appears to be a resumption of some spawning activity, during the last 5 years, in the Gulf Island area. We see no such resumption in the Sechelt area but we expect to. For this reason we recommend that herring spawn surveys continue as an important criterion of herring distribution, if not their abundance. We also recommend that this issue be re-examined in a few years.

Summary of Reviews and Subcommittee Discussions

The reviewers stated that this was an important paper in that it showed that changes in spawn distribution occur over time and that herring "recolonize " a spawning location, a fact which has strong management implications. While no specific conclusions are provided as to why these changes occur, a number of possible explanations are provided for further study. It was recommended there be a clearer definition of the term "shifts in spawn" and "changes" in spawn distribution. The Subcommittee questioned whether shifts in spawn were due to colonization/extinguishment or a change in distribution. There is a need to define hypotheses for shifts in spawn that can be tested. The shifts in spawn also need to be looked at in relation to stock size. The paper was accepted with minor revisions.

INVERTEBRATES

I. STEERING COMMITTEE REPORT

The PSARC Steering Committee met September 26-27, 1995 at the Pacific Biological Station to review the Invertebrate Subcommittee Report. Steering Committee noted the Major Concerns identified by the Subcommittee and recorded the following discussion and decisions.

POACHING

Steering Committee highlighted the problems for stock evaluation caused by illegal, hence unrecorded, removals of invertebrates and welcomed news of increased enforcement activity. However, it was noted that low levels of compliance with regulations for many invertebrate fisheries is still a problem, e.g., the recreational harvest of undersize Fraser River area crab. The request for summaries of enforcement action against illegal harvest of invertebrates was endorsed. These summaries should assist assessment staff in assigning confidence to records of removals.

SURVEYS AND HABITAT STRATIFICATION

Steering Committee welcomed the progress reported on survey design and methodology for bivalves and agreed that the developments should be reviewed for applicability to surveys of other invertebrate species. It also supported the concept of multi-disciplinary resource habitat surveys and mapping. Noting the wide range of agencies carrying out or supporting resource surveys, Steering Committee endorsed strongly the need for a major role of DFO in coordination of all such surveys, including the provision of standard survey methodologies and education. This coordination will be necessary whether surveys are conducted by provincial, First Nation, industry, or other government-sponsored agencies. Steering Committee recommends that the task of reviewing and coordinating standards for agency survey programs be assigned to the Data and Systems Subcommittee.

FISHERIES DATA

Notwithstanding improvements in processing of logbooks, Steering Committee was concerned by the continued problems of poor compliance with reporting requirements and validation, and with the use of inappropriate formats, particularly by contract fishery observers and port validators. Subcommittee's suggestion that the Data and Systems Subcommittee be asked to develop common reporting formats and standards was adopted.

ALTERNATIVE ASSESSMENT AND MANAGEMENT STRATEGIES WORKING GROUP

Recognizing the inherent difficulties in assessing and managing the many small populations of the sedentary invertebrate species, Steering Committee endorsed the concept of a Working Group as described by the Subcommittee. It was agreed that it should be established with membership from both within and outside DFO. Bruce Adkins was proposed as Chair, for RMEC consideration. It was further agreed that such a working group should work closely with similar PSARC and DFO activities addressing other species groups, both in the Pacific Region and elsewhere.

AQUACULTURE AND DEVELOPING FISHERIES

Steering Committee recommends that a formal process be established for review of initiatives in aquaculture involving natural populations as a source of grow-out individuals or brood stock, and in the development of new or modified fisheries. Steering Committee is concerned that the implications for natural populations of harvested invertebrates, particularly concerning those depleted by fishing, need to be considered when approval is sought for such initiatives. Mitigative measures designed to rehabilitate such populations may be ineffective if these aquaculture initiatives or other activities remove potential recruits to these populations.

With respect to reviews of the Working Papers and Fisheries Updates that were included in the Subcommittee report, Steering Committee provided the following comments and recommendations.

195-12 Survey Methodology for Intertidal Bivalves

In addition to discussion of the general topic, as recorded under Major Subcommittee Concerns, Steering Committee accepted the recommendation that the manuscript be adopted as a reference document in the development of a protocol for multi-stage sampling of clams. It also endorsed investigating the applicability of the protocols to small beaches and discussion with user groups in order to develop a "user friendly" sampling guide.

195-13 Manila Clams on Savary Island

Steering Committee noted the wide ranging Subcommittee discussion of clam assessment and management that was generated by this paper and endorsed the following concepts:

- Clam fisheries are heavily oversubscribed and assessments are being compromised by unregulated harvests and/or unrecorded removals. Objectives for management

and implementation measures such as quota management and size limits should be reviewed by revitalizing the existing Clam Management Reform process.

- There is a need to evaluate the biological basis and benefits of minimum size regulations.
- Managers should be aware that opening closed areas to "depuration fisheries" will increase pressure on the total resource, since it is possible that these closed areas have been providing reservoirs of breeding animals whose progeny have been recruiting to open areas.

The possibility that contaminated beaches may be breeding "refugia" highlights the need for further research into stock identity and recruitment mechanisms. The Recreational Catch Data Working Group should review the rationale for recreational reserves, and particularly the collection and evaluation of recreational catch data. DSSC could assist in the latter.

The Steering Committee adopted the yield estimates.

I95-14 - Green Sea Urchins

The Steering Committee endorsed the yield options and stressed the need for a cautionary approach to management because of the incomplete data from the fishery. It was noted that management decisions concerning issues such as rotational openings can compromise the ability to assess stocks. The impact of such measures needs to be taken into account in developing alternative management measures. Steering Committee recommends that managers and assessment biologists work jointly in the development of management strategies, so that data needs for assessment are met. Steering Committee also supported the need to review the biological basis for the current minimum size.

I95-15 - Sea Cucumbers

The Steering Committee concurred that there was no basis for changing current management controls and stressed the need to develop measures that address depletion of local concentrations.

I95-16 - Red Sea Urchins

The Steering Committee endorsed the yield recommendations and the need to examine the biological basis for the minimum size limit.

I95-17 - Geoducks

The Steering Committee endorsed the yield recommendations and drew attention to the factors contributing to the downward revision of the estimates. The major factors

leading to the revisions are improved estimates of geoduck densities based on a steadily improving survey database, and adjustments to the estimates of past removals to account for underreporting, as indicated by validation reports. Steering Committee notes that the revised estimates of yield are a significant reduction and endorses the need to reduce fishing mortality rate. However, the Committee also supports the initiative of managers and assessment staff to examine a staged reduction to these reduced mortality levels.

Shrimp

The Steering Committee endorsed the need to establish an assessment database and to analyze the by-catch data, particularly for the Strait of Georgia fishery.

Crabs

The Steering Committee draws attention to the concern that effective conservation is being compromised by the lack of implementation of either ring size or soft-shell restrictions in some areas. The Committee also noted that the deployment of other fishing gears during periods of softshell closures may negate the benefits of such closures. Appropriate managers are urged to develop joint programs to facilitate conservation goals.

Euphausiids

Steering Committee supported the recommendation that there be no expansion of the fishery without an assessment of the ecosystem impacts of additional harvest.

Abalone

Steering Committee reiterates the requirement for a review of methods employed worldwide to rebuild abalone stocks, and an evaluation of their effectiveness, in order to formulate the appropriate management options for B.C. abalone stocks.

Other Species

Steering Committee accepted without comment the Subcommittee's consideration of octopus, squid, horse clams, goose barnacles, scallops and prawns.

II. INVERTEBRATE SUBCOMMITTEE REPORT

1. INTRODUCTION

The Invertebrate PSARC Subcommittee met twice during 1995; January 24 and 25, and September 12-14 in Nanaimo. The September meeting addressed advice and recommendations for management of invertebrate fisheries in 1996 and identified concerns and research needs for invertebrate fisheries. A list of 1995 participants is appended (Appendix 1). Seven working papers and 14 fishery updates were reviewed (Appendix 2).

This report is a summary of advice and recommendations resulting from the September meetings and provides the basis for advice to the Regional Executive Committee for development of 1996 Management Plans and stock assessment research required for invertebrate fisheries.

2. MANAGEMENT FRAMEWORK

Invertebrate fisheries are managed by a variety of regulations and management techniques depending on the biology of the animal, the fishing gear utilized, the advice received from client groups and the status of stock information available for the particular species (Table 1).

3. CATCH TRENDS

A total of 1358 fishing vessel licences and 1958 personal fishing licences without vessels were issued for invertebrate fisheries in 1994. The total number of licences issued was down by 5% from 1993.

Invertebrate landings have increased rapidly since 1981 and peaked in 1992 at 31,463 tonnes (Table 2). Preliminary landings for 1994 show a 9% decline from 1993 to 25,982 tonnes.

The total landed value of invertebrate fisheries was 91.1 M, up 13% from 1993 (Table 3). Geoducks continue to have the highest landed value, at 33.5 M. The crab fishery had the second highest landed value of 24.1 M.

4. YIELD OPTIONS

A number of categories of yield options are presented. All may not be appropriate for a particular species or stock. The levels of risk associated with these yield options 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.

5. MAJOR SUBCOMMITTEE CONCERNS

Poaching

Illegal harvesting continues to prevent conservation objectives from being met in several fisheries. The Subcommittee notes that enforcement effort increased in some fisheries, particularly north coast crab, WCVI sea cucumber, and abalone with positive results. The Subcommittee requests summaries of enforcement actions be prepared (possibly by C & P staff) in order to track the benefits of these enforcement actions and identify specific areas of concern. In particular, enforcement directed at abalone, crabs, south coast intertidal clams, geoducks and sea cucumbers should be documented. The subcommittee restates its belief that extensive public and native involvement in preventing illegal harvesting is essential, and should be developed through education and publicity campaigns.

Surveys and Habitat Stratification

The Subcommittee notes that considerable progress was made on survey design and methodology (see WPI95-11) for bivalves and believes this may be applicable to other invertebrate species. It endorses the concept of conducting multi-disciplinary habitat surveys, particularly in the area of habitat/resource mapping.

Stock assessment surveys have been carried out cooperatively with commercial and native users for a number of invertebrate species, in particular, geoducks, red urchins, and intertidal clams. It is expected that the scope of these surveys will expand substantially in the near future. The subcommittee has supported the surveys and recognizes the value of the data collected; however, it is emphasized that the integrity of data collected must be ensured. There is a requirement for DFO to maintain a strong coordinating function for all surveys. All cooperative assessment programs should be provided with standard survey methodologies and participants educated in appropriate sampling techniques.

Fisheries Data

There has been considerable progress in streamlining the system for collating, correcting, compiling and accessing invertebrate logbook data. However, lack of compliance with licence requirements for monthly submission of logbooks, and validation of logbook information remains a problem. The subcommittee reiterates the seriousness of this problem and its impacts in a number of fisheries.

Concerns were expressed about the collection of data by contract fishery observers and port validators. Often data is collected and submitted in formats that require considerable time to import the data. This has been the case in a pilot program for

the collection of logbook data by port validators in the geoduck fishery. There are also difficulties in utilising data submitted in the red sea urchin fishery by contract validators.

There is a need to establish common reporting formats for fisheries that will be managed by individual quotas, where catch and effort data are collected by contractors. This information is extremely valuable if it could be accessed on a more timely basis. This issue could be addressed by the Data and Systems Subcommittee.

Alternative Assessment and Management Strategy Working Group

The Subcommittee notes that many of the fisheries upon which it is asked to provide advice are characterized by very recent initiation, poor catch and effort data, little biological knowledge, or explosive fishing pressure. Many of these stocks, due to the biology of the species and the speed of fishery development, may have experienced substantial exploitation before management controls were in place. Management programs may simply be trying to limit increasing exploitation rates until the requisite knowledge for the appropriate strategy is acquired. In other instances, while fisheries may be recent, the user group expectations are for higher yields than the underlying species biology or fisheries on the same species elsewhere would suggest. Management may have adopted a risk-averse approach for these stocks, although some available yield may be forgone under such this policy. In other instances, perceived stock units may be highly localized and the Subcommittee is concerned that catches for these stocks may be above high risk levels. Further, the data requirements to conduct traditional assessments of these stocks are large and the prospects for obtaining these data in the near future are poor.

Both of these scenarios are familiar in B.C. invertebrate fisheries and the Subcommittee believes that we should explore alternate management and assessment frameworks that may increase our rate of learning about how best to manage these species. The Subcommittee therefore RECOMMENDS that a working group be formed to develop recommendations for such alternate management and assessment strategies. The suite of potential solutions could include, but not be limited to, experimental harvest programs, community management, protected areas, staggered closures, adaptive management programs, community arrangement program, industry operated surveys and data collection programs, and the development of new indices of stock status. The Subcommittee notes that a similar recommendation was made by the PSARC Groundfish Subcommittee and suggests that a joint approach by the two groups would be beneficial.

Aquaculture and Developing Fisheries

The Subcommittee noted a number of recent initiatives in aquaculture or fisheries development which could potentially have impacts on Invertebrate Stock Status (examples: purple sea urchin fishery, ponding of green sea urchins). There appears to be no mechanism for reviewing impacts of such activities on stock status. The Subcommittee requests guidance on the appropriate format for reviewing impacts of new aquaculture activities and developing fisheries on invertebrate stock status.

6. SUMMARIES OF WORKING PAPERS, FISHERY UPDATES, REVIEWERS' COMMENTS AND SUBCOMMITTEE DISCUSSIONS

(a) Intertidal Clams

Two working papers and a fishery update were reviewed by the Subcommittee.

I95-12 Survey Methodology for Intertidal Bivalves

Summary

Surveys of intertidal bivalves are routinely conducted on selected beaches by the Department of Fisheries and Oceans (DFO) to estimate standing biomass for the purposes of assigning harvest levels and/or to determine population age, size, and growth characteristics. This paper describes survey sampling methods applicable to intertidal bivalves. Selected survey strategies used by the DFO, the Washington Department of Fish and Wildlife, and the British Columbia Ministry of Agriculture, Fisheries and Food are reviewed. The class of multi-stage sampling designs is suggested as a candidate for use by the DFO or other parties for the assessment of wild stocks of intertidal bivalves. The feasibility of the approach is evaluated for the Manila clam (*Tapes philippinarum*) stock at Savary Island, British Columbia.

Reviewers' comments

Both reviewers were complementary of this Working Paper and endorsed the approach and results. Both reviewers noted the applicability of the 0.25 m^2 quadrat size for Manila and Littleneck clams, and commented on the need for further work on the cost/variance effects of sampling strategies. Reviewer comments also addressed issues of sampling protocols for different sized survey areas, and of estimating biomass in areas where fishing actually occurs (i.e. presumed high density areas) as a subset of the full distributional area.

Subcommittee discussion

The Subcommittee accepted this manuscript as a reference document for setting sampling protocols for clams. Discussion included the need to sample the full bed

distribution. The broader issue is the need for knowledge of the scale of variability, so that effort can be allocated to detailed sampling at the first, or subsequent, stages of the design (i.e. optimal allocation of sampling effort). Discussion also included alternate methods of presenting the results, for example as 3-D contour plots, although this may vary for the intended audience. The basic methodology proposed in this Working Paper should be broadly applicable to species other than Manila and Littleneck clams, although details such as the sampling intensity need to be addressed separately for each species. The protocol should also be applicable to areas other than Savary Island. **The Subcommittee 1) accepts this Working Paper; and 2) endorses development of a more "user-friendly" sampling guide. The latter might include working with a selection of user groups and on smaller (e.g. 5-15 ha) beaches to confirm the sampling protocol and transfer of technology to third party users.**

I95-13 Assessment of Manila Clams, *Tapes philippinarum*, Stocks at Savary Island, B. C. - 1995.

Summary

Savary Island Manila clam stocks produce a large proportion of landings from Statistical Area 15, in the South Coast of British Columbia. Combinations of winter mortality and greatly increased harvests in the late 1980's resulted in a conservation closure during 1990-93. The stocks had recovered sufficiently for the fishery to open in 1994. A stock assessment survey at Savary Island was completed in 1995. This paper presents the results of the 1995 survey, and recommends yield options for the fishery. Biomass estimates produced by Kronlund *et al.* (1995) were compared with historic survey results, and the biological characteristics of the stocks were described. The available stocks were dominated by a few year classes (4-6) which had only recently recruited to legal size. Harvest rate models used by the Washington Department of Fish and Wildlife to manage Manila clam stocks in Puget Sound were used to derive a range of harvest rate scenarios. A maximum sustained yield model for limited data was used to explore an MSY approach to determining harvest levels. High (96-153 t), moderate (84-122 t) and low (60-111 t) risk yield options were presented. Managers were advised to avoid high risk options at this time, due to a demonstrated lack of recruitment in recent years at Savary Island. Recommendations for further work are presented.

Reviewers' comments

Both reviewers considered that this was a comprehensive analysis of the data available and had various suggested editorial changes. Reviewer 1 requested a better definition and rational for use of risk levels and need for quotas in addition to size limits. More discussion is required to put into perspective how growth, mortality and biomass variation could influence quota estimation. Reviewer 2 requested more explanation of how differing levels of recruitment, exploitation or environmental factors could influence different trends in biomass among sites. Some discussion could be focused on why recruitment patterns seem inconsistent over time suggesting recruitment is driven by

environmental factors and which could have implications to monitoring populations after fisheries have been closed.

Subcommittee discussion

The Subcommittee concurred with the authors' recommendations and accepted the paper after suitable revision suggested by reviewers. Although management of manila clams in B.C. is mainly by a size limit and seasonal area closures, quotas are in effect for some areas such as Savary Island.

Long term studies such as on Savary Island should be encouraged to refine survey methodology and to measure recruitment, growth and mortality of intertidal clams in relation to commercial harvests.

There is a need to develop clear policies by managers, assessment biologists and industry (possibly through the Pacific Conservation Council) to rationalize management objectives of different management strategies and their implications to intertidal clam stocks. A review of the quota management system and size limits on intertidal clams is required.

Fishery update

Four species of intertidal clams, manila, littleneck, butter, and razor clams comprise the major portion of landings in the commercial and recreational fisheries. The manila clam is the most significant and comprises approximately 70% of the landings. Combined clam catch in 1994 was 1743 t, up from 1445 t in 1993. Landed value is up accordingly at $4 million compared to 3.1 million in 1993. Much of this increase can be attributed to the reopening of Savary Island for a limited fishery as well as better than average landings in the Campbell River and Nanaimo areas.

