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Pacific Stock Assessment Review Committee (PSARC) Annual Report for 1992

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S.M. McKinnell, B.M. Leaman, and V. Haist (Editors)

Biological Sciences Branch
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Nanaimo, British Columbia V9R 5K6

1993

Canadian Manuscript Report of Fisheries and Aquatic Sciences 2196

Fisheries and Oceans Pêches et Océans

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Canadian Manuscript Report of Fisheries and Aquatic Sciences

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Canadian Manuscript Report of

Fisheries and Aquatic Sciences No. 2196

March 1993

PACIFIC STOCK ASSESSMENT REVIEW COMMITTEE

(PSARC)

ANNUAL REPORT FOR 1992

by

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Cat. No. Fs97-4/2196E ISSN 0706-6473

Correct citation for this publication:

Irvine, J. R., R. D. Stanley, D. McKone, S. M. McKinnell, B. M. Leaman, and V. Haist (Editors). 1993. Pacific Stock Assessment Review Committee (PSARC) Annual Report for 1992. Can. Manuscr. Rep. Fish. Aquat. Sci. 2196: 199 p.

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ABSTRACT

Irvine, J. R., R. D. Stanley, D. McKone, S. M. McKinnell, B. M. Leaman, and V. Haist (Editors). 1993. Pacific Stock Assessment Review Committee (PSARC) Annual Report for 1992. Can. Manuscr. Rep. Fish. Aquat. Sci. 2196: 199 p

This report summarizes activities undertaken by the Pacific Stock Assessment Review Committee (PSARC) during 1992. During this year, 36 reviewed 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 six PSARC Advisory Documents which summarize the Working Papers, reviewers comments, subcommittee discussions, and Steering Committee comments.

RÉSUMÉ

Irvine, J. R., R. D. Stanley, D. McKone, S. M. McKinnell, B. M. Leaman, and V. Haist (Editors). 1993. Pacific Stock Assessment Review Committee (PSARC) Annual Report for 1992. Can. Manuscr. Rep. Fish. Aquat. Sci. 2196: 199 p

Le présent rapport fait le point sur les activités du Comité d'examen de l'évaluation des stocks du Pacifique (PSARC) pour l'année 1992. Trente-six documents de travail révisés ont été présentés lors des réunions des cinq sous-comités du PSARC (saumon, invertébrés, poissons de fond, hareng et données et systèms). Ce rapport annuel contient un survol des activités, rédigé par le président du Comité directeur du PSARC, et six documents consultatifs résumant les documents de travail, les observations des réviseurs, les travaux des sous-comités et les observations du Comité directeur.

Section I - Chairperson's Report for 1992

This is the sixth annual report of the Pacific Stock Assessment Review Committee (PSARC). The report summarizes the seventh year of operation for this committee, which provides scientific advice for the management of Pacific fisheries resources. The PSARC terms of reference (Appendix 1) provide a historical overview of PSARC, describe the organizational structure for this review committee, its main objectives, and the process by which these objectives are met.

Process for the Provision of PSARC Advice

Stock assessment advice is provided by PSARC in the form of PSARC Working Papers and Advisory Documents, as well as minutes from 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. Each subcommittee holds one or more meetings annually. Stock assessment documents (Working Papers) are prepared prior to subcommittee meetings and are reviewed by at least one individual before these meetings (Fig. 1). Pre-meeting reviewers are normally external to the subcommittee and may be external to the Department of Fisheries and Oceans (DFO). 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.

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 (Fig. 1).

After Advisory Documents have been presented to 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 finalized 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, section, program or individual is assigned responsibility for

each major recommendation made. RMEC meeting minutes record the assignment of responsibility.

Summary of 1992 PSARC Activities

During 1992, PSARC continued to make the stock assessment review process more open and thorough. This process was formalized with the approval of revised PSARC terms of reference (Appendix 1).

The procedure for reviewing PSARC Working Papers has been strengthened. Working Papers now are required to be reviewed prior to, as well as at, subcommittee meetings. The rigour of reviews at subcommittee meetings has also increased. External stock assessment experts, some from the Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC), participated at PSARC Subcommittee meetings during 1992.

The process by which Working Papers are accepted was reinforced during 1992 and Working Papers accepted by subcommittees are publicly available. The role of non-DFO staff in the stock assessment review process for the Pacific Region was expanded. A senior provincial Fisheries Branch scientist is now a permanent member of the PSARC Salmon Subcommittee. Non-DFO staff also participated at meetings of the Herring, Groundfish, and Invertebrate Subcommittees.

In 1992, six major subcommittee meetings were held (Table 1) resulting in the six Advisory Documents contained in this annual report. At these meetings, Working Papers and unreviewed reports and updates were presented (Table 2). The reader is referred to the Advisory Documents for summaries of: Working Papers, reviewers' comments, subcommittee discussions, and Steering Committee comments.

The first Salmon Subcommittee meeting (21-24 April) and the 12 May Steering Committee meeting resulted in PSARC Advisory Document 92-1. Five Working Papers plus the Chairman's report were reviewed and accepted by the Salmon Subcommittee. The Stock Assessment Section of the Advisory Document contains chapters providing stock status information for Fraser River chum salmon and early run Skeena River coho salmon, as well as an evaluation of the conservation program for chinook salmon in the southern Strait of Georgia. The Methodologies Section contains an evaluation of the 62 cm size limit for chinook salmon in the Georgia Strait recreational fishery, as well as a paper considering steelhead trout productivity and stream carrying capacity for the Skeena River watershed. Three additional papers were submitted to the Salmon Subcommittee but either were received too late to permit adequate review, or were judged inadequate by the Subcommittee.

PSARC Advisory Documents 92-2, 92-3, 92-4, and 92-5 were produced following meetings on 25-28 August, 31 August-3 September, 8-10 September, and 11 September of the Groundfish, Invertebrate, Herring, and Data and Systems Subcommittees, respectively, and subsequent discussions by the Steering Committee on 29 and 30 September.

The issue of biological objectives was discussed at each of the fall marine species meetings. As a result, a biological objectives working group was formed with Fisheries Branch and Science Branch members from each of the four species subcommittees (Herring, Salmon, Invertebrate, and Groundfish). This group was tasked with reviewing previous work on biological objectives, proposing biological objectives for important fishery resources in the Pacific Region, and recommending a framework for developing non-biological objectives. The group has been directed to produce a draft report that can be reviewed by the species subcommittees during 1993 and presented to the Steering Committee at its September 1993 meeting.

At the Groundfish Subcommittee meeting, 14 Working Papers were presented (Table 2). In addition to reviewing the status of major groundfish stocks, this subcommittee considered aspects of a proposal on assemblage management, addressed the feasibility of indexing juvenile recruitment with field surveys of juveniles, and discussed the development of biological and management objectives. The Steering Committee supported the recommendations of the subcommittee, provided feedback on the assemblage management issue, recommended the preparation of a Working Paper estimating marine mammal predation on lingcod, and also recommended that Fisheries Branch and Science Branch investigate the effectiveness of alternative strategies such as reserve areas for conserving inshore rockfish (Advisory Document 92-2).

At the Invertebrate Subcommittee meeting, 12 Working Papers were presented covering a wide variety of species and stocks (Table 2). This subcommittee expended considerable effort during 1992 on geoducks, which continue to be the highest landed value invertebrate fishery. However, red urchin landings doubled in each of the last 2 years and the landed weight for this species is now the greatest of all invertebrate species. Both the Invertebrate Subcommittee and the Steering Committee stressed the importance of restricting this fishery until better biological data have been collected and analyzed. The Steering Committee encouraged the subcommittee to develop a series of protocols to be followed for experimental fisheries that undergo a sudden expansion, such as the red sea urchin. The Steering Committee also recommended that the timely processing of logbooks be treated as a high priority (Advisory Document 92-3).

Four Working Papers were presented at the Herring Subcommittee meeting (Table 2). Major issues and recommendations are documented in PSARC Advisory Document 92-4. Managers were advised to distribute harvest as widely as possible off the West Coast of Vancouver Island. The need for an investigation of the error structure of the spawn survey data and an explanation of differences between results of escapement and age-structured models before next year's meeting was stressed.

The Data and Systems Subcommittee (Advisory Document 92-5) identified the need to complete Working Papers on the status of biological databases by the fall of 1993. This subcommittee recommended, and the Steering Committee concurred, that separate Working Papers be prepared for each major species grouping. The subcommittee also reviewed its ongoing evaluation of the Fisheries Management Information System Study Team (FMISST).

The Salmon Subcommittee held a special workshop from September 8-11, 1992 to develop a plan for assessing salmon stocks in the Pacific region. The main objectives of the workshop were to: identify important salmon stocks or stock aggregates in the Pacific Region; develop a system of prioritizing these stocks, and assign scores under various categories to develop an overall rank for each stock. Preliminary rankings of stocks/stock complexes by Division were developed and distributed.

At the fall (16-18 November) meeting of the Salmon Subcommittee, three Working Papers were presented although only one, dealing with forecasting methods, was accepted, subject to revision (Table 2). In Advisory Document 92-6 the PSARC Steering Committee recommended that salmon expectations and forecasts not be publicly released by DFO without PSARC review of at least the methodologies used to generate these forecasts.

The Salmon Subcommittee spent considerable time during 1992 developing a preliminary definition for salmon conservation. Recently negotiated agreements with aboriginal groups contain statements regarding conservation. Because of the difficulty of developing a legally acceptable definition of conservation, it was decided that the best approach will be to meet with individual user groups and negotiate conservation issues.

In November 1992 a representative from PSARC attended a joint marine mammals meeting also attended by representatives from the Arctic Fisheries Science Advisory Committee (AFSAC) and CAFSAC. It is recommended that joint marine mammal meetings be held in the future.

The prominence of stock assessment within the Pacific Region is increasing. There is a need to improve the quality of information for most major fishery stocks. DFO appears to be moving towards a separation between scientific advice for the establishment of harvestable levels which will satisfy conservation needs, and management advice which will allocate available harvests among different user groups. A new advisory process is being developed on the east coast, and proposals for changes to the stock assessment process for the west coast have also been made. Regardless of what develops, the peer review process is essential to ensure not only that stock assessment advice is as good as possible, but also that the advice is defensible. It is expected that PSARC will continue to play a major role in stock assessment in the Pacific Region.

At the end of 1992, V. Haist, B. Leaman, D. McKone, and R. Stanley retired as PSARC Subcommittee Chairpersons and replacements were identified. The contributions made by the retiring chairpersons are acknowledged with gratitude.

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.

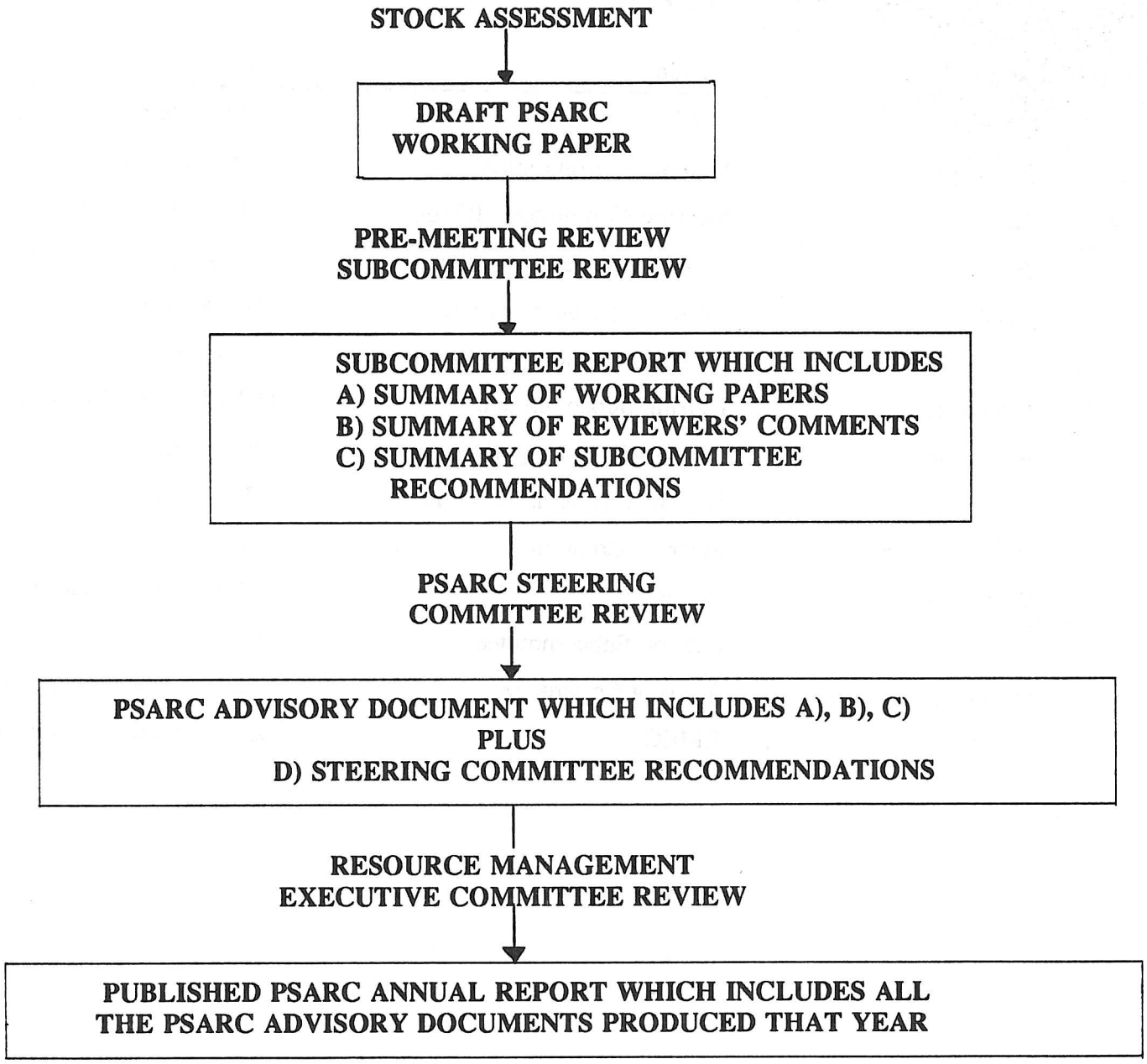

Figure 1. Steps in the generation of PSARC annual Reports. In the figure, reports are enclosed in boxes.

Table 1. Major PSARC Meetings Held During 1992

Date	Meeting	Location
7 January	RMEC	555 W. Hast. Vancouver
21-24 April	Salmon Subcommittee	O'Doul's, Vancouver
12 May	Steering Committee - RMEC	555 W. Hast. Vancouver
16 July	Data and Systems Subcom.	555 W. Hast. Vancouver
25-28 August	Groundfish Subcommittee	PBS, Nanaimo
31 Aug.-3 Sept.	Invertebrate Subcommittee	Coast Bast., Nanaimo
8-10 Sept.	Herring Subcommittee	Delta Pacific, Richmond
8-11 Sept.	Salmon Subcom. (workshop)	IOS, Sidney
11 Sept.	Data and Systems Subcom.	PBS , Nanaimo
29-30 September	Steering Committee	Coast Bast., Nanaimo
6 October	RMEC	555 W. Hast, Vancouver
16-20 Nov.	Salmon Subcommittee	IOS, Sidney
8 December	Steering Committee	555 W. Hast. Vancouver
14 December	RMEC	555 W. Hast. Vancouver

Table 2. List of PSARC Working Papers Accepted During 1992.

SALMON SUBCOMMITTEE

S92-01	A method for evaluating the 62 cm size limit for chinook salmon in the Georgia Strait recreational fishery. T. Gjernes
S92-02	Assessment of Fraser River chum salmon. M. Joyce and A. Cass
S92-03	Stock assessment of early run Skeena River coho salmon (through the 1991 return year). R. Kadowaki, T. Pendray and L. Janz
S92-05	1991 evaluation of the conservation program for chinook salmon in the southern Strait of Georgia, excluding Fraser River stocks. B. Riddell, T. Perry and L. Lapi
S92-06 and S92-08	Steelhead trout productivity and stream carrying capacity for rivers of the Skeena drainage. (Incorporates a habitat-based model of steelhead carrying capacity for the Skeena River and a productivity model for steelhead stocks and its application to the Skeena River.) A. F. Tautz, B. R. Ward, and R. A. Ptolemy
S92-12	Two examples of methods used in forecasting stock abundance and adult migration behaviour in some stocks of southern pink and sockeye salmon. D. J. Blackbourn

GROUNDFISH SUBCOMMITTEE

G92-1	The feasibility and value of juvenile abundance indices for groundfish populations on the Pacific coast of Canada - M. W. Saunders and R. D. Stanley
G92-2A	Inshore lingcod stock assessment for 1992 and recommended yield options for 1993 - D. J. Murie, L. J. Richards, and K. L. Yamanaka
G92-2B	Offshore lingcod stock assessment for 1992 and recommended yield options for 1993 - G. A. McFarlane and B. M. Leaman
G92-3	Pacific cod stock assessment for 1992 and recommended yield options for 1993 - M. Stocker and C. M. Hand
G92-4	Flatfish stock assessments for 1992 and recommended yield options for 1993 - J. Fargo

G92-5 Sablefish stock assessment for 1992 and recommended yield options for 1993 - M. W. Saunders and G. A. McFarlane

G92-6 Pacific hake stock assessment for 1992 and recommended yield options for 1993 - M. W. Saunders and G. A. McFarlane

G92-7 Spiny dogfish - B. L. Thomson

G92-8 Walleye pollock stock assessment for 1992 and recommended yield options for 1993 - M. W. Saunders

G92-9 Slope rockfish stock assessments for 1992 and recommended yield options for 1993 - L. J. Richards

G92-10 Shelf rockfish stock assessments for 1992 and recommended yield options for 1993 - R. D. Stanley

G92-11 Inshore rockfish stock assessment for 1992 and recommended yield options for 1993 - K. L. Yamanaka and L. J. Richards

G92-12 Hagfish stock assessment for 1992 and recommended yield options for 1993 - R. J. Beamish and C. M. Neville

G92-13 Pacific halibut assessment and recommended yield options for 1992 - B. M. Leaman

INVERTEBRATE SUBCOMMITTEE

I92-01 Density and distribution of geoducks in two study areas of southern British Columbia. A. Campbell and D.W. Welch

I92-02 Yield and risk analyses for the geoduck fishery in two areas of southern British Columbia. A. Campbell and J. Dorocicz

I92-03 Study of geoduck populations from two areas in southern British Columbia: growth and mortality. A. Campbell and D. J. Noakes

I92-04 Geoduck quotas for the 1992-1993 geoduck clam fishery. R. Harbo, G. Thomas, and K. Hobbs

I92-05 West coast of Vancouver Island intertidal clam surveys areas 23 to 27 - 1989 to 1992. S. R. Heizer

I92-06 Clam survey at Savary Island, British Columbia 1987-1991. B. E. Adkins

I92-07 Assessment of the area 124 Shrimp, *P. jordani*, trawl fishery. J. A. Boutillier and C. G. Wallace

I92-08 Review of the use of logbook data in invertebrate fisheries research and management. G. S. Jamieson, R. Harbo and K. Hobbs

I92-10 Sustainable fishing patterns for geoduck clam (*Panopea abrupta)* populations in British Columbia. P. A. Breen

I92-11 Re-evaluation of dungeness crab morphometrics. G. S. Jamieson

I92-12 Sea cucumber assessment. S. R. Heizer, G. Thomas and R. Harbo

I92-13 Size structure and gonad quality of purple sea urchins, *Strongylocentrotus purpuratus* in southern British Columbia. A. Campbell

HERRING SUBCOMMITTEE

H92-1 Stock assessment for British Columbia herring in 1992 and forecasts of the potential catch in 1993. J. Schweigert, V. Haist, and C. Fort

H92-2 The implications of size-at-age trends on the assessment of British Columbia stocks of Pacific Herring. R. Tanasichuk and D. Ware

H92-3 Limits and potential of hydroacoustic biomass estimation of Pacific herring in northern B.C. D. Hay, R. Kieser, and B. McCarter

H92-4 Offshore herring distribution and recruitment forecast for the south west coast of Vancouver Island. D. Ware and R. Tanasichuk

Appendix 1. PSARC Terms of Reference

Terms of Reference[1]
Pacific Stock Assessment Review Committee
(PSARC)

History

Stock assessments have been carried out within the Pacific Region for many years. In the 1960's and 1970's, annual assessments were conducted for various important stocks. These assessments were reviewed internally and often by external experts, as well. However, there was no formal structure within the Region to ensure that these reviews were conducted regularly and consistently. In 1985, a peer review system to take responsibility for stock assessments was formalized within the Pacific Region. This review process began with groundfish, herring, and shellfish. In 1986, terms of reference for PSARC were approved. In 1986, PSARC again reviewed groundfish, herring, and shellfish stock assessments as well as several salmon projects. In 1987, PSARC published an annual report covering activities for the previous year in the Canadian Manuscript Report Series of Fisheries and Aquatic Sciences; similar reports have since been published annually. During 1991 and 1992 the PSARC terms of reference were revised and approved.

Organizational Structure

PSARC is a departmental committee that assesses and reviews the status of stocks within the Pacific Region, and provides biological advice for their management. The Committee reviews data collection and analytical methods and criteria employed in the stock assessment process, presents advice to senior management on stock status and biological aspects of management, and identifies resource assessment needs. PSARC is directed by a Steering Committee, the Chairperson of which is appointed by and reports to the Resource Management Executive Committee - Pacific (RMEC), a subcommittee of the Regional Executive Committee. The Steering Committee takes the responsibility for advice from individuals in the stock assessment community and formulates it for regional executive decision-making. The PSARC chairperson normally serves for a 2-year term.

The technical work of PSARC is performed by subcommittees, organized on a species or subject basis. Subcommittees are established and disbanded by decision of the Steering Committee and report to it. There are currently five subcommittees as illustrated in Figure 1.

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[1]Approved May 1992

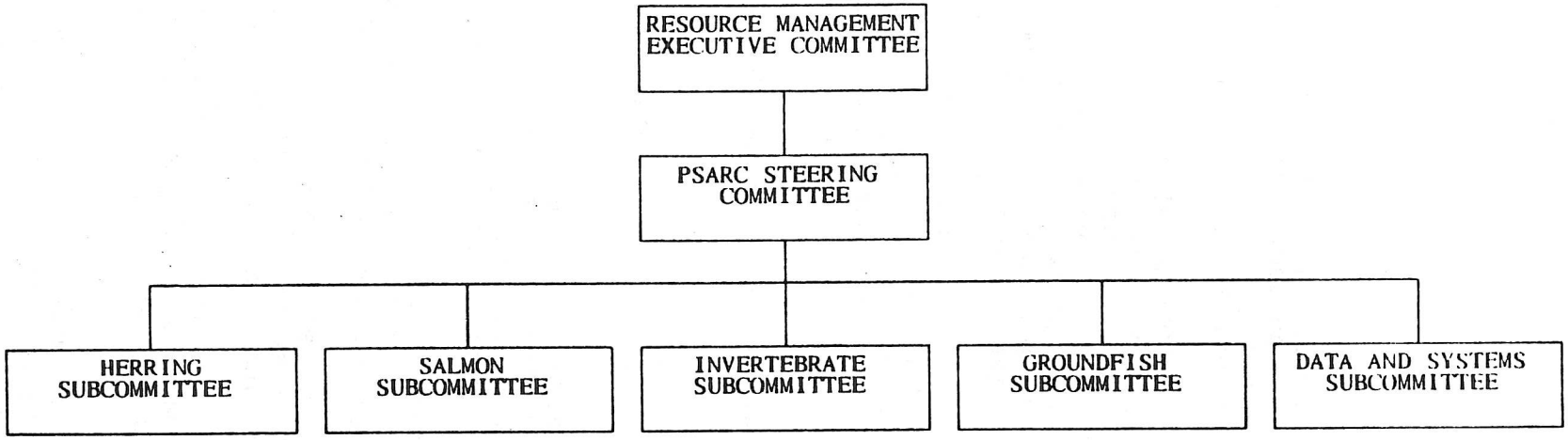

Figure 1. Relations between PSARC Resource Management Executive Committee, PSARC Steering Committee, and PSARC Subcommittees.

Principal Objectives

1. PSARC is responsible for reviewing and evaluating biological, statistical, and technical information on the status of Pacific fisheries resources.

2. PSARC evaluates and may develop methods for assessment of Pacific fisheries resources, and provides the RMEC with biological advice for fisheries management in the Region.

3. PSARC provides scientific and technical advice to the RMEC on matters relating to fishing statistics, sampling of catches, and other information needed for stock assessment.

4. PSARC identifies and provides recommendations for coordination of resource assessment and related projects among Branches and by so doing, provides input into the regional planning process.

5. PSARC ensures liaison with other regional committees. Such liaison includes mutual referral and joint meetings in other fora as required, so as to ensure the nature of biological advice is appropriate to long-term Pacific fisheries management objectives.

The Steering Committee

Composition

The Steering Committee shall normally include the following members:

1 Chairperson
1 Past-Chairperson, PSARC
5 PSARC Subcommittee Chairpersons
1 Director, Pacific Biological Station
1 Biological Sciences Branch (BSB) Division Head, Marine Fisheries
1 BSB Division Head, Salmon
2 BSB Section Heads, Salmon
2 BSB Section Heads, Marine Fisheries
1 Director, Regional Planning and Economics Branch
1 Director, Salmonid Enhancement Program (SEP)
1 Director, Fisheries Branch (FB)
1 Director, Science Branch
1 Director, Fisheries Research Branch, Ottawa
3 Area Managers, Fisheries Branch

The immediate past Chairperson and appointed members normally serve on the Steering Committee for 2-year terms. The Steering Committee may invite additional participation for specific topics, and with the concurrence of the RMEC, add members.

Responsibility of the Steering Committee

The Steering Committee provides input to the Regional Executive by reviewing Subcommittee Reports to ensure all relevant information has been evaluated and thoroughly analyzed, and by formulating appropriate biological and statistical advice on management questions in the broader context of Departmental policy. It is also vested with the responsibility for identifying weak areas in the scientific database and methods used by the Subcommittees to reach conclusions, and to recommend corrective actions. Items may be referred back to the Subcommittees for further consideration, or be accepted as a basis for advising senior management, in the form of Advisory Documents or memoranda.

Responsibility of Steering Committee Members

To provide a broad-based evaluation of biological advice generated from PSARC, it is the responsibility of members of the Steering Committee to attend all regular meetings if possible, regardless of whether or not items being discussed are in their area of expertise. If members cannot attend meetings, they should appoint an alternate.

Members are required to send copies of all correspondence, reviews, and reports pertaining to PSARC business to the Chairperson so up-to-date files can be maintained.

Each Steering Committee member, when asked for a scientific opinion on matters contained in approved Advisory Documents, should give the collective judgement of the Steering Committee even if it differs from his/her personal opinion.

Schedule of Meetings

The Steering Committee has at least three regular meetings annually. Generally, these meetings occur in the early fall for developing marine species Advisory Documents, and in the spring and late fall for developing salmon and other Advisory Documents. Other meetings may be called as required at the discretion of the Chairperson, or by request of members of the Steering Committee.

Communications

Each Subcommittee produces a Subcommittee Report which contains summaries of Working Papers and other documents presented at the Subcommittee meeting, summaries of reviewers' comments, the Subcommittee's discussions, and recommendations to the Steering Committee. The PSARC Steering Committee reviews the reports and recommendations provided in the Subcommittee Report and prepares its own report, which is attached at the beginning of the Subcommittee Report. This becomes a PSARC Advisory Document which is presented to the RMEC. Responses to advice in Advisory Documents are documented by the RMEC.

After Advisory Documents are approved for release by the RMEC, they are distributed. At the end of each year, all PSARC Advisory Documents produced that year are amalgamated into an annual report published in the DFO Manuscript Report Series. A distribution list for PSARC Annual Reports includes fishing organizations and native groups. Other individuals or groups can receive PSARC Annual Reports on request to the PSARC Steering Committee Chairperson.

Subcommittees

1. The following five Subcommittees deal with the specialized areas indicated:

PSARC Salmon Subcommittee
PSARC Herring Subcommittee
PSARC Groundfish Subcommittee
PSARC Invertebrate Subcommittee
PSARC Data and Systems Subcommittee

2. Subcommittees shall nominate candidates for the position of Chairperson of their Subcommittee to the Steering Committee. The Steering Committee shall recommend candidates to the RMEC. Chairpersons are responsible for communicating proposed agendas to members, participants and reviewers, and coordinating their preparations for and participation at Subcommittee meetings. The office of Chairperson of a particular Subcommittee should normally rotate among the relevant branches every 2 years where practical.

3. Participation at Subcommittee meetings shall include departmental staff (Science Branch, Fisheries Branch, Regional Planning and Economics Branch, and SEP as appropriate). At the discretion of the Subcommittee Chairperson, DFO staff from other regions, and non-DFO staff may be invited for discussion of specific topics. Attendance at Subcommittee meetings is flexible in order that advantage can be taken of expertise as required to discuss the topic at hand. However, if an individual arrives at a meeting uninvited, the person can be asked to leave by the Subcommittee Chairperson.

4. Stock assessment documents prepared for PSARC Subcommittees shall be in one of two categories:

a) PSARC Working Paper - A PSARC document that normally has been reviewed by at least one individual external to the Subcommittee prior to the document being presented and reviewed at a PSARC Subcommittee meeting.

b) PSARC Fishery Update - A brief compilation of fishery statistics presented at a PSARC Subcommittee meeting that is not reviewed.

5. The Steering Committee Chairperson shall approve reviewers external to the Department of Fisheries and Oceans nominated by a Subcommittee Chairperson for particular Working Papers.

6. Each Subcommittee Chairperson shall normally insist that reviewers' written comments on PSARC Working Papers are submitted one week prior to Subcommittee meetings. The Subcommittee Chairperson is responsible for providing these comments to authors of PSARC Working Papers at least several days before the Subcommittee meeting. The intent is to guarantee sufficient time for authors to make changes they feel are appropriate to their Working Paper before the meeting, and to enable authors to constructively respond to reviewers' criticisms.

7. Each Subcommittee Chairperson shall provide reviewers of PSARC Working Papers with guidelines for their reviews.

8. Reviews of PSARC Working Papers are only released to members of the relevant Subcommittee, unless they are pertinent to subsequent reviews. Although reviews are not distributed, they are summarized in Subcommittee Reports.

9. Each Subcommittee shall reach a consensus before acceptance of the conclusions and recommendations contained in PSARC Working Papers. Each Subcommittee Chairperson is authorized to request such changes in Working Papers as are required to rectify any deficiencies identified during the review process. If a paper is not accepted by the Subcommittee, the Subcommittee can decide not to include the summary and recommendations from the Working Paper in their Subcommittee Report, and to suggest that the Working Paper be revised and re-submitted at the next Subcommittee meeting.

10. PSARC Working Papers are to be marked **DRAFT** until they are accepted by the Subcommittee. Changes to Working Papers must be completed and accepted within 45 days of a Subcommittee meeting. After PSARC Working Papers have been accepted by the Subcommittee, they may be released. Requests for copies should be made through the relevant Subcommittee Chairperson. PSARC Working Papers should not be cited as full publications, but they can be cited in other PSARC documents.

11. The cover page of all approved Working Papers should have the following footnote: **"PSARC Working Papers document the scientific basis for fisheries management advice in the Pacific Region. As such, they provide one component of the assessment process, and are not intended as comprehensive treatments of stock management."**

12. PSARC Fishery Updates are prepared for a specific Subcommittee meeting. All inquiries concerning Fishery Updates shall be directed to the author(s) or, should it no longer be possible to contact the author, to the author's institution at the time of writing of the document. Distribution of Fishery Updates is entirely the responsibility of the author and the individual's line management and should conform to any policies and procedures in place for distribution of unpublished data and analyses which pertain in the establishment. Authors, or their institutions, should remove any PSARC designation from any such documents released.

13. PSARC Subcommittees should communicate to the Steering Committee concerns about timely release of Working Papers materials. Also, PSARC Subcommittees should alert the Steering Committee of potential problems identified in the review process which may be relevant to further publication of the material, and recommend that line managers be advised of these concerns.

14. Meeting participants in receipt of Working Papers, Fishery Updates, or reviews of Working Papers, should respect these guidelines, referring all inquiries concerning material contained in these documents to the authors or the Subcommittee Chairperson.

15. Each Subcommittee member, when asked for a scientific opinion on matters contained in approved Advisory Documents, should give the view stated in the Advisory Document, even if it differs from his/her personal opinion.

Salmon, Herring, Invertebrate, and Groundfish Subcommittees

These PSARC Subcommittees are to provide the scientific basis for advice to the Steering Committee on the status and management, as appropriate, of all salmon, herring, invertebrate, and groundfish stocks in the Pacific Region presently exploited, or with potential to be exploited, by:

- responding to requests directed through the Steering Committee;

- reviewing all pertinent information and analyses, or by conducting such analyses as may be required, to establish the status of stocks and to predict the biological consequences of alternative management measures;

- reviewing stock assessment programs and commenting on their relevance;

- providing a forum for coordination of stock assessment programs;

- reviewing requirements for stock assessment, and recommending initiation of such programs as may be required to the Steering Committee; and

- maintaining a written record of the proceedings of each Subcommittee meeting, documenting the recommendations of the Subcommittee, and the scientific basis for such recommendations.

Data and Systems Subcommittee (DSSC)

It is the responsibility of the Data and Systems Subcommittee to provide the scientific and technical basis for PSARC advice on matters concerning fisheries statistics, sampling of commercial catches, and biological surveys by:

- investigating and developing recommendations to address data and systems needs identified by the Steering Committee;

- providing a forum for discussion, review, and evaluation of methods of data collection, information collected, and analyses concerning fisheries

statistics, commercial catch sampling, and biological surveys;

- providing the Steering Committee with recommendations for actions to improve fisheries statistical information, biological surveys, and commercial catch sampling; and

- maintaining a written record of the proceedings of each Subcommittee meeting, documenting the recommendations of the Subcommittee, and the scientific basis for such recommendations.

Appendix 1

Past and Present Chairpersons of the PSARC Steering Committee and Subcommittees

PSARC Steering Committee

1985	D. Schutz
1986 - 1988	M. Stocker
1989 - 1990	S. Farlinger
1991 - 1992	J. Irvine

Groundfish Subcommittee

1986 - 1990	A. Tyler
1990 - 1992	B. Leaman

Herring Subcommittee

1986	S. Farlinger
1987 - 1988	J. Schweigert
1989 - 1990	D. Chalmers
1991 - 1992	V. Haist

Salmon Subcommittee

1986 - Sept. 1989	B. Riddell
Sept. 1989 - Sept. 1991	A. D. Anderson
Sept. 1991 -	S. M^{c}Kinnell

Invertebrate Subcommittee

1986 - November 1987	R. Harbo
November 1987 - 1989	N. Bourne
1989 - 1991	G. Thomas
1992	D. McKone

Data and Systems Subcommittee

1986 - 1988	L. Lapi
1988 - 1990	D. Radford
1991 - 1992	R. Stanley

Appendix 2. 1992 PSARC Steering Committee Membership

Dr. J. R. Irvine, Chairperson
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Pacific Biological Station
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Ms. S. Farlinger, Past Chairperson, PSARC Steering Committee
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Chairperson, PSARC Salmon Subcommittee
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Dr. B. Leaman, Chairperson
PSARC Groundfish Subcommittee
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Mr. R. Stanley, Chairperson
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Section II - PSARC Advisory Documents

PACIFIC STOCK ASSESSMENT REVIEW COMMITTEE

PSARC ADVISORY DOCUMENT 92-1
MAY 1992

BIOLOGICAL ADVICE ON PACIFIC SALMON

CONTENTS PAGE

I. STEERING COMMITTEE REPORT

At its meeting on 12 May 1992, the PSARC Steering Committee reviewed the Salmon Subcommittee Report which follows. Five Working Papers plus the Chairman's report were reviewed and accepted by the Salmon Subcommittee and are summarized in this document.

The Chairman's Report for the 1991 Salmon Subcommittee contains sections on: recommendations from PSARC Advisory Documents 90-1, 90-5, 91-1 and 91-6; performance of 1991 forecasts; and proposed work plans for the Salmon Subcommittee for the remainder of 1992 and beyond. The latter were discussed and modified by the Steering Committee; the list in the Subcommittee Report has been updated.

The Stock Assessment Section of the Subcommittee Report contains chapters providing stock status information for Fraser River chum salmon and early run Skeena River coho salmon as well as an evaluation of the conservation program for chinook salmon in the southern Strait of Georgia. The Methodologies Section contains an evaluation of the 62 cm size limit for chinook salmon in the Georgia Strait recreational fishery as well as a paper considering steelhead trout productivity and stream carrying capacity for the Skeena River watershed. Three additional papers were submitted to the Salmon Subcommittee but either were received too late to permit adequate review or were judged inadequate by the Subcommittee.

STEERING COMMITTEE RECOMMENDATIONS

Each chapter of the Salmon Subcommittee Report contains advice for fisheries management and/or recommendations to improve stock assessments. All major recommendations were considered by the Steering Committee and the consensus of the Steering Committee on specific recommendations in the Subcommittee Report follows.

A) Advice from Stock Assessment Papers

Fraser River Chum

1. The Steering Committee supports the Subcommittee's recommendation that the escapement target of 700,000 be increased to a minimum escapement of 800,000 naturally spawning chum salmon.

2. The Steering Committee agrees that an assessment of the apparent decline in abundance of late run wild stocks would be useful but does not consider this as a high priority. The Steering Committee is unsure whether appropriate data are available to do the analysis and recommends that if the assessment is undertaken that enhancement effects on run timing be considered.

3. The Steering Committee agrees that a request for estimates of the contributions of

enhanced Fraser River chum to Washington fisheries should be made. Escapement estimation programs on the Harrison, Stave, and Chilliwack Rivers are important requirements for a proper assessment of Fraser River chum but the Steering Committee needs additional information on the costs of these programs before it can recommend their implementation.

Skeena River Coho

1. The Steering Committee supports the recommendation for a minimum spawning escapement of 36,000 coho as measured by the test fishery to August 24. However the Steering Committee is concerned whether DFO will be able to detect this relatively minor change. The effects of this increase in escapement will depend on the distribution of productivity throughout the watershed and it is felt that more stock specific information is needed. The Steering Committee points out that an increase in escapement for coho means a concomitant increase in escapement for other species.

2. The Subcommittee agrees that it would be useful for the test fishery to continue until the first week of September.

3. Estimates of the escapement and the in-river harvest of tagged fish are desirable.

Evaluation of Georgia Strait Chinook Conservation Program

1. The Steering Committee strongly endorses the recommendation that a statistical method for comparing harvest rate changes, based on coded wire tag recoveries, be developed.

2. Pooling harvest rates over fisheries to increase sample sizes is appropriate and the 1984-1987 base period appears to be better for comparing the effects of management and enhancement than the single year, 1987.

3. The Steering Committee recommends that the sampling rate on the SCTR and GSTR fisheries be increased wherever possible.

4. The Steering Committee supports the recommendation that the native harvest in the Squamish be reduced but acknowledges the difficulties of implementing this recommendation.

5. The Steering Committee agrees that the feasibility and costs of producing a habitat assessment and report for the Squamish, Nanaimo, and Cowichan Rivers should be undertaken.

As well, the Steering Committee recommends that the Salmon Subcommittee investigate what appears to be high levels of pre-spawning mortality of hatchery and wild chinook and that the

effectiveness of the three facilities designed to rebuild LGS chinook populations should be evaluated.

B) Advice from Methodology Papers

Evaluation of the 62 cm Size Limit for Georgia Strait Chinook

1. The Steering Committee agrees that the analytical approach used in this Working Paper should be developed further.

Skeena River Steelhead Trout

1. Habitat-based models of steelhead production have the potential to serve as the basis for establishing steelhead management objectives in watersheds throughout the Pacific Region. Management objectives defined through the use of these models will frequently constrain management options recommended for other stocks and species. It is therefore essential that model testing and validation be pursued to confirm model applicability to new stocks and watersheds. The Steering Committee agrees that the habitat-based estimate of a minimum carrying capacity at replacement with no exploitation of 80,000 adult steelhead in the Skeena River watershed appears reasonable if the assumptions in the model are appropriate. The Steering Committee emphasizes the importance of verifying the assumptions in this model for the Skeena watershed.

2. The Steering Committee encourages the initiation of research programs to test assumptions of the habitat-based model in the Skeena River.

3. The Steering Committee accepts the spawning levels for substocks of Skeena River steelhead provided in the Subcommittee Report as provisional rebuilding targets.

4. The Steering Committee supports the recommendation that a model to develop fishery management options for fisheries on mixed populations of steelhead with differing productivities be developed.

C) Advice from other Working Papers

Smith Inlet Sockeye

1. The Steering Committee supports the Subcommittee recommendation that a comprehensive stock assessment of Smith and Rivers Inlet sockeye be undertaken.

Skeena River Steelhead run timing

1. The Steering Committee supports the recommendation that fishery management

options for fisheries on mixed populations of steelhead with differing productivities be developed. The resulting Working Paper should consider the development of an assessment strategy to determine whether management objectives have been achieved.

Forecasting Methodologies

1. All major forecasting methods should be reviewed by PSARC. The Steering Committee endorses the recommendation that a Working Paper be prepared which will describe several examples of predictions and provide detailed models, data, performance and diagnostic information to support the methods.

II. SALMON SUBCOMMITTEE REPORT

INTRODUCTION

The Salmon Subcommittee met in Vancouver from April 21 to 24, 1992. The Subcommittee considered nine working papers. Lists of participants and of working papers are appended (Appendix 1, 2). The purposes of the meeting were:

- to review assessments, methods, and advice provided in working papers,
- to develop a consensus on Subcommittee recommendations and advice,
- to identify program and/or information needs,
- to identify required research, and
- to address other business issues of the Subcommittee.

This report provides a synopsis of the working papers, reviewers' comments, Subcommittee advice and recommendations. Draft minutes of Other Business were circulated to the Subcommittee for comment. Working Papers S92-05 and S92-10 were submitted with insufficient time for external review. S92-7 and S92-10 have been rescheduled for the Fall 1992 Subcommittee meeting. S92-05 was reviewed and discussed in a special conference call on May 7, 1992.

1. CHAIRMAN'S REPORT FOR THE 1991 SALMON SUBCOMMITTEE (Working Paper S92-09)

1.1 INTRODUCTION

This report provides a summary of the Salmon Subcommittee activities during 1991. In this regard, information is provided on the Subcommittee's two reports of 1991 (91-1 and 91-6) and the actions taken on major recommendations. These reports, prepared for the

Pacific Stock Assessment Review Committee (PSARC), were presented to the Steering Committee and then to the Regional Management Executive Committee (RMEC). This report also comments on additional topics considered by the Subcommittee during the year in addition to working papers, the accuracy of the 1991 abundance forecasts for 11 major salmon stocks (Table 1), comments on publication of assessments presented in 1991, identifies topics needing continuing work and provides an outline for future activities, and concludes with information on the status of the Subcommittee's membership.