The fishery is heavily over subscribed and the number of fishing days each year are decreasing in most areas. Of significant concern is the increase in poaching and digging in closed areas. Area licensing was introduced in 1989 and 7 licence areas were developed in order to spread out the fishing effort, with the exception of Area C (Sunshine Coast). There is no limit on the number of participants in any area. The number of licensed diggers increased by 12% in 1994 , to 1,844 coastwide.

The clam fishery has expanded in recent years to include a depuration harvest in the South Coast and well as several First Nations initiatives. There are presently 3 bivalve plants with licenses to harvest in contaminated areas and depurate clams. Depuration harvest amounts to approximately 200 t annually. The Heiltsuk Band has an exclusive licence to harvest up to 250,000 lbs each of manila, butter and Littleneck clams annually from local beaches in Area 7 . There are smaller First Nations initiatives at Squirrel Cove, Kuper Island and Kulleet Bay in the South Coast. Demands for expansion

of all these fisheries is increasing and the biological impacts as well as a policy for allocation must be determined.

A process of clam management reforms was initiated in 1992 and has involved considerable consultation with user groups. As part of this initiative, a pilot project was developed in Area C (the Powell River/Sunshine Coast area) in 1994. This project incorporated community based management and limited entry licensing. Under this pilot, the fishery was much better managed and economic gains were realized . Based on a third-party review, this pilot has been extended for an additional two years. Similar initiatives have been recommended for other licence areas.

The commercial clam fishery is heavily oversubscribed and needs to be rationalized. This should be addressed through Clam Management Reform.

Subcommittee discussion

The Subcommittee reviewed the fishery update on intertidal clams and had the following comments on the issues raised.

The Subcommittee noted the lack of knowledge in stock recruitment relationships and stock identity and endorsed evaluating the effect of the size limit.

The Subcommittee supports the recommendation that the Clam Management Reform be continued.

The need to review recreational reserves should be addressed through the Recreational Catch Data Working Group. There is a need for the collection and evaluation of recreational fishery catch data and this should be incorporated into the mandate of the Recreational Catch Data Working Group.

The Subcommittee reiterates its concern about the opening of closed contaminated areas. A management strategy for the harvest of clams in contaminated areas is required because of the uncertain linkage between recruitment in open areas and possible clam brood stock source from currently closed areas.

Results of previous steering committee recommendations on intertidal clams:

1. After a 4 year closure, Area 26 was reopened in 1995 for three four-day periods with a substantial catch of about 0.25 million lbs.

2. Recommendation was not acted on; no WP prepared to document the size, age and species composition of the commercial catch.

(b) Green Sea Urchins

One working paper and a fishery update were reviewed by the Subcommittee.

I95-14 Review of Fishery-Dependent data and quota recommendations for 1995/96 for the Green Sea Urchin Fishery in B. C.

Summary

The fishery for green sea urchins (*Strongylocentrotus droebachiensis*) on the British Columbia coast developed rapidly from 1987 to 1991, peaked in 1992 with landings of 1042 t, followed by declining landings and catch per unit of effort and the imposition of management restrictions since 1992. In 1994, coastwide landings were 324 t, with South Coast landings of 276 t, below the quota of 449 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. Information on catch per unit of effort was derived from the harvest logbook data, and separated into northern and southern regions of the South Coast - inside waters to distinguish the major fishing areas. A biomass dynamic model was developed for the northern region (Management Areas 11 to 16) with an estimated maximum sustainable yield (MSY) of 257 t. A scaling factor was developed to estimate the MSY for each Management Area. Considering the uncertainties in the input CPUE data and its persistent downward trend, and the weaknesses of the dynamic production model, caution is advised in the management of this stock. Yield options range from 0 (no fishing) to 0.5 - 0.6 of MSY for each Area. This provides estimates up to 222 t for the South Coast and 29.6 t for the North Coast, although few data are available for this latter region. Recommendations are provided on improvements to the harvest logbook process and database, quotas, and provision of fishery-independent and biological information.

Reviewers' comments

One reviewer requested a more concise review of the fishery and management actions as they relate to the analysis. The authors were requested to discuss whether the concentration of the fishery into a few areas is related to stock availability or is an economic consideration. This is important as average landings by area are used to develop quotas.

The authors were requested to include the results of modelling for all areas, and to discuss the reasons for the results from the model. Some advice was provided to guide further development of the models used in this paper, for future work.

The reviewers requested further discussion of the paper's recommendations, to provide support and place the recommendations in context. In particular it would be helpful to outline how detailed analyses of the variability of green sea urchin distribution in

time and space will address management concerns (recommendation 2). How will information on larval biology and recruitment be used for stock assessments (recommendation 3)? Finally, why are the quota estimates considered to be preliminary (recommendation 2), and what further work is required before the estimates are finalized?

Subcommittee discussion

The Subcommittee recommended:

(1) expanded discussion of the option of no fishery in 1995/96 and inclusion of this option into the recommendations of the paper;
(2) further discussion of the applicability of the Schaefer model to the logbook data;
(3) identification of concerns of Subcommittee regarding reduced stock levels, degree of confidence in biomass estimates, and specific statement that managers should be cautious;
(4) acceptance of the paper pending revisions suggested by reviewers and Subcommittee.

Much discussion revolved around the option of closing the fishery in 1995/96. The authors discussed this option in the text but not within the recommended yield options. The fact that the fishery is prosecuted in only a few areas (4 Statistical Areas) left few other options to limit effort.

The quality of the logbook data used in the analysis was questioned. Information is lacking regarding stock dynamics and behaviour of the species, relative to harvesting an aggregated resource and the ability of the logbook data to detect decreases in CPUE at the appropriate resolution. If animals from suboptimal habitats move into fishing beds as abundance is decreased, the decline in stocks may be greater than indicated by the model. There are indications that the stock is greatly reduced: i.e. decreased CPUE, and inability to achieve quota in 1994/95, although this may be influenced by management actions.

The Subcommittee discussed whether the use of the Schaefer surplus production model was appropriate, given the expansion of fishing beds and increased depths fished. The odd combination of high rate of increase and low exploitation rate returned by the model was noted.

The Subcommittee discussed the possibility of collecting data by working under exploratory protocols (limited catch, observer on board) with fishers who wish to explore new areas.

Fishery update

A decrease in CPUE indicates possible overharvesting in this fishery. Product value continues to rise ($6.46/kg). Fishers failed to land all the 1994 quota since they

held product until late in the year, then were unable to fish it due to weather and other reasons. Fishers implemented a voluntary IVQ in 1994. Catch and effort data are of suspect quality. An exploratory protocol needs to be developed for underutilized areas on the coast. There is still a need for more basic biological information in support of the management of this species.

Subcommittee discussion

There were concerns expressed by the Subcommittee that a 55 mm minimum size limit may not be adequate, therefore, the Subcommittee recommended that the minimum size limit be reviewed.

Reporting problems were noted with the harvest logbooks, especially the poor returns in 1994 (61%). These reporting problems should be reduced under the new I.Q. system.

(c) Sea Cucumbers

One working paper and a fishery update were reviewed by the Subcommittee.

I95-15 Stock Assessment and Quota Options for the Sea Cucumber Fishery

Summary

Giant red sea cucumber (*Parastichopus californicus)* stocks in British Columbia have in past been managed by arbitrary area quota using reduction in CPUE from observation of the fishery and declining landings from sales slip data as indicators of overharvest. Little is known of growth rates, recruitment , age or natural mortality for this species. In the absence of sound biological data, a surplus production model using biological parameters derived from harvest logs and from published sources was used to indicate low, medium and high risk harvest quotas by statistical area for 1995.

Analysis of catch logs and sales slip data has revealed several shortcomings in our data base related both to the difficulty in defining biomass in such a plastic and seasonally variable animal, and to errors or omissions in reporting. Owing to the management strategy of rotational closure now in place, there are few areas which have been fished in consecutive years from which production and recruitment information can be derived. Finally, divers move between isolated concentrations of cucumbers before any reduction in CPUE is apparent. Pre-season scouting and stockpiling may artificially increase production. The cumulative effect is to make any estimate of biomass subject to a great deal of uncertainty. Notwithstanding, the density estimates made from our calculations agree favourably with other independent estimates. Harvest quotas proposed for the low risk option are in many instances near those set for the 1994 fishery. Present analysis indicates that the north coast is generally harvesting below MSY while the south coast is harvesting at or slightly above the MSY.

Recommendations to address these problems include:

- changing logbook data collection and revamping the database
- managing on a finer scale than the 5 quota areas now in place
- managing in a manner to provide consistent stock information
- seeking biological information through other fisheries or aquaculture ventures
- sanctioning fishers who fail to report or report incorrectly

Reviewers' comments

Both reviewers felt the paper was a good effort to complete and interpret available data. They pointed out that some important data are of questionable quality, particularly data on weight to piece conversions, fishery effort, and bed areas. Given this, there was concern as to how to use the yield options provided. Basis for yield option categorization needs further explanation.

The Subcommittee accepted the report with major revision.

The Subcommittee recommendations are:

1. Investigate the value of experimental management to obtain required biological data, since the way the fishery is currently managed seems unlikely to ever produce these data. It is recommended that before experimental management is initiated, a proposal for the study be presented to the Subcommittee.

2. The committee emphasized that while the report was accepted as the best analysis available at this time, data qualifications were of sufficient magnitude to mean that yield estimates should not be accepted as presented.

Fishery update

For the first time since 1987, quotas were not exceeded in this fishery. One of the two South Coast areas did not open, in 1994, due to past overages. The value has been steady at around $1 million in spite of decreased catches. Fishers attempted, but failed, to implement an IVQ system in 1994. There is little biological data or comprehensive stock assessment done for this species. Historical data are confounded by an inability to discriminate between amounts of product landed 'split' or 'round'.

Subcommittee discussion

The Subcommittee notes that problems still exist in the use of conversion rates between product forms, particularly in the standardization of historical catch data. The Subcommittee recommends that existing data be reviewed to determine the most

acceptable factors to convert between various product forms and further recommends that biological samples be collected through the IVQ validation program to obtain additional data on conversion factors.

(d) Red Sea Urchins

One working paper and fishery update were reviewed by the Subcommittee.

I95-16 Catch, Effort and Quota Estimates for the Red Sea Urchin Fishery in British Columbia.

Summary

Annual landings of Red Sea Urchin (*Strongylocentrotus franciscanus*) started to grow rapidly in the early 1980's for the south coast and the late 1980's for the north coast of B.C., but subsequently were reduced and stabilized by arbitrary quotas. Coastwide landings were 5,818 t valued at Can $7.8 million with 110 licences issued during 1994. Logbook data indicated that there were no clear trends in annual CPUE (kg per dive hour) over the 1984 - 94 period for each statistical area or general region in B.C. Review of published surveys conducted to date provided estimates of density, mean weights and bed areas allowing preliminary estimates of biomass of red sea urchins in B.C. Assuming 2 % annual fishing removal rate from estimated biomass suggested preliminary quotas were calculated at 5344 t for the North Coast, 937 t for South Coast Inside waters and 390 t for the west coast of Vancouver Island of B.C. Further surveys of red sea urchin density in southern B.C. and more accurate estimates of bed areas are required.

Reviewers' comments

Reviewers indicated that the analysis was appropriate and presented the information clearly. Reviewer 1 noted that new approaches to assessment of stocks consisting of small units distributed over a wide range might be required. Further exploration of CPUE data, in particular on a smaller spatial scale. Reviewer 2 suggested that more information be given on the two methods of estimating bed area including an assessment of which was more reliable, and questioned how areas with "high density" and "poor roe quality" were selected for exclusion from the analysis. This reviewer recommended a modification of the Gulland approach used here which would be more appropriate for stocks which are already exploited. Both reviewers questioned whether the lower bound in the yield estimates was really as conservative as indicated.

Subcommittee discussion

The Subcommittee accepted this paper with minor revisions. The assessment included conservative assumptions and choices at several points (eg natural mortality value; excluding certain areas where urchins are known to occur) but may not have been

conservative in others (eg applying a standard density in areas which have been depleted by fishing).

The recent coastwide decline in CPUE is a possible source of concern but the Subcommittee noted that there were factors which could explain the decline (more search time for high quality urchins in response to changing market requirements; implementation of IQs). There is a need to clearly define the exploitable stock, by clarifying elements of the stock or data which had been excluded from the analysis.

Fishery update

The fishery continues to grow in value in spite of recent decreases in catch. Voluntary IVQ's have allowed the fishery to pace itself so as to maximize the price paid to harvesters. IVQ's have needed third party validation which has improved the monitoring of catches. The fishery no longer exceeds area quotas as a result. There is still a need for more basic biological information in support of management of this species. Fishers request a review of the 100 mm minimum size limit.

Subcommittee discussion

The Subcommittee discussed the general need for basic biological information in support of management of red sea urchins. The Subcommittee recommended that the minimum size limit (100 mm) should be reviewed for this fishery.

(e) Geoducks

Two working papers and a fishery update were reviewed by the Subcommittee.

I95-17 Quota Options and Recommendations for the 1996 Geoduck Clam Fishery

Summary

The geoduck stock assessment presented in this document is the first that has been prepared by Science Branch whereas, to date, assessments had been completed by Fisheries Branch. Geoduck stocks were examined for the north coast, west coast of Vancouver Island and waters inside Vancouver Island. The assessment methodology has remained unchanged from previous assessments in it's basic approach. It is a habitat-based assessment which incorporates the area of known geoduck habitat, estimated geoduck densities and mean weights and an estimated sustainable harvest rate into quota calculations.

Changes in this year's assessment include the use of recent survey data for estimates of geoduck density, the use of new estimates of mean geoduck weight from commercial samples and new measurements of harvest areas with modern digitizing equipment. The approach initiated in 1994 of reducing quotas where overharvesting had

occurred, according to stock status relative to a 50-year cycle, was continued in the South Coast and extended to the North Coast. Similarly, the correction of landings reported on harvest logs with sales slip or port validator information was continued in the South Coast, as had been initiated in 1994, and extended to the North Coast.

Recommended low to high risk yield options range from 636,043 to 1,051,076 lb for Inside Waters, 781,135 lb for the West Coast and 745,785 to 2,198,425 lb for the North Coast. Low, medium and high risk individual vessel quota recommendations are 39,327 lb, 55,044 lb, and 73,284 lb, respectively, for 55 licences. This represents a reduction of 53%, 34% and 13% from the 1995 fishery.

The reduction in 1996 resulted from a continued critical review and adjustment of landings, geoduck densities and estimates of fishing areas.

Reviewers' comments

Both reviewers felt the paper was a thorough examination of the available information which represents completion of the preliminary phase of assessing the geoduck fishery with the development of a process for deriving first estimates of sustainable harvest. Given the paper provides initial estimates of yield for this fishery, reviewers question whether the next phase in the process will be undertaken or is underway. Reviewers identified the following questions for phase II. What have been the impacts of past harvests and can we test whether historical harvests are sustainable. How are yield options presented in the document affected by illegal removals or misreporting of catch? What are harvesting affects on density, growth and recruitment?

Subcommittee discussion

The Subcommittee accepted the paper and endorsed the yield recommendations.

Discussions centred on the level of uncertainty around quota calculations and the various risk (yield) options presented. Yield calculations are based on density estimates which are derived from few sites. Proposed yield reductions are due to lower mean densities used in the calculations, amortization of yields over 50 years and compensation for under reporting of catch. Density estimates may not represent the entire area to which they have been applied. Following surveys, density estimates used for deriving quotas have been reduced. Estimates of bed area are also uncertain. The paper reviews uncertainties around the exploitation rate of 1%. The Subcommittee noted that the paper deals with exploited biomass with the understanding that there are deep water populations that are not currently exploited.

The Subcommittee believes reduced fishing mortality is required in many areas. Quotas have been reduced by 48% since 1990, however, the value of the fishery continues to escalate. The Subcommittee recommends an analysis of incremental

reductions over time (3 years or 9 years) rather than taking the full reduction in one year, but with planned reduction to lower risk options.

The Subcommittee notes that studies are currently underway to collect information on density, growth, recruitment, productivity and fishery effects. This will form part of the information to address the questions proposed by the reviewers. The Subcommittee also recognizes other sources of information, in particular, Washington state fisheries, and suggests a review of information available.

I95-18 A Survey of Geoduck Population Density at Price Island, 1993-94

This working paper was withdrawn by the author.

Fishery update

The geoduck fishery is managed by area quotas, area licensing and 55 equal individual licence quotas since 1989. There is a three year rotation of fishing in most areas to minimize the number of landing ports each year. There are often observers on the grounds and each landing is validated at the dock.

The quotas for geoducks have decreased annually since 1990, based on assessments and studies conducted in cooperation with industry and recently First Nations. A number of studies are on-going and there has been a program of annual surveys. The 1995 annual quota was 4.6 million pounds (2096 t) with I.Q.'s of 84,030 lb. There were 30 licences assigned to the north, 12 on the Inside south and 13 on the west coast of Vancouver Island. The 1995 I.Q. is 53% of the initial I.Q. of 160,000 lb. in 1989. The average price has increased seven-fold to $6.87/lb. ($15.15/kg) from $0.97/lb. in 1988, prior to I.Q.'s.

The shift in markets from a processed product to live markets has significantly increased the value of this fishery. The landed value was $34 million in 1994 and has increased again in 1995.

The licence holders contribute approximately 3 to 6% of the landed value to validation, PSP and water quality programs, management programs, stock surveys, hatchery programs and enhancement studies.

Subcommittee discussion

This fishery update highlighted various issues including aquaculture, enhancement, a market sampling program, surveys, and the requirement for recruitment information. Most notable among the issues was continued reports of highgrading and poaching.

The Subcommittee noted that highgrading and poaching activities may negatively impact stock productivity, but no data are available to assess the effects. Subcommittee discussion noted that reports provided by contractors were often in formats unsuitable for use by the Department. Data collection capability appears to be good, however, some bottlenecks in data processing persist. A pilot observer program to collect logbook data was implemented in 1995 for South Coast inside waters. This program will be expanded to all areas in 1996.

(f) Shrimp

A fishery update was reviewed by the Subcommittee.

Fishery update

The British Columbia shrimp trawl fishery targets primarily on three species of shrimp: *Pandalus jordani* (smooth pink), *P. borealis* (northern pink) and *Pandalopsis dispar* (sidestripe). Humpback shrimp, *Pandalus hypsinotus*, and prawns, *P. platyceros* are caught incidentally or in small quantities in this fishery. Fishing occurs in three major areas; the inshore waters of Vancouver Island including the Strait of Georgia and some mainland inlets, areas off several north coast inlets and off the lower west coast of Vancouver Island.