1.2 SUBCOMMITTEE ACTIVITIES, 1991

In 1991, the Salmon Subcommittee submitted two reports summarizing 10 working papers. The reports consider various topics related to salmon stock assessment including the Chairman's report for the 1990 Salmon Subcommittee, an assessment of the status of WCVI chinook salmon, the evaluation framework for assessing the 1989 sport fishing regulation changes in Georgia Strait, forecasting methods and the late South Thompson sockeye for 1991, stock status of upper Johnstone Strait coho, Nass River sockeye, Fraser River coho (including a floor escapement goal), and the evaluation of the Georgia Strait sport fishing regulations changes for 1989-90, and for the first time two documents on Skeena River steelhead were submitted by the Province of British Columbia for review.

1.3 MAJOR RECOMMENDATIONS IN PSARC ADVISORY DOCUMENT 91-1

A) Advice for Fisheries Management

1. Stock status information on chinook salmon on the west coast of Vancouver Island was presented and five recommendations were made. Recommendations 1-3, and 5 were accepted. Recommendation #4 was changed by the Steering Committee. Without additional information, the Steering Committee did not accept the Subcommittee recommendation that the wild stocks are probably not rebuilding and did not accept that the indicator stocks group, currently used by the Chinook Technical Committee, should be revised, only that it should be considered. The RMEC endorsed the recommendations in the Steering Committee report. Fisheries Branch was given responsibility for implementing recommendations A.1.a, A.1.b (SCD), A.1.c (SCD), A.1.e, and joint responsibility for A.1.d was given to Fisheries and Biological Sciences Branches. The Subcommittee did not assign any additional reporting requirement on this topic.

B) Information and Research Needs

1. Methods used to forecast the 1991 return of sockeye salmon to the South Thompson Rivers system were presented and four recommendations were made. The Steering Committee and the Subcommittee supported all four recommendations. Fisheries Branch - Fraser River Division was assigned responsibility for implementing the recommendations B.1.a through B.1.d.

The Subcommittee did not assign any additional reporting requirement on this topic.

2. The Subcommittee reviewed the work on developing an evaluation framework for assessing the 1989 sport fishing regulation changes. Eleven recommendations were presented to the Steering Committee. The general concerns of the Subcommittee (Subcommittee Recommendations 1-3) were acknowledged and the remaining specific recommendations were supported by the Steering Committee and the RMEC. These recommendations resulted in the selection of two preferred methods (exploitation rate and depletion methods) to be used to conduct the evaluation.

   One reviewer of this working paper proposed an alternative to either of these methods. The Subcommittee recommended that the method be submitted to the Strait of Georgia Evaluation Committee for a full review and possible presentation to the Subcommittee. The method was not presented for review in 1991. The Subcommittee offered an invitation to submit the method as a working paper for Spring, 1992.

   Steering Committee recommendations B.2.a through B.2.f were assigned to Biological Sciences Branch, B.2.g to Fisheries Branch, and B.2.h to Resource Enhancement Branch.

   The results of the analyses were reported at the Fall, 1991 Salmon Subcommittee meeting.

   At the July 2, 1991 RMEC meeting, the RDG emphasized the importance of assessing the entire LGS chinook rebuilding program. Fisheries Branch was asked to investigate the feasibility of improving escapement estimates to the Squamish, Chemainus, Nanaimo, and Cowichan River systems. Primary responsibility for assessing the overall LGS rebuilding program is to the Biological Sciences Branch.

1.4 MAJOR RECOMMENDATIONS IN PSARC ADVISORY DOCUMENT 91-6

A) Advice for Fisheries Management

1. In Advisory Document 89-5, the Steering Committee endorsed the Subcommittee recommendation to replace the existing escapement goal for Fraser River coho. A working paper on this subject was submitted to the Subcommittee.

   The Subcommittee reviewed the concept of a floor escapement for Fraser River coho salmon and 4 recommendations were made. The Steering Committee agrees that recommendations 1 and 2 appear to be suitable interim measures, however, the remaining recommendations should be considered by the coho assessment working group.

2. The Subcommittee noted that the status of Johnstone Strait coho stocks was uncertain.

3. The analysis of the 1989 sport fishing regulation changes for chinook salmon in the lower Strait of Georgia were reviewed by the Subcommittee. The Subcommittee made 5 recommendations which were accepted by the Steering Committee.

4. The Steering Committee and the RMEC agreed that harvest rates and escapement targets for Nass River sockeye should not be changed at this time.

B) Information and Research Needs

1. Two working papers on the reconstruction of historical steelhead data for the Skeena River were presented by the Province of B.C., reviewed by the Subcommittee, and 2 recommendations were accepted by the RMEC and the Steering Committee. The Subcommittee did not provide advice concerning the management of steelhead in the Skeena River pending a more thorough review of the scientific basis for the recommendations and examination of the assumptions used in the analysis presented.

   The Province of B.C. was requested to undertake certain analyses for the Spring 1992 meeting.

2. The Subcommittee made 2 recommendations on the management of upper Johnstone Strait coho salmon and noted that the status of these stocks is uncertain. The Steering Committee was unwilling to accept the recommendation that two stocks (the Keogh and one other) be selected as exploitation rate and productivity indicator stocks until additional information and more clearly stated goals were presented.

   A coho assessment working group was formed and asked to consider the Steering Committee requests for information.

3. Concerning the recommendations on Fraser River coho stocks, the RMEC and the Steering Committee supported the establishment of a working group which would examine alternative assessment methodologies for coho. The results of the working group will be reported as a working paper for the Subcommittee. (Kadowaki et al.)

   This report meets the outstanding requirement identified in Advisory Document 89-5.

4. The Steering Committee accepted the advice of the Subcommittee on the regulation changes for Lower Strait of Georgia chinook and enhanced recommendation #2 to request that programs needed to improve the understanding of size at age of Strait of Georgia chinook should be identified in the Spring 1992 working paper on overall assessment of the Strait of Georgia chinook rebuilding program.

The development of methods needed to determine confidence intervals on parameters in models using coded wire tag data, is required.

5. The Steering Committee agreed that an evaluation of the Nass River and Skeena River test fisheries should be undertaken and noted that NCD has proposed to do the work.

The Steering Committee recommended that a working paper related to Nass River sockeye recommendations 3 to 5 should be prepared when the work described in these recommendations is completed.

1.5 OUTSTANDING RECOMMENDATIONS FROM PSARC ADVISORY DOCUMENT 90-1,90-5

1. 90-1: The Subcommittee requested that NCD resubmit a revised working paper on the Assessment of Kitimat Arm Chinook stocks. The RMEC and the Subcommittee requested attention to certain particulars in the paper.

2. 90-1: The RMEC endorsed the recommendation to establish a formal working group, consisting of PSC and DFO staff, to review the accuracy and precision of stock identification of Fraser River sockeye populations.

3. 90-1,5: The RMEC endorsed recommendations concerning the need and proposed program to improve the quality and consistency of salmon escapement data.

4. 90-1: The Subcommittee identified the need for further work on the WCVI troll fishery simulation model and assigned the task to the yet to be established Regional Modelling Group.

1.6 PUBLICATION RECORD

The Salmon Subcommittee reports from the 1991 meetings are published in:

Irvine, J. R., A. D. Anderson, V. Haist, B. M. Leaman, S. M. McKinnell and G. Thomas (Editors). 1992. Pacific Stock Assessment Review Committee (PSARC) Annual Report for 1991. Can. Manuscr. Rep. Fish. Aquat. Sci. 2159: 201 p.

1.7 OTHER SUBCOMMITTEE BUSINESS

The Salmon Subcommittee developed a draft definition of conservation as it applies to commercially exploited species of *Oncorhynchus sp.* in British Columbia. The draft document was presented to the RMEC on January 7, 1992 whereupon it was returned to the

Subcommittee for additional work. The draft was returned to the RMEC in early March, 1992. In a memo from the RDG to the ADM/Science (May 5,1992), the Subcommittee's definition and a different definition from that proposed by the Subcommittee was sent to Ottawa.

1.8 FUTURE WORK PLANS

Working Papers - Fall 1992

1. Coho salmon habitat paper - Title unspecified. T.G. Brown and C. Scrivener
2. Steelhead run timing and options for management - NCD and MOELP.
3. Inseason forecasting of Fraser pink, chum, and sockeye- Blackbourn.
4. Revised Fraser River escapement targets- Harrison.
5. Barkley Sound hake/salmon interactions.-B. Hargreaves,S. McFarlane

Working Papers - Spring 1993

1. Comprehensive assessment of Rivers and Smith Inlet sockeye-Unassigned.
2. North Pacific production levels, carrying capacity, and evidence for marine density-dependent growth-Unassigned.
3. Report of the Coho Working Group on Assessment Methods-Kadowaki, Chair
4. Assessment of bias in the Skeena/Nass test fisheries.-NCD.
5. Prediction methods for forecasting chinook returns.-Unassigned.

Working Papers - After Spring 1993

1. Kitimat Chinook- Unassigned.
2. Nass River sockeye-Wood et al. (followup to Ad.Doc.91-6) - Fall 1993.
3. Assessment of the apparent decline in abundance of late run wild chum stocks in the Fraser River-Joyce.

Working Groups

1. Coho Working Group on Assessment Methods.
2. Special Workshop of the Salmon Subcommittee (Sept. 8-11) has been scheduled to develop a longterm plan for the assessment of salmon stocks/stock complexes.

1.9 SUBCOMMITTEE MEMBERSHIP

Since the spring 1991 meeting and up to and including the spring 1992 meeting, the following changes in membership have occurred:

- S. M^{c}Kinnell, BSB, was added to Subcommittee as Chairman effect Sept. 4/91.
- T. Perry is acting as the SEP representative, replacing K. West.
- P. Delaney was added to the Subcommittee as a new representative from Habitat Management. This completes the Subcommittee's task related to this issue.
- Dr. A. Tautz, Prov. of B.C.: M.O.E.L.P., was added as a new member for discussion and development of recommendations and advice related to steelhead working papers.

Table 1. Performance of 1991 forecasts for selected stocks.

Species	Stock	1991 Forecast Return	Mean Deviation[1]	1991 Observed Return	1991[2] Deviation
Sockeye	Fraser River (1987 cycle)	14,500,000	21% (8)	12,291,000	15.2%
	Barkley Sound	660,000	19% (4)	1,800,000	-63 %
	Smith Inlet	522,380	40% (7)	714,290	-26.9%
	Rivers Inlet	811,781	71% (6)	499,795	62.4%
	Skeena River	2,100,000	43% (10)	2,900,000	-27.6%
Pink	Fraser River Southern B.C.	11,000,000 1,705,000	70% (10)	N/A[3] 869,000	N/A 96 %
	Skeena River	5,000,000	51% (10)	9,000,000	-44.4%
	South B.C., Johnstone Strait	3,179,000	32% (23)	2,679,500	19.0%
Chum	Fraser River	1,202,000	N/A	1,173,000	2.5%
	Area 8	607,124	106% (7)	258,783	134.6%

1. Sum of the absolute value of (forecasted-observed returns)/total number of years forecasted.
2. Positive deviation indicates a shortfall from preseason forecasts.
3. N/A indicates not available.

STOCK ASSESSMENTS

2. Assessment of Fraser River chum salmon (Working Paper S92-02)

The purpose of this assessment is to describe the status of the stock and management strategy for Fraser River chum. An assessment of wild stock productivity, including an evaluation of an appropriate escapement target is presented. Evidence for density dependency over the range of spawner-recruit data for wild chum, all stocks combined, (1959-86 brood years) was explored using the Ricker model (Fig. 1). It was not possible to distinguish between a linear spawner-recruit relationship (b=0) and a density dependent relationship (b>0). The degree of density dependency is influenced almost exclusively by a single spawner-return data point (1985). Anecdotal information suggests that the 1985 brood year suffered from atypical freshwater mortality, independent of density dependent effects, as a result of freezing during the egg stage. Results of the stock-recruit analysis implies that optimal escapement is poorly determined from the data. It is unlikely that density dependent effects are going to be tested unless escapements ≥ 800,000 chum are realized.

Methods used to estimate spawning escapements vary considerably among individual spawning populations. Wild escapements to the Harrison R. and many small spawning systems are likely estimated with a high degree of measurement error. Estimates of spawning escapements to the Fraser mainstem are also poorly determined. Despite inadequate wild escapement estimates on some systems, there is a good correlation between indices of escapements based on the Albion test fishery and spawning ground estimates (Fig. 2). There are indications that the dynamics of Fraser chum have changed since 1985. Hatchery activities concentrated on the early timing component and a decline in late run productivity has possibly led to a stronger early run and weak late run, as measured by CPUE in the Fraser R. terminal test fisheries (Fig. 3). As a result, wild stocks co-migrating with the stronger early enhanced component are subject to higher harvest rates. The apparent decline of late timed stock is a concern.

Based on the relationship between the Mission fry index and subsequent adult returns there is no evidence for density dependent marine effects on survival (Fig 4). There is also no evidence that Fraser R. pink abundance in odd numbered years influences survival or growth of Fraser R. chum.

At this time it is not possible to assess the impacts of enhancement on Fraser chum production. Enhanced returns have only contributed significantly to total Fraser chum production beginning in 1985. Of the major enhanced systems, only the Chilliwack River, with its recent increases in escapement, is above historical escapement levels. Harrison River escapements have apparently declined despite lower fishing effort levels in the late portion of the run. However, because the relationship between fry CPUE and adult returns is linearly related to fry output, enhancement should result in a net benefit to the chum resource.

2.1 REVIEWERS' COMMENTS

Reviewer-1 (Internal)

The reviewer commented on the good job of assessment and presentation of biological information. The reviewer agrees with the authors' recommendation that escapements in excess of 800,000 should be set to improve the estimate of optimum spawning escapement. The reviewer does not agree that optimal escapements for individual systems should be pursued given the overlap in timing of migration of stocks, the lack of ability to identify stocks, and the current manner in which the fishery is conducted. Additional research on whether there are differences in productivities of odd and even year Fraser chums needs to be explored, and if found to be significantly different, should be considered independently. The mainstem spawning population should be incorporated into the CPUE vs. escapement relationship developed for 4 major non-mainstem spawning areas. The wild spawning escapement estimate for 1987 used by the authors (385K) should be reviewed as it differs from the Chum Salmon Technical Committee estimate of 431K.

Reviewer-2 (External)

The reviewer complimented the authors on a thorough, well prepared document. There were no major comments on the document and 15 minor ones which the reviewer noted were largely editorial. This reviewer noted the need to provide better documentation related to the poor performance of the 1985 brood.

2.2 SUBCOMMITTEE DISCUSSION

The Subcommittee noted that escapement estimates were developed in various ways in different years. Some consistent method of estimating escapement should be developed. In response to a reviewer's comments, the authors noted that there is no appearance of interspecific competition with pink salmon. For example chum returns per spawner and chum fry survival did not seem to be related to pink abundance. There appears to be a good relationship between the Albion test fishery and current escapement enumeration techniques (Fig. 2). Further efforts are warranted to enable calibration of the Albion test fishery as an index of absolute escapement. The Albion CPUE could then be used to back-calculate total escapement in previous years. Using hatchery operation information, the authors might want to document that egg viability or some similar factor may have been responsible for low survival in winter of 1985/86.

The current escapement target is 700,000. The escapement level that would allow for MSY is thought to lie above 800,000 naturally spawning chum salmon (based on current methods of spawner enumeration). The time taken to determine this level is made will depend on the magnitude and frequency at which escapements above 800,000 are allowed. Fishing plans should be adjusted to adequately distribute the escapement among populations over the run. Longterm studies of fry production downstream of the Mission fry index site would be

particularly useful for determining total Fraser chum fry production. There was concern that less productive wild stocks (a small portion of the run) may be affected by fisheries targeting on enhanced runs in the early part of the run. The latter part of the run is declining with no known reason.

2.3 SUBCOMMITTEE RECOMMENDATIONS

1. The Subcommittee recommends that the escapement target of 700,000 be increased to a minimum escapement above 800,000 naturally spawning chum salmon (based on current methods of enumeration) in the Fraser River.

2. The Subcommittee recommends that an assessment of the apparent decline in abundance of late run wild stocks be undertaken.

3. The Subcommittee recommends that the following data collection activities need to be initiated or improved:
   a) Estimates of the contributions of enhanced Fraser River chum to two Washington fisheries in areas 4B,5,6C, and 7-7A should be obtained by formally requesting through the PSC that the U.S. sample these fisheries for marked fish.
   b) To estimate chum escapement, the Subcommittee recommends the development of a mark-recapture program on the Harrison River and the continuation the mark-recapture program on the Stave River. (Current plans are to discontinue this program). The dead-pitch enumeration on the Chilliwack River should be continued.

3. Stock assessment of early run Skeena River coho salmon (through the 1991 return year) (Working Paper S92-03)

This paper updates the 1988 stock assessment with new information on run timing and stock composition provided by new coded wire tag recovery data. In addition, an alternative approach to establishing spawning escapement goals using habitat based carrying capacity estimates is explored.

Recently obtained coded wire tag data indicate that coho migrating through the Skeena River estuary in July and August are not discrete from populations migrating later in the season. Migration timing of spawning populations vary but overlap considerably. Unfortunately, the data available for this analysis did not permit an assessment of the later timing component of the run.

Estimated escapement by fishery officers has declined since the 1960's in both the upper and lower parts of the watershed (Fig. 5). Babine fence coho counts to September 13th (partial count) have declined since the 1960's and the 1970's (Fig. 6). Skeena test fishery indices of escapement have declined in a similar manner to the Babine fence counts (Fig. 7). The test fishery index has increased since 1989. In 1988, PSARC recommended management actions to increase coho escapements in the Skeena.

Stock recruit analysis using the Ricker model was performed on nine data sets reconstructed with different assumptions about ocean harvest rate (10%/40%, 20%/50%, 30%/60%) and Area 4 gillnet stock composition (25% to 45%, 35% to 55%, 45% to 65%). The estimate of the minimum spawning escapement required to August 24th (Fig. 8) as measured at the test fishery is 36,000 fish (3,000 higher than the target developed in 1988). We recommend caution in applying the stock recruit results literally since we believe that any errors and biases in the analysis would cause the stock to appear more productive than it really is. For this reason, the spawning escapement goal might be more suitable as a minimum requirement rather than a target.

The 1988 PSARC assessment indicated that increases in spawning escapement of early run Skeena coho were required immediately if the declining trend in the stock was to be reversed and production maximized. The spawning escapement in 1988 was the lowest on record, but management actions have been taken in the troll and terminal net fisheries since 1989 to pass more fish to the spawning grounds. Escapements in 1989 and 1990 exceeded the recommended escapement goal while the 1991 escapement did not.

Habitat based estimates

In this exercise, we chose a simple relationship between stream length and spawning escapement that identifies a maximum sustainable yield spawning escapement goal between 25 and 75 spawners per kilometre of accessible coho producing habitat (B. Holtby PBS, Nanaimo, pers com). It is recognized that this is a superficial approach which does not consider many variables of individual stream productivity which undoubtedly affect coho production.

The Morice and upper Bulkley rivers complex was selected as an example application of this approach for two main reasons. First, there are chronic coho conservation concerns in

this area, and second, past studies (related to Alcan's Kemano Completion project) and more recent field work by DFO have identified the extent of coho utilization. We have therefore been able to selectively include in the habitat measurements only those areas which actually contribute to coho production. The results of this analysis indicate that the spawning escapement required to maximize production is between 11,000 and 33,000 coho for those two rivers. Even with tributary spawning escapement goals there remains the difficulty of determining what the escapement is in a particular year. Innovations in escapement enumeration are required if reliable estimates are to be generated. Nevertheless, this approach to estimating spawning escapement goals can provide a useful check on the validity or reasonableness of the stock recruit derived goal and can be useful for habitat management and enhancement planning purposes.

3.1 REVIEWERS' COMMENTS

Reviewer-1 (Internal)

The reviewer noted the absence of hard data but concluded that the author's methods and interpretation seem appropriate. The reviewer noted the absence of information about the later component of the run due to the early (for coho) termination of the sockeye/pink test fishery. Gear saturation in the existing test fishery was noted as a potential source of bias in measuring escapement. The reviewer believes that assuming an ocean harvest rate of 55% is likely more appropriate. The reviewer suggests that reported MSY parameters should be considered maximum rather than minimum values to avoid overfishing.

The reviewer offered comments on the author's recommendations and added an additional recommendation: the test fishery on the Skeena River should be extended as late in the season as is possible to determine the nature of the middle and late components of the Skeena coho populations.

Reviewer-2 (External)

This reviewer found it difficult to evaluate the analysis as the reviewer was unable to evaluate the validity of the data. The reviewer questioned the general concept of long-term sustainable production and recommended that the author consider the apparent differences in coho production levels pre- and post- 1975 brood year. Early Skeena River coho declines appeared prior to a similar decline in Washington/Oregon coho. The reviewer recommended switching from escapement management goals to perhaps focus on exploitation rate goals.

3.2 SUBCOMMITTEE DISCUSSION

The Subcommittee noted that the protracted timing of the early component of the Skeena coho run into September is new information on these stocks, however, the data on these stocks remains sparse. The Subcommittee noted that some rewording of the original

draft document would be desirable given that only part of the required data for a comprehensive stock assessment is available for analysis. The Subcommittee also requested that the analysis include fishing effort-corrected tagging data used in run timing.

Methodologies for estimating escapement goals for coho using habitat based approaches should be developed further. A better understanding of the factors limiting the production of northern and interior coho would improve habitat based escapement goals.

3.3 SUBCOMMITTEE RECOMMENDATIONS

1. A minimum spawning escapement of 36,000 coho as measured by the test fishery to August 24th is recommended.

2. The Subcommittee recommends that, at a minimum, the test fishery should be continued to the first week of September on the Skeena River to assess performance against Recommendation 1, above.

3. Estimates of the escapement and the in-river harvest of tagged fish should be generated to permit the direct calculation of exploitation rates.

4. 1991 evaluation of the conservation program for chinook salmon in the southern Strait of Georgia, excluding Fraser River stocks. (S92-05)

During 1988 and 1989 a conservation program for depressed populations of chinook salmon from the lower Strait of Georgia was implemented. The long term goal of this program is to restore spawning escapements of all natural chinook populations in the lower Strait of Georgia (LGS, excluding the Fraser R.) to target levels by 1998. These populations include all chinook producing rivers on the east coast of Vancouver Island north to the Big Qualicum River and those flowing into the large inlets on the mainland side of Strait of Georgia, beginning with Howe Sound and ending with Toba Inlet. However, due to information limitations or the extent of artificial production in some rivers, the conservation program has focused on chinook populations in the Cowichan, Nanaimo, and Squamish rivers. The conservation program consists of new management actions in fisheries where these chinook were principally harvested, additional enhancement production, and a commitment to evaluation and future adjustments if needed. The objective of the fishery management actions was to obtain at least a 20% reduction in the annual harvest rate, relative to recent levels in 1987, beginning in 1988 and continuing to the end of the rebuilding program. The adequacy of this reduction in achieving the escapement goals was contingent on additional production from enhancement programs. Consequently, any evaluation of the conservation program must assess both enhancement and fishery management programs.

Management Actions (1988-1991)

The management actions implemented, during 1988 and 1989, to achieve the 20% decline in harvest rate were:

Strait of Georgia Sport Fishery

Raised the minimum size limit to 62 cm (nose-fork length) in the entire Strait of Georgia (1989 only).

Established an annual bag limit of 8 chinook per year (1988) and raised the annual bag limit to 15 in 1989.

Closed a number of specific terminal areas for varying periods of time to all sport fishing (1988 and 1989).

In 1988, the Strait of Georgia sport fishery was defined as occurring in the waters which extend from Sheringham Point in Juan de Fuca Strait to Chatham Point in the lower part of Johnstone Strait. Therefore, all catches and tag recoveries occurring in those waters would be used in the evaluation for that year and previous years.

In 1989, the section of Juan de Fuca Strait from Sheringham Point to Cadboro Point was removed from the management regulations designed to reduce harvest rates on lower Strait of Georgia stocks. At the same time, the waters of Johnstone Strait beginning at

Chatham Point and extending to the surf line drawn from Cape Sutil on Vancouver Island to Hope Island to Shelter Bay on the mainland coast were added to the area covered by the management regulations.

Strait of Georgia Troll Fishery (GSTR)

The required harvest rate reduction was implemented by a catch ceiling of 31,000 chinook in statistical areas 13-19 and 29, assuming that chinook abundance vulnerable to this fishery is equal to or greater than that in 1987. If the catch ceiling was reached before the fishery closed on all species then non-retention of chinook was to be implemented. During these periods, area closures and barbless hooks would also be implemented to reduce the incidental mortalities on released chinook. The minimum size limit for chinook salmon has been 62 cm nose-fork length since 1986.

Johnstone Strait Seine Fishery (JSN)

Limitations on fishing time (days open) and maximum catch levels were established for each year since 1987. The harvest rate reduction in this fishery must be compared to several base years since the fishery responds to the abundance of Fraser River sockeye and pink salmon. The basic management action was to reduce the number of days open by 20% relative to the previous cycle year of Fraser sockeye (eg. the 1990 days open were reduced relative to the 1986 fishery). However, additional actions such as area closures and shortened fishing days have also been implemented. Non-retention of chinook was implemented in small fisheries in the mouths of the mainland inlets. Maximum catch levels were established as "safe guards" but have not been acted upon.

South Central B.C. Troll Fishery (SCTR)

Portions of statistical sub-areas 10-1,10-2,11-1, and 11-2 were closed to fishing. A catch ceiling of 19,000 was established for the remainder of Statistical areas 10,11,110,and 111 (except for 1989 when the ceiling was increased to 21,000 due to the general increase in catch ceilings allowed by the Pacific Salmon Commission); again assuming that abundance was equal to or greater than recent levels. If the ceiling was reached then additional area and/or effort limitations would be implemented.

Native Food Fisheries

Actions taken in these fisheries were specific to each river. In the Nanaimo River, the Nanaimo Band agreed not to fish for chinook in the river in exchange for sockeye salmon provided under an agreement with the Band. In the Cowichan River, days open are limited to reduce fishing opportunities. This fishery is managed under a co-management agreement but recent management reports are not yet available. Management actions in the Squamish River vary depending whether the fishery occurs along reserve land or not. In August 1989, a B.C. Supreme Court decision ruled that reserve land included adjacent river waters. Fishery

management of these waters was re-assumed by the Band, and DFO retained regulatory control of non-reserve waters. Management plans include limiting days open and gill net mesh size. However, since the 1989 decision, the fishery has been open seven days per week on reserve lands.

Enhancement Program

New enhancement efforts were focused on the three index stocks - Nanaimo, Squamish and Cowichan, but also included expanded production in the Burrard Inlet area (Capilano Hatchery and associated saltwater release sites) and at Little Qualicum. The Burrard Inlet and Little Qualicum projects both produce transplanted chinook stocks (because natural stocks did not exist or had been lost) for the purpose of increasing chinook catch. Enhancement of the index stocks was intended to accelerate rebuilding of the natural spawning populations in order to meet the 1998 interim escapement targets with less disruption to existing management plans.

Enhancement guidelines were developed to ensure that hatchery production complemented, rather than dominated, natural production. The guidelines addressed the balance between hatchery and natural production, and the rate of increase in hatchery production.

Guideline 1: To limit enhanced production during the rebuilding of the natural chinook population, SEP returns will not exceed 50% of the total adult escapement target when the stocks are rebuilt.

The Cowichan Hatchery required a major expansion to meet proposed production levels while the Nanaimo facility required upgrading to improve fish culture conditions. The Tenderfoot Hatchery on the Squamish River had been expanded in 1987/1988 and capacity already exceeded Guideline 1 at the assumed return rate of 1.4%. There was, however, less certainty this return rate would be achieved for the Squamish stock. Enhanced and proposed enhancement production in the three index rivers are presented in Table 2.

Table 2. Existing hatchery capacity in 1987 for Cowichan, Nanaimo and Squamish Chinook and proposed hatchery capacity for Cowichan Chinook. Capacity is calculated on the basis of rearing rather than incubation facilities. Catch is calculated assuming 1.4% survival of smolts and 70% total exploitation rate by brood year. Escapement excludes age 2 returns (usually male "jacks"). The 1998 escapement target is the current goal for naturally spawning chinook adults in each river.

CAPACITY	NANAIMO (Existing)	SQUAMISH (Existing)	COWICHAN (Existing)	COWICHAN (Proposed)
Eggs	700,000	2,500,000	700,000	3,500,000
Smolts	500,000	1,800,000	500,000	2,500,000
Catch	4,900	17,640	4,900	24,500
Escapement Adult	1,500	5,400	1,500	7,500
1998 Escapement Target	3,450	6,860	11,250	11,250

Guideline 2: To limit the impact of brood stock removals, on natural spawning populations, as production from the hatcheries increases. Enhancement production for the Nanaimo, Squamish and Cowichan chinook stocks will not increase beyond the 1987 level until spawning escapement in the rivers exceeds the 1987 spawning escapement. The 1987 enhancement target will, however, be pursued in 1988 and beyond, even if escapement decreases from the 1987 level.

Further, transplants were prohibited as a means of increasing chinook abundance in the index streams and techniques such as seapen rearing were to be considered to accelerate enhancement returns. Seapen release of smolts was implemented for the Squamish stock in 1988. Rearing of Cowichan and Nanaimo chinook smolts to maturity in seapens was initiated in 1988.

Assessment Results

Catch and Spawning Escapement:

Catch has been reduced substantially in the SCTR, GSTR, JSN and GSPT fisheries (Table 3) but may be a function of both reduced chinook abundance and management actions.

In the troll fisheries with catch ceilings, the ceilings have not been exceeded in the SCTR area but were exceeded slightly during 1990 and 1991 in the GSTR fishery. Native food fishery catches were included with the spawning escapement (Table 4) to summarize total return to the rivers. The total return data (Table 4) include estimates of chinook spawning naturally, chinook removed from the river for hatchery brood stock, and the reported native catch but exclude small jack chinook. Returns to each river increased relative to 1986 and 1987 but have not increased equally among rivers. The returns increased 3-5 fold in the Cowichan but only marginally in the Nanaimo River; and the total returns for the Nanaimo between 1989-1991 also include pre-spawn mortalities in the natural population. Total return data for each river were presented in Appendix 3 of the working paper.

The only catch result which significantly exceeds the chinook conservation objectives is the increased Native harvest in the Squamish River. Since the 1989 change in regulatory control, catch and effort has increased substantially in this fishery. Before 1990, effort in the chinook season (July through September) was less than 100 net-days but since 1990 has increased to over 400 net-days (Al MacDonald, DFO, New Westminster, B.C.; pers. comm.). The resultant catch has increased but catch per unit effort has not. Similar catch rates are consistent with the trend in spawning escapement which does not indicate a significant increase in abundance; except in 1991.

Table 3. Catch in fisheries included in the chinook conservation program for lower Strait of Georgia chinook salmon: South central B.C. (Statistical areas 9-11); Johnstone Strait nets includes seine and gill net catch (Statistical areas 12+13); Inside troll includes the Strait of Georgia troll fishery and a small troll fishery in Area 12; and the St. Georgia sport fishery includes sport catch from Sheringham Point (Area 20) to the northern tip of Quadra Island except since 1983 when the Victoria area (Area 19B+ in the creel survey) was excluded from the annual catch. Sport fishing in Johnstone Strait was not surveyed until 1991 and has been excluded from these data.

Year	South Central B.C. Troll	Johnstone ST seine & gillnet	Inside Troll	St.Georgia Sport Fishery	TOTAL
1975	34547	44672	195467	398000	672686
1976	51144	54381	228282	490000	823807
1977	50505	65732	275930	372000	764167
1978	33975	80949	228356	500000	843280
1979	36133	42917	270332	350000	699382
1980	36399	43003	284899	371000	735301
1981	31401	41772	251578	253300	578051
1982	23937	39046	189840	163793	416616
1983	49924	51220	119997	168206	389347
1984	39302	32163	96969	345092	513526
1985	11150	42733	59248	206995	320126
1986	27771	21013	47850	147509	244143
1987	37429	17205	40475	96203	191312
1988	18888	10014	21177	87884	137963
1989	7945	32847	30299	100307	171398
1990	11182	19248	36692	81787	148909
1991	4935	14373	33415	96817	149540

Table 4. Total return of chinook salmon (excluding jack males) returning to the Nanaimo, Cowichan and Squamish Rivers since 1975. Natural spawners are the number of fish which spawned in the river naturally. Hatchery removals include all fish transported to the hatchery regardless of their fate (brood stock, pre-spawn mortalities, etc.). Native catch is the reported number of fish harvested by the Native band on the river.

Year	Natural Spawners	Hatchery Removals	Native Catch	Total Return
1975	9525	0	1415	10940
1976	8740	0	1400	10140
1977	10205	0	2010	12215
1978	7835	0	940	8775
1979	11650	236	635	12521
1980	11530	419	1898	13847
1981	10420	345	2215	12980
1982	9520	647	749	10916
1983	9030	531	491	10102
1984	11150	561	581	12292
1985	5010	569	939	6518
1986	3038	768	1149	4955
1987	2630	1379	720	4729
1988	7040	1495	818	9353
1989	6830	1306	1253	9589
1990	7635	794	1688	10367
1991	12895	1678	1365	16138

1979-1982 Average 10,780 (natural spawners only)
Escapement target 21,560 (natural spawners only)

Enhancement Results:

Whether the hatchery programs will comply with Guideline 1 can not be assessed until the late 1990s when adults of all age classes return from full capacity hatchery releases and natural spawning. For example, if Cowichan Hatchery operates at full capacity in 1990, 1991 and 1992 the first full-scale return will be in 1995. The first full-scale returns from capacity natural spawning populations (ie. the interim escapement target) are not expected until 2000. However, the programs have complied with Guideline 2 and an increasing abundance of hatchery adults is apparent in all three rivers. In 1991, marked (CWT recoveries) groups of hatchery chinook accounted for 59% of the Nanaimo return, 47% of the Squamish return and 13% of the Cowichan return (Table 5). Brood years without CWTs are not included (eg. 1986 brood 5 year old fish returning to Cowichan and Nanaimo in 1991), so these values slightly under estimate the total contribution from hatchery production.

Table 5. Chinook returns to the Nanaimo, Squamish, and Cowichan rivers and the contribution of hatchery returns based on CWT recoveries to the spawning population in each river; plus estimated numbers of non-native hatchery returns (strays) in 1988-1991. Returns of small chinook(<50cm) males (jacks) are excluded from all data.

River	Year	Total Spawners[1]	Hatchery returns		Strays	
			Number	Per cent	#	Source Stocks
Nanaimo	1988	1,079	NM[2]	-	38	Chemainus, Cowichan
	1989	1,552	NM	-	50	Chemainus, Puntledge
	1990	1,397	NR[3]/NM	-	183	Chemainus
	1991	935	550/NM	59	81	Chemainus, Cowichan
Squamish	1988	1,279	147	11	0	
	1989	1,068	223	21	0	
	1990	1,413	274	19	6	Little Qualicum
	1991	2,230	1,011	47	4	Indian Arm
Cowichan	1988	6,177	27/NM	0.4	19	Chemainus, Samish
	1989	5,516	36/NM	0.6	36	Chemainus
	1990	5,619	834/NM	15	58	Chemainus
	1991	11,408	1,463/NM	13	212	Chemainus, Squamish, Big Qualicum, Saanich

1. Does not include pre-spawn mortalities or IFF catch.
2. Hatchery returns expected, but were not marked so no estimate was possible for some or all age classes.
3. No CWT recoveries although some were expected - no estimate made.

Forecasts of hatchery adult returns were only made for the Cowichan stock since this was the only project to be significantly expanded. Estimated adult returns based on CWT recoveries compared to forecast are shown below (since unmarked groups have also contributed to these returns, recent total returns are likely close to the forecasted returns):

Cowichan Hatchery Chinook Adults

Year	Forecast	Observed
1988	397	27
1989	635	36
1990	1281	834
1991	1697	1463
1992	2213	-

Review of the hatchery brood stock records and tag recoveries revealed two other concerns: significant straying rates of non-local stocks into these three rivers (Table 5), and pre-spawning mortality of adults collected for brood stock. The latter varied between 20 and 40% of females collected for the Cowichan project but was usually less in the other two projects. However, high pre-spawn mortalities have been noted in the Nanaimo River chinook, both hatchery and wild fish, in the past three years. Survival from egg to smolt has been high at all three hatcheries, partially compensating for pre-spawning losses. Smolt to return data are incomplete for 1988 and later broods but appear consistently with forecasts for Cowichan and variable for Nanaimo and Squamish chinook.

Preliminary returns for seapen releases of the Squamish stock have exceeded expectations. Eggs from fish raised to maturity in seapens were an important supply for Cowichan and Nanaimo hatcheries in 1991.

Harvest Rate Analyses:

Exploitation rate analyses as presented by Starr (1991, PSARC S91-10) were extended to the four ocean fisheries. The basic data for these analyses are observed recoveries of coded-wire tag (CWT) groups by age and fishery strata. The numbers of observed recoveries were examined by stock and age in each fishery since 1979. When a stock/age combination was rarely recovered in the fisheries considered, this combination was excluded from these analyses to reduce the chance of random error. Small numbers of tags will reduce our ability to detect and measure a change in a fishery harvest rate. The numbers of observed tags were tabulated in the working paper.

The stock/age combinations used in this assessment were:

Fishery	Big Qualicum Hatchery			Quinsam Hatchery		
	Age 3	Age 4	Age 5	Age 3	Age 4	Age 5
SCBC Troll	YES	YES	NO	NO	YES	YES
JSt. Net	YES	YES	NO	YES	YES	YES
GSt. Troll	YES	YES	NO	NO	NO	NO
GSt. Sport	YES	YES	NO	YES	YES	YES

Small numbers of tags are clearly a problem with using exploitation rate analyses in some fisheries. For example, in 9 of the past 10 years, there are 9 or fewer observed recoveries for the 5 stock/age strata in the south central B.C. troll fishery. Consequently, the harvest rate change estimated by combining the four fisheries was also estimated. Combining the recoveries over fisheries substantially reduces the number of strata with small numbers of recoveries.

Substantial harvest rate reductions, relative to the 1979-82 Pacific Salmon Commission chinook base period, are estimated for 3 of 4 fisheries (SCTR, GSTR, JSN) but only a small reduction in the Strait of Georgia sport fishery (GSPT) (Figure 9). The trend indicated for the GSPT is very similar to the one presented by Starr (1991, PSARC S91-10). In the harvest rate analysis, two periods of reduction should be evident: (1) in 1985, a reduction for the chinook rebuilding program under the Pacific Salmon Treaty, and (2) in 1988, for implementation of the LGS chinook conservation program. Reductions are observed for the SCTR fishery but the harvest index increased in 1990 and 1991. On average, the target reduction (approx. 60% of the base) for these two programs has been achieved in the JSN fishery. Reductions in the JSN must be assessed as 4 year averages due to the cyclic return of Fraser sockeye salmon that this fishery targets on. A harvest rate reduction following 1987 is not evident in the GSTR fishery but a substantial reduction is obvious from 1985 onward. Given the small number of tags now recovered in this fishery we suggest that detecting the second reduction is unlikely using this exploitation analysis.

The harvest rate index of the combined fisheries indicates a much more consistent trend but again does not demonstrate 2 periods of reductions (Fig. 10). Harvest rate reductions for the combined fisheries averaged 0.4 during the past 4 years compared to the 1979-82 base period, and follow the trend pattern observed in the GSPT. However, the LGS conservation program refers to at least a 20% harvest rate reduction relative to recent years. This would imply a more recent base period than the PSC base. Starr (1991, PSARC S91-10) used 1987 as a 1-year base but this is inappropriate for evaluation of net fisheries and may generally be unadvisable because of the between year variation observed in the Harvest Rate Index. Figure 10 also presents a harvest rate index for the 4 combined fisheries relative to the most

recent 4-year period prior to the LGS conservation program (1984-87). The 1984-87 index parallels the 1979-82 index but the recent average value is 0.83, above the minimum target value of 0.80.

The impact of selecting various base periods was also examined. The trend in harvest rates is the same for all base periods (1987, 1986-87, 1985-87, 1984-87) but the value of the changes varies, except using the 1984-87 and 1986-87 bases which overlap completely. The 1987 base has the lowest harvest rate and, therefore, results in the largest harvest index values. Given the need to account for the 4-year cycle in the JSN fishery and the variability between years in the indices, we suggest using 1984-87 as the base period for the LGS evaluation.

Starr and Argue (1991,PSARC S91-3) examined four possible methods for evaluating the sport fishery harvest rate and two were applied in the subsequent evaluation (Starr, 1991, PSARC S91-10). Given the limited number of observed recoveries in some fisheries it would be advisable to develop independent evaluation procedures for the other 3 fisheries also. In the troll fisheries, however, the alternative evaluation may simply be whether the fisheries have kept within the established catch ceilings. This is not an adequate evaluation, however, since abundance of chinook vulnerable to these fisheries cannot be determined and effort directed on chinook is unknown. In the JSN fisheries, the management actions have been directed at reducing effort and the rate of incidental catch of chinook salmon in the seine fishery.

Managers of the JSN seine fishery have reduced the days open to fishing relative to the previous 4-year period but the number of vessels reporting landings from fisheries has increased. Consequently, if the number of vessels participating in the fishery increases as the number of days becomes more limited, the net effect will be less of a reduction in the chinook harvest rate than expected. The number of chinook caught per day fishing during 1988-91 has been similar or slightly higher than past years but total catch has, on average, decreased. Fishing effort per day and the chinook catch per day suggest that harvest rates have not been reduced in proportion to the reduction in days open. We suggest though that the Harvest Rate Index based on direct sampling of catch and tag recoveries is a preferable evaluation method in this fishery. The fishery has been consistently sampled between years and large numbers of tags have been recovered for the 2 exploitation rate indicator stocks.

Brood Year Exploitation Rates:

The principal indicator stock for total exploitation on LGS-type fall chinook salmon is the Big Qualicum Hatchery stock. Two brood years have now been harvested under fishing regimes established by the Pacific Salmon Treaty and the LGS conservation program (i.e. 1986 returns are complete, 1987 returns through age 4). The total exploitation rate is estimated over all ages and fisheries and should be the most reliable measure of the harvest impact on a stock. Brood years since 1984 all indicate a substantial reduction in exploitation based on reported catch only, but less reduction when total fishing mortality is included. This is consistent with recent management actions to increase size limits in the troll and sport fisheries and periods of chinook non-retention in some ocean troll fisheries. These unreported mortalities are now estimated to be equivalent to the actual catch of the stock! In general

though, management actions have successfully reduced the total fishing mortality exploitation to about 70%, a 10% point reduction from the base brood years (1975-78).

4.1 REVIEWERS' COMMENTS

Reviewer-1 (External)

This reviewer noted that a major contribution of the authors was the use of base periods (eg. 1984-1987) other than 1987 for determining the change in harvest rate. The reviewer was not convinced that the evidence for rejecting the 1987 base period was convincingly presented in the Working Paper. The selection of the 1984-1987 base period was considered to be a good recommendation but it requires more rigorous support. The reviewer noted that a 20% reduction was achieved in 1988 and 1990 but not 1989 or 1991. Both reviewers noted that the declining catch and the variation in harvest rate may have little to do with the management actions and recommended that other explanations be discussed.

The reviewer noted that the goal of meeting 50% of the escapement through enhancement is being approached (exceeded in Nanaimo R. 1991) but target escapements have not been met. The reviewer was concerned that interim and final evaluations of the LGS chinook conservation program were being undertaken with the uncertainty in the quality of the escapement data.

Reviewer-2 (External)

The main theme of the review was that no measures of variability, nor statistical tests of hypotheses have been performed and this is the major weakness in the Working Paper. The reviewer speculates that the increase in returns is more likely due to better ocean survival than to either regulatory changes or enhancement. The reviewer noted that none of the authors' recommendations considered assessing the reliability of the data and the reviewer suggested that this should be the top priority. The reviewer recommended that a likelihood distribution would be appropriate for assessing whether the regulations have been effective.

Harvest rates:

The lack of statistical analysis leads the reviewer to the general conclusion that it is unlikely that the regulations, implemented in 1988 and 1989, reduced harvest rates.

Escapements:

The reviewer noted that, in the absence of estimates of variance, it is difficult to conclude that there are differences in returns between 1988-1991 and previous years. The reviewer suspects that some of the recorded increase since 1988 is real. Some clarification is required on changes, if any, in the methods for determining escapement.

Hatcheries:

Given the proportion of the return taken as brood stock, the reviewer believes that

contribution of the hatchery program is likely 10-15%.

4.2 SUBCOMMITTEE DISCUSSION

In the evaluation of the LGS chinook conservation program, the lack of suitable measures of variability on the estimates of harvest rates is a recurring theme. Without these estimates, there is uncertainty about whether any of the apparent harvest rate trends are real. The members of the Subcommittee continue to be disappointed that the statistical methods for determining variance estimates on harvest rates and related parameters have not been developed.

The first point raised in the discussion of this paper concerned the future evaluation of the conservation program. The catch reduction in the SCTR and SGTR troll fisheries has made the recovery of coded wire tags a less likely event. If there is still a commitment to assess harvest rate changes separately in each of the 5 fisheries, the sampling rate for tags needs to be increased. Future evaluation and analysis could be strengthened by pooling fisheries, by additional tagging, and improved escapement enumeration in the Cowichan River where good returns are anticipated. The Johnstone Strait sport fishery should be considered in future evaluations. A suggestion was made to consider expanding the evaluation to include the Central BC troll fisheries in addition to SCTR.

The Subcommittee advises that additional research will be needed to understand the dynamics of the GSPT fishery and to more critically evaluate harvest rates in this fishery. The present process of relying on voluntary tag returns should be replaced with a designed program for randomly sampling for tags, or some defensible recovery process because the current process of voluntary recoveries of tags may be biased.

The Subcommittee advises that the depletion rate analysis on the 1991 GSPT will be completed after the catch at age data become available.

The Subcommittee notes that the harvest rate of chinook in the Native fishery on Squamish River chinook is inconsistent with the Minister's conservation goal of reducing harvest rate 20% by fishery.

Given the relatively poor performance (to date) of the Squamish and Nanaimo River chinook stocks, the Subcommittee is concerned about the status of chinook habitat. The potential productivity of these systems for chinook salmon may be decreasing as a result of habitat loss or alteration. In the extreme, this would negate any positive effects of management, enhancement, or regulatory actions aimed at rebuilding these stocks.

The Subcommittee noted a need to improve data quality. In particular, the mark rate is required by sample, and there are currently no estimates of jack chinook escapement or sex ratios in the spawning population.

4.3 SUBCOMMITTEE RECOMMENDATIONS

1. The Subcommittee recommends that a statistical method for comparing harvest rate changes, based on coded wire tag recoveries, be developed to test whether the

observed trends in harvest rate are real.

2. Given the low frequency of tag recoveries in the troll fisheries, the Subcommittee recommends pooling harvest rates over fisheries to increase the sample size of recoveries of coded wire tags. The 1984-1987 base period for comparing the effects of management and enhancement is preferred to the use of the single year, 1987.

3. To continue to use the exploitation rate analysis to evaluate the compliance of SCTR and GSTR fisheries with harvest rate reductions, the Subcommittee recommends that, at a minimum, the sampling rate on these fisheries should be doubled.

4. The Subcommittee notes that the increasing harvest rates on Squamish River chinook in the Native fishery on the Squamish River are inconsistent with present harvest rate goals and recommends that this harvest rate be reduced, or be compensated for by reductions elsewhere. The Subcommittee notes that the compensation for the catch of mature escapement (in river) would require a significant reduction in ocean harvests of this stock.

5. The Subcommittee recommends that a report on the feasibility of undertaking chinook habitat assessments on the Squamish, Nanaimo, and Cowichan Rivers (in order of priority) be developed. The report should consider (but not be restricted to) habitat issues related to chinook productivity that have been previously identified on these rivers. The report should also include options, costs, and schedules for implementing the assessments.

METHODOLOGIES

5. A method for evaluating the 62cm size limit for chinook salmon in the Georgia Strait recreational fishery (Working Paper S92-01)

An index of harvest rate reduction (IHRR) based on fork length (FL) frequency of chinook salmon in the exploitable population in Georgia Strait is proposed. The documentation of this method was requested by the Salmon Subcommittee (Ad. Doc. 91-1,91-6). The proposed index is estimated from the percentage of sub-legal fish in the population in three areas within Georgia Strait at several times of the year. Length data are collected via (chartered) commercial trollers, sport fishing charter boats and volunteer anglers. Ideally the exploitable chinook population should be sampled in each of the areas (area 13, areas 14-16, areas 17-19 and areas 28-29) each month. However to date this has not been achieved so some interpolation and extrapolation is required. Most of the fish measured have been tagged and released.

To provide an IHRR, the proportion of sub-legal fish in each area-time block is reduced by 15% to correct for hooking mortality. Only the proportion of fish between 45 and 60cm rather than 62cm is used in order to allow for growth of the fish during the month. To correct for growth and subsequent recapture of released fish the index is weighted by the chinook catch in that area-time block. This discounts the IHRR for the January to May period by about 60% relative to the June-August period. The index for the September to December period is discounted by an even greater amount via the weighting process. To account for growth of chinook between June and August the index was reduced by 4%.

The calculated indices of IHRR are 35.5% for 1989 and 31% for 1990. Tag recovery data indicate the above indices are realistic. The reduction in IHRR results from the release of Age II and III chinook salmon since older fish are larger than 62cm (FL). The harvest rate in older fish may increase if anglers continue to fish (and release small fish) until a legal fish is caught. Limited tag recovery data do not indicate an increase in the harvest rate of older fish but there are not enough data to allow an unequivocal decision on this.

Tag recoveries also indicate the harvest of U.S. chinook in Georgia Strait has also been reduced substantially as a consequence of the 62cm size limit. The new size limit has reduced anglers catch of chinook salmon to a greater extent in southern Georgia Strait than in the northern portion.

The technique of estimating IHRR described in the paper is easily understood by the recreational fishing community. This is important because it makes management measures more acceptable to anglers when they can understand the results of the measures. The technique can be further refined by use of more samples which would allow for calculation of confidence limits on the IHRR.

5.1 REVIEWERS' COMMENTS

Reviewer-1 (External)

This paper estimates harvest rate reduction (HRR) due to an increase in the legal size from 45 to 62 cm. The estimate of HRR is the proportion of the population between 45 and 62 cm, with a correction for hooking mortality. This method is biased, overestimating HRR, if harvest rates of large (62 cm and over) chinook are increased by the change in size limit. An increase in the harvest rate on large fish is expected if total catch was limited by bag limits. This may explain why estimates of HRR obtained using this method are greater than those obtained using other methods. The tagging data presented in the paper are either too limited to be useful or do not address the question being asked by the author. The main points that need to be addressed are:

(1) Was the harvest rate on chinook 62 cm and over affected by the size limit change?
(2) Why are length frequencies adjusted for a monthly growth rate of 2cm? Presumably these are an average size distribution for the month.
(3) The hooking mortality rate used here (0.15) is apparently much lower than that used in some other analyses (0.30). Perhaps, estimates should be given for a range of hooking mortalities (if point (1) can be addressed).

There is a potentially serious flaw in the method used in this paper. The aim of the paper is to estimate harvest rate reductions resulting from an increase in the legal size from 45 to 62 cm. The method used equates harvest rate reduction (HRR) to the proportion of the population between 45 and 61 cm (p) with a correction for hooking mortality (h). That is, ignoring some minor refinements,

$$HRR = p(1-h).$$

A critical assumption of this method is that harvest rates on fish over 61 cm are not affected by the change in regulations. In 1987, before the regulation change, an annual bag limit of 20 fish was in effect. In 1989 and 1990, the limit was 15 fish. If harvest rates were constrained by the bag limit in 1987, then harvest rates on large (>61 cm) fish would be expected to increase after the size limit increase. In this case, the method used in this paper will overestimate *HRR*. This overestimation could be extreme. If bag limits are a significant constraint on harvest, then harvest rates on large fish could increase substantially under the increased size limit, and, after accounting for hooking mortality of released undersized fish, overall harvest rate could in fact be increased rather than reduced. This could explain the differences between estimates of HRR using this technique and those estimated using CWT exploitation rate analysis or the depletion method. These latter two methods, which do not assume constant harvest rates on fish over 61 cm, yield lower estimates of *HRR* (and, in some cases, even estimate harvest rate increases rather than reductions).

The bag limit in 1989 and 1990 was admittedly only 75% of that in 1987. However, p in 1989 and 1990 was about 40%. So some increase in the harvest rate of fish 62 cm and

over can be expected for 1989 and 1990. If harvest rates on large fish cannot be assumed constant, then the method presented here must be modified to incorporate variation in this parameter. Let p be the proportion of the population between 45 and 61 cm, and q the proportion over 61 cm. Assuming that fishing is not size selective, then p/q sublegal fish are caught for every legal fish. Then,

$$HRR = (1 + ph/q)\ (C_r N_0)/(C_0 N_r)$$

where C_0 and N_0 are the catch and population size in 1987 (before regulation changes), C_r and N_r are these parameters in year r after regulation changes, and h is the hooking mortality. Unfortunately, this revised method requires estimates of sport catch and population size, eliminating one of the main advantages claimed for this technique.

Reviewer-2 (Internal)

The manuscript is a useful attempt to quantify the impact on chinook harvest rate of an increase in the size limit from 45 to 62 cm in the sports fishery. The assumptions of the harvest rate reduction are not clearly defined. The key phrase of the paper is on page 3 "a one month period the proportion of fish less than 60 cm or greater than 45 cm can be considered an index of harvest rate reduction (IHRR)." The proportion which I think is a ratio is undefined. It is crucial to provide the reader with formulae which clearly define the components of the model. From clear definitions, the results will be better understood. At the moment the results given in that table are difficult to verify. The reviewer suggests that what we prefer to know is total harvest rate in 1990 and how it compares with that in previous years and that cannot be done by looking solely at ratios such are described in this paper.

5.2 SUBCOMMITTEE DISCUSSION

The author combined commercial and sport caught length data in the analysis. Due to the possibility of inherent differences in gear selectivity, the author should demonstrate that there are no significant differences between the gear types. Some distinction should be made between the presentation of this working paper as a reasonable scientific method versus accepting the analysis of the data as presented. The Subcommittee has some concerns about the author's conclusions based on the treatment of the available data in this document. A significant number of multiple recaptures of sublegal size fish would overestimate the harvest rate reduction. Therefore the Subcommittee requested that the author present information (data or analysis) to support this effect of this potential bias. The Subcommittee and a reviewer were concerned that the method may overestimate harvest rate reduction if bag limits resulted in an increased harvest rate of legal sized fish.

The Subcommittee acknowledges that there is a certain intuitive appeal to the method developed by the author. The method provides an estimate of the effectiveness of an increased size limit in reducing harvest rates but does not measure the absolute reduction in harvest rate which is the Department's original objective. Rather, the proposed method estimates how

much higher harvest rates would have been if the size limit had not been imposed. It does not confirm a reduction in harvest rate unless all other factors affecting harvest rate have remained unchanged since 1987. Thus, the proposed method is not directly comparable to methods presented in Advisory Document 91-1 which estimates harvest rate and harvest rate reduction directly. It is possible that differing results (the author's proposed method and the methods previously approved by the Subcommittee) indicate that other factors affecting harvest rate have in fact changed since 1987.

5.3 SUBCOMMITTEE RECOMMENDATIONS

1. The Subcommittee recommends that the analytical approach used in this Working Paper be developed further. It should address the issue raised in the Subcommittee Discussion (above). The sensitivity of the method to changes in the parameters of the model require evaluation.

6. Steelhead trout productivity and stream carrying capacity for rivers of the Skeena drainage (Includes Working Papers S92-06,S92-08)

The Skeena River contains a major proportion of British Columbia's summer-run steelhead trout. These fish are a highly-prized sport fish which are intercepted in commercial fisheries targeting mainly on sockeye and pink salmon. To manage steelhead more effectively, estimates of (1) the capacity of the freshwater habitat to produce smolts, as well as (2) stock productivity, expressed as the number of spawners required to sustain each of the Skeena's many individual populations, are required.

Habitat-based models of carrying capacity were examined to determine the potential of the Skeena drainage for the production of adult steelhead. Estimates were based on a) smolt production per **stream area**, b) smolt production per **stream length** and c) a **process model** that considered variation in stream productivity, growing season, and space required to produce a smolt, for smolts of varying ages.

There are several distinct populations of steelhead which inhabit several streams in the Skeena drainage. The streams likely to contain steelhead were identified using stream order (from the MOE stream atlas; 1:50,000 scale maps) and water yield, as criteria. Glacial streams were excluded. Estimation of the total area and total useable area of streams containing steelhead was calculated for the summer low-flow period. Mean annual discharge was used to estimate average stream width, and usable width was derived from habitat suitability curves based on samples of steelhead populations from several stream reaches within B.C. Skeena values for smolt production were estimated by calibrating the physical characteristics against those of the Keogh river, which has served as an intensively studied index system for British Columbia steelhead. Throughout the analysis, a constant smolt-to-adult survival of 14% was used to convert smolt production to adult production.

The Skeena River was estimated to contain 2,062 km of steelhead habitat. At 40 adults$\cdot km^{-1}$ (Keogh standard), 82,500 adults are predicted at capacity for the Skeena system (linear model). Useable area in the Skeena was estimated as 11,400,000 m^2. Based on 0.058 smolts$\cdot m^{-2}$ of usable area at Keogh, Skeena adult production was estimated as 92,500 fish. Estimates based on total area of the Skeena River ($4.6 \cdot 10^7 m^2$) produced an unacceptably high estimate of adult production in excess of 400,000 adults. Using conservative assumptions and discounting a significant amount of mainstem area, an estimated upper limit of approximately 200,000 fish was obtained. The result points to the desirability of using usable area as opposed to total area as a parameter, particularly for large systems. However, Symons (1979) used a total area model for Atlantic salmon, but adjusted for smolt age and survival. Using his estimates for 4+ smolts per m^2 and applying the values to the Skeena resulted in an estimate of 115,000 adults.

Using the more detailed process model, an adult capacity of 80,500 fish was derived for the Skeena (Table 6). The model incorporated the usable area concept, calibrated for the Keogh, with additional adjustments for productivity differences between streams, smolt age and survival, and space required per smolt.

Overall, the models produced estimates of potential production in the range of 80,000 to 200,000 fish, with the most likely value in the range from 80,000 to 120,000 adults. The

value represents what could be expected in an average year under conditions of no exploitation.

Stock productivity refers to the ability of a population to withstand a particular level of harvest on a sustained basis. Alternatively, it may be considered as the number of spawners required in order to achieve a given level of recruitment (i.e., more productive stocks produce more recruits per spawner at an equivalent number of spawners). The Skeena River contains a number of distinct populations of steelhead inhabiting a variety of habitat types. They vary in characteristics such as smolt age and fecundity, which directly influence their productivity. The productivities for individual Skeena stocks were not measured directly. They were estimated from survival patterns reported in the literature and for the Keogh River. These values were used to adjust fry-to-smolt survival for the older smolt ages characteristic of the Skeena tributaries. Overall, each additional year of freshwater rearing was assumed to add a 50% mortality factor.

Maximum Sustainable Yield (MSY) was estimated from stock-recruitment analyses using Beverton-Holt equations (Ricker 1975). A Beverton-Holt stock-recruit curve was fitted to the long term data available for the Keogh. This produced an estimated allowable harvest of 72% at MSY, for a system producing smolts averaging 2.8 years old. The annual juvenile mortality at MSY was 48.8%. The Skeena survival rates were calculated at MSY by adjusting for mean smolt age (additional mortality) and higher fecundities (potentially greater productivity). Mean smolt age for Skeena populations varied from 3.5 to 4.5 years, suggesting a lower productivity relative to the Keogh. On the other hand, the number of eggs per fish was higher in the Skeena for most stocks. Overall, and taking the stock-specific factors into account, Skeena stocks appeared to be able to withstand exploitation rates ranging from 31% to 72% at MSY. With the exploitation rate at MSY established, it was then possible to estimate the number of spawners at MSY, the number of recruits at MSY, and other stock-recruit characteristics (Ricker 1975).

Results of this analysis (Table 7) indicated that some Skeena stocks may be exploited at rates in excess of their MSY requirements in most years. Of particular concern are the Sustut, Kluatantan, and Morice Rivers, and several other minor upper tributaries. Summing the stock-specific requirements indicated a total of 23,000 spawners. However, this cannot be equated with the number of fish which must pass the Tyee test fishery, other than to say that the number past Tyee must exceed 23,000 by a factor which takes into account the native fishery, additional mortality, distribution, and weak-stock requirements.

	AREA	THEOR. USABLE AREA	THEOR. USABLE AREA			TOTAL ALKALIN.	SMOLTS PER (/100m2)	GROWTH season		SMOLT AGE	ADJUST SMOLTS (/100m2)	SMOLT YIELD at Capacity	ADULT PROD'N at CAP
MAINSTEM	(/100m2)	(/100m2)	%	%tribtot		(mg/l)	USABLE	days	eam	yrs	#	#	#
LOWER SKEENA	290938	15802	5.43			30	7.955	137.0		3.5	5.7	90652	12691
MIDDLE SKEENA	233609	16268	6.96			15	5.625	135.0		3.5	4.0	64824	9075
UPPER SKEENA	40337	4179	10.36			15	5.625	100.0	est	4.4	3.0	12355	1730
TRIBUTARIES		tributary total		77692							0.0		
ZYMOETZ	77700	11041	14.21	14.21%		19.2	6.364	113.0		4.0	3.7	41145	5760
LTRIBS	8381	2805	33.47	3.61%		30	7.955	102.0	est	4.3	4.3	11922	1669
KITWANGA	7390	1651	22.34	2.13%		35	8.592	102.0		4.3	4.6	7579	1061
KITSEGUECLA	4918	1308	26.60	1.68%		40	9.185	122.0	est	3.8	5.8	7596	1063
BULKLEY	167219	24870	14.87	32.01%		35.8	8.690	138.0		3.5	6.3	157257	22016
SUSKWA	10589	2113	19.95	2.72%		35.2	8.617	120.0	est	3.9	5.4	11315	1584
MORICE	24311	9255	38.07	11.91%		27.9	7.671	123.0		3.8	4.9	45277	6339
KISPIOX	43224	8542	19.76	10.99%		35.7	8.677	127.0		3.7	5.7	48940	6852
BABINE	48717	6185	12.70	7.96%		35	8.592	145.0		3.3	6.7	41200	5768
UTRIBS	12431	2696	21.69	3.47%		20	6.495	100.0	est	4.4	3.4	9203	1288
SUSTUT	32356	3765	11.64	4.85%		20	6.495	105.0		4.2	3.6	13394	1875
UP SUSTUT	14707	2258	15.35	2.91%		20	6.495	95.0		4.5	3.3	7400	1036
KLUATANTAN	6136	1203	19.61	1.55%		24	7.115	100.0	est	4.4	3.7	4499	630
TOTALS	1022963	113941										574557	80438
Trib totals	458079	77692											

Table 6. Estimated adult production at capacity for Skeena River steelhead.

	GROWTH season	SMOLT AGE	MEAN EGGS/ FISH	FRY TO SMOLT AT MSY	RECRUITS PER FISH AT MSY	HARVEST RATE at MSY	BEVERTON HOLT A	ADULT PROD'N at CAPACITY	SPAWNERS AT MSY	RECRUITS AT MSY
MAINSTEM	days	yrs	(no)	(%)	(no)	(no)	(no)	(no)	(no)	(no)
LOWER SKEENA	137.0	3.5	2615	0.082	3.0	0.668	0.890	12691	3162	9529
MIDDLE SKEENA	135.0	3.5	2615	0.080	2.9	0.658	0.883	9075	2314	6761
UPPER SKEENA	100.0	4.4	2644	0.043	1.6	0.374	0.608	1730	666	1064
TRIBUTARIES										
ZYMOETZ	113.0	4.0	2444	0.055	1.9	0.469	0.718	5760	1997	3763
LTRIBS	102.0	4.3	2444	0.045	1.5	0.348	0.575	1669	658	1011
KITWANGA	102.0	4.3	2615	0.045	1.6	0.391	0.629	1061	402	659
KITSEGUECLA	122.0	3.8	2615	0.064	2.4	0.576	0.821	1063	316	747
BULKLEY	138.0	3.5	2374	0.084	2.8	0.640	0.870	22016	5826	16190
SUSKWA	120.0	3.9	2830	0.062	2.5	0.595	0.836	1584	457	1127
MORICE	123.0	3.8	1868	0.066	1.7	0.417	0.660	6339	2334	4004
KISPIOX	127.0	3.7	2906	0.070	2.9	0.650	0.877	6852	1778	5073
BABINE	145.0	3.3	2762	0.093	3.6	0.722	0.923	5768	1256	4512
UTRIBS	100.0	4.4	2644	0.043	1.6	0.374	0.608	1288	496	792
SUSTUT	105.0	4.2	2853	0.048	1.9	0.473	0.722	1875	647	1228
UP SUSTUT	95.0	4.5	2644	0.039	1.4	0.308	0.522	1036	424	612
KLUATANTAN	100.0	4.4	2644	0.043	1.6	0.374	0.608	630	243	387
TOTALS								80438	22976	57462

Table 7. Estimated MSY harvest rates and productivies of Skeena River steelhead by system.

6.1 REVIEWERS' COMMENTS

Reviewer-1 (External)

The authors used 3 models to estimate steelhead carrying capacity: lineal, areal, and process. The reviewer thought there were too many assumptions for the process model to be acceptable with the authors ignoring the variance added at each step. The reviewer suggested keeping the simpler models and testing them with field data. The use of Keogh River field data to describe the Skeena River was thought to be of little use if it does not adequately describe the Skeena River. The reviewer recommended improving sampling and aging techniques.

The reviewer assessed the productivity model for Skeena steelhead as well. The reviewer noted that standard survival rate calculations might be affected by density. The reviewer also offered a more general comment that it was unclear in the document how the conclusions of the paper would result in management advice.

Reviewer-2 (External)

The reviewer failed to submit reviews by the deadline.

6.2 SUBCOMMITTEE DISCUSSION

Although the working papers were submitted as individual documents, the Subcommittee felt that a more unified approach was advisable. The authors were advised to revise the structure and present the information in a single document. The Subcommittee requested clarification of certain items in the papers. The Subcommittee was concerned that the relationship between smolt age, growth and survival relative to temperature and space requirements need to be better described. This is important in determining whether the productivity information from the Keogh River is transferable to the Skeena. The Subcommittee noted that a simple table showing estimates of carrying capacity of adults from all the models is required for comparison. The Subcommittee noted that information should be provided in the document to show why a sex ratio of 1:1 was used. In addition, it should be emphasized that eggs/spawner rather than eggs/female are used in the computations. The Subcommittee noted that there was no obvious compensatory relationship between freshwater and marine survival. Additional mortality experienced by older smolts would not be compensated by increased marine survival.

The Subcommittee considered that there may be opportunities to provide more effective expenditure of resources through cooperative MOELP/DFO field programs where information on both coho and steelhead is required.

6.3 SUBCOMMITTEE RECOMMENDATIONS

The Salmon Subcommittee reviewed working papers on habitat and productivity models for steelhead in the Skeena River system.

1. The Subcommittee recommends a habitat-based model indicating a minimum carrying capacity at replacement with no exploitation of 80,000 adult steelhead in the Skeena River watershed. Various models provide estimates between 80,000-200,000 adults.

2. Research programs to test assumptions of the habitat-based model in the Skeena River are required. Focus of the research should include obtaining estimates of adult escapement, smolt numbers, as well as surveys designed to collect juvenile habitat information.

3. The Subcommittee recommends the following spawning levels for substocks of Skeena River steelhead:

Mainstem:	
Lower Skeena	3160
Middle Skeena	2310
Upper Skeena	670
Tributaries:	
Zymoetz	2000
Lower tributaries	660
Kitwanga	400
Kitseguecla	320
Bulkley	5830
Suskwa	460
Morice	2330
Kispiox	1780
Babine	1260
Upper tributaries	500
Sustut	650
Upper Sustut	420
Kluatantan	240

These are the best available estimates of required spawning levels based on estimated exploitation rates at MSY for substocks of Skeena River steelhead that range from 31 to 72%. Future target escapements may change as additional analyses or data become available.

4. The Subcommittee recommended previously (Advisory Document 91-6) that a model to develop fishery management options for fisheries on mixed populations of steelhead with differing productivities be developed. This recommendation is repeated with an

additional request that the document should consider the development of an assessment strategy to determine whether proposed management objectives have been achieved.

DEFERRED OR REJECTED WORKING PAPERS

1. **Smith Inlet sockeye stock status update and revision of escapement goal (Working Paper S92-04)**

This working paper did not meet the expectations of the Subcommittee and was not accepted.

RECOMMENDATION

1. The Subcommittee recommended that a comprehensive stock assessment of Smith and Rivers Inlet sockeye be undertaken.

2. **Run timing in relation to the minimum required escapement estimates for steelhead stocks in the Skeena River (Working Paper S92-07)**

Working paper withdrawn by the authors and is expected to be resubmitted in the fall 1992.

RECOMMENDATIONS

1. The Subcommittee restated a previous recommendation (Advisory Document 91-6) that fishery management options for fisheries on mixed populations of steelhead with differing productivities be developed.

2. The Subcommittee requests that the proposed Working Paper (1-above) should consider the development of an assessment strategy to determine whether the management objectives have been achieved.

3. **An overview of methods used in forecasting stock abundance and adult migration behaviour in some stocks of southern pink, chum, and sockeye salmon. (Working Papers S92-10)**

In these annual or near-annual forecasts, simple and routinely available indices of oceanographic, climatic and biological data are applied in linear regression equations to predict stock abundance, return timing and migration routes of some important stocks of southern pink, chum and sockeye salmon. The relationships between the variables are largely based on published hypotheses or models, or on broadly observed generalities. Plots of the variables show very few cases of apparent non-linear interaction. The great majority of the

forecasts are made 'pre-season'; often in a series which may extend to the start of the major fisheries on a particular stock, as more, and more specific, data become available. Forecasts are given to science branch colleagues, SEP biologists, and fishery managers; and with the permission of the latter, to the Pacific Salmon Commission (PSC).

SUBCOMMITTEE DISCUSSION

This document was not received in sufficient time for review. A more complete document is expected from the author at the fall 1992 meeting. The Subcommittee appreciated the opportunity to review the overview of the methods used by the author in forecasting pink, chum, and sockeye salmon abundance and migration behaviour.

SUBCOMMITTEE RECOMMENDATIONS

1. The Subcommittee recommends that rather than providing detailed methods and descriptions of all stocks for which predictions are made, that the author select good examples of the general classes of predictions (eg. migration behaviour, timing, or abundance), choose appropriate stocks, and provide detailed models, data, performance and diagnostic information to support the methods.

2. The Subcommittee recommends that the author consider including a co-author with strong quantitative skills to assist with the analyses and submit a PSARC working paper on these topics for the fall 1992 Salmon Subcommittee meeting.

LITERATURE CITED

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 191:382p.

Symons, P. E. K. 1979. Estimated escapement of Atlantic salmon (Salmo salar) for maximum smolt production in rivers of different productivity. J. Fish. Res. Board Can. 36:132-140.

APPENDIX 1

List of participants at the Salmon Subcommittee Meetings. April 21-24, 1992 and May 7, 1992.

Members:

1. Don Anderson, SCD
2. Gordon Berezay - PP&E
3. Al Cass, BSB
4. Peter Delaney, Hab. Mgmt. (absent Apr. 23)
5. Robin Harrison, FR&YD
6. Mike Henderson, BSB (absent Apr. 22)
7. Jim Irvine, BSB
8. Ron Kadowaki, BSB (absent Apr.23pm and Apr.24)
9. Skip M^{c}Kinnell, BSB, Chairman
10. Dave Meerburg, FRB - Ottawa
11. Dave Peacock, NCD (absent Apr.22am,May 7)
12. Ted Perry - REB
13. Brian Riddell, BSB (Unable to attend Apr. 21-24)
14. Art Tautz (Steelhead) Prov. of B.C. - Apr. 21 only
15. Chris Wood, BSB

Authors:

1. T. Gjernes
2. Province of British Columbia, Anonymous
3. R. Kadowaki, T. Pendray, and L. Janz
4. M. Joyce, A. Cass
5. R. Goruk, K. Hyatt (both absent)
6. D. Blackbourn (absent)
7. B. Riddell, T. Perry, and L. Lapi

APPENDIX 2

LIST OF SUBMITTED WORKING PAPERS
SALMON SUBCOMMITTEE, APRIL 21-24, MAY 7, 1992

STOCK ASSESSMENTS

1. Assessment of Fraser River chum salmon. M. Joyce and A. Cass (Working Paper S92-02)

2. Stock assessment of early run Skeena River coho salmon (through the 1991 return year). R. Kadowaki, T. Pendray and L. Janz (Working Paper S92-03)

3. 1991 evaluation of the conservation program for chinook salmon in the southern Strait of Georgia, excluding Fraser River stocks. B. Riddell, T. Perry and L. Lapi (Working Paper S92-05)

4. Run timing in relation to the minimum required escapement estimates for steelhead stocks in the Skeena River. Anonymous. (Working Paper S92-07)

5. Smith Inlet sockeye stock status update and revision of escapement goal. R. Goruk and K. Hyatt (Working Paper S92-04)

METHODOLOGIES

4. A method for evaluating the 62cm size limit for chinook salmon in the Georgia Strait recreational fishery. T. Gjernes (Working Paper S92-01)

5. Steelhead trout productivity and stream carrying capacity for rivers of the Skeena drainage. Anonymous. (Incorporates A habitat-based model of steelhead carrying capacity for the Skeena River (Working Paper S92-06) and A productivity model for steelhead stocks and its application to the Skeena River (Working Paper S92-08)

6. An overview of methods used in forecasting stock abundance and adult migration behaviour in some stocks of southern pink, chum, and sockeye salmon. D. Blackbourn (Working Paper S92-10)

FIGURES

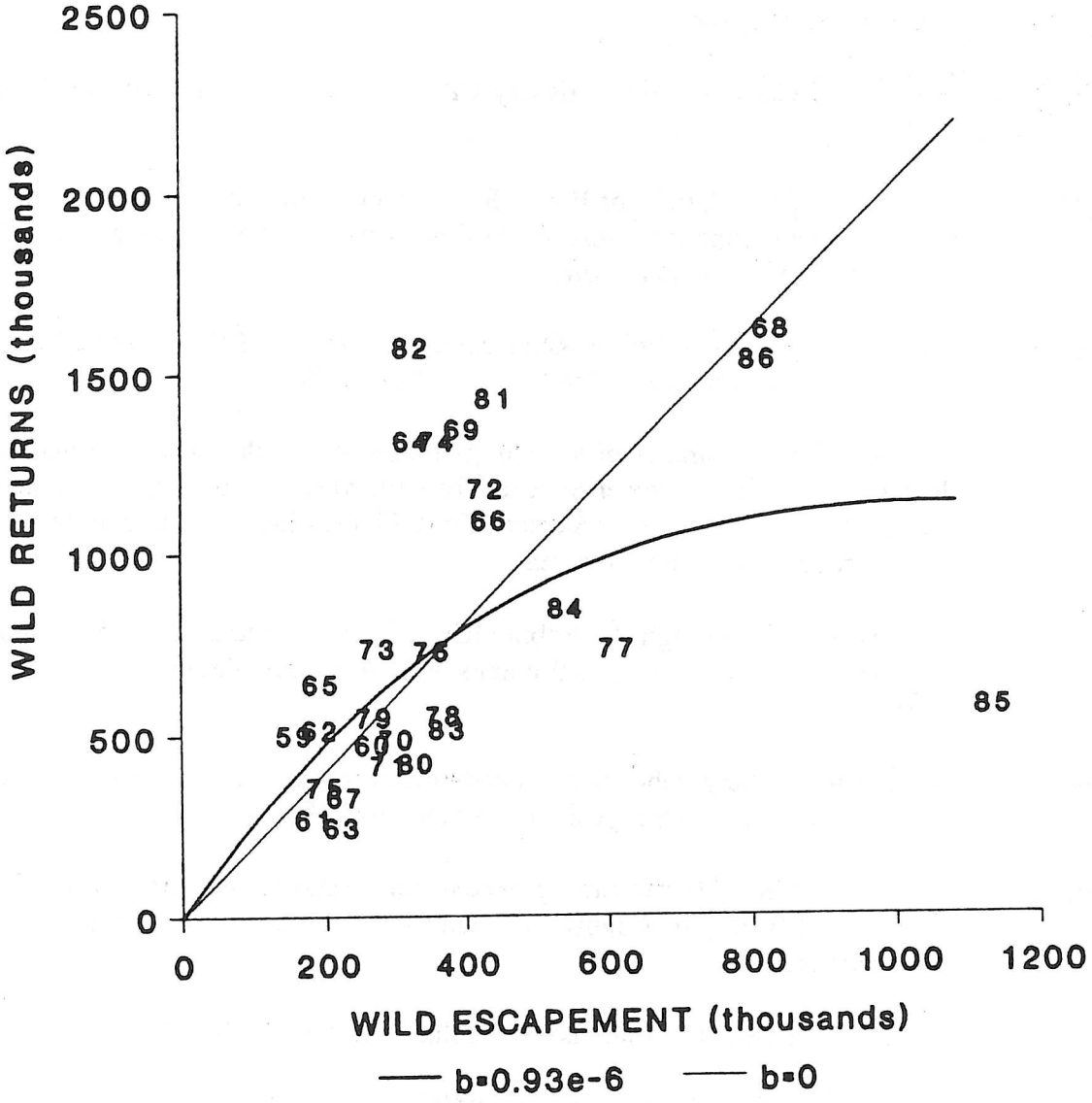


Figure 1. Relationship between spawning escapement and returns for wild Fraser River chum salmon showing Ricker recruitment curve for parameter b>0 and b=0 for brood years 1959-86.

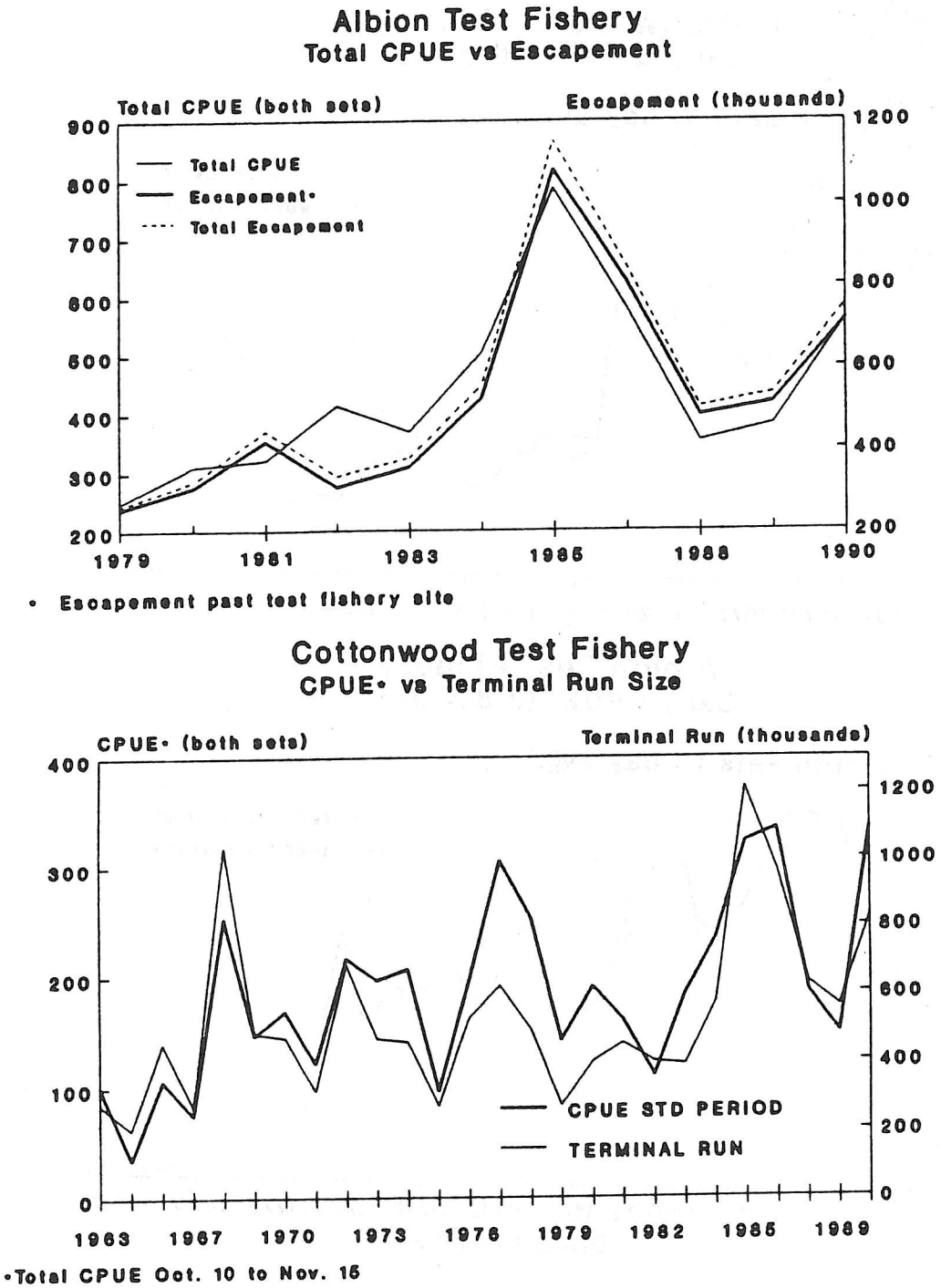


Figure 2. Albion and Cottonwood test fishery CPUE and escapement estimates for Fraser River chum.

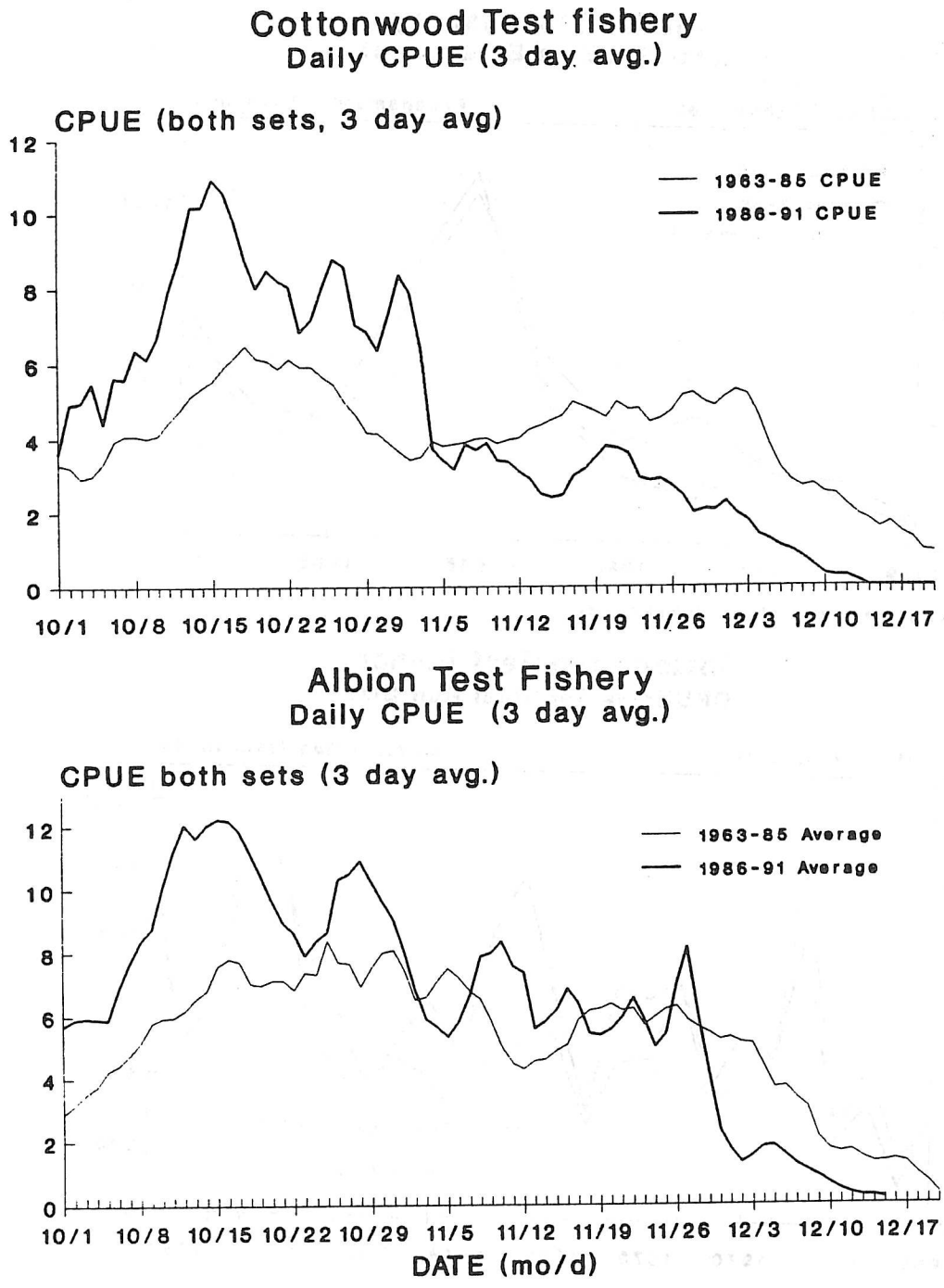


Figure 3. Average seasonal CPUE of Fraser River chum in the Cottonwood and Albion test fisheries comparing average run timing prior to enhancement (1963-85) with timing after enhancement.