The landed value of the shrimp fishery is highly dependant on landings and ex-vessel prices in the Washington, Oregon and California shrimp fisheries which tend to dwarf the British Columbia fishery by comparison. The annual landed value of the B.C. shrimp fishery has varied between $2.5 M and $4.5 M annually since 1987 when this fishery showed a resurgence. Preliminary data for 1994 showed total landed value at $4.5 M, an increase of $1.0 M from 1993.

There are several issues facing the effective management of the shrimp trawl fishery:

1. As stated in the 1994 Shrimp Trawl Fishery Update, a biological database needs to be established in order to properly assess shrimp stocks in the inshore areas on the east coast of Vancouver Island and to develop an effective management plan for this fishery.

2. Incidental catches of prawns in the shrimp trawl fishery continue to be a problem particularly in the inshore areas and during the winter closed period of the prawn trap fishery. Bycatch allowance of prawns should be readdressed in consultation with the Prawn and Shrimp advisory committees.

3. Public concerns regarding the bycatch of other fin fish species, particularly in the inshore areas, have escalated during 1994 and 1995. Consultation on gear selectivity devices is required as well as quantification of actual bycatch.

Subcommittee discussion

The Subcommittee requests analysis of shrimp inshore fisheries data to examine, increases in effort, bycatch of prawns and other species and the public concern the bycatch causes. The Subcommittee endorses consultation with the Advisory Committee on gear selectivity devices, and recommends that bycatch be quantified.

(g) Crabs

A fishery update was reviewed by the Subcommittee.

Fishery update

Dungeness crabs, *Cancer magister*, are harvested commercially by trap under authority of an R (crab) Licence. In 1991, the Department created a limited entry, area based licence. Fishers were required to choose one of six licence areas, including the offshore area. Starting in 1992, fishers could choose between five licence areas, on an annual basis, and all licensed fishers could fish in the offshore area.

The Dungeness fishery continues to maintain record high landings. However, total catch declined by 11% to 5,647 t compared to 1993 (Table 1). Although this decline in catch is mainly attributed to Area A, Queen Charlotte Islands, this area continues to report landings more than 155% above the 1980-89 average (Table 2). Despite the decline in landings, value of the fishery increased to the highest on record of $24.1 million resulting in an average price of $4.25/kg. The number of licence holders selecting Area A continues to increase in response to the large crab abundance. This migration of vessels is mainly from Area E, the West Coast Vancouver Island.

As reported in the 1994 PSARC Fishery Update, reporting of landings both on sales slips and harvest logs reached a level of great concern in 1994, particularly in Area B. As a result, the Area B fishery was closed from October 25 to November 8, 1994. The fishery was reopened when it was felt that missing sales slips had been submitted. Numerous charges were laid against 31 of the 35 licence holders fishing in Area B as a result of investigations of non-reporting of catch.

In 1994, the Department agreed to investigate the possibility of closures during soft shell periods as an alternative to larger escape holes. No agreement was reached between fishers and DFO on appropriate times for soft shell closures for 1994, therefore, no new closures were implemented. It is apparent that, based on the 1994 fishery in Area A, that softshell is a concern which needs addressing.

The king crab fishery continued at low levels with declines in catches and effort noted for 1994. Total catch was 9 t in 1994 for a total value of $60,100. The main fishers

in this fishery have moved to a different licence area to concentrate on the Dungeness fishery and little interest in king crab fishing remains.

The tanner crab fishery remained closed for 1994 under the moratorium for scientific licences. Requests for experimental licences for this species continue.

Subcommittee discussion

The Subcommittee notes that progress has been made toward ring limiting, 110 mm escape rings in Area B, and that softshell closures have been in place since 1983 in the Area D.

However, the Subcommittee suggests that managers continue to work with Area Committees to ensure implementation of conservation measures. Several Area Committees have opposed any of the proposed measures. The Subcommittee reiterates that action needs to be taken on ring size or softshell closures in areas which have implemented neither, to date. The Subcommittee also notes that actions by other gears may dissipate the beneficial effects of these measures in some areas. In light of resistance by Area Committees, managers need direction from RMEC on how to proceed.

(h) Euphausiid

Fishery update

The 1994 landings were within the range previously recorded from 1988 to 1992. In 1989 to 1991, fishing was more dispersed to mainland inlets as a result of establishing individual quotas for those areas. This was done to reduce effort on Jervis Inlet. Since 1991, the fishery has re-centralized in Malaspina Strait as a result of the management practice of reassigning unused inlet quotas. This calls into question the practice of setting for individual inlet quotas, if they are essentially not being used.

This fishery is market limited. Some industry members have expressed interest in increased quotas for this fishery although the existing quota has not been achieved since 1990. There will be a krill workshop in November 1995 at U.B.C.

Subcommittee discussion

The Subcommittee supports the continued monitoring of the euphausiid fishery and will not support an expansion without an assessment of the impact of commercial harvest on fish stocks. There are no biological concerns for euphausiids at the current low levels of exploitation.

(i) Octopus

Fishery update

The octopus fishery has declined by 20% since 1992 in terms of days of fishing effort, and by 30 to 45% since 1992 and 1993 in terms of landings. This is attributed to lower demand for this product as bait for halibut fishing, resulting from implementation if the halibut individual vessel quota program. The decline in harvest reflects market conditions solely, there is no indication that this reflects on stock biomass for which there is no information at present.

Subcommittee discussions

Given the amount of available data, the Subcommittee has no basis upon which to comment on stock status. The Subcommittee notes that the harvest of octopus is generally localized, whereas the stock distribution is widespread.

(j) Squid

Fishery update

Squid landings and landed value in 1994 were the highest on record, and were almost entirely from area 23 (Barkley Sound). The fishery remains market limited. Although up to 47 licences have been issued in recent years, only 7 vessels have reported landings in 1993 and 1994. It appears that the remainder of the licences are being held for speculation. There is continued interest in the harvest of other squid species, notably flying squid in offshore waters. This falls within the current moratorium on new and experimental fisheries. A scientific permit to test pair trawl gear was issued in 1994. This did not contravene the moratorium but only allowed squid taken on the high seas to be landed in Canada.

Subcommittee discussion

Given the amount of available data the Subcommittee has no basis on which to comment on stock status.

(k) Horse clams

Fishery update

The horse clam fishery has been limited to subtidal waters (>10 feet below chart datum) under the G- licence for geoducks and horse clams. There are concerns that the fishery may disrupt eelgrass and other vegetation that support herring spawn. Currently, the intertidal clam licence does not include horse clam harvest.

Historically there has been limited effort for these clams due to the lack of markets. The meat recovery is low and processing costs high for these species.

Less than half the fleet participates and exploitation by divers has been limited to levels of historical catches in an area and limited to areas open to geoducks, once every three years. Landings are required to be validated in 1995 and catch and effort data completed on harvest logs. Most of the effort has taken place in Areas 14,15,17 and 24. There have been some incidental landings in the north coast in Areas 2E,4,5,7 and 8.

Some biological samples have been taken and some survey data collected as part of the geoduck programs. These data have not been analyzed and presented in a stock assessment.

Landings have been limited from 200 to 630 t annually. Landings in 1994 were 62 t, valued at $111,000. Landed values have been modest and average prices in 1994 were $0.81 /lb. or $1.79/kg.

Subcommittee discussion

Given the amount of available data the Subcommittee has no basis on which to comment on stock status. The Subcommittee notes the assessment is planned for the near future.

(l) Goose Barnacles

Fishery update

Goose barnacles, *Pollicipes* spp., are harvested by hand picking in intertidal areas in exposed coastal locations. A category "Z - 6" licence for fishing without a vessel is required to harvest this species.

Almost all of the harvested barnacles are exported live to Spain or other destinations. This market is limited and has restricted the development of this fishery. The value of this fishery has been relatively minor (between $200,000 and $500,000 annually) since 1987. The landed value of the product is high (around $10 kg^{-1} since 1988) and hence has attracted considerable interest to this fishery. The whole landed value of goose barnacles in 1994 was $9.81 kg^{-1}.

There are currently no catch limits in the goose barnacle fishery since most of the stock is not available for harvest due to inaccessible harvest locations or unsuitable size or quality of the barnacles. It was estimated, in 1988, that less than 10% of the stock was available to the fishery. The low portion of the standing stock available for harvest may provide adequate biological protection for the species.

Subcommittee discussion

Given the amount of available data the Subcommittee has no basis on which to comment on stock status.

(m) Scallops

Fishery update

The fishery takes pink and spiny scallops, *Chlamys* spp., by divers (Z-I licence) and by small drags (Z-R) licences. The licences are not limited entry. Landings are currently limited by markets and a minimum size limit.

Landings in 1994 were 106 tonnes, with 101 t landed by divers and 5 t landed by vessels with drags. The landed value in 1994 was $504,000. The effort and landings in the drag fishery has declined and this trend should be investigated.

Most of the landings come from the Strait of Georgia, Areas 14,17,18 and 19.

Subcommittee discussion

The Subcommittee supported the recommendation that the declines in landings in the trawl fishery be investigated. The Subcommittee has no basis upon which to comment on stock status. There is potential for expansion of this fishery into new areas.

(n) Prawns

Fishery update

The landed value of the fishery has continued to increase and was $11.2 M in 1994, the highest on record. The season closed in November, earlier than previous years. Landings in 1994 were approximately equivalent to 1993. There has been an annual increase in the north coast contribution to the coast wide landings. Effort control remains an important issue. Industry was balloted in late 1994 and agreed to the implementation of trap limits for the 1995 season. Further measures are necessary. The domestic market is over-supplied during periods of high production, particularly April to July. The export market for B.C. spot prawns improved in 1994 as foreign cold water shrimp fisheries were in decline. This has resulted in an increase in effort in the fishery and early in-season closures in many areas. Area 12 landings declined in 1994 which may warrant further review and study. The prawn spawner index represents an excellent proactive management tool when biological samples are collected as fishery concentrations develop. However, when used in a reactive mode in response to reports of declining stocks from the fishing grounds, 4 to 6 weeks is required to collect samples, analyze data and implement closures if needed. The question raised is if the logistics required to assess prawn spawner index in a reactive mode may expose local stocks to over-exploitation and if so, is this a significant risk to the stocks on a larger scale. If not, then the current management regime is entirely satisfactory, to the best of our present

knowledge. If some significant risk exists, then current management regimes may have to be supplemented by other sources of in-season management information.

There is a consistent pattern of reports from industry as the season progresses in 1995 alleging overexploitation of stocks attributed to too much effort, and expressing concern for sustainability of the fishery. These reports are often provided by experienced fishers who have significant personal knowledge of the areas. It is suggested that these reports deserve attention. If true, significant changes in the current management regime will have to be implemented. If review and study determines that the allegations are unfounded, then the industry should be so assured.

Subcommittee discussion

Declines were noted in the south coast landings in 1994, largely driven by declines in landings in Area 12. There is a need to analyze current data from the fishery in order to assess the impacts of the fishery on prawn stocks and to assess the impacts of spawner indices on fishery sustainability. A working paper was recommended summarizing the results of research programs in experimental areas.

The Subcommittee notes there is a need to develop a process to evaluate spawner index information in a timely manner.

(o) Abalone

Fishery update

A fishery update was not provided as there is no legal fishery for abalone. At present, the Subcommittee cannot provide a working paper on abalone poaching, but recommends that C & P provide information on abalone enforcement activities, including the enforcement effort, the scope of the problem in individual enforcement cases, numbers of charges, outcome of charges and future plans.

A working paper was not provided on the worldwide methods, and the degree of their success, of attempts to rebuild abalone stocks. The Subcommittee concurs with the need for this paper and notes that no author was assigned the task during work planning.

7. ADDITIONAL SUBCOMMITTEE DISCUSSIONS

Publications

Revised working papers from the 1994 meetings (and 2 pre-1994 working papers) are in press in the Technical Report Series. Fishery updates presented in 1994 meetings have been compiled and will be published shortly.

Process for Advice

The Subcommittee reviewed the existing process of receiving requests for advice from managers, the generation of responses from the Stock Assessment Division, and the role of PSARC in this process. The mandate of PSARC to provide a peer-review forum for stock assessment information and advice is clear. However, the terms of reference for PSARC may be changed to accommodate its interaction with a Pacific Fishery Resource Conservation Council, expected to be formalized later this year.

Some uncertainty regarding the process for requesting and responding to stock assessment advices exists among the various PSARC Subcommittees. The Invertebrate Subcommittee requested a review of the process at the Steering Committee level. The information needs of managers must be met in a timely fashion but they must also be reviewed for consistency by the Head of PSARC and, for major activities, fit into the work planning process directed by the Head of the Stock Assessment Division. The Subcommittee stressed the need for flexibility and timeliness in addressing managers' needs, while ensuring thorough peer review of the advice provided.

Subcommittee Chair

Subcommittee notes that Mr. G. A. McFarlane's term as Invertebrate Subcommittee Chair will expire at the end of 1995.

APPENDIX 1. LIST OF PARTICIPANTS 1995.

NAME	AFFILIATION
G. McFarlane	Subcommittee CHAIR
B. Leaman	PSARC A/CHAIR
B. Adkins	Operations Branch, South Coast Division
A. Campbell	Stock Assessment Division, PBS
D. Einarson	Operations Branch, North Coast Division
J. Fargo	Stock Assessment Division, PBS
G. Gillespie	Stock Assessment Division, PBS
V. Haist	Stock Assessment Division, PBS
C. Hand	Stock Assessment Division, PBS
R. Harbo	Operations Branch, South Coast Division
W. Heath	M.A.F.F., B. C. Provincial Gov't
S. Heizer	Operations Branch, South Coast Division
D. Heritage	Stock Assessment Division, PBS
K. Hobbs	Operations Branch, South Coast Division Stock Assessment Division, PBS
G. Horonowitsch	Stock Assessment Division, PBS
G. Jamieson	Stock Assessment Division, PBS
G. Jorgensen	Stock Assessment Division, PBS
M. Joyce	Operations Branch, Fraser River Division
R. Kronlund	Stock Assessment Division, PBS
J. Morrison	Operations Branch, South Coast Division
I. Perry	Stock Assessment Division, PBS
H. Powles	Fisheries Research Branch, Ottawa
R. Stanley	Stock Assessment Division, PBS
G. Thomas	Operations Branch, North Coast Division
B. Waddell	Stock Assessment Division, PBS
R. Webb	Operations Branch, South Coast Division
I. Winther	Operations Branch, North Coast Division

APPENDIX 2. LIST OF WORKING PAPERS AND FISHERY UPDATES SUBMITTED TO THE PSARC INVERTEBRATES SUBCOMMITTEE, SEPTEMBER 12-14, 1995.

WORKING PAPERS

I95-12 **Survey Methodology for Intertidal Bivalves.**

Authors: A. R. Kronlund, G. E. Gillespie, G. D. Heritage
Reviewers: C. J. Schwarz - Simon Fraser University
V. Haist - P.B.S.

I95-13 **Assessment of Manila Clam, *Tapes philippinarum*, Stocks at Savary Island, B. C. - 1995.**

Authors: G. E. Gillespie, A. R. Kronlund, G. D. Heritage
Reviewers: G. Jamieson - P.B.S.
J. Fargo - P.B.S.

I95-14 **Review of Fishery-Dependent Data and Quota Recommendations for 1995/96 for the Green Sea Urchin Fishery in B. C.**

Authors: R. I. Perry, B. J. Waddell, A. Campbell, K. Hobbs
Reviewers: B. Adkins - South Coast Division
R. Kronlund - P.B.S.

I95-15 **Stock Assessment and Quota Options for the Sea Cucumber Fishery.**

Authors: A. Phillips, J. Boutillier
Reviewers: G. Kruse - A.D.F.G.
S. Heizer - South Coast Division

I95-16 **Catch, Effort and Quota Estimates for the Red Sea Urchin Fishery in B. C.**

Authors: A. Campbell
Reviewers: M. Saunders - P.B.S.
I. Perry - P.B.S.

I95-17 **Quota Options and Recommendations for the 1996 Geoduck Clam Fishery**

Authors: C. Hand, K. Hobbs, R. Harbo, G. Thomas
Reviewers: R. Stanley - P.B.S.
A. Phillips - P.B.S.

I95-18 **A Survey of Geoduck Population Density at Price Island, 1993-94.**

Authors: A. Campbell, K. Cripps, B. Clapp
Reviewers: I. Perry - P.B.S.
B. Leaman - P.B.S.

FISHERY UPDATES

1.	Shrimp	- M. Joyce, B. Adkins
2.	Sea Cucumber	- S. Heizer, G. Thomas
3.	Geoduck	- R. Harbo, S. Heizer, G. Thomas, I. Winther, K. Hobbs
4.	Intertidal Clams	- R. Webb, K. Hobbs
5.	Crabs	- M. Joyce, S. Heizer, I. Winther
6.	Euphausiid	- J. Morrison, B. Adkins
7.	Octopus	- J. Morrison, B. Adkins
8.	Squid	- J. Morrison, B. Adkins, M Kattilakoski
9.	Horseclams	- R. Harbo, K. Hobbs
10.	Goose Barnacles	- S. Heizer
11.	Scallops	- R. Harbo, K. Hobbs
12.	Green Sea Urchins	- S. Heizer, K. Hobbs
13.	Red Sea Urchins	- S. Heizer, S. Neifer, K. Hobbs
14.	Prawns	- B. Adkins, J. Morrison, I. Winther

Table 1. Management framework for Invertebrate fisheries, 1995.