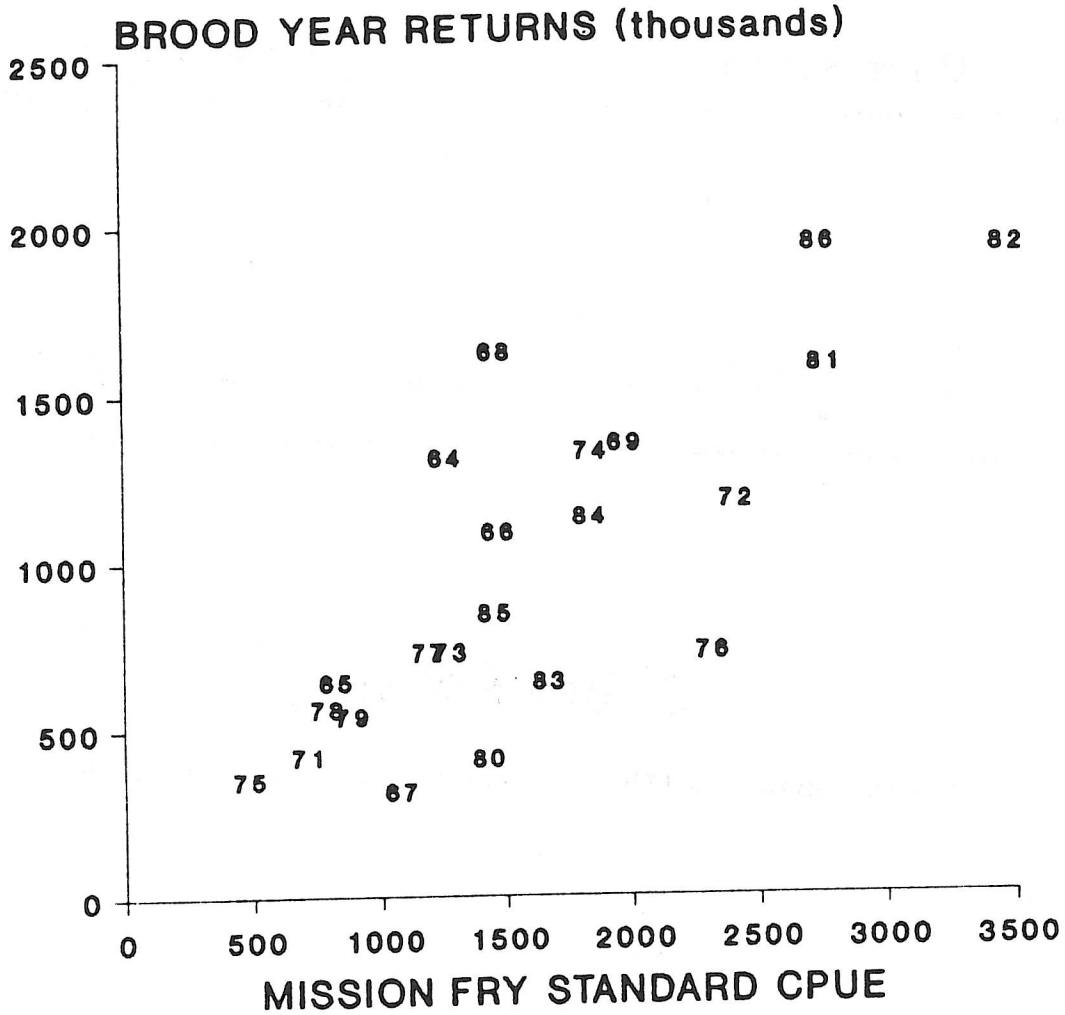
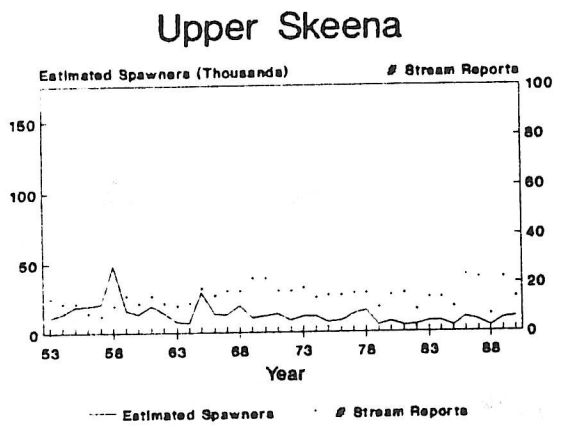
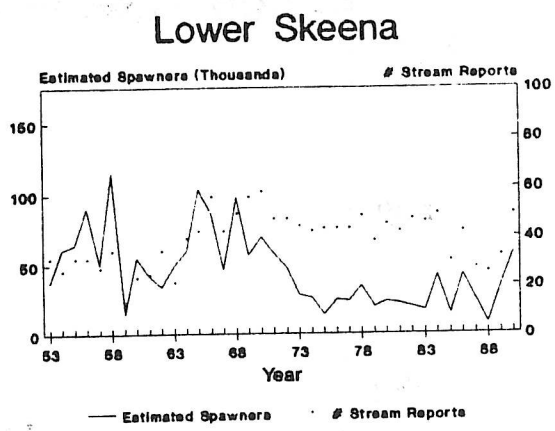


Figure 4. Relationship between Fraser River chum salmon fry CPUE measured at Mission and brood year returns for brood years 1964-86.





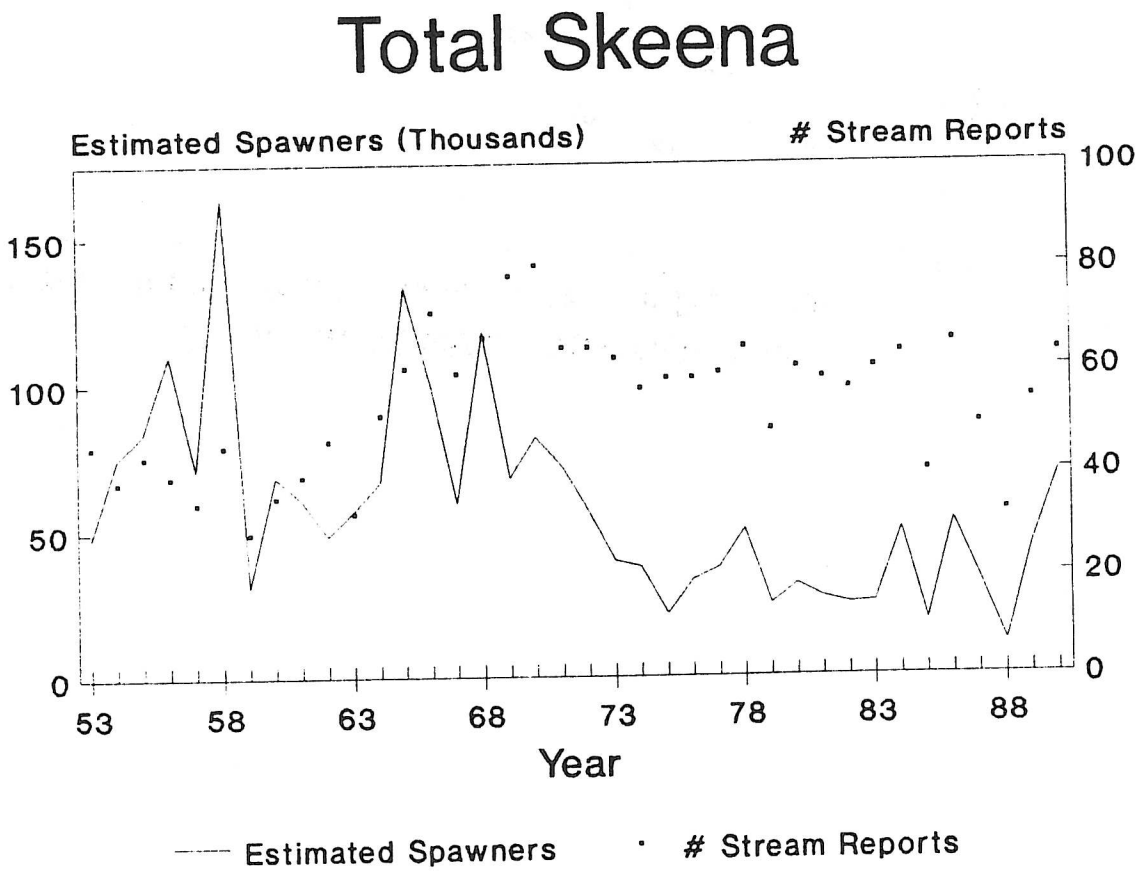


Figure 5. Fishery officer estimates of spawning escapement to the upper Skeena (Kispiox River and upstream), lower Skeena River (downstream of Kispiox River to the Ecstall River) and the total Skeena River. Figures include numbers of stream survey reports for coho each year.

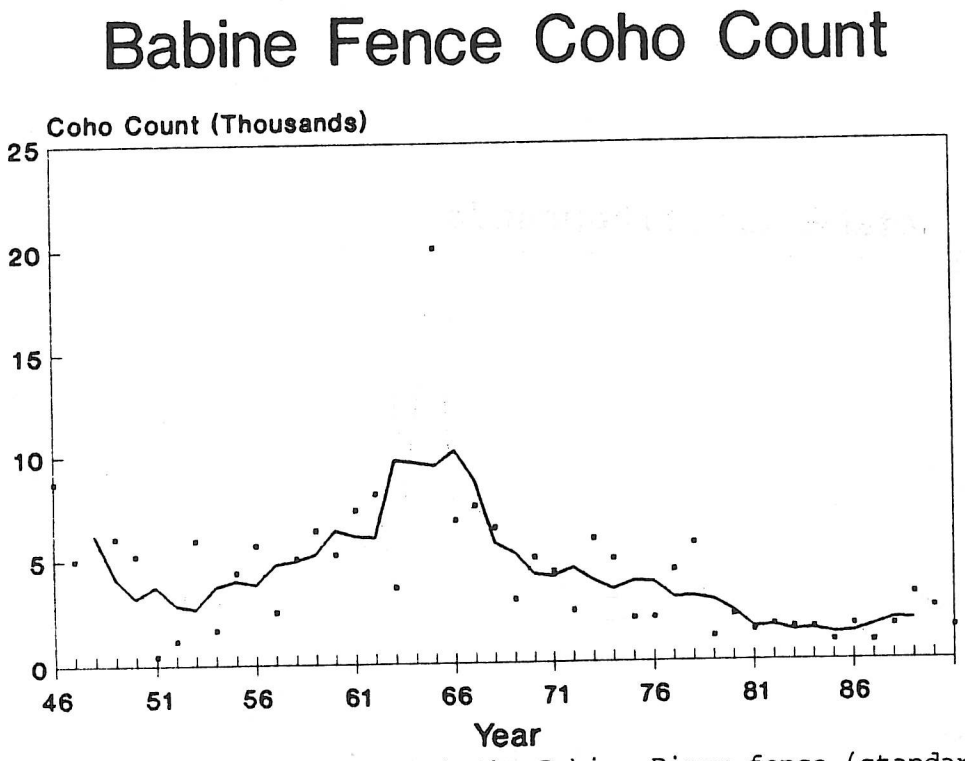


Figure 6. Counts of coho through the Babine River fence (standardized to September 13th end date) showing annual counts and the 5-year running average, 1946-1991.

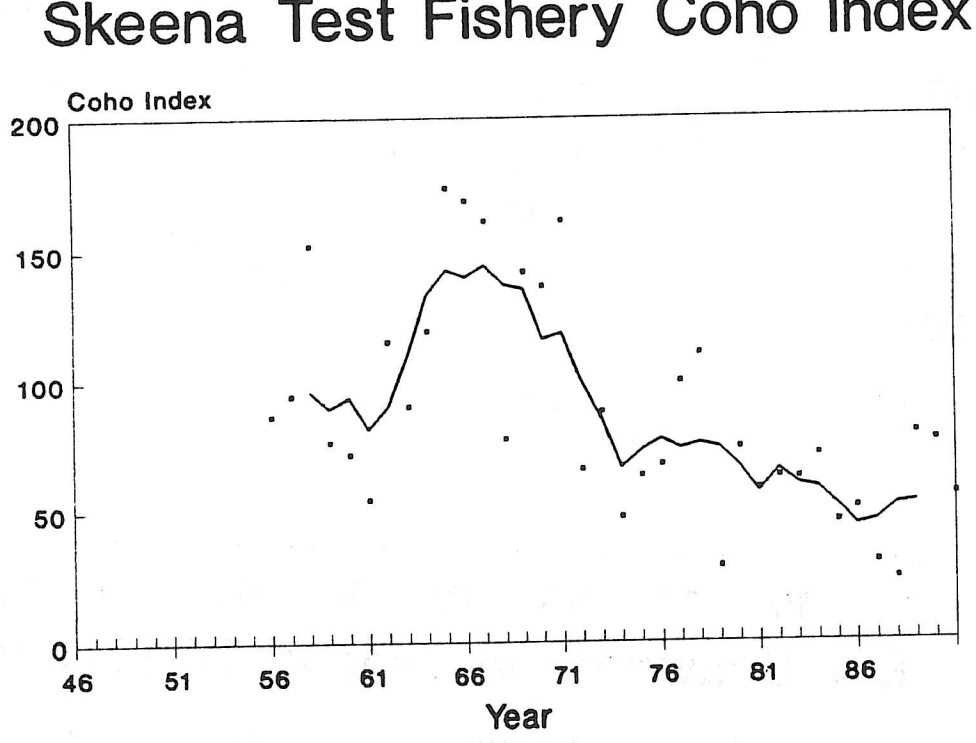


Figure 7. Skeena test fishery coho index (standardized to August 24th end date), showing annual indices and the 5-year running average, 1956 to 1991.

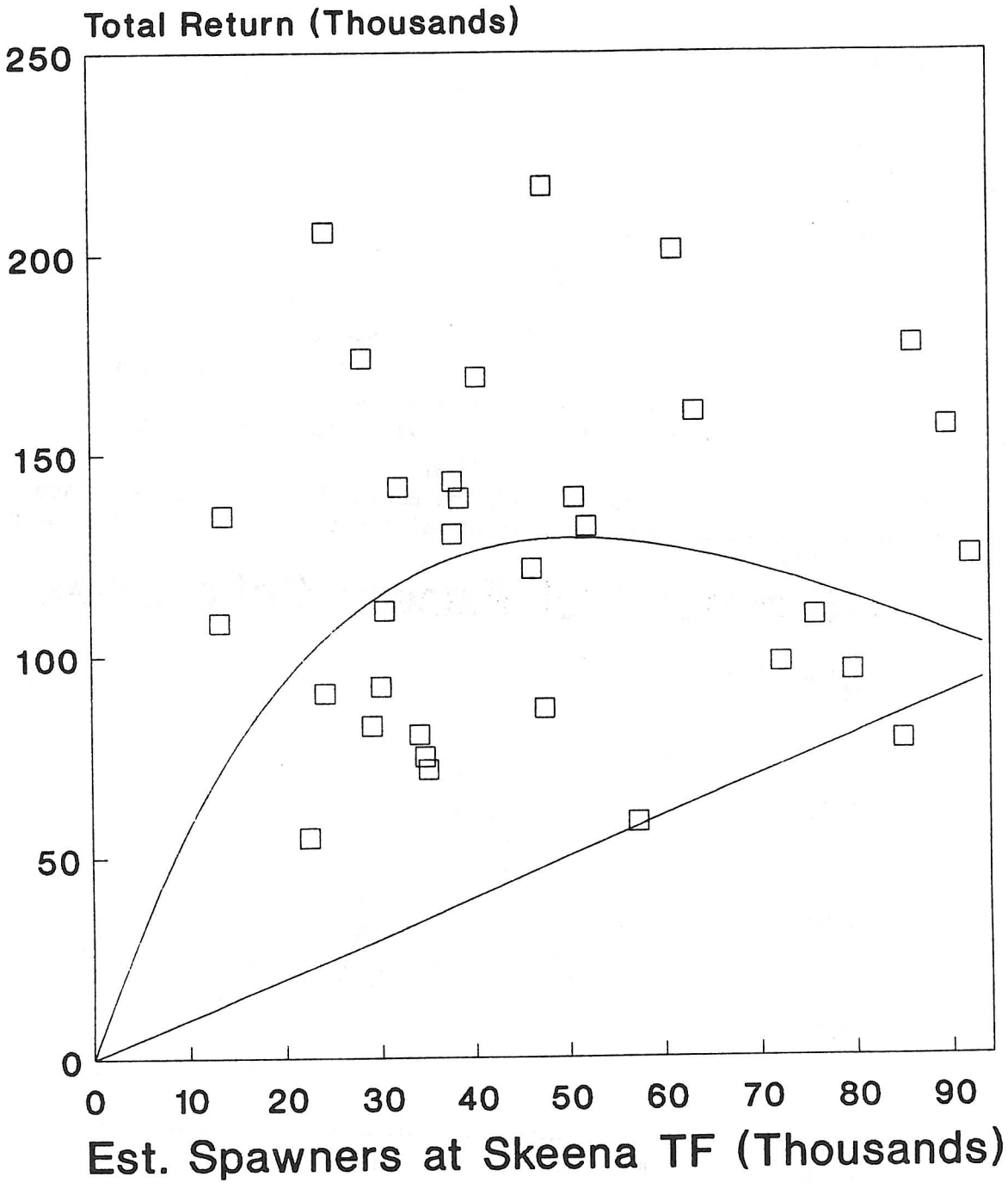


Figure 8. Total return of early run timing Skeena coho versus spawners estimated at the Skeena test fishery to August 24th, with RICKER curve and replacement line superimposed.

Figure 9. Harvest rate trends in four fisheries relative to the 1979-82 base.

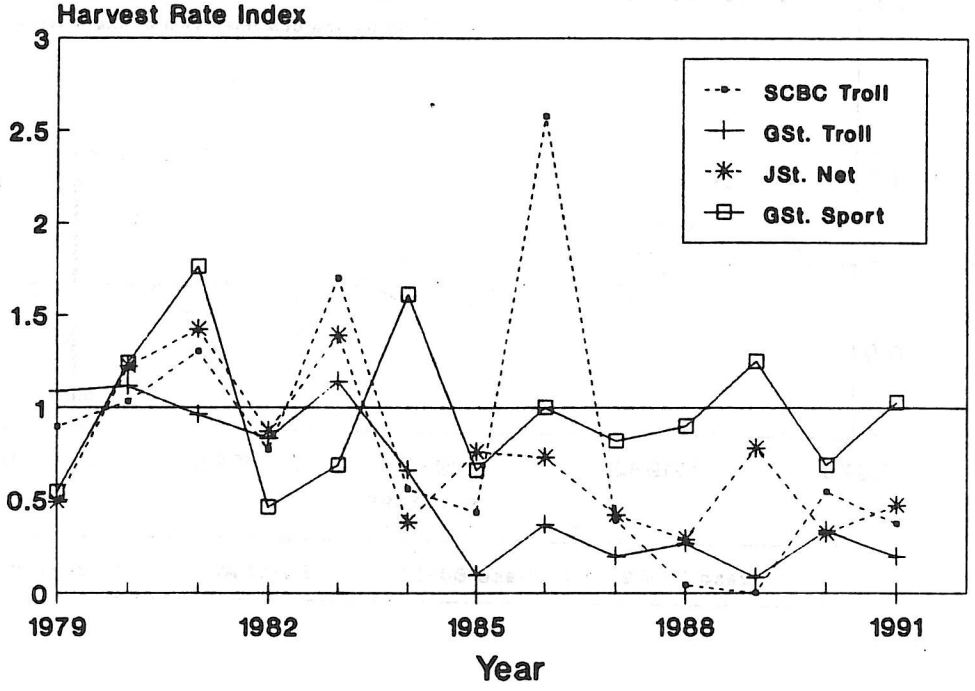
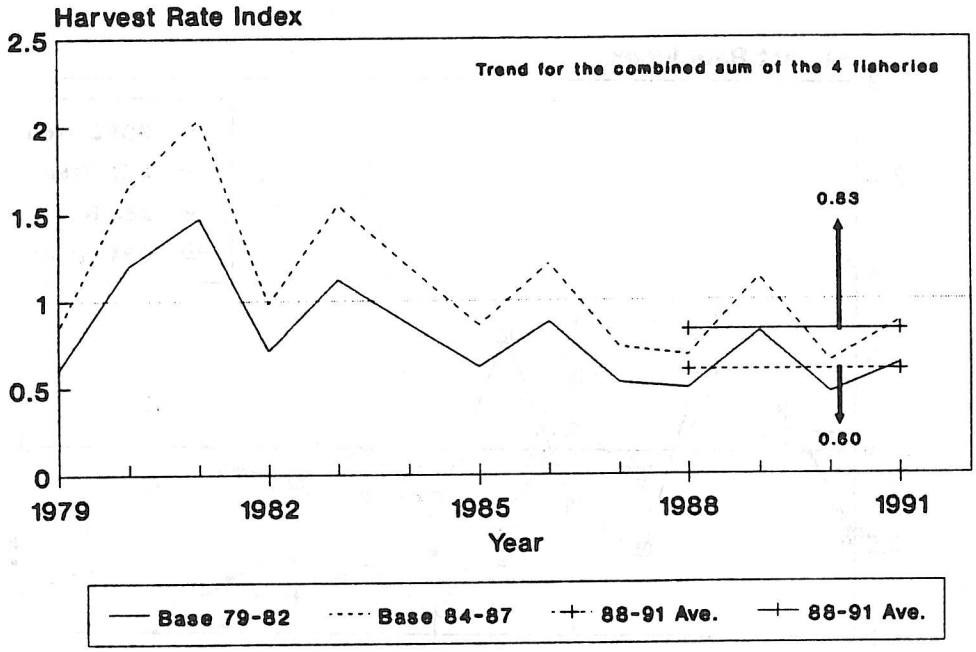


Figure 10. Harvest rate reductions
comparing 1979-82 and 1984-87 base periods.



PACIFIC STOCK ASSESSMENT REVIEW COMMITTEE

PSARC ADVISORY DOCUMENT 92-2
SEPTEMBER 1992

GROUNDFISH

CONTENTS PAGE

I. STEERING COMMITTEE REPORT

The PSARC Steering Committee met September 29, at the Coast Bastion Inn, Nanaimo to review the Subcommittee report. The Steering Committee supports the recommendations of the Subcommittee and wishes to highlight the following.

The Steering Committee appreciates the efforts of the regional working group on rockfish management reform and the Groundfish Subcommittee, for their work on assemblage management. The proposal for assemblage management developed by the regional working group has not evolved to the stage that details of potential management responses to shifts in expected species landings by area or time have been developed. These responses must be developed and evaluated before the need to invoke them arises.

The Steering Committee felt that assemblage management for rockfishes would be practical, provided the total yield recommendation for the assessed species did not exceed the sum of the parts, and was less than that if there were no mechanisms in place to distribute effort among species and areas. Safeguards must be built in such as time and area closures, gear restrictions, etc. The program must be accompanied by dockside monitoring. Because of concerns of potential dumping and waste there should also be adequate monitoring at sea.

In addition, the Steering Committee recommends the following:

(i) A paper should be prepared for PSARC in which data are reanalysed, and supplemented where feasible, to provide the best estimate of marine mammal predation on lingcod, and to evaluate the impacts of marine mammals on lingcod.

(ii) Fisheries Branch and Science Branch should investigate the effectiveness of alternative strategies for conserving inshore rockfish such as reserve areas. A workshop may be appropriate.

(iii) Steering Committee recommends that a working group be established to review previous work on biological objectives, propose biological objectives for groundfish, herring, and invertebrates in the Pacific Region, and recommend a framework for developing non-biological objectives. Membership of the working group should be chosen from within the Salmon, Groundfish, Herring, and Invertebrate Subcommittees. The working group should complete a draft report by February 1993. This report should then be discussed by the respective Subcommittees prior to review by the Steering Committee.

II. GROUNDFISH SUBCOMMITTEE REPORT

BIOLOGICAL ADVICE ON MANAGEMENT OF BRITISH COLUMBIA GROUNDFISH FOR 1993

This document contains synopses of stock conditions and management recommendations for the major groundfish stocks off British Columbia. It also contains summaries of reviews of these assessments by the PSARC Groundfish Subcommittee. The report is based on more extensive working papers prepared by the staff of the Marine Fish Division of the Biological Sciences Branch, located at the Pacific Biological Station, Nanaimo, B.C.

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 in intervening years. Intervening year assessments will also provide information on any significant changes in stocks, particularly those that may dictate more frequent assessment revisions. Recommended yield options will normally remain unchanged between major assessments. This initiative arose out of recognition of the time scale of the underlying population dynamics of most groundfish species. These species are long-lived and have extended recruitment phases, such that annual recruitment is a small proportion of the exploitable biomass. This means that the stock biomass supporting the fishery will normally change very little among years. Some shorter-lived groundfish species (e.g. Pacific cod) may

require more frequent assessment updates. It is anticipated that this schedule will permit greater depth of investigation during major assessment years, and also provide more opportunity for economic planning by the groundfish industry. The Subcommittee reviewed the format for these interim assessments in 1992 and recommends, in accord with the definitions contained in the revised Steering Committee terms of reference, that in future they be presented as Fishery Updates, rather than Working Papers.

Marine Fish Division biologists begin their assessments in the spring of the year using a multi-year data base of fishery statistics and biological sampling. A variety of assessment models are used including several catch-at-age, age-independent surplus production, yield-per-recruit, and other linear models. Stock assessments are assigned to reviewers by the Subcommittee chairperson, 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 investigator. Assessments and recommended yield options are then reviewed by the Subcommittee as a whole, which includes representatives from Fisheries Branch management staff. The Subcommittee, following instructions from the Steering Committee, must reach a consensus on any recommendations presented in assessments before submission to the PSARC Steering Committee.

1992 WORKING PAPER TOPICS AND AUTHORS

Juvenile surveys - M. W. Saunders and R. D. Stanley
Inshore lingcod - D. J. Murie, L. J. Richards and K. L. Yamanaka
Offshore lingcod - G. A. McFarlane and B. M. Leaman
Pacific cod - M. Stocker and C. M. Hand
Flatfish - J. Fargo
Sablefish - M. W. Saunders and G. A. McFarlane
Pacific hake - M. W. Saunders
Spiny Dogfish - B. L. Thomson
Walleye pollock - M. W. Saunders
Slope rockfish - L. J. Richards
Shelf rockfish - R. D. Stanley
Inshore rockfish - K. L. Yamanaka and L. J. Richards
Pacific hagfish - R. J. Beamish and C. M. Neville
Pacific halibut - B. M. Leaman

PSARC Groundfish Subcommittee overviews on current condition of groundfish species or species groups off the west coast of Canada.

Species or species group	Current stock condition
Strait of Georgia lingcod	Low
Offshore lingcod	Average
Pacific cod	Low to average*
Petrale sole	Low
Rock sole, English sole, and Dover sole	Average to high*
Sablefish	Average
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*
Hagfish	Unknown
Pacific halibut	Average

* depending on specific stock.

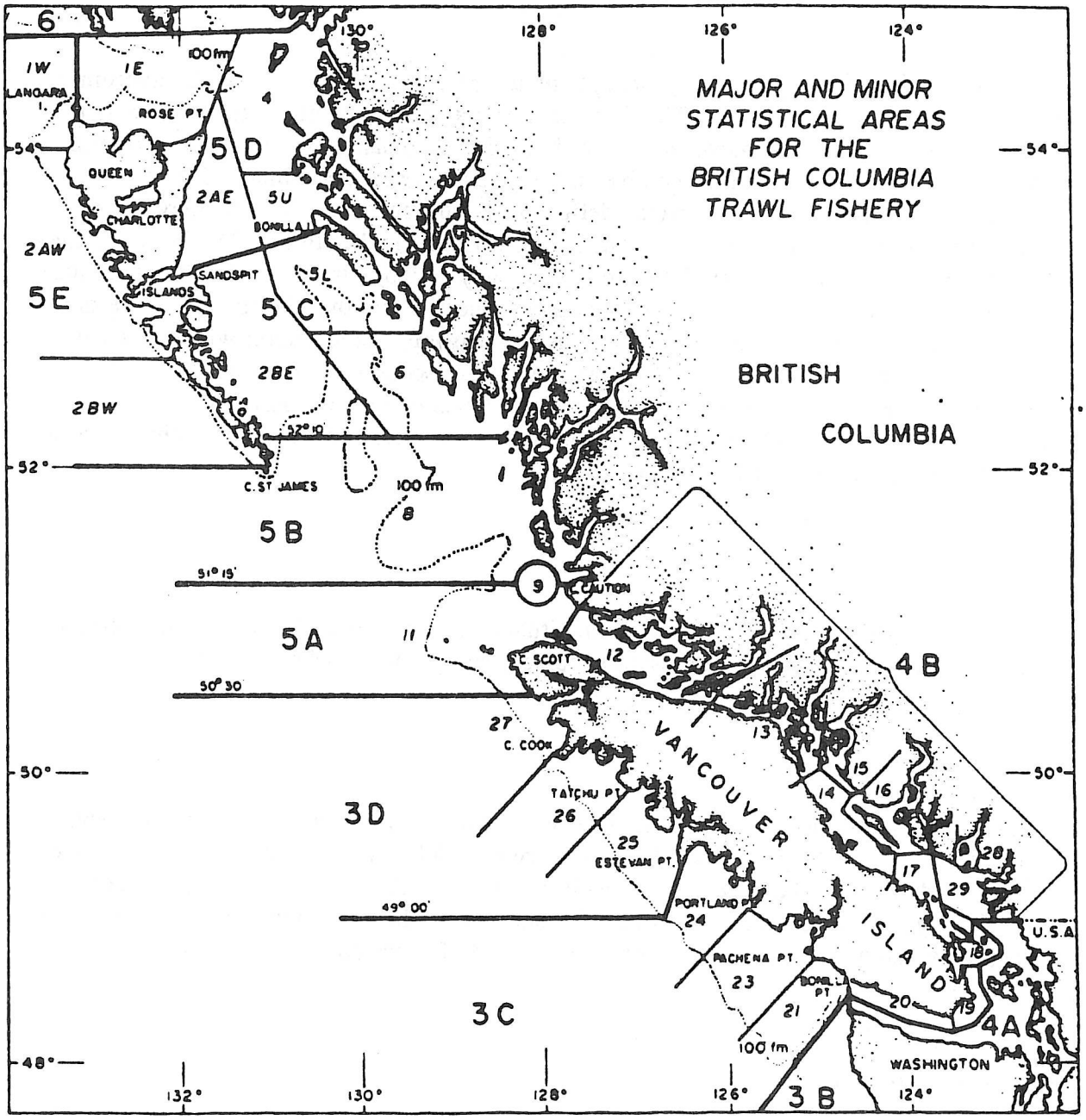


Figure 1. Major and minor statistical areas for groundfish fisheries on the west coast of Canada.

YIELD OPTIONS

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 sustainable yield; (iii) sustainable yield; (iv) high risk sustainable yield; (v) unrestricted yield. These levels of risk are subjective 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. The basis for these categories was presented first by Leaman and Stanley (1985). In 1992, the Subcommittee reviewed the definitions of these categories and requested that they be revised. The draft revisions are summarized here. If there is insufficient information upon which to base an assessment of stock condition, investigators may not propose yield options. In general, yield options are proposed to achieve appropriate levels of fishing mortality. It is these levels of fishing mortality that are the actual targets for stock management, rather than how they may be expressed as catch quotas.

(i) Zero yield

This option would be entertained in situations of known and severe stock depletion, or where particular areas may represent necessary refugia for stocks.

(ii) Low risk sustainable yield

Under this option the probability of overfishing is minimized. With the exception of option (i), this option will incur the lowest risk of deleterious fishing effects on stock biomass or dynamics. However, some yield from the stock may be lost to the fishery under this option. In general, this level of yield will be the sustainable level if pessimistic assumptions about stock dynamic parameters and the factors controlling recruitment are true.

(iii) Sustainable yield

This option suggests the opportunity to maintain stocks at existing levels. The term 'sustainable' should be understood in its broad sense, i.e., that the stock will undergo natural increases and decreases around the expected level as a result of variation in recruitment, rather than be maintained at a fixed level. The magnitude of this variation will change considerably among and within stocks at different levels of biomass. In

general, this level of yield contemplates average values of stock dynamic parameters and recruitment.

(iv) High risk sustainable yield

This level of yield will be sustainable if optimistic assumptions about stock dynamic parameters and the factors controlling recruitment are true. For example, if future recruitment is assumed to be consistently above average, then this yield level is estimated to be sustainable. It is considered to be high risk because recruitment of groundfish stocks is known to vary, often widely, and a consistently high level of recruitment is uncommon.

(v) Unrestricted yield

A very limited number of situations would call for consideration of this option. Depletion of stocks and elimination of fisheries when harvests are uncontrolled are well documented throughout the world. However, this option might be considered for experimental purposes. It should only be employed after thorough review of potential consequences. Employment of this option implies either experimental or non-biological management, because stock declines are highly probable with this option in effect over a significant proportion of the average life of a population cohort.

Concomitant to the use of this option is the requirement that management will have to shift to a more restrictive option prior to major and irreversible changes in the target stock. The residence time of a cohort in the exploited stock and the age at recruitment to the fishery will be key determinants in the detection and response times for the effects of the option. Where residence is long or recruitment occurs at older ages, yields may be maintained over several years in spite of strongly deleterious, yet undetected, effects on stock productivity. Whenever fishing mortality is high, relative to estimated sustainable levels, careful monitoring is essential if deleterious effects are to be detected and avoided.

Risk assessment

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 them. For stock assessments, biologists are attempting to estimate the probabilities concerning stock conditions, rather than the broader consequences to the fishery. This process also involves 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. However, both these and other work

indicates that the risk to stock productivity is not uniform across yield options. Rather, there is a sharply increasing probability of deleterious effects as fishing mortality increases, and the potential changes in stock dynamics are much greater with high risk yield options than with low risk options. This non-linear risk trajectory should be considered in the choice of yield options.

MAJOR SUBCOMMITTEE CONCERNS

With the adoption of coastwide trip limits for most rockfishes, the groundfish fleet does not apply fishing effort on individual stocks in a manner commensurate with their productivity. Instead, vessels have fished at the closest point offering acceptable catch rates (Leaman 1988). Some stocks are therefore experiencing unsustainably high exploitation rates. In addition, the rapid subscription of quarterly quotas often means that fishing trips are subject to low trip limits for some species for much of a quarter. The incidental catch of some low-limit species while fishing for species with higher limits creates problems of discarding, wastage, and potential misreporting of catch by area or species. The regional initiative on re-structuring rockfish management arises directly from these concerns.

For inshore areas, rockfish species (quillback, copper, yelloweye rockfish) are being taken in some locations of the Queen Charlotte Strait, Johnstone Strait, and Strait of Georgia at rates greater than can be supported by natural production. Strait of Georgia lingcod have also been over-exploited. There is evidence that the initial depletion of lingcod was due to the commercial fishery. That fishery is now closed and the sports fishery, which accounts for all fishery removals, is also under restriction. However, the Subcommittee noted that there was no effective means of assessing compliance with the voluntary 10-fish annual recreational lingcod catch limit. The Subcommittee has also expressed concern in past reports that predation by marine mammals may produce mortality sufficiently large to interfere with attempts to rehabilitate this stock.

The Subcommittee's understanding of the status of the Pacific cod stock in Hecate Strait is highly uncertain. We do not believe this stock is presently in great danger but are unable, on the basis of presently available information, to estimate available yield with precision. The recommended yield options span a range of 3200-6500 t. Additional guidance on an appropriate level within this range will depend on the strength of incoming recruitment. This recruitment will be censused by biological sampling early in 1993. That information will be used to provide managers with a more precise set of yield recommendations. Until then, managers are urged to exercise caution in assigning harvest levels from this stock.

Several assessments noted that changing fishery regulations (trip limits) and frameworks (IQ systems) erode the value of traditional indices of abundance, such as

CPUE. This trend suggests that assessment biologists and managers should consider designing management strategies which both achieve stock objectives and preserve the value of fishery-based indices of abundance, wherever possible. Biologists may also have to develop new and fishery-independent indices of stock abundance. The following Section contains a summary of Subcommittee discussions on the potential uses of juvenile surveys to index groundfish recruitment.

ADDITIONAL SUBCOMMITTEE DISCUSSIONS

1. Assemblage management of rockfishes

The Subcommittee was asked by the PSARC Chairperson to consider aspects of a proposal on assemblage management, posed on behalf of the regional working group on rockfish management reform.

Background

Increasing fishing effort for the complex of rockfish species by the B.C. trawl fishery has resulted in a suite of progressively smaller trip limits and shorter fishing periods over the past several years. Major differences in area and species-specific available yield levels, in combination with trip limits applied on a coastwide basis, have created significant problems of quota overruns and yield optimization for groundfish management. In addition, this management framework creates economic inefficiency for the trawl fleet, variable supply problems for processors, a high potential for wastage of the resource through discarding, as well as misreporting of species and area catches by the fleet. A regional working group was struck to formulate alternative management approaches which might alleviate some or all of these symptoms. The primary objectives of the group were to devise an approach to management which would: (i) produce a simpler management plan; (ii) improve compliance with the management plan; and (iii) promote stewardship of the resource.

The working group considered this problem and reached a consensus that these objectives could be best met if all rockfish species within a delineated area were managed as a single assemblage. In conjunction, numerous measures to validate catch statistics, ensure monitoring of landings, allow flexibility in trip limits, provide incentives to distribute fishing effort, prohibit discarding, diminish economic differentials among species, and provide at-sea monitoring were key provisions of the plan. Members of the working group at the Subcommittee meeting elaborated further that the measures proposed were viewed as the most likely to advance all of the three objectives. The Subcommittee was asked to provide advice on a series of questions which address the biological aspects of this proposal.

The Subcommittee held an extensive discussion on these questions. A consensus of the Subcommittee was that significant problems associated with the present management framework were eroding the quality of the data being used for stock assessment and compromising the achievement of conservation objectives. It is clear that changes to the management program are required. It was also noted that the decreasing trip limits and shorter seasons were symptomatic of the underlying problem that the fleet catching capacity is well in excess of available yield. Vessels now operate at lower trip landings than in past years, because of trip limitations. The Subcommittee was pleased to note that Program, Planning and Economics Branch staff are conducting an economic evaluation of the fishery. A second consensus of the Subcommittee was that any new management programs should, on average, perform at least as well as the present program in terms of achieving management goals.

A large part of the discussion dealt with clarifying the specifics of the assemblage management proposal. This discussion identified that the management of an area as an undifferentiated assemblage of rockfishes was not the intent of the proposals, at least at the initial stage. Working group members stated that yield targets for individual species were included in the proposal, i.e., that the species composition of the assemblage was a management concern, but it would not be enforced at the level of an individual vessel landing. In addition, the fact that differences in area-specific productivity would need to be considered, was also identified. The initial proposal could therefore be described as an aggregate quota management program. The key element is that there would be a relaxation of restrictions on species landing limits, at the level of individual vessel trips. This element could avoid the incentives to misreport and discard. Overall species and area targets would be addressed at the level of annual or quarterly monitoring and adjustment. The landings from stocks would be regularly contrasted and evaluated with yields estimated to have been attained using single-species approaches. The Department must have the ability to react quickly if serious problems of overharvesting are identified by the catch monitoring. Fishermen would be provided with the opportunity, and responsibility, of achieving these limits over a broader time horizon than specified in the existing management program. A major positive aspect of this approach is that the quality of data obtained would likely be higher and more reflective of actual catches than present landings data, which ignore a potentially large amount of discarding.

The working group members also believe that the proposal will protect against simultaneous overharvesting of all commercially desirable stocks, by providing an upper limit total harvest and discouraging dumping. In terms of the three objectives, the majority view of the Subcommittee was that the proposal, as presented, would probably produce a management plan of similar complexity to the existing one. It is likely that it will also result in better compliance, initially, but will not necessarily avoid rapid subscription of quotas because there is still catching capacity in excess of available yield, and vessels will be restricted in their harvest potential. Many members of the Subcommittee felt that an initiative to reduce fleet capacity was fundamental to any long term improvements in stewardship of species being exploited presently.

The Subcommittee noted that the proposal was not developed to the stage that details of potential management responses to shifts in the expected species landings by area or time had been developed. The Subcommittee expressed its concern that these responses should be developed and evaluated before the need to invoke them arises.

A synopsis of discussion on the questions posed to PSARC by the regional working group follows.

(i) Are there compelling biological reasons to reject the approach of managing all rockfishes in an area as one assemblage? If so, what is the biologically preferred alternative?

The Subcommittee consensus was that the inherent differences in productivities among rockfish species present compelling biological reasons to manage them on an individual basis, if a management objective is to try to obtain the most yield from each species. It believes that, while some shifts in species' proportions in an area will occur naturally, management without respect to species composition would result in overexploitation of many species, so that productivity would probably be reduced to some average level. It would not be possible to rehabilitate overexploited stocks, or to harvest commensurate with available yield with such an approach. Shifts in the proportional species composition of an area would also be an inevitable consequence. Such shifts could result from differences in species availability and/or from targeting behaviour by fishers. The Subcommittee was particularly concerned that the latter should be deterred, because the long-term consequences from the shifts associated with targeting would likely be much more severe than those arising from availability differences. The consequences of overexploitation resulting from availability differences are more difficult to predict; some losses in productivity are probable, although they may be less severe and more controllable than those resulting from targeting. The Subcommittee agreed that careful monitoring of catches would be essential under any assemblage or aggregate plan, to enable evaluation of the effects of management on the stocks. The Subcommittee also agreed that management plans must contain provisions to ensure we can protect individual stocks, if specific concerns are identified.

The Subcommittee could not say that a particular alternative was 'the biologically preferred' alternative, rather it simply noted that harvesting on the basis of productivity reflects underlying species' biology. Harvesting on a basis other than this will produce results that cannot be predicted with confidence. The Subcommittee does not wish to imply that the objective of harvesting in exact proportion to available yield can necessarily be achieved by management, simply that it is recognized as a desirable result.

(ii) Is there a biological requirement to distribute fishing effort widely?

Areas are not equivalent in terms of species composition, exploitation history, or area productivities. The Subcommittee's view was that exploitation without respect for

these differences would likely result in a general lowering of productivity to some coastwide average productivity, that would be lower than distributing effort among areas. The relevant areas are those respecting stock boundaries, which are encompassed, in general, by major statistical boundaries.

(iii) What are the pre-eminent multispecies objectives that should be embodied by the Management Plan? What is an acceptable approach for developing yield options to meet defined objectives?

The Subcommittee deferred discussion of this question because the definition of objectives is an active topic for PSARC as a whole, that will be dealt with in the coming year. There was a range of opinion in the Subcommittee as to whether single-species or multispecies concerns should be the prime determinant in formulating biological and management objectives. The Subcommittee felt that until true multispecies assessments have been completed and reviewed, if multispecies quotas are constructed they should constructed from the component single-species yield options. The Subcommittee consensus was the total yield recommendation should not exceed the sum of the parts. Additionally, if the management plan does not provide mechanisms to distribute effort among species and areas, the multispecies quota should be less than the sum of the parts, to reduce the potential for targeting on particular species or stocks.

(iv) How might an appropriate range in species composition [for an assemblage] be determined?

The Subcommittee did not discuss this item in detail and no strong views on the determination of an appropriate species composition were presented. A consensus view was that if species are caught together consistently and unavoidably, they should be part of any assemblage, but those species would not necessarily be the only ones included.

The Subcommittee viewed the initiative to alter the management framework for rockfishes in a very positive light. The working group has developed initial proposals that have both significant benefits and evident shortcomings. It encouraged the working group to continue its efforts to develop a workable framework.

2. Feasibility of indexing juvenile recruitment with surveys

At the 1991 Subcommittee meetings, several assessments noted the potential value to providing longer-term management advice which could be gained if suitable indices of the strength of incoming cohorts were available prior to their recruitment to the fishable stock. PSARC Working Paper G92-1 was prepared to address the issue of whether a combined field survey of juveniles of several groundfish species could provide such indices.