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.	1995 quota reduced to 2096.3 t for I.V.Q.'s of 38.1 t (84,030 lb) of coastwide quota).Quota not taken in 1995 cannot be carried to 1996.	Varies by area - North Coast opened in Jan .95.	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 in 1995 with permit and plan for decontamination. Pilot harvest log/ validation log for Inside Licences.
Horse Clam	Limited to the 55 geoduck licences	Catch ceilings were recommended for open south areas: West: 87 t Inside: 65 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 Lemmens Inlet in 1995
Green Sea Urchin	Limited entry. 49 licences Notification required prior to commencement and termination of fishing in an area. (ZA tab)	1995 quota reduced in South to 60% of historical landings at 267 t. North: 90.7 t set for areas 3 and 4.	No Jan-Feb fishery in South Coast,1995 Fall 1995 TBA	Minimum size limit in effect. Voluntary IVQ program under-taken by fishers in fall 1994
Red Sea Urchin	Limited entry. 110 licences ZC tab with area election. Notification required prior to commencement of fishing. Weekly catch hails required on the south coast	South coast quota: 1383.9 t quota overruns to be deducted from 1996 quotas. North coast quota: 5445 t	South coast: Jan, Feb Oct - Dec, summer expl. variable days with IVQ North coast fishing periods: Jan-May, June, Aug, Oct-Dec.	Rotational areas in the north Minimum size limit in effect. Voluntary I.V.Q. system undertaken by the licence holders for part of 1994 and 1995
Gooseneck Barnacle	Not limited entry (Z6 tab) 114 licences issued in 1994.	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 - 32 licences issued in 1994 for trawl or drag .	None. Managed by size limit.	Some permanent area closues	
Pink and Spiny Scallop (Dive Gear)	Not limited entry. ZI - 37 licences issued in 1994 for diving.	None. Managed by size limit.	Some permanent area closues	Must be landed at a registered Shellfish plant, PSP monitoring
Plankton - Euphausiids	Limited entry. 19 ZF eligible licences, 18 issued in 1994 Notification and hail requirments	Mainland inlets: 275 t. Strait of Georgia: 215 t.	Inlets closed June 1 to August 15. Strait of Georgia open Oct 1.	Poor markets continue limiting this fishery in 1993-1995

Table 1. (Cont'd)

PECIES	LICENCES	QUOTA	SEASONS	COMMENTS
ctopus (by Trap)	Not limited entry. ZP tab. 161 licences issued in 1994	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.
ctopus (by Dive)	Not limited entry. ZG tab. 62 licences issued in 1994	None.	All year with seasonal closures for spawning	Harvest from vessel only. Poor markets have limited fishery in 1993-1994.
rawn/Shrimp / Trap	Limited entry. W tab. 260 licences eligible 1994, 257 issued	Managed by time and area closures based on a minimum escapement of the spawner cohort. Minimum size limit and gear escapement regulations.	3 month seasonal closure: Jan - Mar.	Delayed openings in Salmon/ Sechlt Inlets, Saanich Inlet, Howe Snd., Alberni Inlet with trap and fishing time limitations in these areas. Trap limits and industry monitoring adopted in 1995.
rimp Trawl	Limited entry. 249 S tab licences, 245 issued in 1994.	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.
quid	Not limited entry. ZE tab. 46 licences issued in 1994. (for opal suid only)	None.	Permanent area closures.	Pacific Rim National park closed in 1995 except in portions of 123-1, 123-5 and 124-1
ab	Limited entry. R tab. 226 licences were eligible in 1994. 221 were issued.	Managed by size limit. No quota. Area-specific trap limits. Trap escapment 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
ertidal Clam	Not limited entry. Z2 tab. 1844 licences issued in 1994	Managed by size limit, not quota	Seasonal openings and closures, staggered openings to maintain market supply. Closures for allocation to aboriginal and sport 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.
a Cucumber	Limited entry. ZD tab. 85 eligible licences. Area licencing in 1994.	1995 quotas set at 55 t split wt (South Coast) and 183 t split wt in the North.	Proposed fishery in October 1995. Area rotation in both north and south coast areas.	Quota overuns are removed from TAC the following year. Voluntary IVQ program failed in 1994. Fishery opening delayed to Oct. pending I.V.Q. development.

Table 2. Landings of invertebrates (t) in British Columbia, 1981-1994.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994*
INTERTIDAL CLAMS - Commercial Fishery:														
Razor	30	68	31	100	90	142	142	155	117	114	117	55	44	105
Butter	120	103	77	130	261	158	68	134	92	109	42	132	102	173
Manila[1]	317	597	1048	1677	1913	1893	3607	3909	2764	1456	982	923	1047	1193
Nat. Ln.	179	241	324	294	191	284	373	290	433	465	201	116	131	92
Mixed	161	155	279	410	477	371	87	27	159	339	137	112	121	104
SubTotal: Commercial Fishery	807	1164	1759	2611	2922	2848	4277	4515	3565	2483	1479	1338	1445	1667
FARMED CLAMS					4	7	25	30	31	39	169	300	300	400
TOTAL INTERTIDAL CLAMS	807	1164	1759	2611	2926	2855	4302	4545	3596	2522	1648	1638	1745	2067
GEODUCK	2704	3135	2636	3483	5370	5006	5734	4567	3985	3956	3333	2864	2455	2227
HORSE CLAM	51	321	21	7	6	96	355	325	115	124	110	2	23	62
SHRIMP	581	413	411	408	678	768	2644	2561	2299	1940	3265	2683	3283	2987
PRAWN	358	274	331	505	514	550	620	720	820	761	961	1168	1215	1208
CRAB	1317	1003	960	1155	1165	1321	1631	1508	1518	2129	1858	3334	6289	5647
ABALONE	85	82	56	58	42	52	49	49	49	50	N/A	N/A	N/A	N/A
OCTOPUS		18	30	25	32	53	129	209	217	198	131	117	145	74
SEA URCHIN -	116	160	986	1764	1815	2067	2223							
RED								2116	2658	3158	6945	12018	6264	5818
GREEN								444	609	475	607	1042	714	324
SEA CUCUMBER[2]				113	346	786	1722	1922	1144	870	1340	1242	812	536
SCALLOP		8	11	18	53	68	66	67	75	69	82	91	90	107
PLANKTON	19		47	103	131	166	130	247	360	530	450	380	53	333
SQUID		29	15	69	111	79	86	88	70	72	116	93	13	165
MUSSELS			tr	1	tr	2	2	3	4	1	tr	0	0	0
GOOSENECK BARNACLES					tr	2	32	49	30	37	40	38	30	27
OYSTERS - Farmed		1579	2453	2897	3420	2864	3482	3702	3721	4547	4482	4500	4000	5000
TOTAL TONNES	6038	8186	9716	13217	16609	16735	23207	23122	21270	21439	25368	31210	27131	26582

* preliminary landings for 1994

[1] the sum of commercial fishery landings and production from clam tenures

[2] landings are round weight

Table 3. Landed values ('000 $) of invertebrates in British Columbia, 1981-1994.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994*
INTERTIDAL CLAMS - Commercial Fishery:														
Razor	24	55	24	123	95	127	126	137	124	130	129	82	67	186
Butter	42	36	33	55	138	75	40	63	44	53	34	81	60	102
Manila	323	611	1043	1813	2278	2762	6003	7175	6003	3761	2574	2180	2570	3399
Nat. Ln.	195	263	329	311	202	327	474	359	588	710	327	190	212	144
Mixed	175	169	293	455	575	510	132	36	196	625	238	187	215	178
SubTotal: Commercial Fishery:	759	1134	1722	2757	3288	3801	6775	7770	6955	5279	3302	2720	3124	4009
Farmed Clams:					4	14	43	59	96	140	556	1000	1200	1300
TOTAL INTERTIDAL CLAMS	759	1134	1722	2757	3292	3815	59	7829	7051	5419	3858	3720	4324	5309
GEODUCK	2434	2814	1818	2937	4605	4294	6184	9762	12967	10582	9659	16237	26994	33552
HORSE CLAM	42	235	12	5	6	63	309	300	144	274	119	2	46	111
SHRIMP	912	644	1073	1022	1180	1240	4609	2802	2985	2637	4430	2831	3494	4483
PRAWN	2019	1545	2138	3262	3379	3734	4326	5724	7083	7006	7728	8380	10121	11174
CRAB	3556	2345	3320	4558	4719	5661	6452	5945	6046	8919	8342	11008	18607	24136
ABALONE	721	696	462	530	442	734	973	1076	1170	1347	N/A	N/A	N/A	N/A
OCTOPUS		39	63	56	82	136	381	651	707	657	415	350	447	234
SEA URCHIN	34	56	358	712	763	1011	1276							
RED								1241	1631	1953	4187	8660	5271	7829
GREEN								584	1020	948	1795	4424	3777	2090
SEA CUCUMBER				22	94	236	768	961	998	1168	1029	1363	982	976
SCALLOP		17	24	56	95	212	244	285	316	317	387	420	423	504
PLANKTON	6	0	19	42	89	113	102	192	223	415	390	318	41	259
SQUID		22	21	84	184	127	132	113	94	81	148	135	17	187
MUSSELS		tr	tr	tr	0	tr	tr	tr	tr	1	tr	tr	tr	
GOOSENECK BARNACLES					1	4	211	479	343	413	418	448	320	270
OYSTERS - Farmed		981	1554	2109	2613	2515	2548	2725	2938	3613	3465	3600	4700	4400
TOTAL VALUE ($000)	10483	10528	12584	18152	21544	23895	28574	40669	45716	45750	46370	61896	79564	95514

*preliminary values for 1994

[1] the sum of commercial fishery landings and production from clam tenures

BIOLOGICAL ADVICE ON PACIFIC SALMON

I. STEERING COMMITTEE REPORT

MAJOR CONCERNS

In the review of the Barkley Sound sockeye forecast working paper (S95-13), it was noted that the baseline date used to partition the catch among stocks using parasites may no longer be valid due to a shift in the levels of infection among stocks. This shift may require re-analysis of catch data for the past decade. The Steering Committee believes there is an urgent need to conduct an evaluation of the impact of this shift on our understanding of stock productivity and dynamics for the Barkley Sound stocks. In particular, there is a need to understand if alternate techniques applied to existing samples (e.g. DNA analysis, scale analysis) can substitute for the missing stock identification data, how long the analysis would take, and the impacts on the stock assessment.

Steering Committee notes that data collection programs for some key salmon stocks are such that minimum data requirements for credible assessments are no longer being met. The Committee requests that the Stock Assessment Division identify appropriate designated salmon stocks and develop the framework and guidelines to achieve this sampling on an annual basis. This commitment should be reflected in the Division's work plans.

S95-7 Biological escapement goal for Alsek River system chinook salmon.

The Steering Committee concurs with the Subcommittee's recommendation that the proposed reduction of the escapement target for the Klukshu River to 1000 fish be rejected and recommends that the PSC Transboundary Technical Committee escapement target of 4700 fish be maintained.

The Steering Committee concurs with the Subcommittee's recommendations on the merits of radio tagging and the review of the MSY management strategy on this stock.

S95-8 Stock status and 1996 forecast of Smith Inlet (Long Lake) sockeye salmon

The Steering Committee concurs with the Subcommittee's recommendation that there is no basis for changing the target escapement for Long Lake.

The Steering Committee recommends an evaluation of the current escapement targets with regard to the productivity of the lake in unfertilized and fertilized states. The Committee recognizes that there has been extensive effort in collecting data (juvenile and plankton) from this system and that these data need to be incorporated in the analysis. Steering Committee notes with concern that the juvenile data were requested for the

present document and were not provided. The Committee endorses the Subcommittee recommendation that these data be incorporated into a Working Paper the fall 1996 meeting of the Subcommittee.

The Steering committee notes with concern the comments of Reviewer 1 with respect to the provision of forecasts outside of PSARC. The Steering Committee reiterates the RMEC decision that PSARC is the Regional forum for review of all stock forecasts and the importance of maintaining a single forum for such review.

S95-9 Evaluation framework for Strait of Georgia conservation measures

The Steering Committee endorses recommendations 1 to 4 presented from the Subcommittee. However, Steering Committee notes that the recommended exploitation rate of 65% may be too high for Strait of Georgia stocks at present productivity levels. The Steering Committee therefore requests the Salmon Subcommittee identify a target exploitation rate for the Strait of Georgia coho based on two scenarios: a) whether coho are principally distributed outside the Strait of Georgia or, b) maintain their historical distribution and remain in the Strait of Georgia.

The Subcommittee should also identify early in-season indicators of use in determining which scenario is more likely. In addition, if the movement of coho outside is the more likely scenario and given the uncertainty of abundance estimates for the outside waters, the Subcommittee should recommend a conservative catch ceiling for the outside area. The Steering Committee strongly endorses recommendations 5 and 6.

S95-10 Harbour seal predation on Puntledge River salmon juveniles

The Steering Committee endorses the recommendations of the Subcommittee. Steering Committee notes that to ensure maximum benefit from such multidisciplinary studies, future experimental work should include salmon population dynamics staff in the design, implementation, and analysis. The Steering Committee also recommends that salmon stock assessment staff assist in preparing the spring working paper regarding seal predation on adult salmon. The report should focus on the impact of predation on salmon in the Puntledge River area, rather than on seal biology.

S95-11 Forecasts of Fraser River sockeye salmon for return year 1996

The Steering Committee endorses the recommendations of the Subcommittee, noting that additional review and analysis is forthcoming.

S95-12 Assessment of recruitment forecasting methods for selected salmon stocks in northern British Columbia

The Steering Committee endorses the recommendations of the Subcommittee.

The cumulative probability plots shown in Figures 12.1 to 12.4 of S95-12 have proved very helpful to managers. Where data and analytical frameworks allow, these diagrams or a suitable facsimile should be presented with forecasts of other salmon stocks.

The authors are encouraged to explore the use of other types of models for generating reliable pre-season forecasts of salmon stocks in northern British Columbia. Data sets, collection techniques, and documentation procedures should be reviewed and adjusted as necessary.

S95-13 Review of 1988-1995 forecast performance, stock status, and 1996 forecasts of Barkley Sound sockeye.

The Steering Committee expressed concern that the final version of the 1994 document dealing with forecasts for Barkley Sound sockeye (S94-21) was not prepared. The Steering Committee also has strong concerns that the recommendations provided by the reviewers in 1994 were not incorporated into the 1996 forecasts for Barkley Sound sockeye.

The Steering Committee expressed strong concern regarding the apparent loss of the ability of the DFO to apportion Barkley Sound sockeye by stock. This situation severely impairs the ability of the DFO to conduct stock assessments and prepare reliable forecasts (See Major Concerns, above).

The Steering Committee notes the need for a rapid evaluation of methods for reconstructing stock composition. The workload and cost for correcting the situation should be defined.

The Steering Committee notes a recent decline in the marine survival of Barkley Sound sockeye. As a consequence, managers should adopt a precautionary approach to the 1996 fishery and use the low end of the forecast range as identified in the Subcommittee report.

OTHER BUSINESS

Steering Committee strongly supports the proposed three-day workshop to be held early in 1996 to update the Fraser River sockeye forecasts for 1996. The Committee encourages that an invitation be extended to PSC staff to contribute their expertise in the analysis of these stocks.

Steering Committee notes the Subcommittee's concern about the timing of assessments and the availability of some data important to the assessments. The Steering Committee requests guidance from RMEC on potential alteration of meeting

schedules to accommodate the incorporation of these data into the assessments. The Committee notes this concern in regard to other Subcommittees as well.

II. SALMON SUBCOMMITTEE REPORT

1. INTRODUCTION

The Salmon Subcommittee met November 15-17, 1995, at the Pacific Biological Station, Nanaimo. Seven Working Papers were presented to the Subcommittee. Meeting participants and reviewers of Working Papers are listed in Appendices 1 and 2, respectively.

2. MAJOR SUBCOMMITTEE CONCERNS

Stock Assessment Data

As stressed in previous Subcommittee reports, data-related problems were noted in several Working Papers. Many salmon data sets potentially useful for stock assessment are not systematically stored or archived. The Subcommittee recommends that a high priority be assigned to the management of stock assessment data. Furthermore, the Subcommittee recognizes the need for allocation of resources to data management.

Standardized Biological Sampling

The Subcommittee recommends that minimum levels of biosampling be developed and adopted throughout the region for designated salmon stocks. Representative samples and reliable biological data are required to estimate stock composition of catches and to determine the sex, size, and age composition of total returns. This information is a prerequisite for any serious assessment of the status of salmon stocks. Stock assessments are only as reliable as the weakest information used in analyses. For example, excellent data on catch and escapement are available to assess the status of Long Lake sockeye, but the utility of these data has been compromised by the lack of reliable age composition data needed to compute returns by brood year.

The Subcommittee considers present sampling efforts inadequate for reliable assessments of many (if not most) salmon stocks. Increasingly, budgetary considerations limit the extent of biological sampling conducted in the Region. Stock assessment activities should be priorized to meet fiscal constraints without sacrificing the quality or quantity of biological samples needed for rigorous assessment. Even so, any increased sampling effort will also entail additional costs in infrastructure (e.g., scale labs) required to process additional samples.

3. WORKING PAPER SUMMARIES, REVIEWS AND DISCUSSION

S95-7: Biological escapement goal for Alsek River system chinook salmon. Clark, Etherton, McPherson

Working Paper Summary

Available information consisting of catches, escapements, and age composition of chinook salmon, *Oncorhynchus tshawytscha*, returning to the Alsek River system during the years 1976-94 was analyzed. Total escapement of chinook salmon to the Alsek River system is not estimated annually. Instead, total escapement of chinook salmon in the Klukshu River, an Alsek River tributary, is enumerated annually. The current escapement goal set in 1991 by the Transboundary Technical Committee is 4,700 chinook in the Klukshu River. The goal was derived as the average of the U.S. goal (4,400 chinook) and the Canadian goal (5,000 chinook). The escapement goal was never achieved during the 1976-94 period. The two highest escapements (3,300 chinook and 3,700 chinook) occurred in 1993-94. However, return data are only available through the 1989 brood year.

The Klukshu River escapement of chinook salmon was expanded into total estimates of Alsek River chinook salmon escapement using four alternate assumptions concerning its proportion of the total (33%, 50%, 60%, and 75%). Estimated age-specific catches of Alsek River system chinook salmon were added to the four alternate sets of age-specific escapements to estimate annual age-specific total runs for the years 1976-94. Four sets of estimated total escapements and total recruitments for brood years 1976-89 were used to develop spawner-recruit relationships. These spawner-recruit relationships were used to estimate the Klukshu River escapement level of chinook salmon that is estimated to provide maximum sustained yield in U.S. and Canadian fisheries. Approximately 1,000 chinook salmon spawning annually in the Klukshu River with a bootstrapped 90% confidence interval from 810 to 1,145 chinook salmon was estimated to be this yield.

The expansion factor for a total Alsek River system chinook salmon escapement goal is unknown and requires further research; recommendations are made concerning this needed research. Until these needed data are available, the authors recommend that the U.S. and Canadian fisheries in the Alsek River be managed to achieve Klukshu River spawning escapements of chinook salmon that are expected to result in sustained yields near maximum.