The working paper addressed the issue in three parts. It first reviewed a number of recent studies on the value of juvenile surveys, then identified the species and species groups that would be most appropriate for study, and finally it discussed the benefits and costs of surveys for selected species/stocks. Pertinent considerations about target stocks for surveys, from other studies, were:

- the earliest feasible time prior to entry into the fishable stock should be chosen;
- multispecies surveys are unlikely to provide results of value compared with surveys designed for the unique characteristics of individual species;
- stocks or species with large recruitment variability were the most amenable targets;
- the species or stock should have well understood partial recruitment functions;
- short-lived species should be chosen since recruitment to the fishable biomass can be an important fraction of the landings;
- the index developed should be a relative rather than an absolute one, but the index must be validated and reflect inter-annual changes in juvenile abundance;
- surveys should be selected that have small anticipated measurement error. Imprecision and inaccuracy of the index should not overwhelm the recruitment variability; and
- habitat usage by the juvenile stages should be examined, so that all important habitats where juveniles occur will be surveyed.

The authors developed a ranking system for evaluating the potential benefits of surveys for juvenile B.C. groundfish. The ranking considered knowledge of the partial recruitment, present knowledge of juvenile distribution/behaviour, capture technology, the potential and precision of biomass estimation, and the knowledge of stock affiliation for juveniles obtained. Hecate Strait Pacific cod was viewed as the assessment for which the most immediate benefits from development of a juvenile survey index could be realized. Surveys of the juvenile stages of other species/stocks, while also leading to improved assessments, would require a larger initial investment of time and resources.

The Subcommittee complimented the authors for producing a paper which directly addresses the concerns expressed at the previous meeting. The Subcommittee concurred with the paper's conclusion that a multispecies juvenile indexing survey was not a desirable approach. Some members disagreed with the paper's judgment that Pacific cod was the most suitable candidate species. Staff responsible for Pacific cod pointed out aspects of its seasonal behaviour that could be important determinants of success, including the necessity of avoiding surveys during the transition periods from summer to winter oceanographic conditions. They also believed that alternative sources of information on Pacific cod, such as logbook records of discards, could provide a cost-effective alternative to juvenile surveys. Other members of the Subcommittee noted the poor area and time

coverage of such data and cautioned that such data might provide inconsistent and contradictory evidence, but could provide a useful adjunct to the design and interpretation of surveys. Observations from on-board observer programs were identified as a high-quality data source.

3. Development of biological and management objectives

The Subcommittee was tasked by the PSARC Steering Committee to propose a framework for the establishment of management objectives for groundfish stocks. This framework would consider biological, economic, and social needs, and should include a feedback mechanism for refinement of the objectives. This instruction did not mean that the Subcommittee was to establish the management objectives, rather that it was to recommend a framework to facilitate their establishment. However, the Subcommittee was to provide recommendations on what it considers to be the key biological objectives. Subcommittee members were asked to submit their suggestions on this topic prior to the meeting.

There was a general consensus of the Subcommittee on the framework that would be required to set *management* objectives. The prime element in this process was perceived to be the necessity of defining objectives from the perspectives of biology, enforcement, data capture and quality, and economic performance. There was also an opinion that the identification of objectives should be separated from their integration and achievement, although this was not universally held since enforceability of strategies may bear on how realistic a management objective is.

Most suggestions contained one or more elements of the following list. In addition, some suggestions for an evaluation framework of the potential objectives were made, involving the elements of multi-attribute utility ranking, simulation of outcome probability, and the development of criteria for acceptability of consequences. Many respondents commented on the need for broad-based representation in the development of the draft objectives. In particular, the importance of economic input (at both harvester and processor levels) in the development and evaluation of management objectives was stressed. Suggestions for the general process can be outlined as follows:

1. Establish a working group/groundfish management plan team under the direction of a Groundfish Coordinator/Manager. Team would encompass the multiple disciplines associated with the groundfish fishery (biology, economics, planning, management).

2. The working group would draft a discussion paper on objectives for groundfish management as expressed in these disciplines. This discussion paper might be preceded by:
   - a review of the fishery;

- an economic analysis of the profitability and social benefits of various sectors of the industry, and the linkages among gear/industry sectors (e.g. corporate, licences, etc.);
- a workshop to articulate the suite of management objectives of these sectors;

3. Solicit comments from all sectors on the draft objective document and revise as necessary.

4. On a stock/species/fishery/area basis, evaluate applicability of objectives and iterate the definition process.

5. Incorporate into management plan.

There was less consensus on the *biological* objectives which would act as one component to guide groundfish management (Appendix I). There was also confusion between biological objectives, management objectives, and the strategies to achieve them. For example, several respondents noted some form of sustainable yield (maximum, optimum, etc.) as a biological objective, whereas yield is more in the realm of management objectives. The appropriate biological objective to a sustainable yield management objective would be to maintain the target stock at a level which permits the attainment of the sustainable yield. After extensive discussion, the Subcommittee decided that as long as the stock abundance is such that production surplus to population maintenance is available, its use is solely the concern of management objectives. This led to the conclusion that the most definable biological objective was to prevent the stock from being reduced to a level that impairs its ability to maintain itself.

The Subcommittee noted that several international agencies have recently struggled with this same problem, and that PSARC could benefit from a review of their findings and conclusions, prior to finalizing any decision on biological objectives. Accordingly, the Subcommittee recommended that the Steering Committee form a working group composed of two members from each of the Subcommittees, to review this existing information and, if possible, develop a set of draft biological objectives. Noting the potentially unique nature of objectives among species, we recommend that this working group at least draft a synopsis of this information for the subsequent consideration of the Subcommittees in their own definition of biological objectives. A deadline of February 1993 is suggested for delivery of this material.

SUMMARIES OF ASSESSMENTS AND REVIEWERS' COMMENTS

Inshore lingcod

The lingcod stock in the Strait of Georgia was assessed using commercial and sport catch, effort, and catch per unit effort as abundance indices. Commercial catch, effort, and the number of vessels participating in a directed lingcod fishery have decreased and, prior to closure, the commercial CPUE was less than 50% of values prior to 1984. Catch and CPUE in the sport fishery have also declined. These declines indicate that the Strait of Georgia lingcod stock is at an extremely low level of abundance. The recommended closure to all commercial and recreational removals into 1993 is necessary to promote stock rebuilding and to prevent further stock depletion.

The reviewer of this assessment concurred with the authors' conclusions on the current status of the stock. A potential, long-term problem in monitoring the stock status, as a result of closure of the commercial fishery, was noted. The lack of a relative abundance index from the commercial fishery poses a significant problem to monitoring the effects of rehabilitation measures, and alternative indices of stock status will be required. The reviewer also noted that the proposed period of closure (until 1995) encompasses only one recruitment cycle, and questioned whether this period would be sufficient to achieve any rehabilitation.

The Subcommittee concurred with the assessment of stock status and the recommended closure, and also shared the reviewer's concerns about whether the suggested period of closure to commercial and recreational removals would be sufficient. It recommended that the suggested time frame for the closure be removed and that the status of the stock be used as the guide to whether the closure should be removed. The Subcommittee suggested the authors contact Washington Department of Fisheries staff to determine the effectiveness of a similar closure enacted to rebuild lingcod in Puget Sound. The Subcommittee also noted that marine mammal predation on lingcod presents a potential impediment to rehabilitation of lingcod, even in the absence of a fishery, and requested that the authors continue liaison with marine mammal staff to assess this potential. Incidental mortality in the hook and line rockfish fishery should also be assessed. Lastly, the Subcommittee noted that there was no effective means of assessing compliance with the voluntary 10-fish annual recreational lingcod catch limit.

Offshore lingcod

Offshore lingcod stocks were examined for the northwest and southwest coasts of Vancouver Island, Queen Charlotte Sound, and Hecate Strait. Changes in age determination criteria during the last decade have created difficulties in identifying cohort strengths accurately over the same time period. This difficulty is also expressed in the

estimation of mortality rates from either age or growth data. Resolution of this problem is underway and involves a detailed examination of lingcod growth history and, potentially, re-ageing of at least part of the existing time series of age samples. Until this work is completed the interpretation of stock condition will rely on recent trends in catch statistics and biological sampling. Off the west coast of Vancouver Island (Areas 3C and 3D) and in Queen Charlotte Sound (Areas 5A-5B), stocks are at moderate levels, although recent declines in CPUE associated with record levels of fishing effort suggest that stock abundance may be declining. Recommended low to high risk yield levels range from 1400-2000 t, 400-800 t, and 800-2000 t for Areas 3C, 3D, and 5A-B, respectively. A report on the increasing fishery in Hecate Strait (Areas 5C-5D) was presented for the first time. The fishery in this area has recently undergone a dramatic increase in effort, but there is little biological information available to guide yield recommendations. A recommended yield level of 1000 t is provided out of concern for the sensitivity of the species to exploitation and the rapid expansion of the fishery.

The reviewer noted that the interpretation of stock status relied largely on catch statistics, and that problems in changing age determination criteria cast doubt on estimates of fishing mortality in this and previous assessments. However, the reviewer believed that, in the absence of a formal analysis, there was insufficient evidence to recommend the quota for Area 3C should be reduced. The reviewer also requested more support for the authors' contention that historical fishing mortality could have been higher than past estimates. The introduction of a precautionary quota of 1000 t for the Hecate Strait lingcod stock was supported, but the reviewer suggested that the authors examine latitude-dependent trends in lingcod abundance and productivity for potential guidance on an appropriate quota for this developing fishery.

The Subcommittee concurred with the reviewer's belief that, while there was concern about the present trajectory of the Area 3C and Area 5A/B stocks and the current record levels of fishing effort, the interim assessment contained insufficient analysis to support a change in the yield quota recommendations for these stocks. The recommended yields for these stocks are therefore 1200-2800 t and 1100-2200 t, respectively. While noting that a winter closure for lingcod retention had been in effect for some time, the Subcommittee felt that the benefits of closing the fishery could not be demonstrated at present. However, such a closure could only act to benefit the stock available to the directed fishery. The Subcommittee concurred with the other yield options presented in the assessment.

Pacific cod

Pacific cod stock assessments were presented for four areas on the British Columbia coast. The basis for the assessment in each area varied in relation to the available information. No new analysis were conducted for the Strait of Georgia stock. The authors concluded that regulation does not appear to be necessary for this stock. Abundance

indicators for the west coast of Vancouver Island suggest that stocks are relatively stable. Above-average recruitment from the 1989 year-class should sustain present fishing levels. No catch limit or closures are suggested for 1993. The Queen Charlotte Sound stock is not assessed for yield potential. The fishery has historically been small. Major new analysis were conducted for the Hecate Strait stock. The catch, effort and age composition data of this fishery were explored in some detail with contemporary modelling tools. There has been a substantial decrease of Pacific cod biomass in Hecate Strait since the peak in 1987. This conclusion is robust to all models examined in this stock assessment. The best estimates indicate that fishing mortality and fishing effort in Hecate Strait are at above-average levels. The abundance estimated with different modelling tools is at average or below-average levels. There is also great uncertainty about recruitment levels for 1993. The abundance of Pacific cod in Hecate Strait is projected to decline further. High fishing mortality in 1993 could reduce the stock size to historic low levels. In light of these dangers the authors believe that management measures are necessary for the Hecate Strait Pacific cod stock in 1993. The recommended yield range at the sustainable level is 3900-5100 t.

The two reviewers for this assessment provided similar and detailed commentary for the authors' consideration. Both reviewers complimented the authors for undertaking a major re-analysis of the Hecate Strait stock and employing a number of assessment methods. However, they also noted important limitations on the applicability of some of the methods, particularly in terms of the assumptions about recruitment to the population. The dynamics of Pacific cod stocks are clearly dominated by annual recruitment, yet the models employed do not simulate this process well. Both reviewers also recommended that sufficient diagnostics be included so that the adequacy of the model performance could be assessed. The reviewers also noted the lack of a framework for combining the various model results into a single perception of stock status. This was felt to be an important component of providing advice in a format most useful to managers. The reviewers suggested methods to address this issue. A number of comments directed to improving the support for particular parameter estimates or process descriptions were also provided. Growth estimation, age determination, and the estimation of fishing mortality were prominent among these elements.

The potential relationship of spawning stock to subsequent recruitment occupies a prominent place in both the assessment and the reviewers' comments. Management advice for this stock is heavily dependent on predictive ability for incoming recruitment. Authors and reviewers concurred that the ability to understand and forecast recruitment is not yet adequate for making accurate predictions.

The Subcommittee engaged in a comprehensive discussion of this assessment, due both to the management problems encountered in 1992, and to the present uncertainty about stock status. The detailed comments of the reviewers were not presented, rather the discussion concentrated on whether any of the models presented described the stock adequately. Reservations were noted about all of the assessment models used and, in the

absence of diagnostics and auxiliary tuning indices, there was no clearly superior choice among the results. The relationship of historical fishing effort, catch, and estimated biomass was examined. It was noted that fishing effort normally declines in response to low stock abundance, which appears to act as an internal feedback mechanism on fishing mortality. All models describe a decline in biomass from peak levels of the late 1980s to the present, but the models differed in their conclusion about present biomass. Some estimates place present biomass near the historical average while others suggest it is near the low end of historical observations. Fishing mortality is variously estimated as slightly above average, to record high levels. Simulations of future stock behaviour are highly sensitive to the assumptions concerning recruitment productivity.

The Subcommittee noted that the stock has always recovered from similar low levels of biomass in the past, because fishing effort declined in concert with biomass. The Subcommittee considered that the stock could therefore not be considered in immediate danger, if a similar response in fishing effort were to occur. There was concern expressed that fishing effort may not be undergoing such a decline, at present. It was believed that the stock should not be allowed to fall below the historic minimum. The Subcommittee concluded that there was no basis for choosing between the estimates of yield presented, because future yield was highly dependent on incoming recruitment, for which there is not yet a reliable estimate. The Subcommittee therefore endorsed a range of yield estimates from 3200-6500 t, but specified that an appropriate choice from within that range could not be made until an estimate of the strength of the 1990 and 1991 cohorts is obtained from sampling conducted in early 1993. Until this information is available, managers are urged to exercise caution in assigning harvest from this stock.

Flatfish

Flatfish stocks were assessed on an interim basis in 1992 using standardized landing statistics, trends in recruitment and yield per recruit analysis. Petrale sole stocks were determined to be at low levels, rock sole stocks at average to high levels, and English sole and Dover sole stocks at average to high levels. Landing statistics for all rock sole stocks were standardized using a multiplicative model accounting for effects of vessel horsepower on CPUE. Recruitment of the strong 1985 rock sole year class continued to contribute to production in 1991. It also appears that the 1986 year class is above average, though not as strong as the 1985 year class. However, yield for these stocks should decrease over the next three years, as the strong cohorts pass through the stock. Estimated sustainable yields for rock sole stocks in all areas are the same as in 1992. The increase in landings of English sole in Hecate Strait in 1991 was the result of above-average recruitment for that stock. CPUE for Area 5C-5E Dover sole has remained stable over the last five years, while that for Area 3C/D Dover sole decreased from that observed in 1990.

The reviewer complimented the author on a very thorough treatment for an interim assessment and provided a number of suggestions for improving the presentation. The

potential problems of changing catchabilities, the effect of trip limits on CPUE, and the applicability of the log-linear model for standardizing effort led to a suggestion that nominal catch statistics be presented along with the standardized statistics. The reviewer noted that the petrale sole yield was defined only in terms of trip limits, rather than with total yield, as is the case for other flatfish yield options. For the Area 3C/D Dover sole stock, the reviewer noted the large increase in effort between 1990-1991, associated with decreased CPUE. Because of the uncertainty about whether this stock is discrete, the reviewer recommended that the 1300 t sustainable yield option be considered a high-risk option. The inconsistency in the averaging period used as a basis for the low risk yield options was noted and a consistent period recommended. The high risk option for the Area 5A stock is presented as 500 t but the reviewer noted this level had been achieved only at the early stages of the fishery, and that subsequent yields of around 400 t have been associated with short-term CPUE declines. Accordingly, it was suggested the high risk option be reduced to 400 t. The reviewer noted the differences that the different averaging periods had on the estimated yield options for rock sole in Areas 5B and 5C, and requested a standardization. The basis for the low-risk and high-risk options for the Area 5D rock sole stock was also unclear, as was the basis for the English and Dover sole yield options in Hecate Strait. Lastly, the reviewer noted the increasing catches of arrowtooth flounder in landings and suggested an updated assessment for this species may soon be required.

The Subcommittee noted the reviewer's comments and requested that the author address the inconsistencies in re-draft. As was the case in the lingcod assessment, the Subcommittee believed that there was not sufficient analysis presented in the interim assessments to change the basic yield recommendations. Therefore, the existing yield recommendations for 1992 were endorsed. However, the generally increasing recruitment of rock sole in most stocks does present an optimistic picture for managers to consider. In addition, the Dover sole stock in Areas 5C-5E appears to be in good condition.

Sablefish

The sablefish stock off the west coast of Canada is estimated to be in good condition. Nominal CPUE values decreased in 1990 from 1989 but remain above the average values for the 1980's. In addition, indices of recruitment indicate that several year-classes in the 1980's are above average. Biomass estimates, based on survey trap catch rates in 1989 and 1991, indicate that total biomass was approximately 55,000 t and 62,000 t, and exploitable biomass was approximately 51,000 t and 55,000 t in 1989 and 1991, respectively. These values are above comparable estimates reported in the early 1980's. Yields ranging from 2900 t to 5000 t, were presented as low to high risk yield options.

The reviewer of this document noted that it was an interim assessment and that it incorporated few changes from the previous assessment. The concerns about VPA

expressed by the previous reviewer were repeated and endorsed. The reviewer noted that the estimates of stock biomass from trap surveys were presented without an estimate of the associated error, and therefore expressed reservation about the validity of the biomass estimates. The use of alternative assessment techniques was also suggested.

The Subcommittee acknowledged the concerns expressed by the reviewer and noted that this stock assessment is undergoing a major revision for the 1994 assessment year, and that the shortcomings of the present age-structured analysis will be addressed. The Subcommittee also heeded the authors' comments that recent recruitment appeared to be average or above average, but that the distribution of the catch had undergone a northerly shift over the past decade, and that the management regime had also undergone successive alterations which hampered the understanding of fishery statistics. In the interim the consensus of the committee was that, while there was no basis for changing the yield recommendations, the concerns expressed by the reviewer and the authors indicate that managers should avoid a high risk approach to harvest levels from the stock.

Pacific hake

In the Strait of Georgia, estimates of biomass from swept-volume trawl and hydroacoustic surveys were 112,000 t and 73,300 t, respectively, in 1988. These estimates compare favourably with identical surveys conducted in 1981. An assessment conducted using Virtual Population Analysis (VPA) and a forward simulation model, indicated that yields up to 14,000 t may be sustainable.

Since 1968, more Pacific hake from the offshore stock have been landed than any other species in the groundfish fishery on Canada's west coast. Coastwide catches of Pacific hake increased from 261,000 t in 1990 to 321,000 t in 1991. The all-nation-catch in the Canadian zone was 104,522 t in 1991, up from 76,680 t in 1990. A failure to agree on an allocation procedure between Canada and the U.S. resulted in harvests that exceeded recommended yield levels in 1990 and 1991. The approach taken in this assessment is similar to the previous one. The stock synthesis catch-at-age analysis, tuned to the U.S. triennial survey biomass estimates, is used to assess the current status of the stock, and an age-structured forward simulation model is used to examine long term (equilibrium) production and short term (look ahead) yield options. Overall abundance as indicated by stock synthesis runs is declining, as the strong 1980 and 1984 year classes move through the fishery. Preliminary evidence suggests that the 1990 year class may be moderate to strong. Yield options for three possible fishing strategies and three risk levels are presented. Available yields for 1993 are estimated to range from 117,000 t to 220,000 t.

There were two reviews of the Pacific hake stock assessment. The first reviewer stated that, in general, the analytical basis for both stocks was appropriate, the data treatment thorough and comprehensive, and the yield recommendations were a reasonable compromise in light of the uncertainty. For the Strait of Georgia stock, the reviewer

stressed that adequate sampling be undertaken now so that information will be available to conduct an age-structured analysis for the next major assessment. For the offshore stock, the reviewer noted that the basis for the assessment was an analysis conducted externally and recommended that, under such circumstances, the PSARC assessment should clearly indicate the author's evaluation of the external work. The review raised several questions about stock structure in the Canadian zone for the author to address in re-draft. It also noted that the impact of the current harvest levels (125% of the quota) could be modelled to provide advice to managers. Finally, this reviewer noted the confounding of some model parameters, the crucial role of the survey as a tuning index, and therefore the critical importance of the hydroacoustic calibration factor. The need for an objective resolution of the differences between the two factors which have been used historically was stressed.

The second reviewer requested inclusion of more quantitative biological information for the Strait of Georgia stock. He also suggested that the differences between the trawl and acoustic survey estimates be resolved, and that alternative models be used in place of age-structured models, if problems in the catch-at-age matrix can not be resolved. Lastly, more details on the basis for the risk levels were requested, particularly as they pertain to uncertainty in the relative inputs for recruitment levels and survey biomass estimates. For the offshore stock, the reviewer noted that use of alternative population models may facilitate examination of the uncertainty of model outputs, and therefore provide better estimation of the risks associated with projected yields. This reviewer believes that risk levels may be currently underestimated.

The Subcommittee noted the confounding of the selectivity and migration vectors for catch-at-age estimation in the Canadian zone, in particular. The fact that the age-structured model behaved so poorly in absence of the tuning index, given the high quality and high contrast in the data set, raised questions in some members about the ability to model this population adequately with an age-structured model. Other members noted the generality of this finding with such models, because of unavoidable parameter confounding. The Subcommittee endorsed the yield recommendations but expressed strong concern that the inability of the two countries to agree on an allocation framework was resulting in fishing mortality above recommended levels.

Dogfish

A summary of fishery statistics was provided, showing catch and effort patterns for the years 1979-1991. Directed effort towards spiny dogfish appears to be market dependent. Yield options are unchanged from recent years at 9,000-25,0000 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 for this assessment noted a lack of detail on stock delineation, data sources, and the nature of the fishery. Measures of effort for the longline fishery were not provided although comments on effort levels for this fishery were made in the document. Several additional sources of mortality, including incidental mortality in other fisheries, were not explicitly accounted for and could represent a large proportion of the total mortality. The reviewer also noted that since management actions were not taken in all quarters of the year, some of the yield options were inappropriate. Lastly, the reviewer noted that a short summary of the basis for the assessment would be valuable.

The Subcommittee endorsed existing yield recommendations, with a request to rationalize the recommendations by quarter for the coastwide stock.

Walleye pollock

The 1991 pollock catch in the Canadian fishery increased from 1571 t in 1990 to 2758 t in 1991. The 1991 incidental catch in the joint-venture and foreign hake fisheries decreased to 383 t, from 584 t in 1990. No new analyses were conducted for this assessment. Low to high risk yield options for the Strait of Georgia, based on Gulland's (1983) MSY model, are 1500 t and 3700 t, respectively. Yield options are not proposed for stocks off the west coast of Vancouver Island, Queen Charlotte Sound, or in Dixon Entrance/Hecate Strait.

The reviewer for this assessment requested additional clarification for segregation of catch statistics for the Strait of Georgia, and details on the segregation between this stock and that in Queen Charlotte Sound. The declining catch in the joint-venture fishery off the west coast of Vancouver Island, coincident with an increasing domestic fishery, was noted with the concern that this might represent stock decline.

The Subcommittee shared the concern of the reviewer about the state of the resource off the west coast of Vancouver Island and noted that increased requirements for whitefish to supply onshore surimi plants could have a significant effect on the fishing pressure on this resource. The status of this stock may require additional monitoring in future. The Subcommittee endorsed the yield recommendations.

Slope rockfish

Based on previous assessments, stocks of Pacific ocean perch (*Sebastes alutus*) and yellowmouth (*S. reedi*), rougheye (*S. aleutianus*) and redstripe (*S. proriger*) rockfishes are in moderate to poor condition, with coastwide yield estimates of 3350-5470 t, 1160-2450 t, 250-400 t, and 1450-3270 t, respectively. Interpretation of fishery statistics is now complicated by trip limits, combined with unknown levels of discarding and non-compliance. Qualified CPUE may no longer provide a meaningful index of stock abundance and the commercial catch level itself is suspect. New analyses of CPUE accounted for trip limits and suggested that abundance of the Goose Island Gully stock of Pacific ocean perch has remained relatively stable over the past six years. In contrast, CPUE for the Moresby Gully stock obviously depends on the trip limit. Catches from both Goose Island and Moresby Gully stocks are now dominated by Pacific ocean perch from the 1976 and 1980 year classes. Fewer age data are available for other stocks.

The reviewer for this assessment, while noting that it was an interim assessment, requested more details of the basis for the current yield levels. This would reduce the need for reference to the last assessment, which was conducted in 1989. The rationale for the shift to 20% qualification level, from the 25% level used in all previous assessments, should be presented. The reviewer also wished to see the output from the new CPUE analysis presented together with traditional CPUE analysis for comparison. The reviewer also felt that the support for conclusions about the new CPUE analysis producing different results was equivocal. More discussion of the significance of the age composition data was requested.

The Subcommittee welcomed new initiatives in analysis of CPUE data and the effect of trip limits. Some members of the Subcommittee, while not addressing the validity of the underlying methodology, felt that the conclusions presented in the assessment concerning trip limit effects on CPUE were not well demonstrated by the example presented. While the Subcommittee recognizes the arbitrary nature of qualification levels used in various assessments, it believes that data series should be maintained in a manner consistent with the basis for assessment advice. Changes to this basis, such as that contained in this assessment, should be accompanied by supporting rationale. The Subcommittee endorsed the yield recommendations of the assessment. It also endorsed the continuation of the experimental program in Area 5E(N). The lack of adherence to stock-specific yields and consequent overexploitation of some stocks is a cause of concern; the same concern was noted in previous years.

Shelf rockfish

Assessments were presented for eight shelf rockfish stocks. The recommendations for the three silvergray rockfish stocks of Area 3C-3D (Vancouver Island), Area 5A-5B (Queen Charlotte Sound), and Area 5C-5D (Hecate Strait) are 150-425 t, 375-725 t, and 150-425 t respectively. For the two canary rockfish stocks of Area 3C-3D and Area 5A-

5B, the recommended yield ranges are 175-550 t and 200-375 t. The recommended yield range for yellowtail rockfish for the joint U.S. and Canadian stock in Areas 3B-3C is 1000-2000 t. For Areas 3D-5E, the recommended yellowtail rockfish yield range is 2500-4900 t, while the coastwide range for widow rockfish is 500-2200t.

The two reviewers of this assessment complimented the author for the thoroughness with which the yellowtail stock, in particular, was examined. The first reviewer noted that the yield levels for many stocks are based largely on CPUE data, whose quality has probably been decreasing, and infrequent biological samples. As such the reviewer questioned whether the changes in yield recommendations were justified, and suggested that a protocol to support yield levels for such stocks was required. The need for fishery independent information to support conclusions about stock dynamics was stressed. The reviewer also believed that a strategy requiring stocks to be maintained at 50% of the unfished biomass was overly conservative, and that in the absence of analysis supporting such a strategy, a level of 20-30% of the unfished biomass should be chosen. For the yellowtail rockfish assessment, the reviewer requested additional support for statements about individual cohort characteristics of the age data. The peculiar relationship of ageing precision vs. age was also noted. More details of the age-structured analysis, perhaps in the form of an appendix would be helpful to understand the model. Similarly, explanations of model performance in terms of residual distribution and support for some model assumptions could be improved.

Concerning the yellowtail rockfish assessment, second reviewer felt that the author had done a good job at explaining the choices for parameter estimates and the rationale for manipulating various parameters and assumed model relationships. The reviewer also believed the inferences made from model output were well explained. Concern over the misreporting of widow rockfish as yellowtail rockfish in the database for analysis was expressed, and it was recommended that every effort be made to minimize this data contamination. The reviewer believed the discussion of estimates of natural mortality could be improved to avoid bias. This reviewer also shared the concerns about the adequacy of age samples to support stock status conclusions, expressed by the first reviewer. The reviewer noted that the age composition data for silvergray rockfish in Queen Charlotte Sound may show more older fish in recent years and that a quota near the high end of the recommended range may not be inappropriate.

The Subcommittee held an extensive discussion on this assessment. For yellowtail rockfish assessment, the Subcommittee noted anomalies in the distributions of residuals by age that should be explained. The basis for the standardization and its interaction with the catchability estimation in the model requires additional explanation. The basis for choosing the fishing mortality level to maintain stock biomass at 50% of the unfished level should also be explained. As a result the reviewers' and the Subcommittee's comments, the author developed a protocol for assigning yield levels to stocks based on the strength of indications of overfishing. The Subcommittee reviewed this protocol and approved its application for these stocks. Although the protocol is subjective, it does present a

consistent and repeatable framework for provision of advice in information-poor fisheries. Revised yield levels based on this protocol were endorsed by the Subcommittee.

Inshore rockfish

The line rockfish fishery has continued to expand in all areas of the coast with the exception of the west coast of Vancouver Island. The stock condition, as assessed by several indices of performance and participation, is poor in the Strait of Georgia, and unknown in other areas. In the Strait of Georgia, yield levels were set by first determining the ratio of catch to habitat area (tonnes per km^2) that was demonstrated to be non-sustainable, in statistical areas where the fishery has been active historically. This ratio was used as the base ratio to apply to other statistical areas on the basis of their rockfish habitat area. In the Strait of Georgia, where there is such evidence of stock declines, low risk and high risk catch ratios were selected as one-third and one-half the base ratio demonstrated to be non-sustainable. In other areas, where there is no evidence of stock declines, the low risk and high risk ratios were selected as one-half and two-thirds the maximum catch to habitat ratio for the region.

The reviewer noted that this is an interim assessment year for the inshore rockfish stocks and the Working Paper contains no new analyses. The sole change of significance in the document is the basis for yield estimation outside the Strait of Georgia. This change involves removal of a productivity reference point for habitat-based yield estimation and requires additional justification and discussion in the document. A statement of rationale for the yield levels is also required. The reviewer noted that licence limitation in the Strait of Georgia and elsewhere may have effects on the indices used to assess the stock, in the future. For the most part the assessment can only be based on the most rudimentary data and some alternative assessment methods are suggested. The lack of attention to the internal dynamics of the "rockfish" category was noted and the basis for it was queried. The appropriateness of applying a previous average of annual catches in a developing fishery was also questioned as being unlikely to be sensitive to recent negative changes in catch statistics. The potential of conducting experimental management to decrease the learning period for yield levels in northern waters was suggested.

The Subcommittee endorsed the yield levels of the assessment. However, the Subcommittee noted that the "rockfish" category includes all species other than red snapper, and that the shifts in the species composition of this group is highly likely in some areas now, and potentially in all areas over time. If this occurs, the Subcommittee will be unable to accurately assess the dynamics and yield of this new assemblage group. This conclusion underscores the need for accurate species composition data for these fisheries.

Hagfish

The condition of the hagfish stock is unknown. No recommendations or conclusions were made on the basis of the data collected to date. The data are collected sporadically from the various subareas and effort fluctuates greatly. There are no biomass estimates upon which to base a stock assessment.

The reviewer of this document believed that it was insufficient, given the information that was available. Details of sampling and samples were not provided, and no rationale for not presenting an analysis of these data was presented. Few comments on the fishery data were presented, although there may be trends in the data. The reviewer requested explanation for the decreasing participation in the fishery.

The Subcommittee agreed with the reviewer's request for presentation of results of biological sampling, especially those data for the index site, and discussion of the fishery data. Although noting the paucity of knowledge for the species, the Subcommittee believes that more information on the data collected from the fishery, both statistical and biological, should be provided. In the interim, expansion of this experimental fishery is not encouraged.

Pacific halibut

A synopsis of the halibut stock assessment conducted by the International Pacific Halibut Commission in January 1992, pertaining to the 1992 fishing year, is presented. The halibut resource continued the decline recorded in recent years. The recruitment to the stock in 1991 showed some sign of increasing recruitment but this increase was confined to only one area. Recruitment remains at historic low levels. Changes in stock assessment methodology resulted in higher estimates of biomass than were presented previously, but these changes did not alter the present trajectory of stock decline. The stock is projected to continue to decline in biomass until at least the mid-1990s. Yield to the setline fishery is decreased by high levels of incidental mortality of halibut in non-directed trawl fisheries, primarily in the Gulf of Alaska. Approximately 18% of the available yield was expropriated for bycatch mortality compensation in 1992. The recommended setline yield from the total stock in 1992 was 28,876 t (63.66 million lb, net weight), and that for British Columbia waters was 3760 t (8.29 million lb). The Commission adopted a more conservative approach than recommended by IPHC staff and approved lower quotas. The respective coastwide and Area 2B quotas were 27,379 t (60.36 Mlb) and 3629 t (8.00 Mlb).

The reviewer for this document, while recognizing that the summary of the International Pacific Halibut Commission assessment was thorough and well organized,

questioned the rationale for inclusion of this material in the PSARC process. An extensive assessment is conducted externally and PSARC provides no advice on its management.

The Subcommittee noted that this document reports on an assessment conducted in another forum, and endorsed the reviewers' conclusions. It suggests that this review be relegated to a fishery update rather than a formal working paper. Relevant information from Canadian programs involving halibut could also be included.

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Leaman, B. M. and R. D. Stanley. 1985. Shelf and slope rockfishes. pp. 247-249 *In:* Tyler, A. V. and G. A. McFarlane (eds.). Groundfish stock assessments for the west coast of Canada in 1984 and recommended yield options for 1985. Can. MS. Rep. Fish. Aquat. Sci. 1813:353p.

TABLE 1.
RECOMMENDED YIELD OPTION SUMMARY

The recommended yield options for 1993 presented in assessment documents are summarized below. A separate summary of productivity estimates for inshore rockfish, by minor statistical area, is included as Table 2. Area designations are as in Figure 1.

AREA	SPECIES	YIELD OPTIONS
4B	Lingcod	Zero yield
Minor Area 12	Lingcod	Winter closure 65 cm size limit
3C	Lingcod	Low risk yield 1400 t High risk yield 2800 t
3D	Lingcod	Low risk yield 400 t High risk yield 800 t
5A/B	Lingcod	Low risk yield 1100 t High risk yield 2200 t
5C/D	Lingcod	Low risk yield 1000 t
4B	Pacific cod	No options proposed
3C/D	Pacific cod	No options proposed
5A/B	Pacific cod	No options proposed
5C/D	Pacific cod	Low risk yield 3200 t High risk yield 6500 t
5E	Pacific cod	No options proposed
Coastwide	Petrale sole	Low risk yield 10,000 lb trip limit, Jan.-Mar. High risk yield 44,000 lb trip limit, Jan.-Mar.
4B	Flatfish	No options proposed
3C/D	Dover sole	Low risk yield 500 t Sustainable yield 1300 t High risk yield 2000 t

AREA	SPECIES	YIELD OPTIONS
5A	Rock sole	Low risk yield 250 t High risk yield 500 t
5B	Rock sole	Low risk yield 250 t High risk yield 600 t
5C	Rock sole	Low risk yield 400 t High risk yield 800 t
5D	Rock sole	Low risk yield 800 t High risk yield 1000 t
5C/D	English sole	Low risk yield 700 t High risk yield 1000 t
5C-5E	Dover sole	Low risk yield 800 t High risk yield 1200 t
Coastwide	Sablefish	Low risk yield 2900 t Sustainable yield 4000 t High risk yield 5000 t
4B, except MSA 19, 20	Pacific hake	Low risk yield 8000 t Sustainable yield 11,000 t High risk yield 14,000 t
3C	Pacific hake	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 15,000 t
4B (Strait of Georgia)	Spiny dogfish	Low risk yield 2000 t High risk yield 4000 t
4B	Walleye pollock	Low risk yield 1500 t High risk yield 3700 t
3C-5E	Walleye pollock	No yield options are proposed
3C (including Areas 25 and 125)	Pacific ocean perch	Low risk yield 100 t High risk yield 200 t

AREA	SPECIES	YIELD OPTIONS
3C	Redstripe rockfish	Low risk yield 200 t High risk yield 1000 t
3D	Pacific ocean perch	Low risk yield 200 t High risk yield 600 t
3D/5A	Yellowmouth rockfish	Low risk yield 250 t High risk yield 750 t
3D/5A	Redstripe rockfish	Low risk yield 350 t High risk yield 900 t
5A/B	Pacific ocean perch	Low risk yield 700 t High risk yield 1000 t
5C/D	Pacific ocean perch	Low risk yield 1900 t High risk yield 3000 t
5C/D	Yellowmouth rockfish	Low risk yield 160 t High risk yield 500 t
5C/D	Redstripe rockfish	Low risk yield 350 t High risk yield 570 t
5E(S)	Pacific ocean perch	Low risk yield 300 t High risk yield 500 t
5E(S)	Yellowmouth rockfish	Low risk yield 400 t High risk yield 700 t
5E(S)	Rougheye rockfish	Low risk yield 200 t High risk yield 300 t
5E(S)	Redstripe rockfish	Low risk yield 50 t High risk yield 100 t
5E(S)	Grouped slope rockfish (Pacific ocean perch, yellowmouth and rougheye)	January-June: Low risk yield 300 t High risk yield 500 t September-December: Low risk yield 600 t High risk yield 1000 t
5E(N)	Pacific ocean perch	Experimental fishing area
5E(N)	Yellowmouth rockfish	Experimental fishing area
5E(N)	Rougheye rockfish	Experimental fishing area

AREA	SPECIES	YIELD OPTIONS
5E(N)	Redstripe rockfish	Experimental fishing area
5E(N)	Slope rockfish (Pacific ocean perch and rougheye)	Experimental fishing area
3B-3C (Combined U.S. and Canadian quota)	Yellowtail rockfish	Low risk yield 1000 t High risk yield 2000 t
3D-5E	Yellowtail rockfish	Low risk yield 2500 t High risk yield 4900 t
Coastwide	Widow rockfish	Low risk yield 500 t High risk yield 2200 t
3C/D	Silvergray rockfish	Low risk yield 150 t High risk yield 425 t
5A/B	Silvergray rockfish	Low risk yield 375 t High risk yield 725 t
5C/D	Silvergray rockfish	Low risk yield 150 t High risk yield 425 t
5E(S)	Silvergray rockfish	No options proposed
3C/D	Canary rockfish	Low risk yield 175 t High risk yield 550 t
5A/B	Canary rockfish	Low risk yield 200 t High risk yield 375 t
3C-5E	Hagfish	Experimental fishery
3C-5E	Pacific halibut	Sustainable yield 3760 t

Table 2A. 1992 and 1993 recommended yield options by statistical area for red snapper. For the Strait of Georgia, red snapper yield options are shown for 1992 surface areas, and 1993 bottom areas, between 50-200 m. For other areas of the coast, the 1992 and 1993 yield options for red snapper are based on the surface areas between 50-200 m.

Statistical Area	1992		1993	
	Low	High	Low	High
Strait of Georgia				
12	19	28	21	32
13	9	13	7	11
14	8	12	11	16
15	6	8	6	9
16	5	8	5	8
17	3	4	3	5
18	4	6	4	6
19	6	9	7	10
20	9	13	10	15
28	3	4	2	2
29	7	10	5	7
West Coast				
11,111	41	61	160	214
21,121	12	17	42	57
23,123	34	51	128	171
24,124	32	48	116	156
25,125	23	35	84	112
26,126	12	19	42	56
27,127	22	33	85	113

Table 2A. (cont'd)

Statistical Area	1992		1993	
	Low	High	Low	High
Queen Charlotte Islands				
1,101	32	48	89	119
2,102	63	94	174	234
130	4	6	10	14
142	7	11	20	26
North Coast				
3,103	6	10	6	8
4,104	22	33	21	28
5,105	39	58	36	48
Central Coast				
6,106	62	92	92	123
7,107	55	83	82	110
8,108	33	50	49	66
9,109	10	16	15	21
10,110	16	25	25	33

Table 2B. 1992 and 1993 recommended yield options by statistical area for rockfish. For 1993, the Strait of Georgia options are based on bottom areas in the 1-80 m depth interval. For 1993, west coast of Vancouver rockfish yield options are based on the bottom areas in the 30-80 m depth interval. For other areas of the coast the yield options for rockfish are based on the surface areas between 30-80 m depth intervals for both 1992 and 1993.

Statistical Area	1992		1993	
	Low	High	Low	High
Strait of Georgia				
12	65	97	68	103
13	33	49	22	33
14	22	33	22	33
15	16	25	13	20
16	13	19	13	19
17	24	35	19	29
18	20	31	13	19
19	25	37	19	29
20	9	14	11	17
28	7	11	11	17
29	12	18	25	39
West Coast Vancouver Is.				
11,111	134	200	45	60
21,121	28	42	10	13
23,123	95	142	32	44
24,124	135	202	46	62
25,125	66	99	22	30
26,126	74	110	24	32
27,127	63	97	25	34

Table 2B. (cont'd)

Statistical Area	1992		1993	
	Low	High	Low	High
Queen Charlotte Islands				
1,101	92	138	16	21
2,102	260	390	45	61
130	2	4	0	1
142	11	16	2	2
North Coast				
3,103	13	20	4	5
4,104	132	198	39	53
5,105	191	286	57	77
Central Coast				
6,106	102	153	70	94
7,107	69	103	47	63
8,108	143	214	98	131
9,109	7	11	5	7
10,110	35	53	27	36

REVIEWER ASSIGNMENTS FOR GROUNDFISH STOCK ASSESSMENTS

TITLE	AUTHORS	REVIEWERS
Inshore lingcod	Murie, Richards, Yamanaka	Fargo
Offshore lingcod	McFarlane, Leaman	"
Pacific cod	Stocker, Hand	Saunders, Rice
Flatfish	Fargo	Yamanaka
Sablefish	Saunders, McFarlane	Stocker
Dogfish	Thomson	Yamanaka
Walleye pollock	Saunders	Thomson
Pacific hake	Saunders	Kimura, Stanley
Slope rockfish	Richards	McFarlane
Shelf rockfish	Stanley	Wilkins, Richards
Inshore rockfish	Yamanaka, Richards	Leaman
Hagfish	Beamish, Neville	Hand
Halibut	Leaman	Hand

PARTICIPANTS AND REVIEWERS AT THE GROUNDFISH SUBCOMMITTEE MEETING
August 25-28, 1992

NAME	AFFILIATION
B. Leaman, Chairman	BSB, Marine Fish Population Dynamics Section, Nanaimo
B. Ackerman	FB, Offshore Division, Vancouver
D. Adams	"
G. Buechler	"
J. Fargo	BSB, Assemblage Management Section, Nanaimo
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J. Irvine	PSARC Chairman, BSB, Nanaimo
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L. Yamanaka	BSB, Assemblage Management Section, Nanaimo
E. Zyblut	FB, Offshore Division, Vancouver

Table 3. Total Canadian landings[a] (t) of groundfish by species, taken from all areas on the Pacific coast, 1981-1991.