The authors recommend that the Alaska Department of Fish and Game and the Canadian Department of Fisheries and Oceans adopt 1,000 chinook salmon annually spawning in the Klukshu River as a formal escapement goal (Klukshu River weir count minus potential harvest in Canadian upstream fisheries). The authors further recommend that a management range of 400 to 1,400 chinook salmon spawning in the

Klukshu River be adopted to guide U.S. and Canadian fisheries management in the Alsek River. The authors recommend this escapement goal policy be used by U.S. and Canadian fishery managers for Alsek River fisheries over the next several years and that the Alsek River chinook salmon escapement goal be reevaluated in the year 2001.

Reviewers' comments

Reviewer #1

Generally, this is an easy to follow and reasonable analysis of stock and recruitment data for this stock. The authors have logically assembled the necessary data for the analysis, and have acknowledged many of the uncertainties surrounding those data. Before adopting the authors' value of optimal escapement, however, Reviewer #1 suggests that simulation studies be used to check the robustness of their recommendation to uncertainties in the escapement data. A more conservative (i.e., higher) escapement goal might be prudent until more data become available and population parameters can be more precisely estimated.

Reviewer #2

Reviewer #2 concurs with the authors that the escapement goal needs to be reconsidered. Chinook returning to other tributaries of the Tatshenshini, as well as chinook returning to the mainstem of the Alsek River, should be included in the escapement. Escapement counts fluctuate only 2.5 times from the lowest to the highest (range of 1,153 to 2,894 chinook). This is a small range of stock sizes over which to compare recruitments. More information is needed at the upper and lower limits of stock sizes. Escapements in 1993-95 were the largest on record and will provide additional information at the upper range of stock sizes when the returns for these brood years are complete. Management actions to vary escapements (and catch) would provide useful information towards determining the escapement goal. Additional coded-wire tagging of juveniles would also strengthen the estimates of recruitment.

Reviewer #2 strongly supports the recommendation that mark recapture studies be conducted in the 1996-98 seasons. Furthermore, Reviewer #2 suggests that the mark-recapture studies be expanded to include recovery efforts in the upper Alsek mainstem if suitable spawning habitat is available.

Subcommittee discussion

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

1. The updated information provided at the Subcommittee meeting should be incorporated into the Working Paper;

2. The CWT recoveries at the weir should be included in the CWT analyses to determine the degree of support for the harvest rates inferred in the paper (16%-30%);

3. The U.S. harvest data should be described in greater detail to inform the reader of potential reasons for the decline in catch, particularly since the late 1970s. A brief description of other areas of potential U.S. harvest (trawl fishery, NSEAK troll fishery, Prince William Sound, etc.) should be provided along with comments regarding the likelihood of Alsek chinook interceptions in these fisheries;

4. Simulations need to be conducted to test the robustness of the stock/recruitment analysis related to uncertainties and potential autocorrelations in escapement and recruitment estimations. As an alternative to the approach of presenting the stock-recruitment relationship for the total reconstructed Alsek stock, the data should be re-examined and also presented in terms of just the Klukshu stock under various plausible assumptions about harvest rate.

The Subcommittee acknowledged the importance of continuing the Alsek chinook stock assessment program since it contributes to one of only a few comprehensive databases pertaining to natural chinook stocks. Although there was general confidence in the Klukshu chinook escapement database, the Subcommittee did not feel the same towards the recruitment or system wide escapement databases as presented. Further analysis of the data was encouraged to quantify, if not reduce, uncertainty in estimates of both total escapement and stock size. A number of additional programs were recommended to address the assumptions regarding expansions of weir and aerial survey data and marine harvest; of these, the Subcommittee recommended that a radio tagging program coupled with a stock identification feasibility study should receive priority if funds become available.

The rationale for the escapement goal recommended in this Working Paper was based on stock-recruitment analyses. The Subcommittee was concerned that the narrow range in Klukshu chinook escapements (1,153 to 2,894 chinook) seriously limits the interpretation of the Ricker curve for this stock. There is a paucity of data from the Klukshu stock which might explain or support the density dependent assumptions inherent in the Ricker model. The inclusion of recruitment data from the escapements observed in 1993 (3,220 fish), 1994 (3,628 fish) and 1995 (5,300 fish), the three highest escapements on record, may contribute to resolving some of the uncertainty in the stock-recruitment relationship at the upper extreme.

The Subcommittee did not endorse the authors' interpretation of the stock-recruit analysis. In the absence of a more detailed explanation regarding historic catch trends, an alternative interpretation is equally plausible. Given the catch history (1955-94) presented in the paper of higher U.S. catches in the 1950s and 1970s and the decline in the 1980s, it is possible that the stock size has been fished down and under-escaped, not over-escaped as stated by the authors. If the stock was over fished, the Ricker curve

would likely bend over pre-maturely and the estimates of optimal escapement would be negatively biased (Walters and Staley 1987: Can. Spec. Publ. Fish. Aquat. Sci. 96: 375-384.).

Regardless of the state of the resource, the Subcommittee did not support the proposed escapement target of 1,000 Klukshu chinook. A more prudent escapement objective is to continue to increase spawning escapements to, and beyond, the upper range of observed levels to test for density dependence and better define optimal escapement. Furthermore, the Subcommittee concluded that reducing the goal now would not likely result in significant information gains before the proposed review in 2001. Given the current level of uncertainty in the data, there would be a high degree of risk in adopting the proposed escapement goal at this time, especially when it is below any previously observed level. In addition, it was noted the proposed goal seemed inconsistent with the historic level of catch, given the apparent low productivity of Alsek chinook.

The premise of this Working Paper is that maximum sustainable yield is the appropriate management policy. The Subcommittee noted that this policy should be reconsidered in light of the park status of a portion of the Alsek watershed. An alternative approach might be to maximize recruitment, providing increased nutrients to the freshwater ecosystem with a modest reduction in sustainable yield.

Subcommittee recommendations

1. The Subcommittee recommended rejection of the author's revised escapement target of 1,000 Klukshu chinook.

2. The Subcommittee recommended that a radio tagging program coupled with a stock identification feasibility study receive priority if funds become available.

3. The Subcommittee recommended that the management policy of maximum sustainable yield be reconsidered for this stock.

S95-8: Stock status and 1996 forecast of Smith Inlet (Long Lake) sockeye salmon. Rutherford and Wood

Working Paper Summary

This paper provides an updated review of the status of the Long Lake (Smith Inlet, Statistical Area 10) sockeye salmon stock. Long Lake sockeye have been managed to an escapement goal of 200,000 sockeye since 1979. Based on catch and escapement data, stock size generally increased prior to 1993. However, the 1994 and 1995 returns are well below average (Fig. 8.1). Only a weak stock-recruitment relationship was observed using a Ricker model (Fig. 8.2), in spite of the reliability of escapement and total return data. The variability in returns reflects true variation in the

survival process rather than measurement error. Further analysis is required to determine whether the observed variation in survival occurred in the freshwater or marine environment. Poor 1994 and 1995 sockeye returns also occurred in neighboring Owikeno Lake (Rivers Inlet, Area 9) and several other southern stocks, suggesting that the recent poor returns were caused by unusual early marine mortality experienced by smolts from the 1990 and 1991 brood years.

The 1996 sockeye run forecast to Long Lake is 348,000 sockeye with a 95% C.I. of 17,000 to 6,914,000 sockeye (see also WP S95-12). Given the wide confidence interval, the forecast will have little practical use for fisheries managers. Low confidence should be placed in the 1996 point estimate. Historically, forecasts for this stock have performed poorly in spite of high quality catch and escapement data.

Reviewers' comments

Reviewer #1

Reviewer #1 comments that the Fertilization Program in Long Lake has contributed to the success of this stock and should be reviewed. If the data had been available, this Working Paper would have encompassed all aspects of stock status. In particular, a summary table of data collected by the Lake Enrichment group could have provided plankton densities, smolt sizes and densities from 1977 to present. Analysis of this information may provide a better method of forecasting adult returns. A stock-recruitment analysis conducted by Reviewer #1 indicated an optimum escapement of 250,000+ sockeye, significantly different than the one suggested in this paper and contrary to results in previous PSARC reports. These discrepancies need to be resolved.

Reviewer #1 also states that the Central Coast Fish Management Group will calculate forecasts for all major Central Coast stocks, including Long Lake sockeye, during the first week of December. These forecasts follow a standard method which allows for the manipulation of age-specific return rates to reflect freshwater survival conditions.

Reviewer #2

Reviewer #2 states that the Working Paper was generally well written and relatively easy to follow. The authors should add an interpretation of current stock status relative to potential exploitation levels over the short and long term. Size and abundance data for juvenile sockeye in Long Lake have been collected since 1976 but, according to the authors, were not available for this Working Paper. These data (and possibly environmental data) should be included in the Working Paper and analyzed to determine whether they could lead to improved forecasts.

The 1996 forecast method based on 5-yr averages is questionable given the large confidence interval (0.02 - 6.91 million fish) and other methods should be examined. For example, stock-recruitment models that look at the residual variation in terms of environmental variables could be considered.

Subcommittee discussion

Long Lake sockeye fishery managers appear to be very effective in managing to the escapement target. This results in apparently log-normal variation in returns near a fixed target escapement (Fig. 8.2), providing little information about stock productivity. This may be a good system for adaptive management of sockeye, or it may provide an opportunity for a harvest rate approach to provide some variation in escapements. The Subcommittee agreed with the authors that the two unfertilized brood years where total return data are available (1973, 1980) should be excluded from the stock-recruit analysis under the assumption that lake fertilization has improved lake productivity. The authors should resolve the source of the discrepancy between optimum escapements provided by the authors and that provided by the reviewer.

Because of interannual variation in age at maturity for Long Lake sockeye, it is critical to obtain annual estimates of age composition in the fishery and the escapement. Sampling of sockeye age composition has not been adequate in some years, and prior to 1984, sampling was not conducted in some years. Sampling appears to be adequate for catch in 1995 but not for escapement. Generally, biological sampling is improving in Long Lake. However, the Subcommittee noted that assessments are jeopardized by the lack of consistent time series of basic biological data on salmon age composition, fecundity, and length/weight frequencies.

Subcommittee recommendations

The Subcommittee recommended acceptance of the Working Paper subject to minor revisions. Given the analyses presented, there is no basis for changing the target escapement to Long Lake from 200,000 sockeye. Forecast recommendations are discussed in conjunction with WP S95-12.

The Subcommittee recommended that a Working Paper on Long Lake sockeye juvenile production be prepared. Annual estimates of the size and abundance of juvenile sockeye provide assessment information that complements information obtained from spawning escapements.

As Long Lake has the potential to be one of the best systems for studying sockeye production in B.C. (if good juvenile data are available), the Subcommittee recommended that reliable basic biological data (age composition, length frequencies, fecundities, etc.) be collected routinely for stock assessments.

S95-9: Evaluation Framework and a pre-fishery assessment of harvest measures to conserve Strait of Georgia coho salmon stocks. Kadowaki and Ryall.

Working Paper Summary

In 1989, PSARC recommended that exploitation rates on wild Strait of Georgia coho stocks be reduced by approximately ten percentage points (from the 75%-80% range to the 65%-70% range) to maximize yield and reduce the risk of overfishing. A multi-branch steering committee was formed to develop and implement a process for addressing the problem. In November 1994, the Minister announced 1995 harvest conservation measures that included: (a) for the recreational fishery (from Cape Sutil in Johnstone Strait to Cadboro Point in the south), a reduction in the daily bag limit for coho salmon from 4 to 2 fish per day and an increase from 30 cm to 41 cm in the minimum size limit, and (b) for the Strait of Georgia troll fishery, non-retention of coho salmon.

The announcement also indicated that DFO was exploring the possibility of a selective hatchery mark fishery for the recreational sector and that DFO would be evaluating options for reducing the impact of fisheries outside the Strait of Georgia. Since the announcement, PSARC reviewed the status of Strait of Georgia coho stocks (WP S94-9) and advised that the previous exploitation rate target of 65%-70% is too high given the recent declines in marine survival rate and continued declines in escapement. An unspecified exploitation rate of less than 65% was recommended.

Evaluation Framework for the Rebuilding Program

Exploitation rates on wild and hatchery indicator stocks will be monitored to evaluate the effectiveness of the implemented management program. Smolt to adult survival rates will be monitored for these same stocks to assess variation in marine productivity to evaluate the appropriateness of the exploitation rate target. Spawning escapement to a small number of fenced streams and to a larger number of index reaches will be monitored and evaluated against escapement goals where they have been developed. Fry size and densities will be monitored in a larger number of streams to assess the seeding level relative to capacity and to assess the adequacy of the spawning population in the previous fall.

Evaluation of fishery performance is a requirement of any harvest management program. Criteria such as fishery harvest rate, catch, landed value, effort, season length and income are often used to evaluate fishery performance. However, this topic requires further discussion with harvest managers and economists before specific recommendations on evaluation can be made.

Effectiveness of Strait of Georgia Coho Management Measures

Data required to conduct a full evaluation of the effectiveness of the measures implemented in 1995 will not be available until the early spring of 1996. Pre-season analyses indicated that the specific measures announced last November, by themselves would not have been sufficient to reduce the exploitation rate below 65% in 1995. These measures were aimed at reducing exploitation rates by 10 percentage points to the 65% to 70% range on average over a period of years. In years of high abundance in the Strait of Georgia, these measures would produce a reduction larger than 10 percentage points while in years of low abundance (e.g., 1995) they would have a smaller or no effect.

To be effective at achieving conservative exploitation rates on Strait of Georgia coho salmon of less than 65% **on an annual basis**, harvest management measures must be considered across the full range of the potential ocean distribution of these stocks. To this end, commercial and recreational fisheries in the Strait of Georgia, off the west coast of Vancouver Island and in the approach waters of Juan de Fuca and Johnstone straits must be part of the harvest management program for these stocks.

Forecasts of abundance and distribution are critical to the success of any stock-based management program. Forecasting capabilities are poor at present and require further work to develop useful tools.

The suite of models used in planning the 1995 fishing season has a number of shortcomings. Neither Canadian nor U.S. stocks are realistically represented in the hook and line models, and escapement from one model cannot be directly passed on to the next model. The ability to evaluate harvest measures in net fisheries is extremely crude. The effect of variability in input parameters such as catchability, total expected effort and effort allocated to species cannot be evaluated.

Recommendations

1. An indicator stock is still required for the mainland side of the Strait of Georgia.

2. An exploitation rate target corresponding to recent smolt to adult survival rates is required. The previous target of 65% to 70% was based on studies conducted during a period when survival rates were more than twice recent levels.

3. Escapement goals are required for rigorously surveyed streams or index reaches.

4. To permit proper assessment of the status of freshwater coho habitats, data on the quantity and quality of these habitats are required.

5. Work on pre-season and in-season forecasting methodologies is required to develop the tools needed by an adaptive, stock-based management program.

6. A credible, adaptive, stock-based harvest management system requires a flexible stock/fishery model that can be used in a variety of fora, either internally or with advisors for fishery planning.

Reviewers' comments

Reviewer #1

Reviewer #1 found this Working Paper poorly focused and difficult to follow. The background section discusses selective mark fisheries at some length, even though this management tool is irrelevant to the main purpose of the paper. There is a section on development of abundance-based management, which has not been implemented and is irrelevant to the assessment of harvest measures actually implemented. The authors also suggest that an untested or evaluated methodology based on juvenile size and density be used to assess the adequacy of spawner escapements. Measurement of exploitation rates is the only tool presented to assess Strait of Georgia harvest measures; exploitation rate measures may not provide information on the effectiveness of specific fishery harvest controls for Strait of Georgia coho. Because coho are known to have annually variable ocean distribution, measurement of fishery harvest rates is possible only if the rearing distribution of Strait of Georgia coho can be directly estimated or reasonably assumed.

In the view of reviewer #1, the current Working Paper should be rejected and in its place two Working Papers should be prepared. The first, short Working Paper would deal with evaluation of the effectiveness of Georgia Strait management actions. The second, more important Working Paper would set out the basic steps and associated information needs and analytical modeling requirements to implement a stock-based management system for wild coho in southern B.C. Options could be provided where appropriate for such fundamental issues as the stocks on which management is to focus, exploitation rate versus harvest rate versus escapement management, inseason adjustment to management plans, conservation objectives, abundance based management, etc. The second Working Paper is overdue, particularly in light of DFO's new conservation ethic - precautionary management to minimize risk to stocks.

Reviewer #2

Reviewer #2 commends the authors for providing (along with S94-9) a wealth of data and information. Reviewer #2 believes that five indicator stocks provide a minimal program for coho escapement. With over 200 Georgia Strait coho stocks, there can be little confidence in escapement trends from such an indicator program. Additional information should be provided on the index reach spawner surveys. Furthermore, the Working Paper should have addressed the coho bycatch in the Fraser River aboriginal fishery on chum salmon and the influence of hatchery stocks of coho on wild coho stocks.

Subcommittee discussion

The Subcommittee accepted the Working Paper with minor revisions.

The Subcommittee believes the Working Paper to be a reasonable presentation of the overall scope of the issues related to evaluating the effectiveness of harvest management measures to conserve Strait of Georgia coho. However, the Subcommittee believes that the stock assessment components of the evaluation framework were much better defined than the harvest management components. More work is required to develop methods for evaluating the effectiveness of harvest management measures in specific fisheries. The Working Paper identified the need for these methods but did not offer any analytical approaches that would measure the net impact of harvest options for coho. For example, the methods for dealing with uncertainty in stock distribution are problematic. One reviewer suggested an approach involving the partitioning of escapement into outside and inside rearing components through scale pattern analysis. Stock abundance in outside and inside fishing areas could then be estimated through stock reconstruction techniques. Harvest rates could then be calculated for the two areas.

Previous experience with evaluating chinook harvest measures demonstrated the difficulty in conducting a proper evaluation. Because of the distribution fluctuations in coho, evaluation of harvest measure may be even more difficult for coho.

The Subcommittee endorsed the recommendations in the Working Paper subject to rewording to reflect previously approved recommendations (i.e., #1 and #4). The authors are asked to provide supporting documentation for recommendation #3 concerning establishment of escapement goals. For recommendation #2, the Subcommittee noted an ambiguity as to whether the approved recommendation of a reduction in the exploitation rate target applies to an annual basis or to an average of years.

There was considerable discussion on the role of PSARC in addressing harvest management issues. The Subcommittee recommends that a working group of harvest managers and stock assessment staff be formed to investigate methodologies for evaluating specific harvest management measures, including the potential development of new fishery models.

S95-10: An assessment of harbour seal, *Phoca vitulina*, predation on outmigrating chum fry, *Oncorhynchus keta*, and coho smolts, *O. kisutch*, in the lower Puntledge River, British Columbia. Olesiuk, Horonowitsch, Ellis, Smith, Flostrand, and Warby.

Working Paper Summary

The authors describe a previously undocumented foraging behaviour in which harbour seals congregated during the night at two bridges in the lower Puntledge River and apparently used the light cast from the bridges to silhouette and capture outmigrating salmon fry and smolts. Predation on chum fry was observed throughout a 7-1/2 week outmigration that extended from 01 April to 23 May. Both foraging effort and feeding rates peaked during the weeks of 23 April - 6 May when nightly consumption was estimated to average about 140,000 (range 54-202,000) fry. Over the entire outmigration, seals were estimated to consume 3.1 million chum fry (with a 95% confidence interval of ±1.3 million), which represents roughly 16% of the total 1995 chum fry production. Predation on coho smolts was observed during a 2-1/2 week period extending from 08 May - 25 May. A distinctive peak occurred during the week of 14-20 May when nightly consumption was estimated to average about 13,000 coho (range 10-16,000 coho). Over the entire outmigration, seals were estimated to consume 138,000 coho smolts (with a 95% confidence interval of ±78,600), which represents roughly 15% of the total 1995 coho smolt production. On the basis of these findings, the authors offer several recommendations for future research and management of Puntledge River salmon stocks.

Reviewers' comments

Reviewer #1

According to Reviewer #1, the purpose is not clearly stated. The Working Paper does describe the unique foraging behavior in the Courtenay River and document the number of seals, their feeding rate and the number of fry and smolts consumed. This aspect of the Working Paper appears to be completed in a rigorous and thorough manner. The Working Paper provides insightful information on which future work, both mitigative and investigational, can be based. However, the impact of seal predation on the continued viability of Puntledge River salmon stocks, particularly chinook salmon, was not addressed.

It is unfortunate that the authors chose to document the impact of seal predation on the more abundant chum and coho. Clearly, it is the chinook that are most at risk in the Puntledge River and the stock that should be the study focus. Had the focus of this study been on juvenile chinook, which were the subject of previous adult studies, the overall effect of seal predation on the viability of Puntledge River chinook could have been evaluated.

In Reviewer #1's opinion, the authors have clearly demonstrated that harbour seals are an effective predator on both juvenile and adult salmon in the Courtenay River and Comox Harbour. The issue now is to what extent this predation is limiting the rebuilding of Puntledge River stocks and if they are causing a conservation concern (particularly for chinook). Clearly, PSARC should review all available information to

establish whether harbour seal predation in the Courtenay River is causing a conservation concern for salmon, particularly chinook salmon.

Reviewer #2

The authors have done a good job in documenting this previously unknown feeding behavior of harbour seals on outmigrating salmonids. Their 1995 study appears to have been carefully designed and conducted. They have been particularly careful to ensure repeatability of observations and have checked for variability between observers. Their methods are appropriate and their conclusions are supported by their data. Their recommendations are reasonable and show considerable common sense.

Presumably, data are available on the timing and number of salmonids leaving the Puntledge River each year. These should be presented in the Working Paper, and an effort should be made to empirically calculate predation rates. The greatest concern in the Puntledge system is predation of chinook salmon, particularly the summer run. The consumption of chinook smolts by harbour seals warrants further study and should be specifically addressed in 1996.

Subcommittee discussion

The Subcommittee generally agreed with the reviewers' views that the portion of the Working Paper dealing with the predatory behavior of seals was well done but that the assessment of impacts on salmon was not supportable. The Subcommittee recommended that the Working Paper be accepted subject to major revisions.

The study appears to have emphasized seal biology rather than rigorously assessing impacts of seals on salmon productivity. Many questions from the Subcommittee concerned the representativeness of observations from various spatial and temporal strata and their use to generate precise and unbiased estimates of average predation rates by seals. The Subcommittee concluded that estimates of consumption rates and average numbers of juvenile salmon eaten by seals in the area of the bridge are reliable. However, the Subcommittee emphasized that point estimates of the proportion of the total stock of juvenile chum or coho eaten by seals are not reliable because they are based on highly uncertain estimates of the total abundance of juvenile salmon during the 1995 downstream migration.

Revisions to the Working Paper should include:

1. Removal of all recommendations that are not strictly related to the contents of the paper;

2. Use of observations in the Working Paper to estimate the range of potential impacts that seal predation may have on juveniles of wild or hatchery chum and coho salmon in the Puntledge River;

3. Deletion of all reference to chinook salmon because study observations are inadequate to quantify any interactions between seals and juvenile chinook;

4. Completion of the analysis of behavior at the level of individually identified seals to strengthen inferences about whether satiation or other effects influence current estimates of mean predation rates and to identify the potential impact on salmon of removing selected seals from the population;

5. Inclusion of a more thorough description of the feeding rate calculation.

Subcommittee recommendations

1. Studies should be designed and undertaken in 1996 to determine whether highway light management can reduce seal predation of juvenile salmon in the Puntledge River.

2. A Working Paper should be prepared for review in spring 1996 regarding seal predation of adult salmon in the Puntledge area.

S95-11: Forecasts of Fraser River sockeye salmon for return year 1996. Cass and Blackbourn.

Working Paper Summary

The previous PSARC Working Paper primarily focused on age-4_2 forecasts and only provided forecasts for age-5_2 sockeye with large age-5_2 components (Birkenhead and Upper Pitt). At the request of fisheries managers, the current Working Paper focuses more on methods for forecasting age-5_2 sockeye for all stocks.

Age-4_2 and Age-5_2 forecasts were made using methods previously reviewed and approved by PSARC. The authors also assess sibling models and the utility of growth indices for forecasting age-4 and age-5 sockeye. Recently, and coincidentally with changes in somatic growth rates, the proportion of age-3_2 jacks has declined to very low levels resulting in highly questionable data quality. Furthermore, abundance estimates of run size required in one-year-ahead forecasts based on sibling relationships are not completed until December (or later) following spawning enumeration. Therefore, the authors presently are unable to forecast 1996 returns using sibling models. The authors' analysis of sibling models is intended to determine whether the proportions of adult siblings corrected for growth effects can be useful predictors of adult returns should the ability to collect samples improve in the future.

Adult returns of sockeye to the Fraser River from the 1996 cycle line are the lowest of the four cycle lines averaging 4.6 million sockeye compared to an all-year mean of 9.1 million sockeye since 1970. The forecast run size of Fraser sockeye in

1996 is 3.1 million age-4_2 sockeye (90% confidence intervals of 1.0-12.1M) and 0.6 million age-5_2 sockeye (confidence intervals of 0.1-5.7M) (Table 11.1). Major stocks (age-4_2 + age-5_2) are Chilko (25%), Birkenhead (22%), Stellako (15%), Weaver (10%) and early Stuart (10%).

Sibling models generally performed poorly on major stocks of age-4_2 sockeye returns. Only Weaver sockeye forecasts appear to benefit significantly from sibling models based on age-3_2 sibling abundance and fish length (growth) corrections. Slightly improved accuracy of age-5_2 forecasts based on age-4_2 sibling abundance and female age-4_2 length are noted for Stellako, Chilko, Birkenhead and Weaver stocks but not for the Early Stuart stock complex. For age-4_2 sockeye, little will be gained from developing programs to improve on the timeliness of data collections for one-year-ahead forecasts based on siblings. For age-5_2 sockeye, given the low survival of the brood, more accurate 1996 forecasts may be likely once the age-4_2 sibling abundance is estimated.

Conclusions

1. Given the high uncertainty in forecasts, the authors recommend that management plans maintain sufficient flexibility to minimize risks of over-fishing.

2. Given the low survivals of the 1991 brood and the improved utility of sibling models in forecasting age-5_2 returns, an assessment of age-5 returns based on age-4_2 abundance estimates is recommended once data become available.

3. This is the third PSARC document in as many years documenting forecasting methods for Fraser sockeye. The authors recommend forecasts based on PSARC-approved methods be provided as annual updates, as required by fisheries managers, rather than extensive and formally reviewed documents.

Reviewers' comments

Reviewer #1

Reviewer #1 suggests that the forecasts begin by recognizing each sockeye stock as a biological entity, having specific spawning and rearing habitats and reproduction, growth, and survival patterns. Forecasting returns necessarily involves all information, not just finding the best model for all stocks. This information includes spawner abundance, conditions at spawning, over-winter water flows, temperatures during incubation, fry, juvenile and smolt data, and indicators of freshwater growth. Intensive examination of jack production data should be conducted to evaluate marine survival. The variability inherent in the jack data due to imprecision of catch and escapement estimates along with the variability due to growth rate effects on maturation has produced greater imprecision in sibling models and has led the authors

to reject this approach. However, in doing so, they reject the use of data which may be of great value in the specific year in question. Reviewer #1 recommends that additional sibling models be examined before finalizing the 1996 forecasts. Reviewer #1 also recommends that Bayes estimates be developed from the suite of models examined as a form of "bet hedging".

Reviewer #2

Reviewer #2 finds that this is a well done and careful analysis of the problem. However, the type of analysis carried out in this document cannot easily be replicated by others because of the lack of centralized data storage that can be accessed by other scientists. The state of the data at present, i.e. nonstandarized spreadsheet files, makes it very difficult for anyone to systematically review these data. It also makes comparisons with other time-series difficult. Reviewer #2 highly recommends that such a centralized, standard database be developed.

Reviewer #2 believes that this problem would benefit from a systematic examination of the life-stages for which density-dependent and stochastic density independent mortality occur for salmon populations. This would set limits on what can and cannot be expected from a forecast model.

There is also a fundamental problem with predictions made from a very few numbers, e.g., from the small number of jacks. The low correlation in survival among rivers would suggest that interannual variability comes not just from marine survival. Finally, it would be best to use one model that seems superior to the rest, e.g. log-log, instead of a different model for each population.

Reviewer #3

Reviewer #3 recommends a meeting of fisheries managers, stock assessment analysts and scientists to discuss the technical forecasts and other factors and come forward with an **official** forecast for management purposes. It would be helpful to have run estimates for each stock at varying levels of probability of achieving or exceeding those run sizes (90%, 75% and 50%). This would give the integrated team the flexibility to adopt run size estimates based on probability of occurrence, along with consideration of qualitative factors and recognition of the risks and how they affect the management plan.

Reviewer #3 believes the inclusion of habitat factors to be essential in evaluating the forecasts, even if the relationships cannot be quantified. Recognition of factors such as peak flows during the spawning and incubation period or the potential for freezing during incubation may help to determine what probability level should be considered for individual stocks. Biological data and observations should also be considered in the forecast discussions. For example, a co-occurrence of mackerel and

Fraser sockeye in 1993 could have affected the 1995 age-4 and the 1996 age-5 returns.

Subcommittee discussion

The Subcommittee discussed the use of either the mean or the mode of the untransformed data as the best stock size forecast estimate. The Subcommittee recommended that the authors continue to present the forecasts through the use of the mode. Discussion then ensued regarding the calculation of a total Fraser River sockeye return forecast, rather than the Working Paper's present method of summing individual stock forecasts. One of last year's recommendations was the development of a Working Paper evaluating forecasts of total Fraser sockeye returns. It was noted by one of the authors that this would only produce a forecast estimate based upon the lowest level of data resolution, spawner and recruits. This type of forecast would then ignore the information available from smolt and sibling relationships. The Subcommittee decided that the Working Paper's current approach of summing individual forecasts in order to provide a total Fraser River sockeye should be reviewed. This review would include a comparison to a forecasting methodology that estimates total stock size.

One item left unresolved by the Subcommittee concerns the Working Paper's current practice of choosing a single best forecast. One reviewer suggested a better approach is to combine the Working Paper's suite of models through the use of Bayesian techniques. This method would then include all information available.

Subcommittee recommendations

1. The Subcommittee recommends that final acceptance of this Working Paper and the 1996 Fraser River sockeye forecasts be delayed until information from the 1995 return year is available for use in sibling forecast relationships. The 1996 forecasts most affected concern the Birkenhead and, to a lesser extent, Chilko stocks. Once the 1996 forecasts are updated through the incorporation of 1995 data, a special meeting of the Salmon Subcommittee and managers will be convened to review these estimates and prepare the recommended 1996 forecast (see 6. Other Business).

2. The Subcommittee reiterates its 1994 recommendation that Science Branch, Stock Assessment Division, undertake the development of a single database covering Fraser River sockeye and pink salmon production data. This centralized system would reduce redundancy in data files, spreadsheets, etc. and provide a standard data set for future evaluations.

S95-12: Assessment of Recruitment forecasting methods for selected salmon stocks in northern British Columbia. Wood, Rutherford, Peacock, and Cox-Rogers.

Working Paper Summary

This Working Paper includes an assessment of the relative performance and utility of ten basic procedures for forecasting adult sockeye returns to Long Lake (Area 10), Owikeno Lake (Area 9), and the Skeena River (Area 4), and pink salmon returns to Area 8. These stocks were selected because adequate data were available on spawning escapements, catches, and in some cases juvenile (freshwater) production. Many of the methods examined have been used previously to forecast salmon recruitment and most are based on known biological relationships.

None of the forecasting models performed well consistently, and none performed much better than the 5-yr average methods (Table 12.1). No method emerged as having been most successful across all sockeye stocks, or across all criteria within any one stock. However, average methods, particularly the recent 5-yr average (*5YAVGCY),* rated best across sockeye stocks within the root mean square error (RMSE) criterion. Average methods also rated best in two of the three sockeye stocks under the mean absolute deviation (MAD) criterion. The linear sibling model (*LSIB)* rated slightly better than the average methods under the mean absolute percent error (MAPE) criterion. Because no method was consistently best for all sockeye stocks, the *5YAVGCY* method was selected to forecast 1996 returns to all sockeye stocks in northern B.C. This method rated best under the RMSE criterion for both Long Lake and Skeena River sockeye, for which more reliable data exist to support forecasting models than elsewhere in northern B.C.

None of the methods successfully forecasted the extremely large and small Area 8 pink salmon returns. The nonlinear (Ricker) stock-recruitment model (*NLSRESC)* method rated slightly better than the average methods under the RMSE criterion that is sensitive to large deviations, as well as under the MAD and MAPE criteria. Consequently, the *NLSRESC* method was used to forecast Area 8 pink returns in 1996.

Forecasts for 1996

Forecasts for 1996 are summarized in Table 12.2 and presented graphically in comparison with historical returns in Figures 12.1-12.4. Because the sockeye forecasts are based on recent average returns, the forecasts for 1996 reflect recent trends. Point estimates are for higher returns than observed in 1995 for Long and Owikeno lakes, and for lower returns than observed in 1995 for the Skeena River. However, the confidence intervals on these forecasts span the entire range of historical values for Long and Owikeno Lakes, and the range of all returns to the Skeena River in the last nine years.

The most likely point forecast for Area 8 pink returns in 1996 is higher than the observed return in 1995 but again the confidence interval spans the entire range of historical returns except for the extremely large returns in 1962 and 1988.

The poor forecasting performance for northern salmon stocks cannot be attributed entirely to unreliable catch and escapement data (see WP S95-8). The catch and escapement data for Long Lake sockeye are among the most reliable for any salmon stock examined so the variability in production must be considered real. The variability is so large that it obscures even basic biological stock-recruitment and sibling age class relationships; thus, it should not be surprising that forecast performance is also extremely poor. It is unfortunate that juvenile data were not available for analysis as intended. Analysis of juvenile data from Long Lake would have indicated whether the variability in survival is associated with freshwater or marine events, and it should be pursued in the future.

The congruence of declining trends in stock size for all three central coast (Area 8-10) stocks, and for other more southerly sockeye stocks in Barkley Sound and the Fraser River over the last two or three years suggests that a common (marine) factor has affected the survival of these stocks. It also suggests that forecasts might be improved by focusing on variables related to marine conditions affecting survival of salmon in coastal areas.

Conclusions

1. Forecasts are useful when they reduce uncertainty. However, the forecasting performance of all methods examined in this Working Paper was so poor as to be of little practical value. In general, methods based on biological relationships performed no better than average return methods. Because of the uncertainty associated with these forecasts, the authors suggest that forecast point estimates be presented with cumulative probability plots as in Fig. 12.1 to 12.4.

2. The authors recommend the 1996 forecasts based on the 5-yr average stock size method (*5YAVGCY*) for sockeye and the Ricker model with escapement data (*NLSRESC*) for Area 8 pink salmon.

3. Further analysis of forecasting capabilities using juvenile data together with coastal marine indicator variables appears warranted for the Long Lake sockeye stock. Time series models may be worth pursuing for the Owikeno Lake and Skeena River sockeye stocks given the existence of autocorrelations in those time series.

Reviewers' comments

Reviewer #1

According to Reviewer #1, this Working Paper presents a well written account of forecasting alternatives for some salmon stocks in northern British Columbia. The authors' general conclusion is that the uncertainty associated with the estimates severely curtails the usefulness of pre-season forecasts. Reviewer #1 suggests technical revisions to the document that relate to assessing the error assumption, bias correction of transformations, computation of prediction error, and notation conventions. With the exception of reinforcing earlier work for southern sockeye stocks, little new advice is provided to fishery managers. Consequently, future work should be conducted with fishery managers to develop harvest policies which ensure that biological objectives are achieved over a long time horizon.

Reviewer #2

This Working Paper provides a useful description of the utility of statistical forecasting methods based on freshwater abundances of salmon (adult escapement) and sibling returns one year prior. It provides a reasonably good summary of the strengths and weaknesses in the data. The Working Paper's weakest aspects are the fact that not all available data sources are used in the paper (i.e. the juvenile time series). In addition, the autocorrelation functions needed to support the authors' statements that time series methods would or would not work for some stocks should be presented.

Reviewer #2 stresses that no accurate forecasts for these stocks will be forthcoming. Clear direction should be given to attendees at the pre-season planning meeting to consider contingencies for a wide range of combinations of possible weak and strong runs. Furthermore, it is possible that we are entering a period of low marine survival for salmon. The collapses of BC pink salmon stocks as well as sockeye returns to the Fraser River, Rivers Inlet and Smiths Inlet strongly suggest a problem with marine rather than freshwater survival.