Species	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1981-90	1991[b]
English sole	1,500	559	532	812	692	452	755	879	1,041	1,266	849	1,157
Rock sole	1,059	745	668	525	430	454	887	1,960	2,066	2,264	1,106	3,441
Petrale sole	290	367	439	417	336	416	445	790	952	1,066	552	792
Dover sole	1,245	914	871	1,148	963	1,167	633	1,281	2,149	2,382	1,275	2,202
Rex sole	190	74	49	219	205	87	83	145	140	134	133	59
Starry flounder	198	168	66	170	66	54	65	110	123	143	116	145
Turbot	946	525	323	369	764	895	1,193	375	609	2,635	863	2,290
Other flatfish	183	220	199	141	161	215	232	147	50	51	160	87
Pacific cod	6,708	4,810	4,505	3,465	2,342	3,650	13,917	11,015	9,149	6,463	6,602	11,954
Lingcod	2,467	4,162	3,755	3,688	5,668	3,827	3,591	3,462	3,980	5,219	3,982	5,389
Sablefish	3,888	3,976	4,414	3,855	4,275	4,668	4,719	5,770	5,493	5,038	4,610	5,271
Pollock	1,251	924	1,070	800	1,895	577	1,270	1,111	443	939	1,028	2,578
Hake	5,691	2,826	3,122	4,600	6,055	6,802	13,275	6,054	8,682	10,609	6,772	22,466
Ocean perch	5,103	5,983	5,655	6,698	6,069	5,914	6,335	6,929	6,004	5,761	6,045	4,325
Other rockfish	4,857	5,093	7,024	8,512	11,709	19,040	18,177	20,399	18,437	22,885	13,613	19,423
Misc. species	266	141	156	175	192	245	344	353	172	122	217	142
Hagfish	-	-	-	-	-	-	-	66	829	213	111	23
Dogfish	1,151	3,875	3,274	2,510	2,815	3,289	3,801	5,483	2,780	4,194	3,317	3,110
Animal food	42	65	94	161	309	255	188	130	127	17	139	tr.
Reduction	302	450	321	244	214	175	210	581	353	210	306	319
Total	37,337	35,877	36,537	38,509	45,160	52,182	70,120	67,040	63,579	71,611	51,795	85,173

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

[b] Preliminary data.

Table 4. Joint-venture and foreign catches* (t) of groundfish from international Area 3C -- southwest coast of Vancouver Island in 1991.

Nation and species	Joint-venture Quota (t)	Joint-venture Catch (t)	Supplemental Quota (t)	Supplemental Catch (t)	Total
Poland					
Pacific hake	62,000	61,484	6,000	6,043	67,527
Walleye pollock	incidental	336	incidental	1	337
Pacific ocean perch	incidental	3	incidental	1	4
Other rockfish	incidental	439	incidental	136	575
Other species	incidental	2	incidental	tr.	2
China					
Pacific hake	6,500	6,627	-	-	6,627
Walleye pollock	incidental	13	-	-	13
Pacific ocean perch	incidental	tr.	-	-	0
Other rockfish	incidental	40	-	-	40
Other species	incidental	tr.	-	-	0
Japan					
Pacific hake	8,000	8,143	-	-	8,143
Walleye pollock	incidental	tr.	-	-	0
Pacific ocean perch	incidental	-	-	-	0
Other rockfish	incidental	31	-	-	31
Other species	incidental	-	-	-	0
Total					
Pacific hake	76,500	76,254	6,000	6,043	82,297
Walleye pollock	incidental	349	incidental	1	350
Pacific ocean perch	incidental	3	incidental	1	4
Other rockfish	incidental	510	incidental	136	646
Other species	incidental	2	incidental	0	2

* Catches (converted from processed weight) are reported by foreign processing vessels and cannot be verified by weight tallies.

APPENDIX I. Summary of suggestions on biological objectives submitted by Groundfish Subcommittee members, August 1992.

1. Fishery-based:

- long-term sustainable yield
    - single species
    - multispecies
- long-term maximum average yield
- maintain stocks at a level to ensure their continued productivity
- sustain stocks while catching as much as possible and accruing the greatest return possible
- no growth or recruitment overfishing
- maintain an effective spawning stock in all areas where the species exists or existed
- maintain a "safe" spawning biomass
- sustain reproductively viable populations at the level of resolution of a fishing ground, or the level of what constitutes a spawning stock, as opposed to a statistical area

2. Ecologically-based

- maintain genetic diversity
- maintain ecological diversity and complexity
- maintain breadth of occupied habitat
- maintain all species at a biomass level sufficiently large to prevent them from becoming endangered
- ensure ecosystem is not affected adversely
- maintain species integrity (growth, mortality, longevity, sex ratio, and behaviour patterns are maintained)

3. Other

- managing for quality of information, both biological and fishery

PACIFIC STOCK ASSESSMENT REVIEW COMMITTEE

PSARC ADVISORY DOCUMENT 92-3
SEPTEMBER 1992

INVERTEBRATES

CONTENTS PAGE

I. STEERING COMMITTEE REPORT

The PSARC Steering Committee met September 29 and 30, 1992 at the Coast Bastion Inn, Nanaimo to review the Invertebrate (Shellfish) Subcommittee Report. Steering Committee noted the large number of recommendations and information needs in the Invertebrate Subcommittee Report. Steering Committee acknowledges that the number of fisheries on invertebrate stocks is increasing much faster than the information bases available for advice on, and management of, those fisheries. Nonetheless, there is no reason to expect significant new resources will be available for research on invertebrate stocks. Steering Committee identifies the need for recommendations and information needs to be prioritized and as specific as possible.

After extensive discussion of the items particularly noted by the Subcommittee, the Steering Committee RECOMMENDS:

1. Greater research attention be given to sea urchins, because of the rapid increases in catches and the little information available on which to base management of urchins. Resources for this work could be diverted from research on geoducks. Geoduck research projects are now established, and continued monitoring of these projects can be carried out at a lower level of resources than was required to establish them.

2. The Steering Committee shared the concern of the Subcommittee regarding the rapid rate of increase of harvest for red sea urchins in the north coast and supported the recommendation of the Subcommittee that landings be capped at some pre-expansion level until appropriate biological data have been collected and analyzed. The continued exponential expansion of the

biological data have been collected and analyzed. The continued exponential expansion of the fishery cannot be sustained and it is therefore imperative that further controls be introduced. An accurate determination of pre-expansion harvests is not possible using the data in Table 1 in part because landings are combined for all regions of British Columbia and red and green urchin landings are combined for earlier years. Steering Committee assumed that most of the urchin catch in Table 1 was from the north coast, and that the bulk of the pre-1989 catch was red urchins. Catches between 1984 and 1990 ranged between 1764 and 3158 tonnes with a mean of 2321. The Steering Committee RECOMMENDS that harvest of red sea urchins in the North Coast Division be capped at 2,500 tonnes annually until data are available to assess the stocks. The Steering Committee also RECOMMENDS the harvest should be managed in a way in which will spread the effort as much as practicable.

3. New invertebrate fisheries are considered experimental and a cautious approach to their management is usually undertaken. However, for existing fisheries that undergo a sudden expansion such as the red urchin, there is a need to develop a series of controls. The controls would be intended to prevent too rapid expansion of these fisheries, with a consequent danger of depletion of the resource base, in advance of gaining the knowledge necessary to develop management plans for sustainable fisheries. Steering Committee acknowledges that the initiatives to develop explicit fisheries objectives will address new and expanding fisheries, but highlights the prominence of this issue in invertebrate fisheries.

Steering Committee noted the request to approve sponsorship of an international symposium on invertebrate stock assessment. While in sympathy with the desire of the subcommittee to gain exposure to as wide an array of assessment methods as possible, Steering Committee questioned the role of PSARC in sponsorship of symposia. A more detailed proposal was REQUESTED, specifying background, costs, organizational effort, objectives, role of PSARC, etc, before Steering Committee would consider such a request. A number of other mechanisms were suggested to increase exposure of Invertebrate Subcommittee members to appropriate assessment methods.

Steering Committee noted the extensive list of Management Policy items in the report. It also noted the lack of explicit and verified biological and/or economic justifications for many of these policies. Therefore Steering Committee RECOMMENDS that, as the initiative to identify biological and management objectives for Pacific Region fisheries progresses, these management policies be reviewed in light of the biological and management objectives, and modified as appropriate.

Steering Committee had an extended discussion of the changes in escape port size for Dungeness crab traps. Steering Committee does not disagree with the conclusion of Subcommittee that carapace size does not show significant variation along the coast. However, there is concern that this analysis alone will not dispel the widespread dissatisfaction of industry with the change in escape ring size, nor with the study which led to the recommendation for the change. Further research and analyses may be required to support

implementation of these changes. Steering Committee RECOMMENDS that such analyses, if needed, should focus directly on key concerns of industry.

Steering Committee also noted that intertidal clams have been managed functionally as an undifferentiated biomass of clams, although comprised of several species. Steering Committee RECOMMENDS that the species compositions from these stocks and fisheries be reviewed, to see if there is useful information to be gleaned about the biological consequences of assemblage management.

In its discussion of a draft of Appendix 3 in the Subcommittee report, Steering Committee noted the expansion of intertidal clam farming, and the potential implications of these farms on wild stocks. This is an issue Steering Committee feels PSARC should deal with although a time-frame and specific issues were not identified.

Steering Committee noted that in the recommendations on geoducks, the Subcommittee specifies 50% of originally estimated biomass as a minimum cutoff for harvesting. It further notes that this value was carried over from earlier work. Research to verify that this is an appropriate minimum biomass level has not been conducted, and the value remains an arbitrary limit.

Steering Committee discussed at length the four recommendations on logbooks. Although the Subcommittee did not give these recommendations special prominence, Steering Committee CONCLUDES that the backlog of unprocessed logbooks is unacceptable, not just in invertebrate fisheries, but in other species as well. Steering Committee acknowledges that reallocation of resources will be required to deal with the backlog, and even after the backlogs are cleared up continuing commitments of resources will be required. Nonetheless, Steering Committee RECOMMENDS that timely processing of logbooks be treated as high priority by Branches responsible for their maintenance. If processing of logbooks cannot be done, compulsory logbooks should be discontinued.

Steering Committee RECOMMENDS that a working group be established to review previous work on biological objectives, propose biological objectives for groundfish, herring, and invertebrates in the Pacific Region, and recommend a framework for developing non-biological objectives. Membership of the working group should be chosen from within the Salmon, Groundfish, Herring, and Invertebrate Subcommittees. The working group should complete a draft report by February 1993. This report should then be discussed by the respective Subcommittees prior to review by the Steering Committee.

II. INVERTEBRATE SUBCOMMITTEE REPORT

INTRODUCTION

This report is a summary of advice and recommendations resulting from the PSARC Invertebrate (Shellfish) Subcommittee, held August 31-September 1-3, 1992 at the Coast

Bastion Inn, Nanaimo. Twelve working papers and eighteen fishery and science updates were reviewed (Appendix 2). Presentations were made by staff from the Shellfish Section, Pacific Biological Station, Biological Sciences Branch, biologists from the North Coast, South Coast, and Fraser River divisions of the Fisheries Branch, and by a biologist from the Province of British Columbia. D. Mackas represented Biological Sciences Branch, from the Institute of Ocean Sciences and D. McKone, Chairman of the Subcommittee also represented the Biological Sciences Directorate, Ottawa.

Invertebrate landings increased rapidly in the 1980's but have declined since 1987 primarily as a result of a reduction in intertidal clam and geoduck landings (Table 1). A decline in manila clam landings of 20% in 1989 from 1988 is followed by a continued decrease in 1990 and 1991. The reduction in landings for this species reflects the fishing down of virgin biomass, annual recruitment to the stock and increased monitoring of the fishery. Dungeness crab landings increased markedly between 1989 and 1990 as a result of increased effort in area 1 but have declined in 1991. The geoduck clam fishery continues to be the highest landed value species in 1991 but red sea urchin landings doubled to become the first in landed weight. This change is from a 70% increase in red sea urchin landings, mainly, in north coast management areas 4 and 5 during 1991.

A total of 887 personal fishing vessel licences and 1998 personal fishing licences without vessels were issued for invertebrate fisheries in 1991. The landed value of invertebrate fisheries was about $43.9 million (including oysters, $3.5 million) in 1991, a slight increase over the previous year (Table 2). The continued decline in value of geoduck and intertidal clam from 1989 was partially compensated for by the value of the increase in total landings of red sea urchins.

Recommendations from this Subcommittee in 1992 provides the basis for advice to the Regional Executive Committee for development of 1993 management plans. Considerable work has been accomplished and initiated but important work has not been undertaken due to lack of resources. As a result, many recommendations this year are the same as in the past and are still regarded as high priority.

Highlights of Subcommittee Report

1.In 1992, the Subcommittee focused on research on geoduck, with 2 modelling papers, a paper on spatial distribution and sampling, a paper on growth and mortality estimates and a paper on geoduck quotas for 1992/93 were presented. There is currently insufficient data to support a change in management strategy, and continue studies on recruitment and mortality estimates are needed to validate the models before considering changes to current yield recommendations (see I92-01 to 04 and 10).

2.The Subcommittee recommends expanded research on growth, mortality and recruitment for all commercially harvested echinoderm species. Red urchins landings have doubled in each

of the last 2 years and the landed weight of this species is now the greatest of all invertebrate species. The Subcommittee is particularly concerned that the exponential increase in landings in the north coast, over the last two years, may not be sustainable and recommends that landings be capped at some pre-expansion level until appropriate biological data can be collected and analyzed. Green sea urchins have shown a decline in CPUE (33-38% since 1989). Purple sea urchins appear to have a low recruitment and a patchy distribution and harvesting should be restricted until more biological information has been collected and analyzed. There is a general lack of biological data on sea cucumbers and trends in the fishery suggest a decline in mean weight and abundance in exploited areas (see I92-13).

3.The abalone fishery remains closed and alternate survey methodologies remain to be determined in cooperation with industry.

4.The 40% decline in intertidal clam landings is not considered a sign of stock collapse but rather removal of the previous accumulated stock and a reduction in days fished.

5. The Invertebrate Subcommittee plans to hold a workshop with US State biologists on geoduck stock assessment and biology in late winter, 1993.

6. The Invertebrate Subcommittee recommends that the Steering Committee approve sponsorship of an international symposium on invertebrate stock assessment and management in 1994.

7. At the request of RMEC the Subcommittee discussed biological and management objectives and suggests the following framework;

> (i) Establish a Biological Objectives Working Group of two people from each of the Groundfish, Pelagic and Invertebrate Subcommittees to develop specific biological objectives. The Subcommittee recommends it's representatives be Sue Farlinger and Glen Jamieson.
>
> (ii) It is recommended that Fisheries Management Branch be responsible for the development of management objectives by establishing a separate Working Group, possibly through the existing Invertebrate Working Group structure.
>
> (iii) It is recommended that a Steering Committee be established to oversee the work of the groups and once draft documents have been produced, consideration be given to solicit comments from non-government groups before finalizing the documents.,

8. The Leslie analysis was not reviewed during this meeting as it was not used in any species assessment. Thus, the Steering Committee recommendation from the previous year on the appropriateness of the model for invertebrate species was not considered.

MANAGEMENT POLICY

Changes to management policies have been made over the last year which are outlined below.

MAJOR FISHERIES

Dungeness Crab Fisheries: Entry was limited in 1991, 224 licences.

- A minimum size limit protects a breeding stock of males and females.
- Non-retention of females sustains egg production.
- Some closures are set for time periods when many crabs have soft shells, to improve quality and reduce handling mortality.
- Limited entry and area licensing control size of fleet and reduce local fishing effort.
- A biodegradable escapement device is required for traps.

Prawn Trap Fisheries: Entry was limited in 1990, 273 licences.

- In season monitoring using a spawner index is carried out to allow a minimum escapement of the spawning cohort of prawns within a management area.
- Trap escapement modifications and a minimum size limit are in place to maximize the economic yield and reduce handling mortalities of prerecruits.
- Study areas were monitored to examine alternative management practises.

Intertidal Clams: Entry is open to anyone with a clam harvesting licence (2655 in 1991). Support vessels are not licensed.

- Minimum size limits allow clams to spawn at least once before being caught in the fishery.
- The coast has been divided into six areas. Harvesters can only dig clams in one area.
- Some beaches are closed seasonally to reduce mortality of sublegal clams from repeated harvesting or due to high risk of paralytic shellfish poisoning (PSP).
- In the north coast, harvesting is limited to razor clams in area 1 and an experimental manila clam fishery (proposed) in area 7 .

Geoducks: A limited entry fishery with 55 vessels, each having equal quota licences.

- Management by maximum sustained yield proposed at annual exploitation levels of 1% of the original biomass.
- Area quotas have been established.
- Equal quotas have been assigned to individual boats to provide a more

efficient year round harvest.
- Validation program monitors landings.
- There are rotational fishing quotas, most areas are fished once every three years.
- Quota areas are subdivided to prevent local overfishing. Heavily harvested beds are closed to allow recovery and effort is redistribute to beds that are fished less heavily.
- P licences have been issued in the north coast, where shore-based processing is less available.

Red Sea Urchin: Entry was limited in 1991, 102 licences.

- Area and subarea quotas have been set in the south coast to limit growth of the fishery while biological data is obtained.
- There is a 100 mm minimum size limit coast wide.
- Quotas for some south coast areas are based on survey data and observed recruitment rates.
- The season in the south coast has been limited to the period October 15 to February 15, and June 1 to August 30. The traditional period of peak demand and highest prices.
- The north coast has been open year round, with substantial increase in landings in 1991. A minimum and maximum size limit (140 mm) and rotational fisheries are in effect rather than quotas.

Green Sea Urchins: Entry was limited in 1991, 47 licences.

- Season is limited to between October 1 to February 28, the period of highest roe yield and market demand.
- A minimum size limit of 55 mm is set as a condition of licence. Proposed for change in the regulations.

Abalone: A limited entry fishery with 26 individual and equal quota licences. The fishery was closed in 1991 and remains closed in 1992. The following restrictions applied in 1990.

- season was limited to 8 months.
- coast wide quota was 47t. Landings were validated.
- size limit allows 2 or 3 y of spawning before recruitment to the fishery.

Sea Cucumber: Entry was limited in 1991, 79 licences.

- Precautionary quotas have been set for five regions of the coast (800 tons in total) to limit growth of this fishery until further biological data are obtained on growth, age and recruitment. There has been rotation of fishing

areas in the south coast.

Shrimp Trawl: A limited entry fishery, 249 licences.

- Several species and stocks are exploited. Generally, the stocks are managed as inshore and offshore.
- It may be possible to manage inshore stocks on a sustained yield basis. Biological data are being collected by a mandatory logbook program, but to date there have not been any restrictions on the fishery.
- Offshore stocks have shown high fluctuations in abundance.

MINOR OR DEVELOPING FISHERIES

Most of the minor or developing fisheries are currently regarded as underutilized. The growth in these fisheries has been mainly limited because of the lack of markets and biological information to assess the possible sustained yield.

The management policy in general has been to allow these fisheries to proceed with few restrictions but to require logbooks to document catch, fishing effort, and locations of harvest. Examples of the minor crab species are, squid, octopus, goose barnacles, clams, and mussels.

Horse clam: Harvest is limited to areas of geoduck fishing.

Euphausiids - Plankton: A conservative quota (500 t) has been set for inshore waters (Strait of Georgia and adjacent waters).

Scallops: Minimum size limits have been set to allow scallops to spawn at least once, and possibly more times, before entering the fishery.

Experimental Fisheries: Invertebrate species fished without a licence under the authority of scientific permits. Permits issuance is restricted in number and by area, and biological sampling is generally required as a condition of the permit.

PAPERS AND RECOMMENDATIONS

This section starts with a summary of biological and management objectives and ends with a summary of a review of shellfish logbook data. The rest is ordered by species and contains summaries of position papers and associated reviews as well as a list of Subcommittee recommendations for the various species. Subcommittee recommendations are based on data presented in position papers. Consideration was also given to information from science updates and fishery updates.

Biological and Management Objectives for Invertebrate Fisheries.

The requirement for explicit biological and management objectives has been raised in regional invertebrate groups, by the PSARC Steering Committee, RMEC and as the subject of an international workshop sponsored by DFO in November 1991. Management strategies and reference points discussed were mostly in terms of target fishing mortality. Fisheries for the numerous invertebrate species are based on an equally numerous set of implicit or stated biological objective (minimum spawning biomass, MSY, and other). They are not however, explicit or documented. The only written objectives are those set out in the annual Commercial Fishery Management Plans which are poorly defined and only measurable in the grossest terms, such as the presence or absence of a fishery. This paper documents strategies, objectives and reference points discernable in the current management system.

As the North-East Pacific invertebrate fisheries have developed as secondary or relatively new fisheries, development of biological and management objectives has lagged behind fishery expansion. Generally, until recently, these fisheries have been under subscribed, of lesser economic importance and free from the scrutiny applied to higher profile species. In the 1980's the profile of these fisheries has changed and they are now subjected to the kind of effort which requires tighter management, adequate stock assessment and a clear statements of risk of harvest levels on the resource. Management to date could be defined as remedial incremental adjustments (Leaman, pers. comm.) and has been plagued by two issues: that population dynamics are poorly understood, and that policy regarding management, social and economic values are not clearly defined and they are interpreted differently by all parties.

Recommendations:

1. Biological objectives be developed by a Working Group composed of a two members from each of Groundfish, Pelagic and the Invertebrate Subcommittees. Management objectives should be developed by Fisheries Branch.

2. The development draft objectives should be overseen by a Steering Committee to consider possible policy implications. A process for non-governmental input should also be considered by the Steering Committee.

Geoduck

I92-01. Density and Distribution of Geoducks in Two Study Areas of Southern British Columbia.

Two half-hectare plots near Gabriola Island and four quarter-hectare plots in Ritchie Bay were permanently marked in geoduck (Panopea abrupta) beds during 1990 and 1991. Divers

counted geoduck necks showing above the substrate in 5 m^2 consecutive quadrats along 50 m strip-transects placed 10 m apart. Average densities (adjusted for proportion geoducks "showing" at any particular time) were 1.89 geoducks/m^2 preharvest and 0.82/m^2 postharvest in harvest plot 1 and 2/m^2 for control plot 2 at the Gabriola study area. Similar results were found for the Ritchie Bay study area although mean densities of geoducks were higher than for Gabriola. The highest mean densities were 5/m^2 for control plot 2 at Ritchie Bay. Comparison of 1 m^2 versus 5 m^2 quadrats along 50 m transects indicated similar mean densities. However, 1 m^2 quadrats transects took three times as long to sample as 5 m^2 quadrats transects. Analyses indicated that the distribution of geoduck densities followed a negative binomial distribution, with variances increasing at roughly 1.26 power of the mean for 5 m^2 quadrats. Maximum likelihood estimates of the parameter k, for the negative binomial distribution, a measure of the spatial aggregation of geoducks, were variable.

The review of this paper and discussions of the Subcommittee focused on whether the methodology could be used in other areas to determine the density of geoducks for assessing stock abundance. The findings that sampling 5m^2 quadrats is more efficient that smaller 1m^2 quadrats could be useful in enumerating densities. The analysis of the data using a Negative Binomial was thought to be useful but the author was encouraged to also explore other methods of analysis.

I92-03. Study of Geoduck Populations from Two Areas in Southern British Columbia: Growth and Mortality.

Samples were taken to determine age frequencies, mean age, growth and mortality rates of the geoduck *Panopea abrupta* from two areas in southern British Columbia. Geoducks were on average older at Gabriola (40.9 y) than Ritchie Bay (35.8 y) with a large recruitment pulse having occurred at Ritchie Bay within the last 20 y. Although growth of *P. abrupta* was variable between individuals within an area, geoducks clearly grew slower at Gabriola than at Ritchie Bay. Shells became heavier at a faster rate than soft body parts for geoducks of equivalent shell lengths from Gabriola than from Ritchie Bay. Overall mortality rates (Z) calculated from log age frequencies were similar for geoducks from both study areas (0.037-0.039 when ages were >29 y and 0.016-0.020 for ages >6 y). These mortality estimates were similar and within the range reported for other geoduck populations in the literature.

The reviewer's comments and the Subcommittee thought that more conclusions could be drawn from the analysis. For example the age distributions were different in the two areas. Further discussion focused on the appropriate ages to include in the log regression analysis estimates of natural mortality. Under sampling for younger ages was discussed and the use of 6 years old as a cutoff point for the age frequency analysis. Including the younger age groups may result in an lower natural mortality estimate as sampling for these groups is though to be poor. Other analysis have indicated that a more appropriate cutoff age might be 12 which would increase the natural mortality estimate to around 0.035. For further discussion see I92-02 and I92-10.

I92-04. Geoduck Quotas for the 1992-1993 Fisheries.

The geoduck clam fishery is managed by setting area quotas which are summed and then equally divided for 55 Individual Vessel Quotas. The coast is divided into three licence areas: north coast, southern inside waters and the west coast of Vancouver Island. A three year rotation of fishing areas was also implemented in 1989, with the Individual Quota (I.Q.) program to reduce the annual number of landing ports.

It appears that the total harvest to date exceeds the current estimates of stock and production. This has been compensated, in 1992 and 1993, by closures and quota reductions.

Due to stock uncertainties, industry agreed to reduce the quotas but on the basis of a two year plan, set so that the industry could plan their fishery and market the product. Reductions of annual quotas by 15 % each season for 1992 and 1993 were accepted by industry in 1991. A licence will be moved each year from the west coast of Vancouver Island to the north coast.

To determine the 1992-1993 quota options, the hectares of known commercial fishing areas were calculated (1-631 ha) and original densities were estimated as 1 geoduck/m^2 for southern inside waters, 2 geoducks/m^2 for the west coast of Vancouver Island and higher densities of 3.5 geoducks/m^2 for beds in the north coast. Yield options of 1% were recommended for all areas in 1992 and 1993. There is a great uncertainty as to the stock size of subtidal geoduck clams. A number of beds that have been heavily exploited were closed in 1992-1993.

The reviewer's comments and the Subcommittee recognized that estimating geoduck abundance is particularly difficult as the bed size must be accurately estimated and estimates of no shows must be known to accurately estimate density. The main sources of information is from limited surveys and logbook information. Due to possible errors in the estimates of population size the current conservative management policy was thought to be the best route to follow. More biological information needs to be collected an analyzed particularly for natural mortality, recruitment and bed size.

I92-02. Yield and Risk Analysis for the Geoduck Fishery in Two Areas of Southern British Columbia.

An age structured model was developed to simulate known geoduck growth and mortality rates to test the effect of changing fixed fishing patterns on the long term yield of geoducks to a fishery. A stochastic component in the model incorporated uncertainty of estimating initial biomass (β_0) of the geoduck population from initial inputs of geoduck density and bed size. The uncertainty of estimating β_0 was incorporated in terms of risk to the fishery under a variety of management options of different harvest rates by a combination of a variety of fixed quota levels (0.05%-70% of β_0) and rotations of pulse fishing (1-70 years). Assumptions were made on constant rates of recruitment and natural mortality rates of prerecruit juveniles

including effects of juvenile vulnerability to indirect fishing effects and juvenile survival to different adult densities.

The model was run at 100 or 200 years per run in sets of 100 runs per set. Each set of runs had the same parameters with a different β_0 randomly chosen per run. Natural mortality was set at 0.02 but also tested at 0.03 and 0.04. Output of model provides statistics on risk of collapse <20% β_0, mean, min, max and SD values on accumulated yield, biomass remaining, year of collapse and age structure of the population from each run.

Assuming low recruitment (1.6% of N_0) the model suggested that average annual removals of near 0.5% β_0 would be appropriate to stabilize geoduck population at about 50% β_0 over a 100 year period. This suggests that (1) a slightly more conservative approach than a 1% β_0 removal rate/year could be adopted and (2) with higher natural mortality (e.g. 0.03-0.04) recruitment would be expected to be higher (e.g. 3-4%) to obtain an population equilibrium. In areas where there might be known higher recruitment (e.g., 6% of N_0) high rates of annual removal up to 2% β_0/year could be appropriate.

Different combinations of quota and rotation (pulse removal) could be employed depending on local geoduck bed conditions as long as the goal of average annual rate of removal was met. Some beds that have had more than 1% of geoducks removed per year should have longer rotation closures to allow biomass recovery.

Without empirical estimates of geoduck biomass, recruitment and natural mortality especially for juvenile prerecruits (ages <7 y) for each geoduck area this modelling exercise should be viewed with caution.

I92-10. Sustainable Fishing Patterns for Geoduck Clam (*Panopea abrupta*) Populations in British Columbia.

A simple age-structured stochastic model was used to examine the impacts of various fishing patterns, all based on a constant-catch fishing strategy, on populations of geoduck clams. The model was initialized from published data on longevity, growth, natural mortality and recruitment; and from unpublished data on recruitment variability. Assumptions were made about the incidental morality of fishing on juvenile geoducks, and on the form of the stock-recruit curve. The fishing patterns examined were combinations of constant catches (in the range 0.2-4.0% β_0) and rotation periods for pulse fishing (in the range 1-14 years).

For each set of 100 runs, statistics were calculated for 6 fishery indicators. Three indicators related to the population biomass and three to the ability of the fishery to take the target catch.

Appropriate fishing patterns were then identified for the 6 indicators defined. Pulse fishing has no obvious biological benefits but confers a small economic advantage. Pulse fishing is useful to examine even if populations are not explicitly pulse-fished, because real fishing patterns are not uniform in space and time.

Previous sustainable yield estimates appear to have been in the appropriate range suggested by this study. The current fishing pattern used by British Columbia fishery managers is conservative.

Sensitivity of one indicator is examined with respect to the major uncertainties: the natural mortality rate *M* is the most important uncertainty.

Science Update 04: Marina Island Geoduck Survey.

A survey of geoduck density and bed area was undertaken by commercial geoduck divers June 23-July 31,1992. Over 13 days, four divers surveyed 67 transects around Marina Island, Area 13, covering more than 100 ha. An additional six transects were surveyed on other project days. A series of nine show plots, each 20 m^2, were established.

Three plots, each 0.25 ha, were marked out in the same manner as plots at Gabriola Island (Area 17) and Meares Island (Area 24). The plots were surveyed and then two plots were harvested. In Plot 1, 1326 geoducks were harvested (0.53 geoducks/m^2) in four days in repeated dives (5 times). There were 878 geoducks taken from plot 2 (0.35 geoducks/m^2) over five days and seven passes were made over the plot. Plot 3 has been left as a control to monitor relative recruitment in harvested and harvested areas.

A biological sample of various size ranges of geoducks (100-200 geoducks) was collected along with a sample of 525 from the harvested plot for ageing.

Geoduck summary of reviewer's comments and Subcommittee discussions of papers I92-01 to 04 and 10:

The reviewer's of I92-02 and I92-10 and the Subcommittee felt these two papers were good first attempts at modelling geoduck populations. Two parameters of the model play a key role in determining the results of the simulations: 1) natural mortality and 2) recruitment. The estimate of natural mortality using age frequency information is particularly sensitive to sampling bias. Since young geoducks are hard to sample, their numbers are usually underestimated and picking the right cutoff age can diminish the effects of sampling bias. Using a lower cutoff age will result in a low natural mortality estimate. Estimates of natural mortality can be used to construct a population and the percent at age can be compared to actual frequencies. From Noakes (I91-03) a reasonable estimate of natural mortality would be 0.035. Further analysis should also consider the possibility that geoduck natural mortality may be age specific rather than constant.

Very little is known about geoduck recruitment except that it is likely very low given the species is long lived. The authors of the two papers used different estimates of recruitment which influenced the simulation results and the conclusions. Breen (I92-10) selected starting values randomly around a Beverton-Holt curve. Campbell (I92-04) used a constant annual

recruitment which gave a number equal to 1.6% and 6% survival of the initial population reaching a fishable age (7 y). Both authors explored pulse recruitment.

Breen suggested the current exploitation of 1% of virgin biomass (β_0) was conservative and that pulse fishing has no obvious biological benefits. Campbell recommended a 0.3-0.5% annual exploitation of β_0 and suggested increasing the time interval between exploitations from the current 3 y for those beds that had been fished above a 1% annual exploitation level.

With their respective starting parameters, Breen ran his model for a 50 y interval and suggested little risk of the biomass collapsing. Campbell agreed with this for 50 y but ran his model for 150-200 y and showed there was risk of collapse after 100 y.

The subcommittee also discussed that a preliminary survey of deep stocks, i.e., below normal diving range, is under way.

Summary of recommendations for papers I92-01 to 04 and 10:

1. The Subcommittee recommends that further work should be done on evaluating recruitment and natural mortality. The assumption of constant natural mortality should also be reconsidered in any new analysis.

2. Conservative levels of harvest should be maintained; quotas should not be increased until surveys have been undertaken on the distribution and abundance of geoduck clams and recruitment.

3. There is concern about local over-harvesting of easily accessible beds of the highest quality. Beds should not be harvested below 50% of the original estimated biomass. Sites heavily harvested 5-10 years ago should be surveyed to determine recruitment responses.

4. Additional information is required on geoduck densities and the size of beds in each management area. Further consultation with fishers and a program of planned surveys should be initiated, surveying one or more areas per year.

5. Market sampling should be undertaken to determine differences in size and age composition between areas (used in evaluating quotas) and to obtain comparison of current data with the 1983 study.

Intertidal Clams

I92-06. Clam Surveys at Savary Island, British Columbia, 1987 to 1991.

Commercial coast wide clam landings increased substantially in British Columbia during the 1980's to 4,360 t in 1988. Since 1988 landings have decreased coast wide and were approximately 1,478 t in 1991. This decline in landings is attributed to several factors; 1) most clam beaches are now fully exploited such that accumulated older year classes of clams, which had supported the fishery, have now been harvested, 2) the clam fishery is now largely dependant on annual recruitment which can be highly variable year to year and 3) there have recently been reduced fishing times in most areas as a result of more conservative management of this fishery.

Savary Island supports one of the most important manila clam fisheries in British Columbia. Due to intensive harvest and declining stocks, the commercial clam fishery on these beaches has been closed since 1990.

Surveys of commercial clam populations have been carried out on three beaches on the north side of Savary Island since 1978. Results of surveys between 1987 and 1991 are reported here. Increased densities of sub-legal sized manila clams as a result of new settlement, were noted on two beaches surveyed in 1991. This followed a second consecutive year of closure. The third site was not surveyed in 1991. Settlement and recruitment of manila clams in 1991 was significantly less than that observed on these beaches during the period 1982 to 1984.

The increased density of sub-legal sized manila clams may be related to the absence of commercial fishing at Savary Island since 1990 or may be the result of a natural phenomenon in the population.

The reviewer's comments and the Subcommittee discussion focused on whether the closure should be continued. Recent recruitment has been good and the stock is rebuilding but there is a possibility that allowing a fishery now could result in a high mortality of the young animals before they recruit to the stock.

Recommendations:

1. If the results of the repeated digging experiments demonstrate significant harvest induced mortality of sub-legal sized clams; then a continued closure of the commercial fishery at Savary Island, in 1993, will allow opportunity for better survival of pre-recruit clams to recruit to the fishery.

I92-05. West Coast Vancouver Island Intertidal Clam Surveys - Areas 23 to 27 - 1989 to 1992.

In the late 1980's and early 1990's, commercially harvested intertidal clams have dropped from the all-time high landings of the mid-1980's. There is concern that overharvesting may be occurring. Consequently, in the past 4 years, open seasons for the harvest of these clams have been progressively shortened.

During the period 1989 to 1992, 20 of the 91 reported commercial intertidal clam beaches were surveyed to estimate stock composition and abundance and to monitor changes in these parameters in the presence of declining effort and catch. Not all beaches were surveyed in each year. Mean densities and length frequency distributions for manila, native littleneck and butter clams were determined for each beach in each year surveyed.

Except at Hillier Island in Area 23, littleneck clams predominate on most beaches on the West Coast of Vancouver Island. Mean densities of legal and sublegal clams are variable between beaches. There has been a general decline in legal littleneck clams over the period surveyed. Littleneck clams recruited more strongly than manila clams, and recruits were most abundant in 1990. Butter clams are not abundant on the surveyed beaches.

Area 26, closed entirely to commercial harvest for the past three years, shows no signs of substantial settlement or recovery through new recruitment as a result of this closure.

The review of the paper and discussion by the Subcommittee indicate that there has been reasonably good recruitment of littleneck but poor for manila. Temperatures have been above normal recently and they will likely continue to be high next year. There is a high probability that there should be an improvement in the spat deposition of manila calms. Continuing with the closure would allow sampling to continue over the next year without the possibility of mortality to the new spat from commercial fishing.

Recommendations:

1. Continue the Area 26 closure for at least one additional year to determine if the effects of El Nino, in 1992, produced a significant spatfall. Sampling for settlement should occur in an open area as well as Area 26.

2. If there has been a better than average settlement, closure of Area 26 should be continued to assess the effects of this closure on settlement and recruitment.

Science Update 02: Deep Water Clams (*Compsomyax subdiaphana).*

The deep water clam, *Compsomyax subdiaphana*, is widely distributed along the Pacific coast of North America in soft muddy substrate in subtidal depths from 2-550 m. Populations were known to occur in British Columbia but industry expressed no interest in harvesting them. Because of the recent decline in intertidal clam landings, a small experimental fishery began in 1991 in the Gulf Islands, in the South Coast District. Most of the fishing has been done with a Fall River rocker dredge and catches have ranged from 27-50 kg per 20 minute tow, mean about 40 kg per tow. Total landings during the period June 1991 to June 1992 were 1.4 t from 14 days of fishing. A wide range of clam sizes observed in catches indicated that regular recruitment has occurred in recent years. Biological data on age, growth, length-height-width and weight relationships, time of spawning and associated fauna are being collected. Development of this fishery will depend on the extent of the resource, markets and the economics of harvesting.

Recommendations:

1. The fishery for *Compsomyax subdiaphana* should remain a small experimental fishery using only rocker type dredges until more biological information is obtained on the extent of stocks.

Shrimp

I92-07. West Coast Shrimp Assessments.

A shrimp biomass survey on the Tofino ground, [fisheries statistical area (FSA) 124] was conducted May 11- 23, 1992 using the research vessel W. E. RICKER. The Tofino shrimp ground lies offshore on the west coast of Vancouver Island between 48°40' and 49°15' north latitude. Since 1973, the survey has been conducted 16 times in the spring (April-May) and 3 times in late summer (August-September). Relative estimates of total biomass, year-class abundance, and distribution of the smooth pink shrimp, *Pandalus jordani* are undertaken.

Analysis of data from the present survey showed a total biomass decline of 53%. The indices of 3+, 2+ and 1+ animals have all declined from estimates in the 1991 survey. The prediction for 1992 was for a small increase over 1991. This prediction was based on a very weak 2+ year class in 1991 resulting in a low 3+ year class in 1992 (which is correct) and a strong 1+ year class in 1991 resulting in a strong 2+ year class in 1992, approximately the size of the 1989 2+ year class (an over-estimate which may in part be due to the heavy fishing mortality experienced in 1991 and the resulting high Z values of 0.65 compared with 1988 where Z=0.13 based on survival of 2+ to 3+ animals). For 1993 the prediction is again for a very weak 3+ year class, the strength of the 2+ year class will depend on the recruitment of the 1+ animals which varies greatly from poor such as was experiencing in 1992 to excellent such as experienced in 1987 and 1989. The one positive note is that some 1+ animals were present

in the samples, unlike in the surveys prior to the total collapse of the fishery in the 1980's. The fishery off the west coast will likely continue on small shrimp off the Tofino Grounds and some effort may move to the Nootka ground.

The reviewer and the Subcommittee recognized that the survey results show a continued decline in the stock to levels where possibly consideration should be given to closure of the fishery. Historically, fishing decreased when stocks declined below economic levels and the stock increased when recruitment improved. Further there is some incentive to decrease effort, in the short term, by fishing on the smaller more abundant Nootka grounds.

Recommendations:

1. It is anticipated that the fishery off the Tofino grounds will be very poor with most of the shrimp being small. If the industry continues in its' restriction on landing of small shrimp (~120 counts) there should be no need for management actions. If however, there is a shift to landing small shrimp the fishery should be closed and the animals allowed to grow.

Urchins

I92-13. Size Structure and Gonad Quality of Purple Sea urchins *(Strongylocentrotus purpuratus)* in Southern British Columbia.

This is an experimental fishery with a population that is limited and with patchy distribution. Size frequency samples indicate low recruitment of subtidal *S. purpuratus* on the southwestern coast of Vancouver Island. Purple sea urchins are difficult to collect since they occur in high wave action areas. Although *S. purpuratus* can occur in dense populations (>100/m^2) their distribution is irregular. Gonad quality was highest during November and December and subsequently declined reflecting the seasonal reproductive cycle. Variation in gonad total weight ratios was greatest in May 1992 compared to November-December 1991. Based on published literature, purple sea urchins from the intertidal zone are shown to have slow growth rates (large individuals can be over 50 yr old), are mature at >40 mm diameter, reproduce annually with large gonads during fall-winter and have low and sporadic recruitment and larval settlement. More information is required on the growth, reproduction distribution and abundance of subtidal *S. purpuratus* in British Columbia.

The major points of the reviewer and the Subcommittee were in relation to the lack of biological information on this species and the patchy distribution. There is high possibility of fishing the stock to low abundance if effort is not controlled.

Recommendations:

1. Recruitment, growth, seasonal gonadal development, spatial distribution and size at maturity should be determined for evaluation of optimal management strategy of purple sea urchins.

2. Catch and fishing effort should be restricted until further biological information on recruitment and growth become available to allow an evaluation before implementing an increased or decreased fishery.

3. Minimum legal recruit size should be increased to protect a greater proportion of spawning population.

Sea Cucumber

I92-12. Sea Cucumber Assessment.

Little is known about age, growth and mortality of the California sea cucumber, *Parastichopus californicus*.

There are numerous data problems in the fishery that make an assessment difficult. Product is sold in both round and split forms but not clearly identified on sales slips or logs. This makes it difficult to convert landings to a single measurement of either round or split weight. Licence holders are not submitting logbook data on a timely basis.

The on-grounds management has had problems with unlicensed boats fishing and the occurrence fishing prior to the opening and stockpiling product. Vessels and packers have not correctly hailed landings and quotas were greatly exceeded again in 1992. There is a persistent illegal recreational fishery that cannot be restricted because there is no sport bag limit. A sport closure should be considered.

A preliminary assessment indicates a serious problem in the South Coast. The diver CPUE has decreased by 60% over the period 1987 to 1991. A limited market sample from heavily fished areas in inside waters indicates the possibility of decreased mean weights of sea cucumbers. There have been numerous qualitative observations that the populations of sea cucumbers have declined in inside waters. Mean weights of WCVI sea cucumbers have increased as fishing was carried out in previously unexploited areas.

The reviewer and the Subcommittee were concerned that there appears to be a decrease in mean weight of animals in highly fished areas. The lack of biological information prevents a good analysis of the stock status.

Recommendations:

1. Trends towards lower mean weight, declines in CPUE, anecdotal information reporting declines in numbers, and a lack of basic biological information requires that conservative management practices continue, possibly by quota reduction or closure.

Crab

I92-11. Re-evaluation of Dungeness Crab Morphometrics.

Morphometric analyses of total body length of Dungeness crab in 1991 showed no significant differences among crab from seven South coast locations, but suggested that Skeena crab might have significantly different body proportions. Subsequent study indicated that carapace length rather than total body length was a more meaningful parameter to measure. Abdominal component of total body length measurement was found to very with the increased time that crab had been removed from water, and this was not standardized in field sampling.

Re-evaluation of crab morphometric data, using carapace length, indicated no significant variability between regional Dungeness crab populations in British Columbia. It is therefore recommended that one escape ring size regulation apply to the whole coast.

The reviewer and Subcommittee support the conclusion of the report. The appropriate escapement ring size of 110 mm should be instituted coast wide.