Subcommittee discussion

The Subcommittee concurs with the authors that forecast performances based on a wide variety of models strongly indicate a poor ability to forecast north coast area salmon stocks. For sockeye, forecast accuracy using 5-yr means performed as well as biologically based models. This is not to say that the underlying biological relationships are not evident, only that the uncertainty in individual forecasts is too large to be informative for management planning.

The Subcommittee notes that 5-yr mean sockeye forecasts cannot be good predictors of short term changes in recruitment. However, other models with explanatory variables failed to perform better in retrospective analyses.

The Subcommittee recognizes the need to convey forecasts and uncertainty so that they can be useful to managers and agrees that managers need to clarify the exact format in which forecasts and uncertainty are most useful. The common measure of uncertainty presented simply as 90% or 95% prediction intervals reinforces the notion of very low precision but likely has little pre-season or in-season applicability. A more appropriate way of conveying forecast uncertainly, considered by the Subcommittee, is to present forecasts at various probabilities of achieving or exceeding the forecast, say at 50%, 75% and 90% probabilities. Over a sufficient range of probabilities, managers could choose a probability level according to their particular management application. Graphic representation of probability plots might also be useful (see Fig. 12.1 to 12.4).

The Subcommittee recognizes that not all relevant data or candidate models were evaluated and supports the use of other models including time series models. A particularly obvious data set not included in the present analysis is the time series of juvenile data for Long Lake sockeye.

Subcommittee recommendation

The Subcommittee accepts the Working Paper with minor revisions and recommends that run size forecasts be presented at 90%, 75% and 50% probability levels of achieving or exceeding the forecasts. Graphic representations of probability distributions of forecasts should also be provided.

S95-13: Review of 1988-1995 forecast performance, stock status, and 1996 forecasts of Barkley Sound sockeye. Hyatt and Luedke

Working Paper Summary

Recent year returns (1991-93) of sockeye to Barkley Sound have ranged between 998,000 and 1.8 million and are well above the 20 year average of 880,000 fish. These returns represent a reversal of the pattern of sub-average returns that characterized Barkley Sound sockeye during the 6 year interval between 1985 and 1990. Large surpluses available for catch in recent years are directly attributable to the combined effects of: (i) concerted efforts by DFO to curtail fisheries and protect escapement during the 1985-90 interval of low production; (ii) ongoing fertilization of Great Central and Henderson lakes to maintain enhanced levels of freshwater production; and (iii) a shift of conditions in the marine environment that favored average to above average survival of sockeye smolts migrating seaward between 1989 and 1992.

In 1994 and 1995, Barkley Sound sockeye returns declined to 23-53% of the 20 year mean. These declines were anticipated by pre-season forecasts and foreshadow entry by Barkley Sound sockeye into a multi-year, sub-average production interval that appears to be driven by periodic changes in marine climate on the west coast of Vancouver Island.

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:

1. The Survival Stanza Method (SStM) forecast exhibits the best performance with a Mean Absolute Percent Error (MAPE) value of approximately 27% over the most recent 8 years. Further, SStM forecasts account for the majority of variation in returns if the extreme observation associated with the 1991 return year is omitted from the analysis.

2. The Salinity Survival Method (SSM) forecast exhibits the next best performance with a MAPE value of 40% over the most recent 8 years of forecasting. SSM forecasts have performed better in the short term than anticipated on the basis of an earlier examination through hindcasting (the MAPE value identified by hincasting was 49%). SSM forecasts also exhibit a statistically significant association with returns if the 1991 return year is omitted from the analysis.

3. SEP Biostandard Method (SEPB) forecasts have performed well over some return intervals but not others. During the 1988-95 testing interval, SEPB forecasts exhibited a substantially higher MAPE value (60%) than that displayed by SSM and SStM forecasts (27-40%). Large magnitude deviations between SEPB forecasts and actual returns tend to occur in consecutive years, eroding confidence in their utility. The SEPB forecast approach may have applicability to stocks for which deviations around mean returns follow a random pattern; however, in instances where either above or below average returns tend to occur for several years in succession due to environmental "forcing", SEPB or analogous forecasts (e.g. average returns per spawner) have limited utility.

4. The Sibling Age Class Method (SACM) forecast exhibits the worst performance of the four indices examined (MAPE value of 65%) and in its current form is unlikely to provide useful forecasts of either the magnitude or sign of annual return deviations for Area 23 sockeye.

All forecasts of total returns indicate little to no surplus of sockeye for catch in 1996. A SStM forecast of 279,000 fish and SSM forecast of 400,000 sockeye suggest returns of less than 50% of the 20 year mean. Comparative performance of the various forecast options and a risk averse approach to management recommend the SStM value of 278,740 sockeye as the preferred, pre-season forecast for 1996.

Reviewer's comments

Reviewer #1

Reviewer #1 notes that the Subcommittee last year recommended that "statistical measures of uncertainty for smolt abundance-based forecasts of Barkley Sound sockeye be developed. The accuracy of these forecasting methods should also be compared to that of more conventional forecasting methods based on total returns and escapement data (i.e. the average return, the average return rate per spawner, and perhaps non-linear functions relating adult returns to spawning escapements) to assess potential benefits from collecting smolt data in other stocks." Steering Committee last year supported this recommendation and further recommended that "estimates of prediction uncertainty be included for each point estimate and submitted to PSARC as soon as possible" and that "many field methods and data pre-processing steps remain undocumented and recommends these methods be documented and reviewed by PSARC as soon as possible." Little progress has been made on these recommendations since last year's meeting and therefore they should be stated again.

Reviewer #1 does not agree with the authors' recommendations for a prediction and its implications. He would like to have seen a plot or table of smolt survivals over time as it appears that survival to return in 1995 was very low (likely about 1.9%), while the forecast of 278,740 assumes a 2.5% survival. Given the uncertainty concerning the forecasts, it would appear that a return less than or equal to the minimum target for escapement (200,000 sockeye) is a possibility. Therefore, Reviewer #1 does not support the authors' conclusion that enough fish will return and that "an initial surplus of 78,740 sockeye ... may be considered".

Reviewer #2

Reviewer #2 believes that the Working Paper would benefit from additional details on the nature and composition of stocks as well as geographical reference to the area under consideration. Specifically, are the stocks wild, enhanced, or a mixture of both? Data sources and the reliability of catch, return, escapement and smolt estimates are not referenced or described, and little reference is included to the biological characteristic data for the stocks in question. This information is needed for readers to place the analytical results in the proper context.

Given the response in survival to small changes in salinity, biological mechanisms associated with the Sea Survival Salinity Model (SSM) should be explained. Forecasts do not reflect uncertainty in any of the parameter inputs, nor in subsequent output; they are essentially point estimates. At the very least, the authors could provide forecasts with plus/minus the mean average deviation (MAD) about the preferred estimate. Given the data and methods employed, the conclusion is supported that 1996 returns will be below the long term average, with little or no surplus for harvest

Subcommittee discussion

The Subcommittee accepted this Working Paper with minor revisions, but had serious concerns about several aspects of these forecasts. Specifically, the Subcommittee does not endorse the presentation of point estimates for 1996 returns and notes that similar concerns were expressed in last year's Subcommittee report. The authors must endeavour to address these concerns and incorporate estimates of the uncertainty about the forecast in their advice. Further, the Subcommittee recommends avoiding any statements regarding allocation of potential catch.

The Subcommittee would have requested major revisions and that estimates of uncertainty in the 1996 forecasts be incorporated into revisions of this Working Paper, but were informed that stock-specific catches and total production could not yet be presented for the past decade. This problem results from changes in baseline data used to allocate catch to stock and the need to examine recent samples collected. To address this problem, parasitic composition of these samples must be completed and catch composition re-examined. The Subcommittee recommends that this work be given high priority. Once catch is allocated to stock, the Subcommittee recommends that the authors undertake a hindcasting analysis of their forecast models to examine the uncertainty and forecasting error (mean absolute deviations) in each model. Regardless of the stock composition analysis, however, the Subcommittee also recommends that hindcasting be conducted for the Barkley Sound aggregate.

On the basis of the information presented, the Subcommittee endorses the authors' recommendation to apply the SStM model for the 1996 forecast. The expected range of returns is therefore likely to be 202,700 to 354,780 sockeye (278,740 $\pm$ 27.3% mean absolute deviation based on historical observations since 1988). The Subcommittee must emphasize, however, that this measure of mean deviation is not a measure of the statistical uncertainty in the forecast and that deviations have exceeded this mean value in 4 of 8 years.

6. OTHER BUSINESS

Fraser Sockeye Forecasts

As noted in the Subcommittee discussion of WP S95-11, a special meeting of the Subcommittee will be convened to review the 1996 forecasts of Fraser River sockeye salmon. This meeting will provide a Regional forum for discussion of data to be included in the final 1996 forecasts, the appropriate forecast methodology, and the format for presentation of forecast advice. The meeting should include Pacific Salmon Commission (PSC) input. The PSARC Chair will send a formal invitation to the PSC, indicating that any requests from the PSC for specific analyses should be submitted well in advance of the meeting.

Although a date for this meeting could not be set by the Subcommittee, the intent was to convene the meeting as soon as possible once reliable 1995 escapement data by stock and age composition estimates become available. The meeting will be scheduled over three days. Day 1 will provide a forum for technical experts to review the input data. The full Subcommittee will convene on days 2 and 3 to discuss the forecast analyses and expected 1996 returns.

Schedule of Subcommittee Meetings

The spring meeting of the Subcommittee is scheduled for April 22-26, 1996, in Nanaimo.

The Subcommittee discussed timing of the forecast reviews. Current year age composition and escapement data by stock are not available for inclusion in forecasts reviewed at a November meeting. The Subcommittee seeks guidance on a more appropriate time frame for the production and review of forecast documents. The Subcommittee notes that provision of advice on an "as early as possible" basis would likely require increased resources for scale reading, data processing, etc.

APPENDIX 1. PARTICIPANTS AT THE NOVEMBER 14-17, 1995 MEETING OF THE PSARC SALMON SUBCOMMITTEE.

Subcommittee Chair: **L. Richards**
PSARC Chair: **B. Leaman**

SUBCOMMITTEE MEMBERS	AUTHORS/REVIEWERS	OBSERVERS
D. Anderson	D. Blackbourn	B. Anderson
S. Argue	M. Bradford	J. Boutillier
D. Bailey	B. Dempson	H. Genoe
A. Cass	P. Etherton	L. Gordon
K. Hyatt	R. Kadowaki	L. Hop Wo
S. Johnston	K. McGivney	A. Lill
S. McKinnell	S. McPherson	W. Luedke
D. Meerburg	P. Olesiuk	J. Mitchell
B. Riddell	D. Rutherford	B. Shaw
P. Ryall	A. Tompkins	
W. Saito	J. Woodey	
M. Stocker		
A. Tautz		
K. Wilson		
C. Wood		

APPENDIX 2. REVIEWERS OF WORKING PAPERS SUBMITTED TO THE FALL 1995 MEETING OF THE PSARC SALMON SUBCOMMITTEE.

Working Paper	Reviewer #1	Reviewer #2	Reviewer #3
S95-7	M. Bradford	A. Tompkins	
S95-8	R. Goruk	M. Stocker	
S95-9	S. Argue	C. MacKinnon	
S95-10	B. Pearce	A. Trites	
S95-11	J. Woodey	R. Myers	K. McGivney
S95-12	R. Kronlund	D. Welch	
S95-13	D. Meerberg	B. Dempson	

Table 11.1. Run size forecasts (R) for Fraser sockeye in 1996 by stock and age (millions) and lower (Rlo) and upper (Rhi) 90% prediction intervals.

	Age-4_2			Age-5_2		
Stock	**R**	**R1o**	**Rhi**	**R**	**R1o**	**Rhi**
Early Stuart	0.337	0.105	1.083	0.024	0.002	0.294
Bowron	0.009	0.002	0.037	0.002	0.000	0.016
Fennell	0.038	0.009	0.162	0.006	0.001	0.048
Raft	0.025	0.006	0.112	0.000	0.000	0.002
Late Nadina	0.019	0.007	0.053	0.029	0.005	0.172
Gate	0.121	0.033	0.450	0.002	0.000	0.022
Seymour	0.042	0.010	0.177	0.005	0.000	0.136
Scotch	0.015	0.000	1.568	0.005	0.000	1.100
Upper Pitt	0.019	0.003	0.109	0.037	0.010	0.142
Late Stuart	0.164	0.017	1.546	0.009	0.000	0.170
Stellako	0.503	0.193	1.314	0.050	0.009	0.274
Quesnel	0.047	0.010	0.220	0.005	0.000	0.585
Chilko	0.881	0.369	2.104	0.056	0.007	0.436
Birkenhead	0.486	0.161	1.464	0.321	0.059	1.753
Late Shuswap	0.051	0.010	0.258	0.018	0.001	0.311
Weaver	0.347	0.091	1.328	0.016	0.002	0.124
Cultus	0.007	0.002	0.031	0.002	0.000	0.015
Portage	0.021	0.004	0.119	0.001	0.000	0.078
Total	3.132	1.032	12.135	0.588	0.096	5.678

Table 12.1 Performance in retrospective analyses under the root mean square error (RMSE) criterion. All years considered.

Forecast Method	Sockeye Long	Sockeye Owikeno	Sockeye Skeena	Pink Area 8
Non-biological:				
AVGCY	271091	602248	1319051	4707960
5YAVGCY	**250877**	602303	**1190126**	5365596
AVGBY	290002	659852	1601088	4707960
5YAVGBY	380196	**278663**	1425434	5365596
Biological:				
LSRESC	302668	689278	1213487	5731374
LSRJUV			1291722	6431173
NLSRESC	324951	657373	2903675	**3823760**
NLSRJUV			1678456	4.171E+09
LSIB	312178	534168	1420400	N/A
NLSIB	337536	612034	1571951	N/A

AVGCY - Long-term average stock size (calendar year)
5YAVGCY - Recent five-year average stock size (calendar year)
AVGBY - Long-term average returns (brood year)
5YAVGBY - Recent five-year average returns (brood year)
LSRESC - Average rate of return from escapement
LSRJUV - Average rate of return from juveniles
NLSRESC - Non-linear stock-recruitment model (returns from escapement)
NLSRJUV - Non-linear stock-recruitment model (returns from juveniles)
LSIB - Linear sibling model
NLSIB - Non-linear sibling model

Table 12.2. Summary of forecasts for 1996.

Stock	Method	Untransformed Values: Forecast ln (N_{1996})	Untransformed Values: Std. Error of Estimate	Transformed Values (millions of fish): Forecast N_{1996}	95% Confid. Interval: Lower	95% Confid. Interval: Upper
A. Sockeye Salmon						
Long	5YAVGCY	12.76	1.08	0.35	0.02	6.91
Owikeno	5YAVGCY	13.02	0.76	0.45	0.06	3.73
Skeena	5YAVGCY	15.22	0.27	4.09	1.95	8.56
B. Pink Salmon						
Stock	Method	Forecast ln (R_{1994}/S_{1994})	Std. Error of Estimate	Forecast N_{1996}	95% Confid. Interval: Lower	95% Confid. Interval: Upper
Area 8	NLSRESC	1.44	0.93	1.55	0.22	11.04

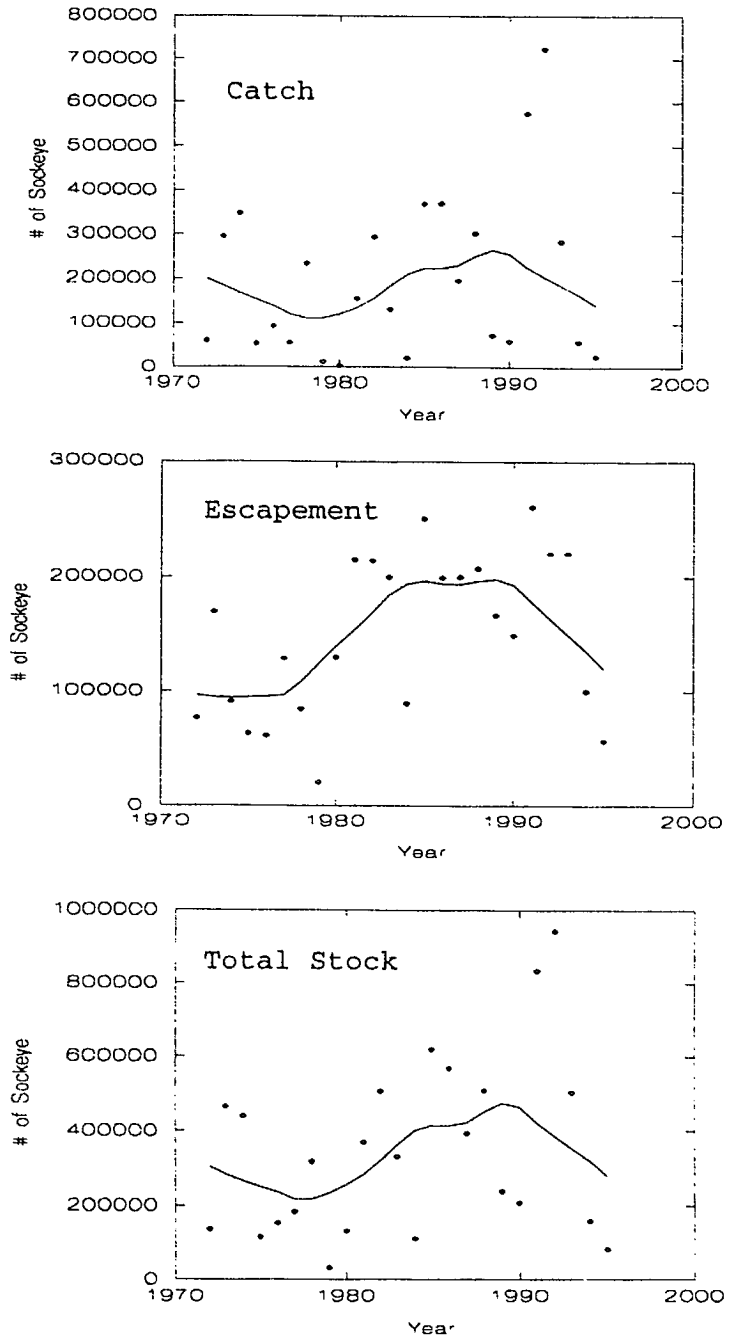

Fig. 8.1. Trends in Area 10 sockeye catch, escapement and total stock, 1972-1995.

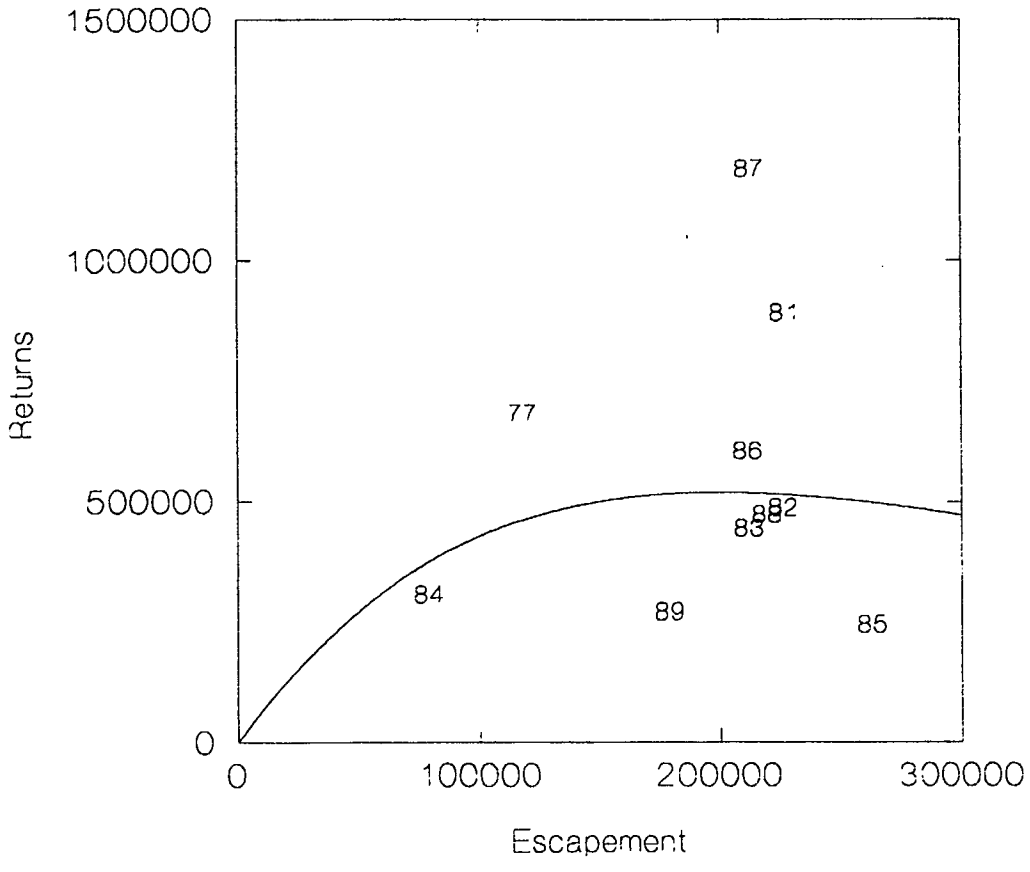

Fig. 8.2. Stock-recruitment pattern for Area 10 sockeye salmon, with Ricker curve fitted to data. Symbols represent brood years. Unfertilized years are not included.

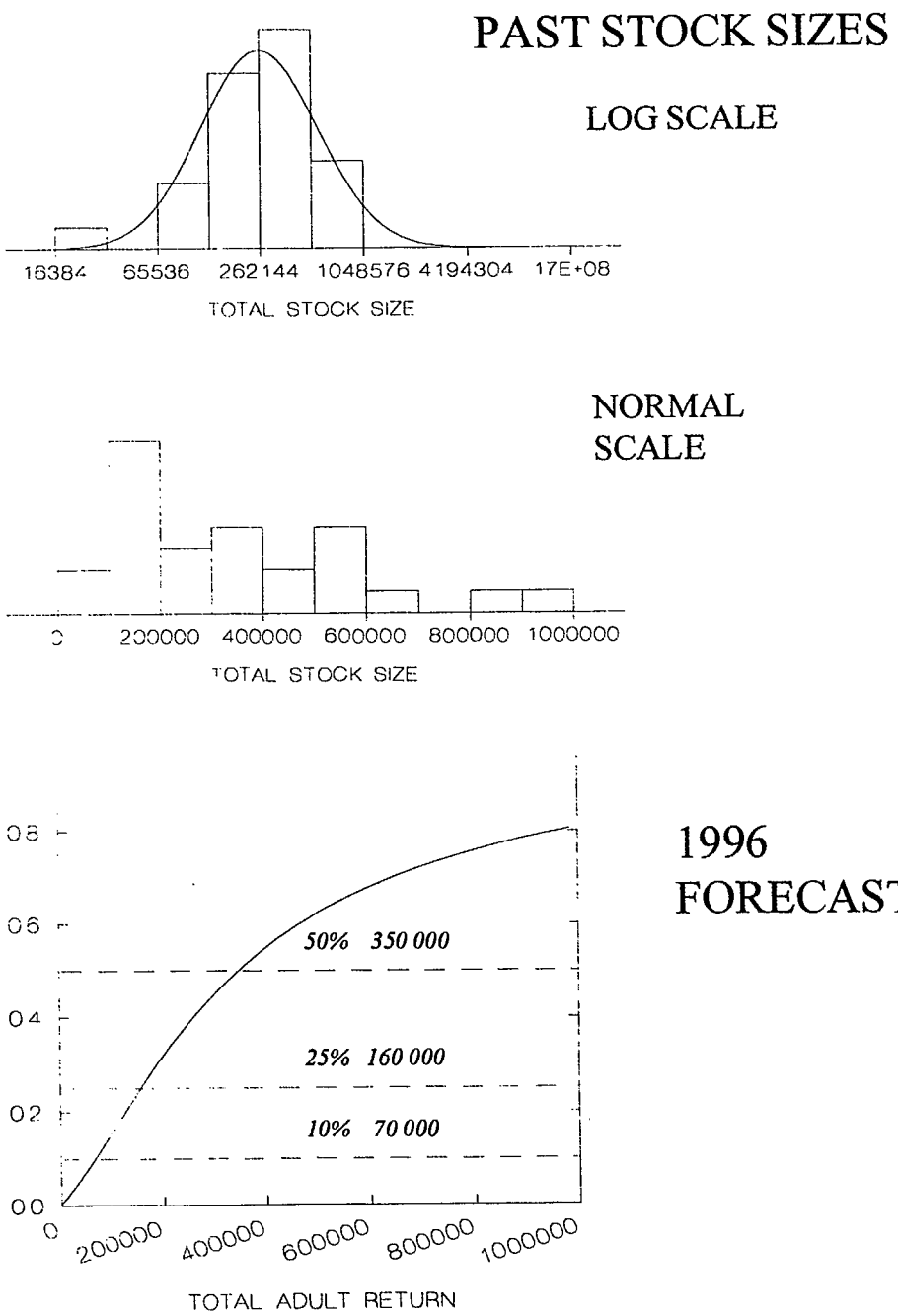

Fig. 12.1. Long Lake sockeye forecast for 1996.

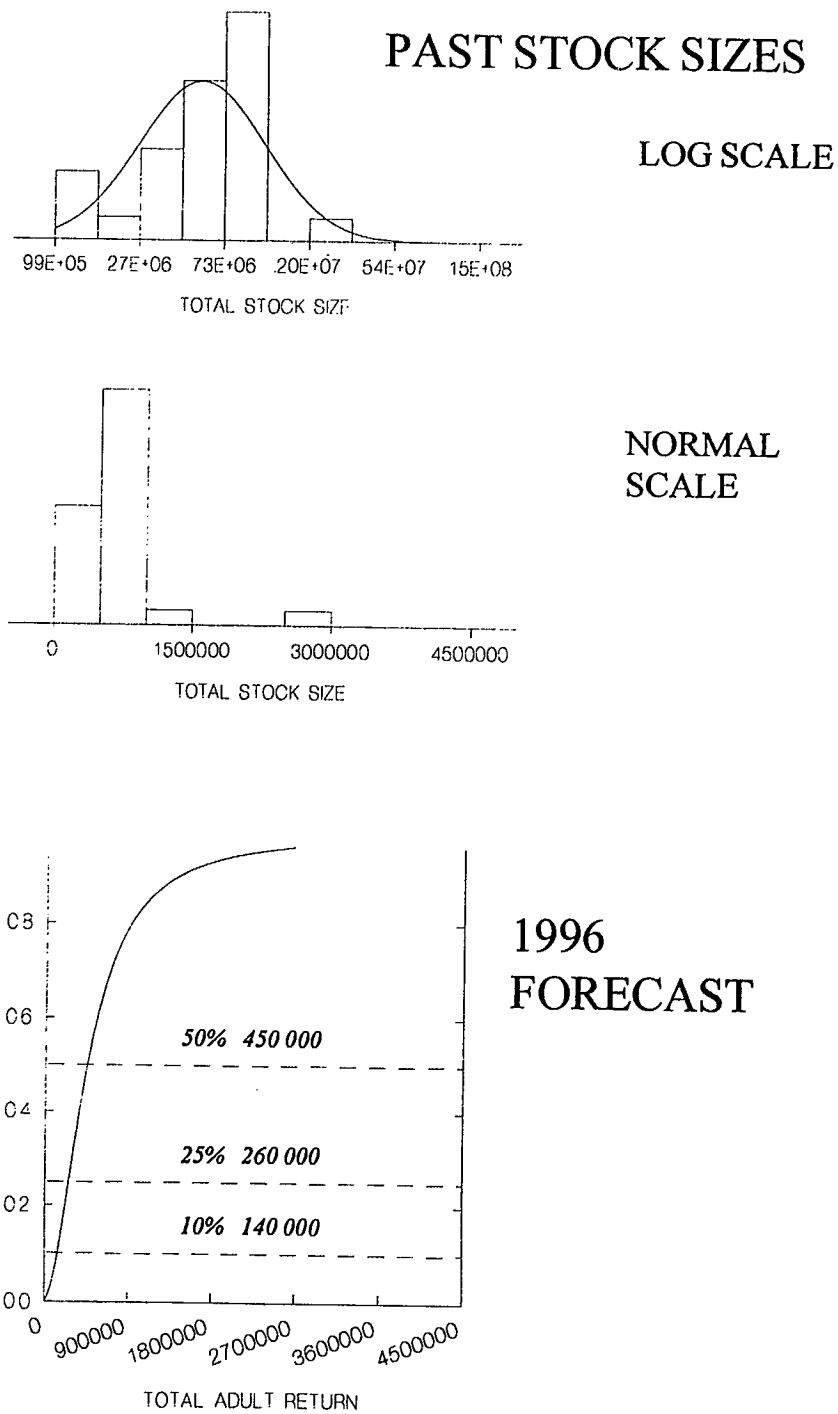

Fig. 12.2. Owikeno Lake sockeye forecast for 1996.

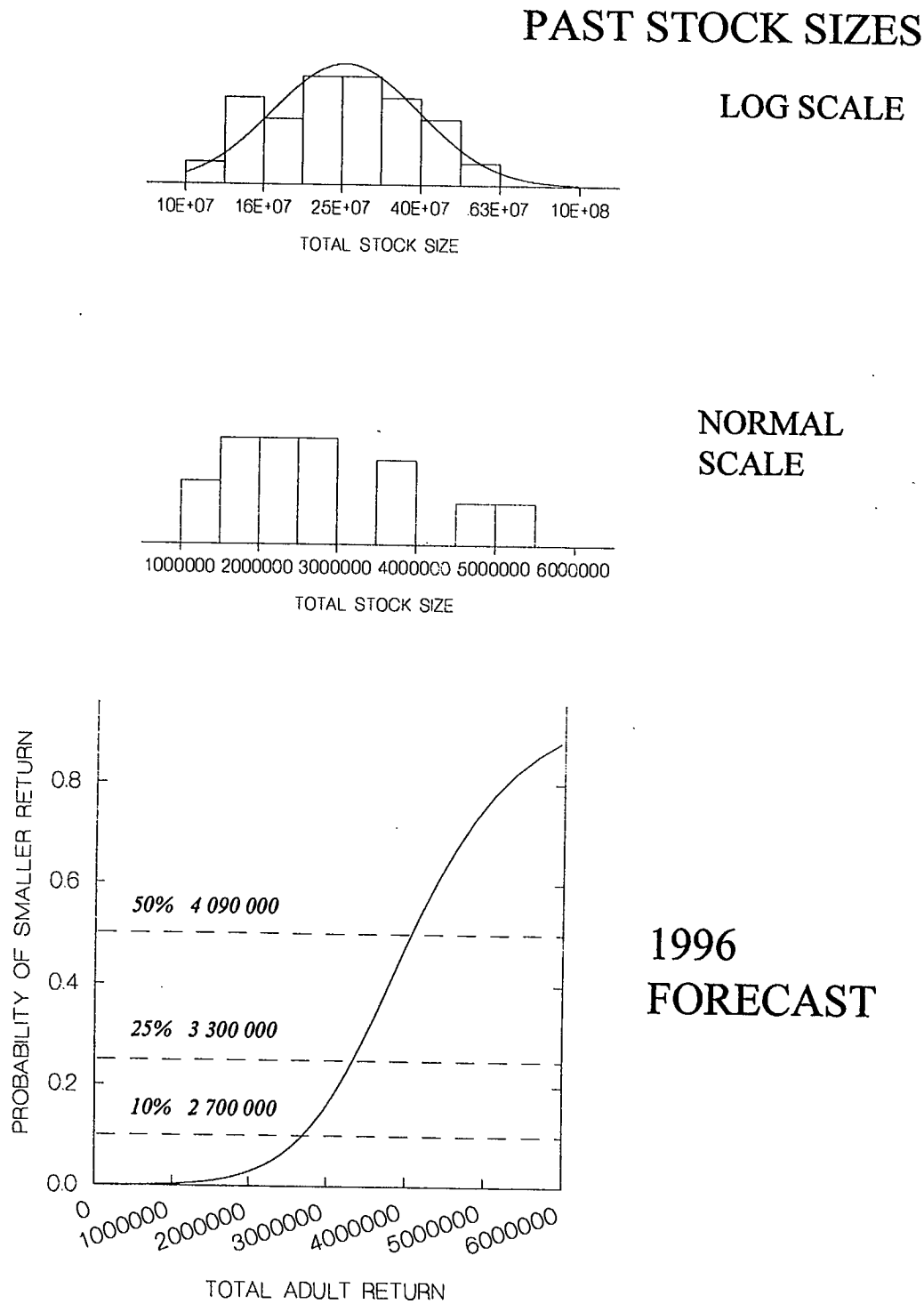

Fig. 12.3. Skeena River sockeye forecast for 1996.

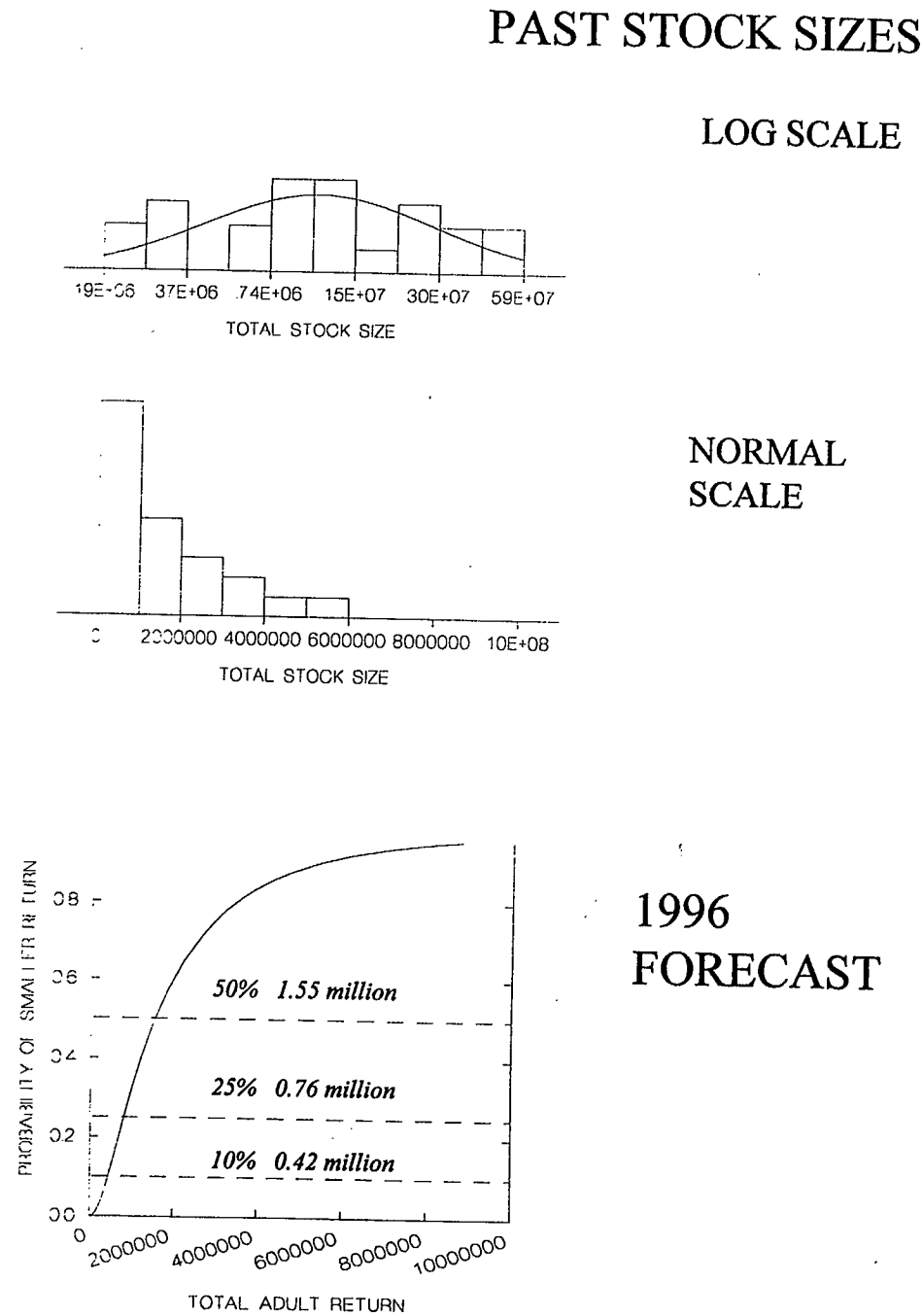

Fig. 12.4. Area 8 Pink Salmon forecast for 1996.