Recommendations:

1. The 110 mm Dungeness crab escape ring previously recommended for the south coast only is now recommended for the entire B.C. coast. No regional variation in escape ring size should occur.

Science Update 03: Box Crabs (*Lopholithoides foraminatus*).

Two permits were issued to fish box crabs, one in 1990 and one in 1991. As a condition of the permit, biological sampling was the responsibility of each fisherman. Results of these samples show that crabs sampled in Area 16 in 1991 were slightly larger than those fished in Areas 23 to 26 in 1990. No permits were requested in 1992.

Barnacle

Science Update 01: Goose Barnacle Survey.

During a feasibility study of harvesting goose barnacles in 1985-86, there was precise recording of experimental harvest locations. This study, 6 y later, revisits some of these harvest sites and describes goose barnacle settlement on them. Two of the study sites revisited were also qualitatively assessed 1, 2, 3, and 4 y after the initial harvest, and these data are also considered.

After 6 years, it was not possible to visually discriminate between harvested and adjacent harvested areas. New bare patches, both outside and within previously harvested areas at the two sites monitored annually, were not the result of the 1985 harvest. Populations of commercial size goose barnacles can develop in 3 y following successful settlement, but such settlement is sporadic. Other barnacle species or animals are just as likely to settle on bare patches. Settlement and growth rates varied considerably among sites.

Recommendations:

1. Sites revisited were not totally reflective of the areas currently fished, and probably provide a conservative estimate of settlement and growth rates. Study of more productive sites is recommended. Growth and mortality data in the exposed areas where the fishing typically occurs is required.

2. Current marketing of only a live product permits exploitation of only about 10% of the goose barnacle population. Should markets for a non-live (e.g., frozen) product be developed, a much greater exploitation could occur. If this is allowed a detailed assessment would then be needed.

3. The use of pneumatic chisels and other powered devices used in goose barnacle harvesting should be environmentally assessed.

I92-08. Review of the Use of Logbook Data in Invertebrate Fisheries Research and Management.

There are 8 logbook formats for more than 30 invertebrate commercial species currently harvested in British Columbia. Annual DFO resources committed to logbooks are estimated to be $35 to 40 k and 2 PYs. Fishers contribute both time to complete logs and pay for the logbooks; it is estimated to cost $25 k for annual printing and keypunching, and $10 k for administration. Cost of the logbook program is relatively small compared to what direct field assessments might otherwise cost.

Logbook data is the basis of assessment in geoduck, documents fishery characteristics in general for all species, and is important in numerous management applications (eg. environmental emergency responses). Logbooks provide detailed catch and effort data and specific harvest locations that are not available from sales slips. Logs have supported many management actions, from closure of the abalone fishery to a reduction of quota magnitude in the geoduck and sea cucumber fisheries. Logbooks may in the future form the basis of new management in the prawn fishery. Logs also form a valuable point of contact and interaction with the fishers.

Logbook status, format, and application are reviewed for invertebrate fisheries in British Columbia. Benefits and usages of logbook data are considered, particularly with respect to stock assessments. It is concluded that the logbook system provides a unique data base important to regional fisheries management. Recommendations are given as to how the logbook data system might be improved in the context of changing available resources to operate it and projected future usages of the database.

The reviewer's comments and discussions by the Subcommittee considered that the paper provided a good background and scope of the present system.

Recommendations

1. Additional resources are required for maintenance and development of logbook data bases, through expansion of cost recovery programs, staffing positions in BSB and FB, and any other possible sources. These resources would be used to address backlogs of unprocessed logbooks for several existing programs, to support new logbook programs in new or expanding fisheries, and to allow development of important analytical uses of logbook databases (e.g., spatial analysis and georeferencing).

2. FB and BSB should review the completed FMIS documentation on shellfish. Following the review, the FMIS Shellfish initiatives should move to implementation. Implementing the Shellfish portions of FMIS should lead to completion of the conversion of logbook databases to INGRESS, and should ensure effective cross-referencing to other databases including the catch-effort database commercial sampling data, bridge logs from commercial vessels, gear descriptions and inventories and patrol vessel fishing activity logs.

3. The format and content of logbooks should be reviewed for each species and modified as necessary. If uses cannot be identified for some items being recorded, consideration should be given to dropping those items. New data uses may justify adding items to logbooks, or modifying formats to allow more efficient uses of data currently captured.

4. Current logbook programs cover only commercial fisheries. For some species (e.g., Dungeness crab, abalone) sport, native and illegal fisheries remove significant amounts of biomass. These removals need to be documented. The feasibility of programs such as creel surveys or logbooks for non-commercial fisheries should be explored for such species, and implemented where they are feasible.

Table 1 Landings of invertebrates in tonnes in British Columbia, 1981 – 1991

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991[1]
INTERTIDAL CLAMS											
Razor	30	68	31	101	90	142	142	155	117	114	117
Butter	120	103	77	131	252	159	69	134	92	109	44
Manila	317	597	1049	1677	1914	1894	3607	3908	2764	1456	979
Nat. Ln.	179	241	325	295	192	285	373	289	433	465	201
Mixed	161	155	280	410	478	371	87	27	159	339	137
TOTAL INTERTIDAL CLAMS	807	1164	1762	2614	2926	2851	4278	4513	3565	2483	1478
GEODUCK	2704	3135	2636	3483	5370	5006	5734	4567	3985	3956	3333
HORSE CLAM	51	321	21	7	6	96	355	325	115	124	110
SHRIMP	581	413	411	408	678	768	2644	2561	2299	1940	3027
PRAWN	358	274	331	505	514	550	620	720	820	761	840
CRAB	1317	895	960	1155	1165	1321	1631	1631	1522	2168	1869
ABALONE	85	82	56	58	42	52	49	49	49	50	N/A
OCTOPUS		18	30	25	32	53	129	209	217	198	117
SEA URCHIN	116	160	982	1764	1815	2067	2223	2559			
RED									2658	3158	6732
GREEN									611	475	574
SEA CUCUMBER				113	346	786	1722	1922	1144	870	450
SCALLOP		8	11	18	53	68	66	67	75	69	81
PLANKTON	19	0	47	103	131	166	130	247	360	530	441
SQUID		29	15	69	111	79	86	88	70	72	88
MUSSELS			tr	1	tr	2	2	3	4	1	tr
GOOSENECK BARNACLES						2	32	49	30	37	40
TOTAL TONNES	6038	6499	7262	10323	13189	13867	19701	19510	17524	16892	19180

[1] preliminary landings for 1991

Table 2 Landings in thousands of dollars of invertebrates in British Columbia, 1981 – 1991

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990[1]	1991[1]
INTERTIDAL CLAMS											
Razor	24	55	24	123	95	127	126	137	124	130	129
Butter	42	36	33	55	138	75	40	63	44	53	34
Manila	323	611	1043	1813	2278	2762	6003	7175	6003	3761	2574
Nat. Ln.	195	263	329	311	202	327	474	359	589	710	327
Mixed	175	169	293	455	575	510	132	36	196	625	238
TOTAL INTERTIDAL CLAMS	759	1134	1722	2757	3288	3801	6775	7770	6956	5279	3302
GEODUCK	2434	2814	1818	2937	4605	4294	6184	9762	12967	10582	9221
HORSE CLAM	42	235	12	5	6	63	309	300	144	274	119
SHRIMP	912	644	1073	1022	1180	1240	4609	2802	2985	2637	4105
PRAWN	2019	1545	2138	3262	3379	3734	4326	5724	7694	7006	6733
CRAB	3556	2345	2866	4558	4719	5661	6452	5555	5012	9350	8613
ABALONE	721	696	462	530	442	734	973	1076	1170	1347	N/A
OCTOPUS		39	63	56	82	136	381	651	707	657	379
SEA URCHIN			358	712	763	1011	1276				
RED								1108	1631	1953	4041
GREEN								569	1020	939	1687
SEA CUCUMBER				22	94	236	768	961	998	1168	942
SCALLOP		17	24	56	95	212	244	285	316	317	381
PLANKTON	6	0	19	42	89	113	102	192	223	415	366
SQUID		22	21	25	184	127	132	113	94	81	112
MUSSELS		tr	tr	tr	0	tr	tr	tr	tr	1	tr
GOOSENECK BARNACLES					1	4	211	479	343	413	418
TTL VALUE ($000)	10449	9491	10576	15984	18927	21366	32742	37347	42260	42419	40419

[1] preliminary values for 1990 and 1991

Appendix 1. Participants

1992 PSARC-Invertebrate Subcommittee Meeting

List of participants

August 31- September 1-3, 1992

Biological Sciences Branch, Pacific Biological Station

Neil Bourne
Jim Boutillier
Alan Campbell
Jake Rice
Ian Perry
Glen Jamieson
Don Noakes
Max Stocker
Jim Irvine (PSARC Chair)
Rick Stanley

Fisheries Branch

Barry Ackerman
Steve Heizer
Frances Dickson
Sue Farlinger
Rick Harbo
Bruce Adkins
Cindy Harlow
Kerry Hobbs
Marilyn Joyce
George Cronkite
Greg Thomas
Scotty Roxburgh
Bob Humphreys

Dave Mackas, Institute of Ocean Sciences
Doug McKone, Biological Sciences Directorate, Ottawa (Subcommittee Chairman)
Bill Heath, Province of British Columbia, Courtenay

Appendix 2. List of discussion papers, position papers, science updates and fisheries updates submitted to 1992 PSARC Shellfish (Invertebrate) Subcommittee

Number	Title and Author(s)
	DISCUSSION PAPER
	Biological and Management Objectives for Invertebrate Fisheries. S. Farlinger
	WORKING PAPERS
I92-01	Density and Distribution of Geoducks in Two Study Areas of Southern British Columbia. A. Campbell and D.W. Welch
I92-02	Yield and Risk Analyses for the Geoduck Fishery in Two Areas of Southern British Columbia. A. Campbell and J. Dorocicz
I92-03	Study of Geoduck Populations from Two Areas in Southern British Columbia: Growth and Mortality. A. Campbell and D.J. Noakes
I92-04	Geoduck Quotas for the 1992-1993 Geoduck Clam Fishery. R. Harbo, G. Thomas, and K. Hobbs
I92-05	West Coast of Vancouver Island Intertidal Clam Surveys Areas 23 to 27 - 1989 to 1992. S.R. Heizer
I92-06	Clam Survey at Savary Island, British Columbia 1987-1991. B.E. Adkins
I92-07	Assessment of the Area 124 Shrimp, *P. jordani*, trawl fishery. J.A. Boutillier and C.G. Wallace
I92-08	Review of the Use of Logbook Data in Invertebrate Fisheries Research and Management. G.S. Jamieson, R. Harbo and K. Hobbs
I92-09	This paper was changed to a fishery update.
I92-10	Sustainable Fishing Patterns for Geoduck Clam (*Panopea abrupta)* populations in British Columbia. P.A. Breen
I92-11	Re-evaluation of Dungeness Crab Morphometrics. G.S. Jamieson
I92-12	Sea Cucumber Assessment. S.R. Heizer, G. Thomas and R. Harbo

Appendix 2 (cont'd)

I92-13 Size Structure and Gonad Quality of Purple Sea Urchins, *Strongylocentrotus purpuratus* in Southern British Columbia. A. Campbell

SCIENCE UPDATES

1. Goose Barnacle Survey. prepared by Khoyatan Marine Laboratory
2. Deep Water Clams, *Compsomyax subdiaphana*. N. Bourne and R. Harbo
3. Box Crabs (*Lopholithoides foraminatus*). S.R. Heizer
4. Marina Island Geoduck Survey. R. Harbo, A. Campbell and S. R. Heizer

Appendix 2 (cont'd)

FISHERIES UPDATES

Molluscs

Geoducks..... R. Harbo, G. Thomas and K Hobbs

Horse Clams..... R. Harbo and K. Hobbs

Intertidal Clams..... F. Dickson and K. Hobbs

Oysters..... W.A. Heath

Scallops..... N. Bourne and R. Harbo

Octopus..... B. Adkins

Squid..... R. Harbo and K. Hobbs

Crustaceans

Crab..... M. Joyce

Prawn..... B. Adkins

Plankton..... B. Adkins

Goose barnacles..... B. Adkins

Echinoderms

Green sea urchins..... R. Harbo and K. Hobbs

Red sea urchins..... G. Thomas, S.R. Heizer and K. Hobbs

Purple sea urchins.....R. Harbo and K. Hobbs

Appendix 3.

SUMMARY OF BIOLOGICAL INFORMATION FOR MANAGEMENT OF INVERTEBRATE FISHERIES IN 1993

Appendices 3a and 3b following, summarize biological information needed for management of major, minor and experimental fisheries in 1993. These include crab and prawn trap fisheries, intertidal clams, diving fisheries for geoducks, sea urchins, abalone and sea cucumber and the offshore shrimp trawl fishery.

Species supporting minor fisheries are discussed in the second section. These include plankton, minor crab species, inshore squid, scallops, horse clams, octopus, goose barnacles and mussels.

A third section of the appendix describes experimental fisheries, including crab, ghost shrimp, deepwater clam, purple sea urchin and marine plants.

Appendix 3a

SUMMARY OF BIOLOGICAL INFORMATION FOR MANAGEMENT OF MAJOR INVERTEBRATE FISHERIES IN 1993

Major Fishery	Biological Information
TRAP	
Dungeness crab	1. Change in escape port size and number (2 ports at 110mm) for 1993. 2. Investigate biological basis for minimum size limit. 3. Continue logbooks.
Prawn	1. Complete analysis of study area data. 2. Continue annual seasonal coast wide closure. 3. Continue logbook and biological monitoring programs.
INTERTIDAL	
Intertidal clams	1. Prepare final report on repeated digging study. 2. Undertake surveys of settlement on the WCVI. 3. Maintain area 26 and Savary Island closure. 4. Research into clam farming techniques is required.
DIVE	
Geoduck	1. Conservative levels of harvest should be maintained at 1% of estimated prefishery stock size. 2. Maintain rotational areas. 3. Quantify geoduck bed areas and densities. 4. Examine heavily harvested areas for incoming recruitment. 5. Re-evaluate yields based on estimates of mortality. 6. Test options for rotational period with model. 7. Continue harvest logbook.

Appendix 3a Cont'd

SUMMARY OF BIOLOGICAL INFORMATION FOR MANAGEMENT OF MAJOR INVERTEBRATE FISHERIES IN 1993

Major Fishery	Biological Information
Red Sea Urchin	1. Landings should be capped at some pre-expansion level until biological information can be collected and analyzed 2. Survey roe quality in north coast. 3. Identify research reserves. 4. Continue harvest log system. 5. Continue and expand research to obtain biological information required to manage resource (evaluate size limits).
Abalone	1. Retain closure in the abalone fishery. 2. Review survey methodology in cooperation with industry..
Sea cucumber	1. Consider the establishment of quota reductions or closures in areas of high harvest. 2. Collecting basic biological data. 3. Examine fishery CPUE and marketing data to determine areas of decline. 4. Continue study of conversion factors. 5. Continue harvest log program. 6. Consider bag limit for sports fishery.
NET	
Shrimp trawl	1. Assess inshore fisheries. Consider active management. 2. Monitor catches.

Appendix 3b

SUMMARY OF BIOLOGICAL INFORMATION FOR MANAGEMENT OF MINOR INVERTEBRATE FISHERIES IN 1993

Minor Fishery	Biological Information
King Crab	1. Establish size limit. 2. Continue harvest logbook program.
Squid inshore	1. Continue harvest logbook program.
Euphausiid	1. Continue and evaluate logbooks.
Scallops	1. Continue and evaluate harvest logbook program. 2. Monitor trawl catches.
Horse clam	1. Catches should be monitored to detect changes in mean size in harvest. 2. Continue and evaluate logbooks.
Octopus	1. Continue logbook program. 2. Monitor offshore trap fishery.
Goose barnacle	1. Continue and evaluate logbook program. 2. Establish research study sites.
Mussels	1. Monitor landings.
EXPERIMENTAL FISHERIES	
Purple sea urchin	1. A cautious approach to purple urchin management should be continued. Any fishing should be closely monitored.
Marine Plants	1. No information available.
Callianassa	1. Monitor developing fishery.
Compsomyax (deepwater clam)	1. Limit fishing effort and restrict types of gear usage.
Tanner, Box, and Galatheid crab	1. Maintain harvest logbook program.

PACIFIC STOCK ASSESSMENT REVIEW COMMITTEE

PSARC ADVISORY DOCUMENT 92-4
SEPTEMBER 1992

HERRING

CONTENTS PAGE

I. STEERING COMMITTEE REPORT

The PSARC Steering Committee reviewed the Herring Subcommittee Report on September 30, 1992 at the Coast Bastion Inn, Nanaimo. The Steering Committee supported the recommendations in Appendix 4 and wishes to emphasize the following:

1) Advice to managers should emphasize that, although the West Coast Vancouver Island has been treated as one stock, managers should attempt to distribute harvest as widely as possible.

2) At the next Herring Subcommittee meeting, the implications to herring population dynamics of allowing total catches to exceed the 20% guideline should be examined. The Steering Committee feels this is an important task, but it also recognizes that recommendations 1 (investigating error structure of spawn survey data) and 5 (explanation of differences between results of escapement and age-structured models) given in Appendix 4 need to be dealt with.

3) The Steering Committee also stressed the importance of the recommendation that the Herring Working Group establish a process to monitor mortality and dumping rates in spawn-on-kelp fisheries.

4) The Steering Committee noted concern regarding the status of bait herring stocks in Johnstone Strait and the Strait of Georgia and requested an examination of the potential costs and benefits of increasing assessment effort on these stocks. In addition, the Steering Committee requested an evaluation of current South Coast Division initiatives with respect to bait fishery applications for these stocks.

5) Steering Committee recommends that a working group be established to review previous work on biological objectives, propose biological objectives for groundfish, herring, and invertebrates in the Pacific Region, and recommend a framework for developing non-biological objectives. Membership of the working group should be chosen from within the Salmon, Groundfish, Herring, and Invertebrate Subcommittees. The working group should complete a draft report by February 1993. This report should then be discussed by the respective Subcommittees prior to review by the Steering Committee.

II. HERRING SUBCOMMITTEE REPORT

The Subcommittee met at the Delta Pacific Conference Centre in Richmond during September 8-10, 1992 to derive a consensus on the status of herring stocks in 1992 and to forecast abundance and potential catch levels for 1993. 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), and summaries of documents, reviews, and Subcommittee discussions of working papers (Appendix 5) are attached.

The primary objectives for the meeting were to:

1. Review the stock assessment source documents and other pertinent stock assessment information, reach a consensus on stock status in 1991/1992, forecasts of abundance in 1992/93, and recommend 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).

Additionally, the Subcommittee had been asked by the PSARC Steering Committee to address the following issues:

1. Provide recommendations for a framework to develop management objectives for B.C. herring stocks.

2. Evaluate the biological implications of the quota overruns which have occurred in most roe herring fisheries since quota management began in 1983. The Steering Committee had expressed concern that localized areas may be overharvested.

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

1. Data quality - catch, spawn survey, age composition.

2. Spawn and stock trends - age-structured model, escapement model, spawn indices, in-season and winter hydroacoustic estimates.

3. Perception of stock status - charter skippers, district staff.

4. Recruitment trends - age-structured model, escapement model.

5. CUTOFF.

6. Forecast weighted run size - weighting and recruitment levels.

7. Additional information.

8. Quota recommendation.

Based on the evaluation of these criteria for each of the major assessment regions, conclusions were drawn on the current biological status of the stock and recommendations made as to the potential catch levels for each. As requested by the PSARC Herring Subcommittee in 1991, relevant assessment data were reviewed for the minor stocks in Statistical Area 27. No attempt was made to evaluate stock status for other minor stocks.

Management Framework

British Columbia herring 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 estimated by simulation analyses. To attempt to harvest herring conservatively, total allowable catch levels (TAC's) 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 harvest policy has been in place since 1983 prior to which the fishery was managed through a fixed escapement policy.

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 1971. 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. Roe herring landings have averaged 31,700 t for the last five years. Allocations to other herring fisheries have averaged 6,400 t.

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[d]
QCI	PSARC[c]					2.2	0.0	2.7	7.1	4.6	3.6
	Quota	*	4.6	5.0	3.8	1.4	0.0	0.9	5.5	4.7	3.3
	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]
PRD	PSARC[c]					6.4	8.7	8.5	4.7	3.9	6.1
	Quota	*	4.0	5.0	6.4	5.4	7.5	7.3	3.5	2.6	4.2
	Catch	0.0	3.5	6.5	8.3	6.1	7.9	8.5	4.7	3.5	4.7
C.C.	PSARC[c]					4.6	4.8	9.7	8.6	7.6	7.5
	Quota	*	6.6	4.1	2.3	3.4	3.7	7.8	7.4	6.2	5.3
	Catch	5.6	7.2	5.2	3.3	3.6	4.5	9.4	8.4	8.9	7.3
GULF	PSARC[c]					10.6	9.3	9.9	11.0	14.0	11.8
	Quota	11.7	11.6	4.7	0.0	8.1	6.4	7.4	7.1	9.1	9.3
	Catch	16.4	10.2	6.2	0.2[a]	9.1	7.5	8.4	8.1	10.5	11.6
WCVI	PSARC[c]					9.7	7.9	10.5	7.2	6.8	5.8
	Quota	4.5	4.5	0.0	0.0	9.4	8.1	10.3	7.2	6.7	2.9
	Catch	8.7	6.7	0.2[a]	0.2[a]	15.9	9.7	13.3	9.8	8.6	3.4
PSARC	Total[c]					33.5	30.7	41.3	38.6	36.9	34.8
Coast	Quota	28.0	31.3	18.8	12.5	27.7	25.8	33.7	30.7	29.3	30.7
Total	Catch	38.8	32.6	24.4	15.6	36.7	29.9	41.7	40.0	38.5	35.4

* 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] 1992 catch data are hail estimates only.

Stock status and forecasts for major assessment regions

For northern B.C., the stock assessment regions used for the 1992 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. On the south coast the herring stock assessment regions used for this year's assessments differ from those previously used. 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. For the west coast of Vancouver Island assessment results were presented for both a southern (Area 23/24) and a northern (Area 25) assessment region as well as for an assessment region which combined the two (Area 23 to 25).

The status of the assessment criteria are listed in Appendix Table 3 and spawning stock biomass trends are plotted in Figures 1 and 2. To provide an overall estimate of stock abundance in 1992 and forecast abundance for 1993, subjective probabilities are assigned to the two analytical models (Escapement Model and Age-structured Model). 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. The potential recruitment 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 1951-92 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. When the forecast run exceeds the CUTOFF level a 20% harvest rate is recommended.

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 due to stock concerns, and since then catch levels peaked in 1990 at 6,700 t and have since been declining.

In general, the quality of the data available for the Queen Charlotte Islands in 1992 is very good. All major spawns were surveyed by SCUBA methods and biological samples were obtained from all areas. The quantity of herring used by Spawn-on-Kelp (SOK) operations in this area may be underestimated due to significant mortality in some of the ponds. Currently, it is assumed that the utilization of the resource for each SOK licence using closed ponding methods is equivalent to 100 t of herring.

The age composition of herring sampling from the Queen Charlotte Islands show a cline along the east coast with a higher proportion of age 2+ fish in more southerly areas. The percent of fish at age 2+ ranged from 19% in Cumshewa Inlet to 73% in Skincuttle Inlet. In the Juan Perez area, where the majority of the stock was found, age 2+ fish comprised 57% of the population.

Both the Age-structured and Escapement Models suggest that the spawning stock biomass in the Queen Charlotte Islands has been declining since 1989, although the decrease from 1991 to 1992 indicated by the Age-structured Model is less than that estimated by the Escapement Model. Other spawn indices and stock estimates from the winter hydroacoustic survey (H92-3) support a decline in abundance for this area. Charter skippers perceptions of stock status in this area are that abundance is currently adequate, but not strong.

Estimates of year class strength from the two analytical models indicate that the 1987 and 1988 year-classes were well below average while the 1989 year-class is close to average.

To forecast stock abundance for 1993, the Subcommittee adopted a 50:50 weighting of the forecasts from the two analytical models. Assuming average recruitment for the 1990 year class, the forecast pre-fishery biomass in 1993 is 17,700 t. The recommended catch at the 20% target harvest rate is 3,540 t. The Subcommittee noted that another year of poor recruitment to the Queen Charlotte Islands would bring the stock close to the CUTOFF level.

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 40,000 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 three years, annual harvests have been approximately 5,000 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 relatively complete. Biological sampling coverage was thorough and the age compositions indicate a higher proportion of age 2+ fish in Kitkatla Inlet (50%) than in Chatham Sound (25%). The variance in the age composition of samples obtained from the gillnet fishery was higher than usual, but the reason for this had not been examined.

Herring abundance in the Prince Rupert District increased in 1992 due to the above average size of the 1988 and 1989 year-classes. Both Age-structured Model and Escapement Model analyses support that current stock abundance is close to, if not above historic high levels, although the spawning stock abundance estimate from the Age-structured Model appear unrealistically high (100,000+ tonnes). No explanation for the recent (since 1989) divergence between the absolute estimates of spawning stock biomass from the Escapement Model and the Age-structured Model was presented. Estimates of recent stock abundance from the Age-

structured Model are suspect because of the large residuals from the predicted versus observed spawn indices. Possible explanations for the high estimates from the Age-structured model include: changes in gillnet selectivity patterns; changes in availability (partial recruitment) to the spawning stock; and persistent differences between age compositions in Kitkatla Inlet versus Chatham Sound. Further work is required to investigate potential sources of bias in the age-structured stock assessments for this region.

Winter hydroacoustic abundance estimates for the Prince Rupert District support that there was a significant increase in abundance from 1991 to 1992. These estimates follow similar trends to those of the Escapement Model and suggest that current levels are at least as high as those observed in 1985 and 1986. Additionally, in-season sounding estimates in the Kitkatla area were the highest ever over the past 10 years. For the Port Simpson/Big Bay area, it is believed that in-season sounding estimates are not reflective of stock trends.

In summary, there is strong support for an increase in herring abundance in the Prince Rupert District in 1992. The Subcommittee did not accept the stock estimates from the Age-structured Model and therefore based the stock forecast entirely on the predictions from the Escapement Model. Based on an assumption of average recruitment to the Prince Rupert District in 1993, the forecast stock biomass is 55,100 t. This forecast yields a recommended catch of 11,020 t, at the 20% harvest rate.

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 (1971-present), landings have not exceeded 15,000 t and since 1989 have been about 9,000 t.

Sampling intensity for age composition was similar to the levels obtained in recent years. The 1989 year-class was dominant in the seine catch during 1992, representing almost 60% with the 1985 year-class representing another 20%. The 1985 year-class composed over 60% of the gillnet catch in 1992.

The spawn survey sampled all major spawning areas in 1992 with only a few very small spawns not being covered. Though dive surveys have been used since the late 1980s, the surface method is still employed for over half of the sample coverage. Trends in the spawn indices used in the Escapement and Age-structured Models were similar, likely due to the high proportion of surface method coverage. The indices show an increasing trend since 1985 corresponding with the recruitment of the 1985 and 1989 year-classes and are now at the highest level since 1950.

Ancillary information from in-season soundings, comments from charter skippers, and observations of district staff support the trend in the spawn index, indicating that the stock abundance is relatively very high. However, district staff feel the stock estimates and forecasts presented in this document are overoptimistic.

The high proportion of surface method coverage for the spawn survey requires that conversion relationships be used to adjust for spawn bed width and to transform layers to egg density. Examination of the data used to derive these relationships indicated that the conversions were ill defined. Consequently, the Subcommittee concluded that reliable estimates of absolute egg deposition could not be derived, thereby invalidating the use of the Escapement Model results for this stock. The parameter estimates of stock characteristics from the Age-structured Model were similar to those for other herring stocks and appeared reasonable. The diagnostics examined did not reveal any problems in the fit of the data to the model with the exception of the tendency for a positive slope in the scatterplot of residuals against predicted spawning biomass, a pattern which occurred for all the stocks. The Subcommittee concluded that the results from the Age-structured Model provided the best description of stock status in this region.

The spawning biomass has shown an increasing trend since 1971 and in 1992 reached the highest level since 1950. The 1985 and 1989 year-classes were exceptionally abundant, only smaller than the very large 1951 year-class. These two year-classes have supported the fishery since 1987 and will continue to contribute substantially to the catch past 1993. There is no information on the size of year-classes following 1989.

Assuming average recruitment for the 1990 year-class, the forecast pre-fishery biomass in 1993 is 70,100 t. To achieve the target 20% harvest rate, the Subcommittee recommends a catch of 14,020 t in 1993. The 1993 forecast catch is about twice the level of the long term sustainable yield for the management target exploitation rate. This is due to the exceptional 1985 and 1989 year-classes and under average conditions, future catch can be expected to decline.

Strait of Georgia

The 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 been between 8,000 and 13,000 t. The area was closed to roe-herring fisheries in 1986, due to stock concerns. Since then harvests have been around 9,000 t.

Records of herring catch improved significantly for the 1991/92 season in that all the food and bait landings were reported on sales slips. Spawn survey coverage appears to be complete with the majority of spawns surveyed by SCUBA methods. Biological sampling was thorough and the age-compositions were relatively consistent throughout the Strait of Georgia.

All indicators of spawning stock abundance are consistent and suggest the Strait of Georgia herring stock has been increasing since 1988. The in-season echosounding stock estimate of 70,000 tons is the highest obtained since 1982. Charter skippers and district staff perceptions were that the Strait of Georgia herring stock was at a level higher than any observed in recent history.

Both the Age-structured and Escapement Models estimate that the 1987 and 1989 year-classes in the Strait of Georgia are very strong. in 1992, these two year classes comprised 17% and 55% of the stock, respectively.

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 91,750 t, which yields a potential catch of 18,350 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 10,00 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 1971 catches have been below the earlier levels, except from 1975 to 1978 when catches ranged from 26,000 to 39,000 t. Since 1983 harvests have been very low in the northern region (zero in 5 of 8 years). In 1985 and 1986 the commercial fishery was closed along the entire west coast of Vancouver Island due to serious concerns about stock status. The 1987 harvest of nearly 16,000 t is the largest since 1978, however harvests have declined since then, and quite rapidly since 1989.

Assessment Units:

The 1991 Subcommittee Report called attention to concerns about the partitioning of the west coast of Vancouver Island into northern and southern stocks. The report requested that for 1992 the assessment be prepared separately for each region, and for the west coast of Vancouver Island as a combined stock.

At this meeting the Subcommittee devoted substantial discussion to the separation of northern and southern stocks. The Subcommittee concluded that the regions should be combined for this assessment. The primary justification for this decision was that when the Age-structured Model was run on the two regions separately, estimates of q and m were problematic. For the southern region the best estimate of q was substantially above estimates for all other regions, and the estimate of m was substantially below estimates for all other regions. Conversely, for the northern region, the estimate of q was substantially lower, and m substantially higher, than for any other region. When the analyses were conducted for the

west coast of Vancouver Island as a single stock, estimates of q and m were well within the range of estimates for other stocks. On the basis of these inconsistencies, the Subcommittee concluded that the dynamics of the "stocks" of the separate regions were not represented as well by either of the analytical models as were the dynamics of the stock in the combined west coast Vancouver Island region.

The other consideration which influenced the decision was that the boundary between the northern and southern "stocks", if recognized, was poorly delineated. This was a particular concern for the 1992 assessment, as the boundary would lie somewhere in the neighbourhood of Hesquiat Harbour. Compared to recent years, in 1992 Hesquiat Harbour received increased spawn survey effort, and the estimate of spawn in Hesquiat Harbour has great influence on the values of all spawn indices for 1992. Through its influence on the spawn indices, this atypical level of survey effort in Hesquiat Harbour has a large influence on the population estimates, particularly in the Escapement Model. Population trends and advised harvest levels for either region would be greatly influenced by the decision on where to allocate the stock estimated from the observed spawning in Hesquiat Harbour. With very little empirical basis for allocating Hesquiat Harbour to either region, the Subcommittee felt it prudent to accept the assessment of the combined region. The Subcommittee stresses that whatever harvest is taken from the west coast of Vancouver Island should be spread among spawning sites within the region, and not concentrated in a small portion of the region. This concern would be important, even if separate northern and southern regions were used.

Assessment Results:

For the combined West Coast Vancouver Island stock, when all spawn survey data are used the Escapement Model estimates stock size in 1992 to be slightly above the 1991 level. The Age-structured Model estimates the stock in 1992 to be slightly below the 1991 level. Both models indicate a decline in stock status in recent years. One of the spawn indices (from the Age-structured Model) is at its second lowest value in 25 years. That model estimates the stock to be nearly as low as in 1984, when concern over stock status led to the fishery closure on the west coast of Vancouver Island. Both models, but particularly the Escapement Model, show a strong effect of the atypically high spawn survey effort in Hesquiat Harbour in 1992, and would estimate substantially smaller populations were the spawn observed there not included in the spawn indices. Reports from district staff and charter captains support strongly the perception that the stock is declining.

Both models indicate most recent year-classes were below average to poor. The exception is the 1989 year-class, which looks above average, and is particularly strong in the northern region. An estimate of recruitment (2+) in 1993, from partial surveys on LaPerouse Bank in summer 1992 (H92-4), is pessimistic. However, the Subcommittee has concerns about the validity of forecasts from that study, until further analyses are completed.

The Subcommittee identified significant concerns with the details of results for both models, when applied to the West Coast of Vancouver Island stock. The Escapement Model is

affected strongly by differences in spawn survey coverage in 1992 compared to preceding years. Therefore quantitative results are difficult to relate to earlier estimates of population size. The Age-structured Model is also affected by the differences in spawn survey effort, although to a lesser extent. The lack of catch data from the northern portion of the area also increases the Subcommittees uncertainty about the absolute estimates of stock size from the Age-structured Model. Additionally, the value of CUTOFF is uncertain for this stock. It had been calculated from parameter estimates of an earlier version of the Age-structured Model, developed and applied before the current decision on stock structure was made.

Because of the uncertainties about results of both models and about CUTOFF, the Subcommittee concurred that it could not provide quantitative estimates of either present stock size or advised harvest level under the present management objectives. However, it is clear that the stock is declining, and there is no reason for optimism that recruitment will be strong in the coming year. Therefore the 1992 harvest level is not sustainable in 1993. Although there is no compelling indication that the fishery on the west coast of Vancouver Island should be closed in 1993, if there is a harvest removals should not reach the level of 1992.

The recruitment assumption, the corresponding 1992 forecasts, and the recommended catches (in thousands of tonnes) are summarized below (also see Appendix 3):

Stock Assessment Region	CUTOFF	Recruitment Assumption	Forecast	Potential Yield
Queen Charlotte Islands	11,700	avg.	17,700	3,540
Prince Rupert District	12,100	avg.	55,100	11,020
Central Coast	10,600	avg.	70,100	14,020
Strait of Georgia	22,100	avg.	91,750	18,350
West Coast Vancouver Is.	(a)	(b)	(b)	(b)

(a) CUTOFF has not been estimated for the current assessment region
(b) Subcommittee could not reach consensus on stock forecast, but recommends the maximum harvest should be less than in 1992.

Minor herring stocks - Area 27

The Subcommittee considered the biological data related to the status of herring stocks in Area 27, as presented in H92-1. Neither spawn data nor age-structure information were available for numerous years in the 1972-92 time series. The Subcommittee concluded that meaningful assessments of stock abundance could not be conducted from the available data sources at this time and recommended that no forecasting of stock availability be attempted.

Framework for development of management objectives

The consensus reached through Subcommittee discussions was that Fisheries Branch should address herring management issues in the Herring Working Group, and the PSARC Herring Subcommittee should address biological objectives. The Subcommittee agreed to provide two people (Jake Schweigert, Science Branch and Dennis Chalmers, Fisheries Branch) to join a regional Biological Objectives Working Group. The Subcommittee would like to be apprised of the conclusions and recommendations of this Working Group prior to their transmittal to senior management.

The Subcommittee discussed a number of biological aspects for managing herring and recognized three principle objectives:

1. Maintain the productive potential of all stocks.
2. Maintain the population age/size structure diversity.
3. Maintain the geographical diversity of the stocks and the fishery.

The Subcommittee then discussed and highlighted a number of assessment strategies for accomplishing these objectives:

- Estimate herring productivity;
- Identify herring stocks;
- Understand the herring ecosystem;
- Identify important spawning habitat;
- Improve recruitment prediction;
- Provide risk estimates;
- Review CUTOFF levels for all stocks, and
- Investigate gear impacts and incidental catch.

Impact of quota overruns

There was no new information presented to the Subcommittee related to the Steering Committee's request for an evaluation of the biological impact of roe herring catches exceeding quota levels in most years and areas. The Subcommittee felt that it would be best to address this issue when specific objectives have been identified for management of herring stocks. Therefore, the Subcommittee agreed to defer consideration of this issue until explicit objectives for fisheries are completed. The Subcommittee will then review the question of quota overruns in the context of specified biological objectives as defined in the management objective framework.

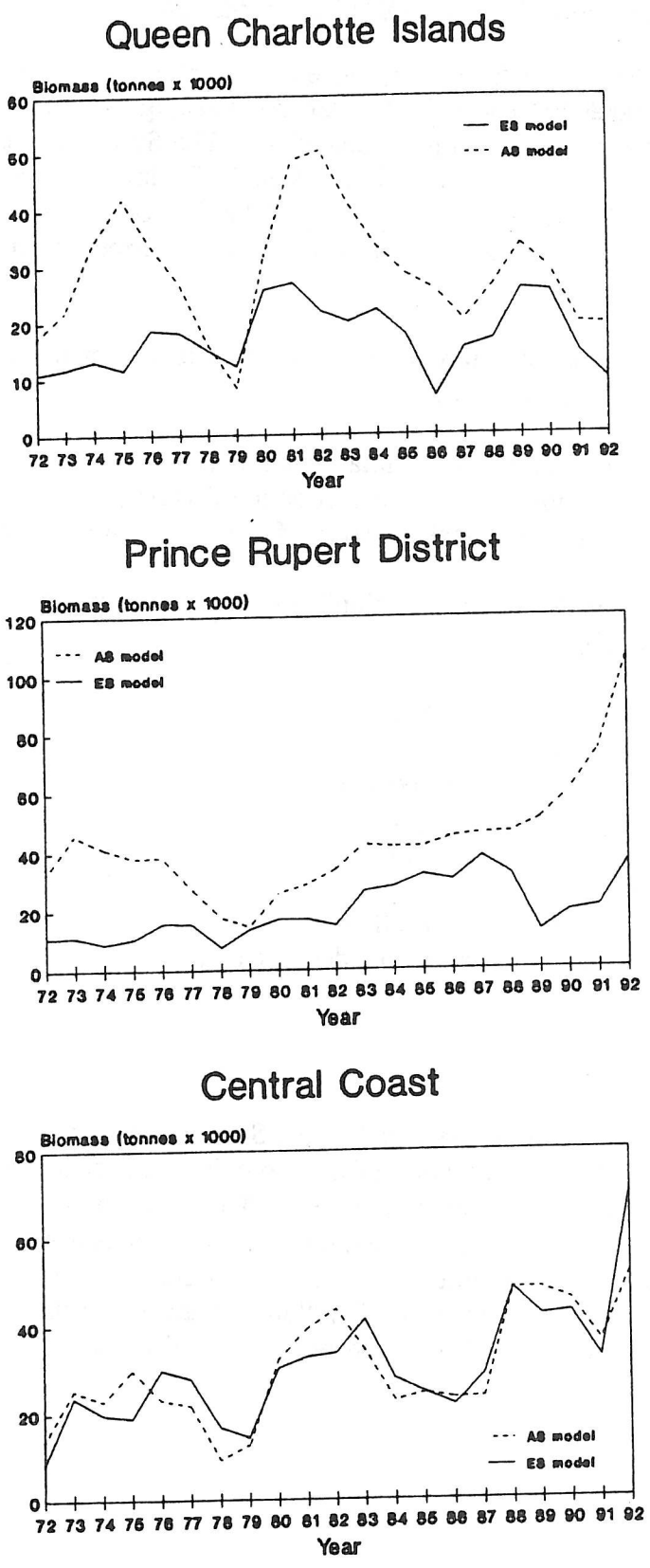

Fig. 1 Estimates of spawning stock biomass (tonnes) from Age-structured and Escapement model analyses for northern B.C. herring stock assessment regions, 1972-1992.

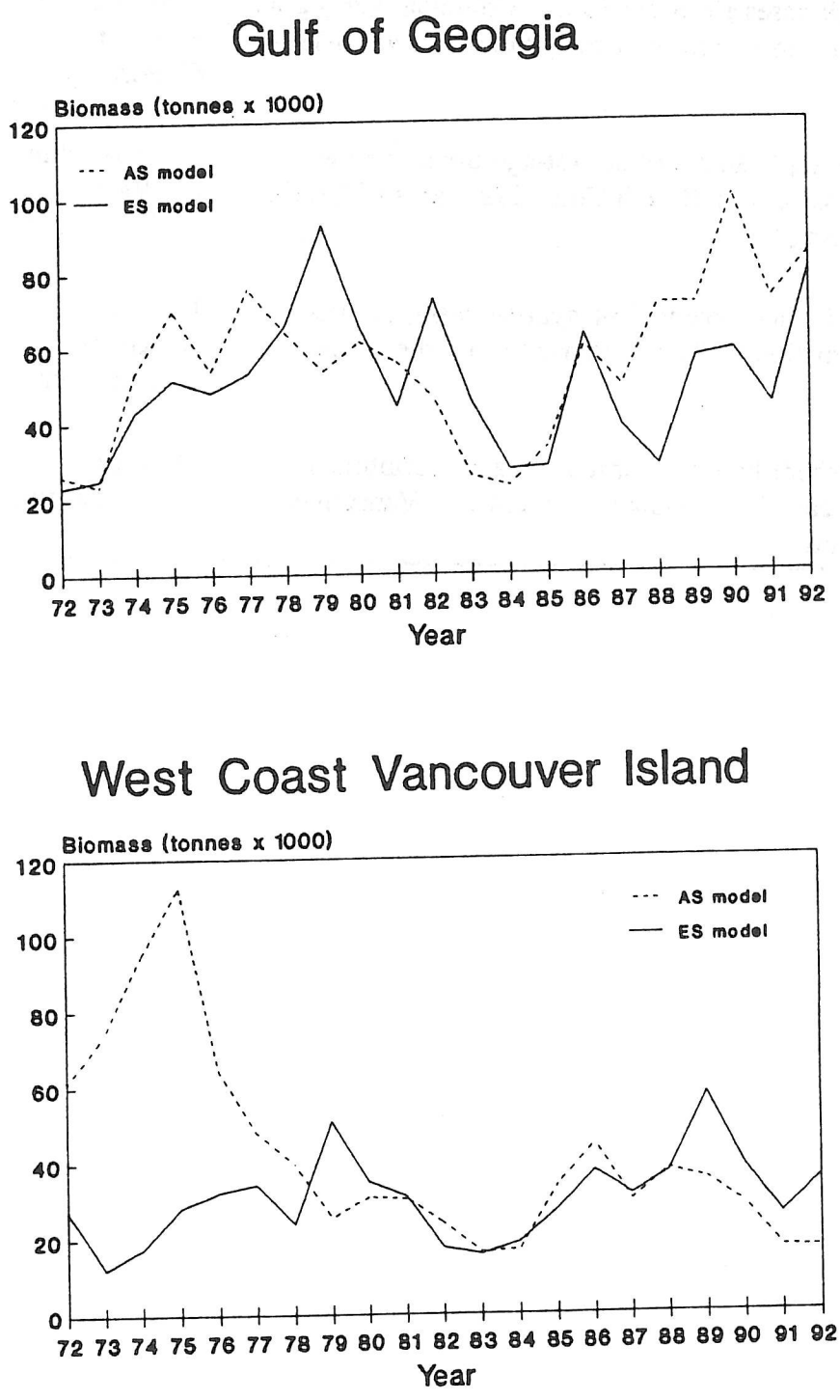

Fig. 2 Estimates of spawning stock biomass (tonnes) from Age-structured and Escapement model analyses for southern B.C. herring stock assessment regions, 1972-1992.

Appendix 1. 1992 PSARC Herring Subcommittee Working Papers.

No.	Title	Authors	Reviewers
H92-1	Stock assessment for British Columbia herring in 1992 and forecasts of the potential catch in 1993	J. Schweigert V. Haist C. Fort	B. Leaman S. Gavaris
H92-2	The implications of size-at-age trends on the assessment of British Columbia stocks of Pacific Herring	R. Tanasichuk D. Ware	R. Kronlund S. Farlinger
H92-3	Limits and potential of hydroacoustic biomass estimation of Pacific herring in northern B.C.	D. Hay R. Kieser B. McCarter	S. McFarlane D. Ware
H92-4	Offshore herring distribution and recruitment forecast for the south west coast of Vancouver Island	D. Ware R. Tanasichuk	D. Welch C. Fort

Appendix 2. List of Participants

Name	Association
Chris Francis	MAF, New Zealand
Jake Schweigert	DFO, Pacific Biological Stn, Nanaimo
Ron Tanasichuk	DFO, Pacific Biological Stn, Nanaimo
Sandy McFarlane	DFO, Pacific Biological Stn, Nanaimo
Doug Hay	DFO, Pacific Biological Stn, Nanaimo
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Doug McKone (Co-chaircritter)	DFO, Ottawa
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Vivian Haist (Co-chaircritter)	DFO, Pacific Biological Station, Nanaimo
Joe Chambers	DFO, Port Hardy
Bruce Logan	UFAWU
Bob Humphreys	DFO

Appendix 3.1. Criteria used in the assessment of stock status for the Queen Charlotte Islands stock assessment region in 1992.

Criteria	Status
1. Data quality	
a) all catch reported	SOK pond usage estimates may be too low - local FO has noted significant mortality in Section Cove ponds and is concerned with possible impacts on spawning habitat.
b) all spawn surveyed	Yes.
c) consistent age composition	Higher proportion 6+ in Louscoone; 2+ in Juan Perez.
2. Spawn and stock trends	
a) age-structured model	Decreasing since 1989, although decrease from 91 to 92 slight
b) escapement model	Decreasing since 1989
c) spawn indices	All indices show decrease from 1991
d) in-season echo-soundings	13,000 tons; (Note: no correlation between other trends and in-season stock estimates.)
e) winter echo-soundings	9,800 tons: Substantial decline between 91 and 92 acoustic estimates.
f) consistent trend info	all indicators suggest decreasing abundance
3) Perception of stock status	
a) charter skippers comments	2E stocks are adequate but not strong; relatively good recruitment.
b) district staff	No info on trends.
4) Recruitment trends	
a) age-structured model	87 and 88 year classes below average; 89 year class considerably stronger
b) escapement model	Same as A.S
5) CUTOFF	11,700 t
6) Forecast weighted run size	
a) weighting	50:50
b) assuming-poor recruitment	15,300 t
- average recruitment	17,700 t
- good recruitment	23,450 t
7) Quota Recommendation	3,540 t

Appendix 3.2. Criteria used in the assessment of stock status for the Prince Rupert District stock assessment region in 1992.

Criteria	Status
1. Data quality	
a) all catch reported	Appears to be reasonably complete.
b) all spawn surveyed	All significant spawns surveyed.
c) consistent age composition	Higher proportion 2+ in section 52; age 2+ and 3+ dominant.
2. Spawn and stock trends	
a) age-structured model	Increasing abundance since 1989; believe 1992 estimate to be unrealistically high.
b) escapement model	Increasing abundance since 1989 - now back to 1987 levels.
c) spawn indices	SAI indicates continuing increase from 1991; Hay's Index and length down.
d) in-season echo-soundings	8000 tons in Kitkatla is highest estimate in last 10 years; Chatham Sd estimate is not useful as index
e) winter echo-soundings	31,500 t - sig. increase from previous year - similar level to 1985, 1986
f) consistent trend info	with exception of spawn indices, all indicators are up
3) Perception of stock status	
a) charter skippers comments	Hard to get good soundings in Port Simpson area. Kitkatla: 7-8000 tons. Feel there was adequate coverage of the area.
b) district staff	eggs surveyed on beach in Chatham Sd. represented significantly more fish that seen prior to or during fishery
4) Recruitment trends	
a) age-structured model	1988 and 1989 year classes highest in time series
b) escapement model	1988 and 1989 year classes above average.
5) CUTOFF	12,100 t
6) Forecast weighted run size	
a) weighting	0:100 (AS:ES)
b) assuming-poor recruitment	51,900 t
- average recruitment	55,100 t
- good recruitment	63,400 t
7) Quota recommendation	11,020 t

Appendix 3.3. Criteria used in the assessment of stock status for the Central Coast stock assessment region in 1992.

Criteria	Status
1. Data quality	
a) all catch reported	Yes.
b) all spawn surveyed	Good coverage. Some very small spawns not surveyed
c) consistent age composition	Yes. Age 2+ fish comprise 58% of the stock.
2. Spawn and stock trends	
a) age-structured model	Highest since beginning of roe fishery.
b) escapement model	Highest since beginning of roe fishery.
c) spawn indices	All indices up considerably.
d) in-season echo-soundings	38,000 tons; incomplete estimate; slight increase from previous years.
e) winter echo-soundings	yes
f) consistent trend info	yes
3) Perception of stock status	
a) charter skippers comments	Best ever seen in the area; up considerably from previous years..
b) district staff	Feel stocks are on increase; recruitment is good.
4) Recruitment trends	
a) age-structured model	Extremely strong 1985 and 1989 year classes.
b) escapement model	Extremely strong 1985 and 1989 year classes.
5) CUTOFF	10,600 t
6) Forecast weighted run size	
a) weighting	100:0 (AS:ES)
b) assuming-poor recruitment	66,600 t
- average recruitment	70,100 t
- good recruitment	80,500 t
7) Quota recommendation	14,020 t

Appendix 3.4. Criteria used in the assessment of stock status for the Strait of Georgia stock assessment region in 1992.

Criteria	Status
1. Data quality	
a) all catch reported	Good for roe and food & bait fishery; some other fisheries not reported.
b) all spawn surveyed	Good survey coverage.
c) consistent age composition	Yes. Age 2+ fish dominant.
2. Spawn and stock trends	
a) age-structured model	Increase in abundance from 1991 to 1992.
b) escapement model	Increase in abundance from 1991 to 1992.
c) spawn indices	Up from 1991.
d) in-season echo-soundings	70,000 tons maximum soundings; highest since 1982.
e) winter echo-soundings	Increase over past few years.
f) consistent trend info	Yes.
3) Perception of stock status	
a) charter skippers comments	Stocks higher than anything in recent history.
b) district staff	Highest abundance seen for very long time.
4) Recruitment trends	
a) age-structured model	Strong 1989 year class; 1987 year class also strong.
b) escapement model	Above average 1987 and 1989 year classes.
5) CUTOFF	22,100 t
6) Forecast weighted run size	
a) weighting	50:50
b) assuming-poor recruitment	78,550 t
- average recruitment	91,750 t
- good recruitment	111,400 t
7) Quota recommendation	Average recruitment: Potential catch of 18,350 t.

Appendix 3.5. Criteria used in the assessment of stock status for the W.C.V.I. stock assessment region in 1992.

Criteria	Status
1. Data quality	
a) all catch reported	Yes
b) all spawn surveyed	Yes, including coverage of Hesquiat.
c) consistent age composition	Higher proportion of age 2+ in Area 25.
2. Spawn and stock trends	
a) age-structured model	Slightly below 1991 levels.
b) escapement model	Slight increase from 1991 levels.
c) spawn indices	Indices are down, but both models show a strong effect of the survey coverage in Hesquiat.
d) in-season echo-soundings	14,000 tons Barkley; 5000 tons area 24; 4000 tons Esperanza; 2000 tons Nootka.
e) winter echo-soundings	N/A
f) consistent trend info	Inconsistent indicators; confounded by increased spawn survey effort on Hesquiat spawn
3) Perception of stock status	
a) charter skippers comments	Barkley stocks reduced from previous years.
b) district staff	No significant change from previous year.
4) Recruitment trends	
a) age-structured model	1989 year class stronger in North than in South portion
b) escapement model	Same.
5) CUTOFF	Value of CUTOFF is uncertain.
6) Forecast weighted run size	
a) weighting	Undecided for this region.
b) assuming-poor recruitment	Numbers cannot be provided because weighting is undetermined.
- average recruitment	
- good recruitment	
7) Additional information	An estimate of 1993 recruitment from Ware & Tanasichuk (H92-4) is pessimistic.
8) Quota recommendation	Subcommittee recommends, in view of poor stock perceptions, that catch does not exceed 1992 levels.

Appendix 4. Recommendations for stock assessment and related activities

1) The error structure of the spawn survey data should be investigated. The analyses should address: the uncertainty due to variance in spawn width, spawn length and numbers of layers; the proper methods for combining surface and dive survey estimates of spawn in all regions, and particularly in the Central Coast where surface spawn estimates still constitute a major part of the spawn surveys; quantify the error structure of any indices developed, and how that error structure should be incorporated in quantitative assessments of stock status. A single index (or, if appropriate, two or more equally plausible indices) should be identified and used as input to all models used in future assessments. (essential to do by next year).

2) The basis for partitioning of the herring on the west coast of Vancouver Island into Northern and Southern stocks should be reviewed in light of the decision of the Subcommittee this year to combine the areas into a single stock. The results of the review should be presented to the 1993 meeting of the Subcommittee, as one or more working papers, and discussed at that meeting.

3) The Subcommittee feels there is information in the hydroacoustic stock estimates which should be evaluated relative to other indices of abundance. Specifically, the Subcommittee suggests that an appropriate method to incorporate hydroacoustic estimates in the assessment process would be to include them as independent abundance estimates in the Age-structured Model. The continuation of acoustic winter surveys in Hecate Strait is supported by the Subcommittee.

4) The Subcommittee currently estimates yield from the sum of the forecast abundance of recruit (age 2+) and older fish. In most cases, recruit abundance is estimated as the "average" of past recruitment levels. Yield estimates may be improved if recruitment forecasting models were used in place of "average" recruitment. This should be investigated.

5) The Subcommittee recommends that the differences in results between the Escapement Model and the Age-structured Model be explained in terms of differences in the relationships and assumptions about population dynamics invoked by each approach. The Subcommittee's deliberations on stock status should then focus on considerations of which relationships and assumptions are more tenable. (essential for next year's assessment)

6) The Subcommittee is concerned that significant quantities of herring used by S-O-K operations are not accounted for in the allocation/catch estimation process. The Herring Working Group should monitor both the total catch and total mortality in S-O-K impoundments. Additionally, potential habitat destruction due to "dumping" of dead herring should be monitored/assessed.

7) The Subcommittee appreciates the improvements in catch and spawn data quality over past years which have been attained through directed efforts of the Herring Working Group and district staff. The Subcommittee requests the Herring Working Group to:

Appendix 4 (cont.). Recommendations for stock assessment and related activities

- reiterate the value of completing the spawn survey summary forms which provide a basis for documenting the relative effort to spawn surveys between years
- annually document (at the spring meeting) estimates of herring utilization by S-O-K operators

Appendix 5. Summary of working papers, reviewers comments and Subcommittee discussions.

H92-1. Stock assessment for British Columbia herring in 1992 and forecasts of the potential catch in 1993.
by J.F. Schweigert, V. Haist, and C. Fort.

The 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 presents forecasts of stock levels for 1993. No significant changes were made to either model for the current assessment. The only change to the Age-structured model was the removal of the stock-recruitment component of the model. Estimates of stock abundance from this model for the Prince Rupert District again exceed credible levels. The apparent age-specific mortality rates introduced last year were again used in the Escapement Model to forecast stock abundances. The major change in this year's assessment was the change in the Strait of Georgia assessment which combined the northern and southern regions into a single area as recommended by PSARC. Similarly, PSARC requested separate and combined assessments of the stocks for the northern and southern west coast of Vancouver Island regions. Abundance estimates are also presented for the stocks in Area 27 from Escapement Model estimates but no forecasts of 1993 abundance are possible. Results from the enumeration of samples of eggs collected throughout the west coast of Vancouver Island indicate slight differences between model predictions and observed egg numbers. Stock forecasts by the two models are generally consistent except for the Prince Rupert District and indicate significant increases in abundance in all but the Queen Charlotte Islands and west coast of Vancouver Island during 1992.

Summary of reviews and Subcommittee discussions:

The Subcommittee had serious concerns that a single source data set (from the spawn surveys) was being used to provide different indices: one from the Escapement Model and a different one for the Age-structured Model. This practice is not justified and discrepancies between the indices should be resolved. Other problems were also noted with the spawn survey based indices. Figure 1 and 2 in the first Addendum indicate problems with the conversion relationships of both the width and number of layers of spawn deposition. Furthermore, more work is needed on integrating results of surface and dive surveys.

For the current year, the Subcommittee is unwilling to accept the adjustments to the Escapement Model for just the Central Coast, until more complete analyses are reviewed for all coastal areas. Issues requiring investigation prior to the 1993 assessments include sampling design of the dive surveys (especially allocation of survey effort independent of expected results), as well as the handling of spawn width, numbers of layers and methods for combining surface and dive surveys.

When a single, coastwide spawn index is developed differences in results between Escapement and Age-structured Models will be due to differences in model relationships and assumptions. Discussions should then appropriately focus on which of these is more tenable and how this impacts on results rather than on how to average results.

Appendix 5. Summary of working papers, reviewers comments and Subcommittee discussions.

H92-2. The implications of size-at-age trends on the assessment of British Columbian stocks of Pacific herring (Clupea pallasi)
by R.W. Tanasichuk and D. Ware

This paper presents data which suggests that herring year-class size, as indexed by parental spawning biomass, has a negative influence on mean weight-at-age 4, the first fully recruited herring age-class. Additionally, it is suggested that oceanographic conditions during the first year of life also affect size-at-age. The study used relationships between mean weight-at-age 4 and biomass estimates to test certain aspects of forecasting B. C. herring spawning biomass. Assuming that stock biomass is related to weight-at-age 4, results suggest that the current weighting of the two assessment models are appropriate for all stocks except the Queen Charlotte Islands, where the Escapement Model alone best describes size-at-age variations. The current version of the Age-structured Model (M is estimated) helps explain size-at-age variation in all stocks except QCI herring. In contrast, the earlier version appeared useful only for the lower west coast Vancouver Island stock. Finally, the appropriateness of combining the northern and southern Strait of Georgia assessment regions was evaluated. Results were equivocal. There was no improvement in describing size-at-age variations after pooling the regions.

Summary of reviewers comments and Subcommittee discussions:

The analyses in H92-2 are consistent with arguments that size-at-age 4 is influenced by cohort size (as estimated by spawning biomass reconstructed to the year the cohort was spawned) and environmental conditions. The Subcommittee concurred that such relationships were plausible, but had little confidence in the specific parameter estimates and functional relationships in the Working Paper. Therefore, based on the large uncertainty in the relationships presented (e.g. Fig. 2 of Working Paper), and the fact that biomasses estimated from weight-at-age 4 are more variable than those from existing assessments, the Subcommittee concluded that the weight-at-age data were not a valid basis for weighting the biomass estimates from the Age-structured and Escapement Models.

H92-3. Limits and potential of hyroacoustic biomass estimation of Pacific herring (*Clupea pallasi*) in northern British Columbia.
by D. E. Hay, R. Kieser, and P. B. McCarter

This paper presents results of winter acoustic surveys, using echo-integration to estimate herring biomass, which started in 1984 in Hecate Strait. The surveys confirmed two specific locations as herring winter 'holding' sites: Juan Perez Inlet and Browning Entrance. The authors believe these sites correspond, respectively, to the harvested herring roe fishery stocks in the southern Queen Charlotte Islands and the Prince Rupert District. In general, the acoustic results indicate that the two largest winter herring distributions are predictable in

time and space. The acoustic biomass estimates were compared with those derived from the two analytical assessment models. In general, acoustic estimates track the other methods and appear credible. The report lists and discusses the effects of sources of error, particularly those of biological origin and survey design. The potential for error is large, although not necessarily greater than other biomass assessment methods. The abundance estimates for the winter of 1991 are provided. The authors recommend continuation of these surveys at the present level for the next two years. The authors suggest that, over a longer term of 5-10 years, DFO should consider expansion of hydroacoustic winter surveys.

Summary of reviewers comments and Subcommittee discussions:

Discussions focused on if and how hydroacoustic results could be incorporated into the stock assessment process. Consensus focused on the issue of providing an absolute versus relative index of abundance (especially as related to target strength estimates). It was concluded that the hydroacoustic estimates can provide a relative index of abundance. More support (i.e.. vessels, equipment) was felt to be required to develop absolute estimates or to improve the precision of relative indices of abundance. It was pointed out that because the survey is conducted in the winter it is too late for inclusion in the stock forecasting procedure but could be used as an index of the previous year's pre-spawning biomass. The Subcommittee suggested that an appropriate method to incorporate the hydroacoustic estimates in the assessment procedure would be to include them as independent indices in the Age-structured Model.

H92-4 Offshore herring distribution and recruitment forecast for the south west coast of Vancouver Island, August 1992.
by D. Ware and R. Tanasichuk

This paper presents results which summarize the summer offshore herring distribution and forecasts the relative strength of the recruiting 1990 year-class. On the basis of modal length analysis the estimated proportion at age 2+ for the La Perouse samples was 22%. Based on a regression model, the prediction of the proportion-at-age 2+ for the lower west coast of Vancouver Island in 1993 is 19%, which implies that the 1990 year-class is below average. This is consistent with research results which suggest that herring recruitment tends to be poor when oceanic conditions are warmer than normal and the biomass of hake is high. Both risk factors were high in 1990.

Summary of reviewers comments and Subcommittee discussions:

The Subcommittee discussions revolved around the point that this paper provides forecasts of the proportion-at-age (2+) which will recruit to the southern west coast of Vancouver Island, not forecasts of relative year-class strength. The paper did not demonstrate the predictive power of the relationship between the August estimates of the proportion-at-age 2+ and the

subsequent pre-fishery estimates of these proportions. Suggestions were made as to how the predictive power or confidence in forecasts could be evaluated. The Subcommittee felt that without an approach which estimates absolute or relative abundance, the results of the La Perouse survey are limited in their value in forecasting recruitment.

Although there are concerns regarding the confidence in the predictions of proportion-at-age, the Subcommittee concurred that the prediction of 19% at age 3 for the southern west coast of Vancouver Island, in conjunction with the current relatively low stock abundance in this area and recent above average water temperatures, is reason for concern.

PSARC STOCK ASSESSMENT REVIEW COMMITTEE

PSARC ADVISORY DOCUMENT 92-5
SEPTEMBER 1992

DATA AND SYSTEMS

CONTENTS PAGE

I. STEERING COMMITTEE REPORT

The PSARC Steering Committee met September 30, 1992 at the Coast Bastion Inn, Nanaimo to review the Data and Systems Subcommittee (DSSC) Report. The Subcommittee Report was discussed and the following recommendations made:

1. The Steering Committee recommends that the working papers on the status of biological databases, identified in the Subcommittee report, be completed for the fall 1993 Subcommittee meetings, subject to the findings contained in the Phase I report of FMISST. It further recommends that the individuals preparing these papers for the Subcommittees coordinate their reviews so that a common terminology and evaluation framework is used, to the extent possible. It also noted that those databases identified by FMISST should be included in this be review.

2. The Steering Committee recommends that the Working Paper, summarizing coding conventions for stock assessment databases and developing standards, identified in the Subcommittee report, be completed for the fall of 1993.

3. The Steering Committee recommends that a Working Paper reviewing the completed report of Phase I of FMISST be produced for the fall 1993 Subcommittee meeting.

The Steering Committee discussed the need for guidance to individuals who may be contemplating changes to or establishment of databases for assessment purposes, with regard to provisions which may be contained in the FMISST report. Members familiar with the FMISST process considered that specific recommendations about databases from this group were some time away. In the interim, individuals working with databases should adhere to existing standards and procedures.

II. DATA AND SYSTEMS SUBCOMMITTEE REPORT

INTRODUCTION

Two meetings of the Data and Systems Subcommittee (DSSC) were held in 1992, on July 16 and September 11. The meetings focused on the FMISST project (Fisheries Management Information System Study Team), Regional coding standards, and the status of biological databases. No Working Papers were submitted to the DSSC in 1992. This report summarizes discussions and the DSSC's proposed workplan for 1993.

1. CHAIRMAN'S REPORT FOR THE 1992 DATA AND SYSTEMS SUBCOMMITTEE

1.1 INTRODUCTION

This report is a summary of the activities of the Data and Systems Subcommittee (DSSC) of PSARC for 1992. The DSSC met twice to discuss the Fisheries Management Information System Study Team (FMISST), Regional coding standards, and biological databases.

1.2 SUBCOMMITTEE ACTIVITIES 1992

The Steering Committee tasked the DSSC with two assignments at the June 1991 meeting. They requested that the DSSC 1) examine the value and costs of shellfish logbooks and, 2) examine the status of biological databases for stock assessment. They asked that the latter study be conducted after the DSSC reviewed the progress of the FMISST.

The responsibility for the Shellfish Logbook review was transferred to Shellfish PSARC in June 1992. The DSSC Chair provided a review of the document during the PSARC Shellfish proceedings.

Phase 1 of FMISST was not completed as of September 11, although it is apparent FMISST has completed some of the preliminary work on biological databases that would be expected of a specific review. The sub-committee reviewed an outline for a proposed Working Paper on this topic and has recommended that the study be completed as four separate Working Papers (herring, salmon, groundfish, and invertebrates) for September 1993.

1.3 SUBCOMMITTEE RECOMMENDATIONS

The sub-committee recommends that the Working Papers on (a) biological databases; (b) Regional coding standards; (c) and FMISST be submitted for September 1993. The sub-committee recommends that the Steering Committee endorses these tasks, assigns responsibilities, and indicates that the tasks be included in the 1993/1994 workplan development.

1.4 SUMMARY of DISCUSSIONS

1.4.1 INVERTEBRATE (SHELLFISH) PSARC WORKING PAPER 92-08

Review of the use of logbook data in invertebrate fisheries in research and management (G. Jamieson, K. Hobbs, and R. Harbo)

The DSSC was originally tasked with participating in this study. This work assignment was subsequently transferred exclusively to the Shellfish Subcommittee. A DSSC member, however, was assigned as principal reviewer for the Shellfish PSARC meetings. Review comments were presented at the meeting; written comments were provided to the senior author and the Chair. The document followed the outline as proposed by Noakes et al (1991). While the document provides a comprehensive summary of all the databases, it fell short of providing a position paper on which databases should be supported and what would be the short- and long-term costs.

1.4.2 STUDY OF BIOLOGICAL DATABASES

In 1991, the DSSC recommended that the study of biological databases await completion of FMISST, under the assumption that FMISST would be completed in early 1992. It is now clear that Phase 1 of FMISST will not provide the detail needed by the DSSC. At the September 11 meeting, the DSSC recommended that PSARC Working Papers on biological databases be submitted for September 1993. These reviews will:

a) Document the nature of biological data for each fishery and the purpose of the data collection;
b) Summarize the format, number of records, and coverage of the data;
c) Discuss data quality with respect to:
    a) accuracy
    b) precision
    c) adequacy of sampling coverage;
d) Discuss data accessibility with respect to:
    a) status of keypunching;

b) linkages to other databases;
c) data standards;
d) database documentation;
e) output procedures;
f) regional access.

It appears that Mr. Bill Shaw (BSB) has been assigned many of these tasks for the salmon databases. The DSSC recommends that the Steering Committee endorse this assignment. Furthermore, the sub-committee recommends that the Steering Committee identify and assign similar tasks for the remaining fisheries. Potential participants include Ms. Lorena Hamer (herring), Mr. Rick Stanley (groundfish), and Mr. Colin Wallace (shellfish). These reports will be reviewed by the DSSC and the other sub-committees during the 1993 PSARC review cycle. The non-salmon sections will each require at least 2-3 weeks for one person. The sub-committee expects that most of Mr. Shaw's time over the next 12 months will be required for the salmon working paper.

1.4.3 PSARC DSSC REVIEW OF FMISST

The DSSC met July 16 and September 11 in 1992 to review the progress of FMISST. This activity of DSSC is mandated by the terms of reference of the subcommittee by PSARC. The Steering Committee re-affirmed this mandate at its June 1991 meeting.

The FMISST project commenced April 12, 1991 and has been discussed on four occasions by DSSC (Sept 6/91, Nov 29/91, July 16/92 and Sept 11/92). In each case, DSSC endorsed the project, although it has voiced concerns about the nature of the finished report and is disappointed that more could not be completed within Phase 1.

As with other DSSC discussions, the intent of the July 16 and September 11 meetings of the current year was to obtain an update on progress. Ms Margaret Birch reported that completion of Phase 1 is possible by April 1, 1993, but it is conditional on the amount of funding this fall and winter. Completion of Phase 1 will require approximately 2K for herring, 15K for groundfish, 12K for shellfish, and 50K for salmon. Recent staffing changes in Informatics Service Division (ISD) may delay completion. The Information Management Committee (IMC) was to meet September 16 to discuss funding.

The DSSC continues to endorse FMISST. It is viewed as a necessary first step in rationalizing the Region's information needs. The DSSC appreciates that the information modelling approach chosen by the FMISST team has emphasized input from users as opposed to being driven by technical issues from the onset. However, it is apparent that the original perception of the resources needed for such a study were profoundly underestimated and the DSSC is disappointed with the continuing delay in completion.

The DSSC strongly recommends that at least some part, and preferably all, of Phase 1 be completed as soon as possible. DSSC is highly concerned that delay in completion is causing support to waver. The DSSC urges the Steering Committee to request that Regional data resources be directed towards completion of FMISST before initiating new database studies.

From a stock assessment viewpoint, the DSSC urges that data **quality** continues to be emphasized. Technical issues of data access and storage generally receive more funding since these problems are easier to solve with a one-time injection of funds. However, unless the Region achieves progress in data quality, in the long-run there will be no improvement in stock assessment advice.

1.4.4. REGIONAL CODING STANDARDS

The DSSC has requested that committee members produce a joint document on standardized codes for the September 1993 DSSC meeting. The Working Paper will summarize the existing codes used by the major stock assessment data systems. The document will also include a recommended Regional standard. Mr. Peter Kho (ISD) has offered to coordinate this initiative. All core members of the DSSC offered to participate. The DSSC sees participation in this process as a non-trivial commitment and requests that consideration of the workload be recognized and endorsed during the development of 1993/1994 workplans. Participants could include all core members of DSSC. Each participant should be expected to commit at least 5- 10 days to the project. Approximately 3-4 weeks may be required of Mr. Kho's time.

2. WORKING PAPERS RECOMMENDED FOR 1993

2.1. A review of the status of the biological databases used for salmon stock assessment (recommended author Mr. Bill Shaw)

2.2. A review of the status of the biological databases used for groundfish stock assessment (recommended author Mr. Rick Stanley)

2.3. A review of the status of the biological databases used for herring stock assessment (recommended author Ms. Lorena Hamer)

2.4. A review of the status of the biological databases used for invertebrate stock assessment (recommended author Mr. Colin Wallace)

2.5. A summary of coding conventions for stock assessment databases and recommended standards (Mr. Peter Kho and DSSC).

2.6. A DSSC review of the completed report of Phase 1 of the Fisheries Management Systems Study Team (FMISST) (DSSC core members as authors)

Literature Cited

Noakes, D., R. D. Stanley, and S. Somjee. 1991. A review outline of Shellfish Logbook Programs. PSARC DSSC Discussion Paper 91-1. 5 p.

Appendix 1. List of Participants at the DSSC Subcommittee meetings

Current membership

Rick Stanley, Chair
Biological Sciences
Marine Fish Division
Nanaimo

Margaret Birch
Fisheries Branch
Biological Services Division
Vancouver

Carol Cross
Salmon Enhancement Project
Division
Vancouver

Leroy Hop Wo
Fisheries Branch
South Coast Division
Nanaimo

Don Radford
Fisheries Branch
North Coast Division
Prince Rupert

Lorena Hamer
Biological Sciences Branch
Marine Fish Division
Nanaimo

Peter Kho
Informatics Service Div.
Vancouver

Louis Lapi
Biological Sciences Branch
Salmon Division
Nanaimo

Attendees

July 16, 1992

Rick Stanley, Chairman
Margaret Birch
Lia Bijsterveld
But Chiu
Carol Cross
Lorena Hamer
Peter Kho
Louis Lapi

September 11, 1992

Rick Stanley, Chairman
Margaret Birch
Peter Kho
Carol Cross
Lorena Hamer
Leroy Hop Wo
Louis Lapi
Don Radford

PACIFIC STOCK ASSESSMENT REVIEW COMMITTEE

PSARC ADVISORY DOCUMENT 92-6
DECEMBER 1992

BIOLOGICAL ADVICE ON PACIFIC SALMON

CONTENTS PAGE

I. STEERING COMMITTEE REPORT

At its meeting on 8 December 1992, the PSARC Steering Committee reviewed the Salmon Subcommittee Report which follows. In general, the Steering Committee supported the recommendations of the Subcommittee. The Steering Committee recommends that salmon expectations and forecasts not be publicly released by DFO without PSARC review of at least the methodologies used. The Steering Committee was appreciative of the efforts of the authors and the Subcommittee in producing the two Working Papers that were deferred or rejected. With regard to proposed additional assessments examining fisheries in Barkley Sound, the Steering Committee supported the concept of producing separate documents for the individual fishery proposals (winter hake, summer hake, summer mackerel) provided there is sufficient concern to evaluate each of these. With regard to the Subcommittee recommendations following the discussion of the coho habitat paper, the Steering Committee felt that because a version of the paper referred to in the first recommendation had already been presented that the completion of this paper was a higher priority than the unassigned general paper examining factors affecting coho productivity in B.C. Any such papers prepared should however be related to specific management issues.

II. SALMON SUBCOMMITTEE REPORT

INTRODUCTION

PSARC Advisory Document 92-1 identified five working papers to be prepared for the 1992 fall meeting of the Salmon Subcommittee. A working paper on Skeena River steelhead run timing and options for management was not completed in time and is now scheduled for the 1993 spring meeting. A working paper on revised Fraser River escapement targets was not submitted to the Subcommittee. A working paper on Georgia Strait coho has been deferred to the Spring 1993. The Salmon Subcommittee met in Sidney, B.C. from November 16 to 18, 1992 to consider three remaining working papers. Lists of the participants and the working papers are appended (Appendices 1,2). The objectives of the meeting were:

- to review assessments, methods, and advice provided in working papers,
- to develop a consensus on Subcommittee recommendations and advice,
- to identify program and/or information needs,
- to identify areas of required research,
- to address other business issues of the Subcommittee.

The next meeting of the Subcommittee is scheduled for April 20-22, 1993. The list of working papers to be developed includes

Working Papers - Spring 1993

1. North Pacific production levels, carrying capacity, and evidence for marine density-dependent growth and survival-Welch, Henderson et al.
2. Assessment of bias in the Skeena/Nass test fisheries.-L. Janz, S. Cox-Rogers
3. Assessment of Georgia Strait coho-Kadowaki et al.
4. Update assessment of escapement goals for Tahltan Lake sockeye-C. Wood, S. Johnson, B. Morley
5. Lower Georgia Strait chinook rebuilding-B. Riddell, T. Perry, L. Lapi
6. Fraser lakes sockeye carrying capacity-J. Stockner et al.
7. Assessment of Quesnel Lake sockeye-K. Shortreed, J. Hume, D. Welch.
8. Methods for estimating Fraser pink escapements.-A. Cass, T. Whitehouse
9. Fry sampling procedures on the Fraser River at Mission.-Unassigned
10. Skeena River steelhead run timing and options for management. B.Ward, S.Cox-Rogers

The following two papers were previously on this list but have been deferred:

Comprehensive assessment of Rivers and Smith Inlet sockeye-Unassigned.
Prediction methods for forecasting chinook returns.-Unassigned.

The stock assessment planning process initiated in 1992 will be used to develop lists of Working Papers for subsequent meetings.

METHODOLOGIES

1. Two examples of methods used in forecasting stock abundance and adult migration behaviour in some stocks of southern pink and sockeye salmon. (Working Paper S92-12)

WORKING PAPER SUMMARY

In these annual forecasts, routinely available indices of oceanographic, climatic and biological data are applied in linear regression equations to predict stock abundance and return timing of some important stocks of southern pink and sockeye salmon. The relationships between the variables are largely based on published hypotheses or models, or on broadly observed generalities. The forecasts are made pre-season, often updated as data become available, through to the start of the major fisheries on a particular stock. Forecasts are provided to colleagues in Science Branch, fishery managers, and with the permission of the latter, to the Pacific Salmon Commission (PSC).

The forecast of adult abundance of Fraser River pink salmon is made between December and April prior to the return year, and is based on prediction of the marine survival rate (MSR) of a estimated number of juveniles leaving the river in every even-numbered year. MSR is forecast from a relationship between marine environmental data from various periods in the life-cycle and MSR from 1962 to present. The forecast model has changed little since the late 1970's. Its dominant feature is a positive relationship between MSR and coastal salinity from three stations near S.W. Vancouver Is. in the juvenile summer (Figure 1).

Most recent MSR values have been close to average (3.1%) so prior average values would have been an equally effective prediction tool in the long-term. However, salinity still accounts for over 70% of the variance in MSR and is very useful in non-average years (e.g. 1989 and 1991). Analysis of the forecast model indicates a satisfactory distribution of residual variance. The only known potential major source of bias in the data concerns the estimation of escapement of the major sub-stock (mainstem Fraser population). The 1991 population estimate is currently under review and, depending on the outcome, may adversely affect the data record and future evaluation of models and forecasts.

Data on the return timing of adult Chilko River (Fraser River) sockeye are available from almost all of the last 40 years. The timing of this stock to Juan De Fuca Strait has shown a trend to be increasingly late over the period (Figure 2), a trend which may have accelerated recently. The only known potential source of bias in the data is a recent change in the level of discrimination of Chilko sub-stocks in the fishery. This is thought to be insufficient to account for much of the trend in timing data. The forecast methodology has changed drastically in the past two years. Up to 1990 a simple forecast, complete by late May, was based on finalized ocean data and a simple general hypothesis about the pre-migration position of the sockeye. As this method failed in 1989 and 1990, in 1991 and 1992 a series of forecasts were made in June and July which were based on several preliminary data sets. These included projections or forecasts of biological and physical data which account for much of the overall variance in timing and which are thought to be related to the

migration speed of the fish (Figure 3). A new regression model incorporating the latter type of data still does not adequately account for the variance in timing due to the trend with time. The model and forecast procedures seem to be of value, but are unsatisfactory in several ways. The future of this forecast method is uncertain.

REVIEWERS' COMMENTS

Reviewer No. 1 (Internal)

The reviewer provided an extensive and thorough review with many technical suggestions for the author to consider in revising the working paper. The reviewer was very concerned about the lack of documentation of data sources, observations, procedures or databases. The reviewer indicated that this leads to a lack of accountability stemming from a lack of confidence in the variables used in the regression analyses. Although forecasts are often developed by individuals, the reviewer noted that any forecast advice that is developed should represent the opinion of the Branch. Therefore, review of the advice provided to management is essential. Finally, the reviewer noted that other methods should be examined other than just simple linear relationships. Some of the independent variables appear badly skewed and are therefore not good candidates for simple linear regressions.

Reviewer No. 2 (External)

This review focused on editorial comments and recommendations for future research. The reviewer complemented the author on the meticulous presentation of the data, methods, and interpretations used in forecasting and noted that the author's discussions were well presented. Although regression type models may be useful, the reviewer emphasized the need for salmon migration and abundance modelling to be undertaken within the context of a general conceptual framework which is currently missing. The reviewer noted that potential biases in the data need to be examined.

SUBCOMMITTEE DISCUSSION

The Subcommittee noted that the models generally used in preseason forecasts for salmon are not sophisticated. Some of the fundamental relationships that underlie the regression models presented in the working paper are not direct (eg. salinity) and may even be spurious particularly if large numbers of explanatory variables have been considered prior to the selection of those reported in this working paper. Others are direct (eg. fish length -> swimming speed -> time of arrival, or temperature -> migration route -> time of arrival). There was some discussion of the value of the forecasts and whether there was a need for greater accuracy considering current use of the forecasts. There was a reluctance on the part of the Subcommittee to recommend the substantial work needed to improve forecasts without

a demonstrated need. Standards for developing and reviewing forecasts in the Pacific Region seem to vary between Branches. This issue will be raised with the Steering Committee.

The Subcommittee needs to be comfortable with the data used, whether there have been changes in collection over time. Some averages of temperature and salinity data seem to be tabulated in the report to greater accuracy than likely originally recorded. There is a potential for significant errors in the assignment of catch and possibly escapement. The methods for run reconstruction are uncertain.

Prior to acceptance by the Subcommittee, the author is required to revise the working paper in consideration of the reviewers' comments. To assess the forecasting performance, the author should provide a track record of previous predictions against the result. Finally, all unpublished detailed data should be reported as an Appendix to the working paper.

SUBCOMMITTEE RECOMMENDATIONS

1. All current forecasting methods for salmon should be identified, reported as working papers and reviewed by PSARC to ensure that the methods are adequately documented, reviewed, and revised where necessary.
2. The need for improving forecast methods should be considered on a stock by stock basis according to the forecasting needs identified in the PSARC Salmon Stock Assessment Data Sheets.
3. The Mission fry sampling procedures need to be documented.
4. The review of methods for estimating Fraser pink escapements should be completed to determine whether there are biases in estimation procedures.

DEFERRED OR REJECTED WORKING PAPERS

1. New fisheries for hake in Barkley Sound, B.C. and implications for salmon stocks Working Paper S92-11)

The working paper summarized information on new or changing fisheries for non-salmonids in Barkley Sound and Alberni Inlet. Some of the processing of hake from the migratory summer hake fishery is moving from offshore processing vessels to a shorebased plant in Barkley Sound. This may alter fishing patterns and increase the bycatch of salmonids. An experimental winter fishery for resident hake stocks has been proposed for Barkley Sound. A summer mackerel fishery was described.

REVIEWERS' COMMENTS

The reviews of this working paper were very thorough. They provided the Subcommittee with a very clear description of the scientific work yet to be done to support recommendations or advice for the establishment or management of these fisheries.

Reviewer-1 (Internal)

The reviewer commended the authors on a well written report, particularly the sections describing the biology of hake and the descriptions of the fisheries. The reviewer noted that the document discussed juvenile and adult salmon bycatch but did not discuss the issue of "feeder" chinook salmon of U.S. or Canadian origin that might occupy the area during the winter. The reviewer felt that an appendix should be provided to document the data, models, and estimation of resident hake biomass in order to assess the variability and sensitivity of the results to various assumptions. The reviewer noted that there appear to be opportunities for cooperative work with those responsible for the hydro-acoustic surveys of adult sockeye in Barkley Sound during the summer that might result in cost savings and better estimates of abundance. The reviewer noted that it might be advisable to examine the relationship between salmon predators (hake) and sockeye abundance in the context of a predator control program in Barkley Sound.

Reviewer-2 (Internal)

This review was very thorough. The major strength of the review was the identification of insufficient documentation of the field methods and of the analytical details needed to provide a rigorous appraisal. The reviewer noted that variance estimates on key parameters are generally absent. The authors should quantify the likely bycatch of salmon in the summer hake fishery and relate that to catches in the region. The estimates of mackerel abundance requires additional work. The reviewer noted that the evidence for substantial losses of Robertson Creek chinook smolts due to predation by mackerel is circumstantial as smolt sampling did not consider potential changes in the distribution of the smolts to avoid areas of high mackerel abundance. The reviewer advised the authors to document the acoustic and balloon trawl biomass estimation procedures noting that the current document has insufficient information to permit the identification of either their levels of precision or accuracy. Statistical analysis of the predation rates is required to assess whether predation rates can be pooled over gear, area or year. The authors made four recommendations. The reviewer did not find sufficient analyses to either reject or support three of these. The fourth involving the experimental winter fishery for resident hake in Barkley Sound was supported by the reviewer.

SUBCOMMITTEE DISCUSSION

The draft working paper described proposals for two new fisheries in Barkley Sound (winter hake, summer mackerel) and the issues and implications of the transition of the summer hake fishery from offshore processing to shorebased processing. The Subcommittee agreed with the reviewers' comments that there were insufficient analyses and/or data in the working paper

to determine whether the advice concerning three fisheries in Barkley Sound was technically sound. The author agreed with the substantive criticisms of the reviewers. The Subcommittee is prepared to request three expanded working papers on fisheries in Barkley Sound: 1) potential salmon bycatch in the summer hake fishery, 2) a new winter hake fishery in Barkley Sound, 3) a summer mackerel fishery. The nature and priority of that work should be a matter for consideration by the Steering Committee. The Subcommittee suggests that the bycatch issues related to the summer hake fishery should be the first priority. The Subcommittee proposes that this review could be rescheduled for the April 1993 meeting. In particular, the detailed presentation by area and time of available data on the bycatch of non-target species in the commercial and research hake catches to assess the significance of bycatch in a "near shore" summer hake fishery. If advice and recommendations are required earlier than May 1993, then an ad hoc meeting could be scheduled. Concerning the proposed winter hake fishery, the Subcommittee noted that insufficient analyses were presented to evaluate the effects or benefits of an experimental fishery on this stock. This document should provide information on conservation levels of the resident hake, include an experimental design for review that should include the magnitude of the benefits of the fishery and provide information on the feasibility of the fishery.

2. Coho freshwater habitats in coastal B.C.:multiple life strategies (Working Paper S92-13)

REVIEWERS' COMMENTS

Review (Internal)

The single reviewer's comments fell into two major categories. The first dealt with the relationship between this working paper and fisheries management in general. The second category was a technical criticism of the authors' assertions and logic. With respect to the first category of comments, the reviewer pointed out that although the authors are directing their paper at fisheries managers, there is currently no convenient means of incorporating their information on coho life history strategies and habitat needs into a fisheries management context. Clear objectives for the stocks and fisheries of concern are first needed. The reviewer then argues that a model of the production system is required to make the information useful. Technical criticisms centred on the importance of lakes in coho production and the mechanisms by which coho occupy the habitats that they do (predetermined behaviour or responses to habitat availability and environmental cues). The reviewer contends that lakes can be very important, especially in large watersheds, and need to be considered in the development of production models. The reviewer also asserts that relatively stable, or even increasing, smolt production at Carnation Creek in the face of habitat degradation and loss, is evidence for serial use of habitats with bottle-neck habitats determining total production rather than simultaneous occupation of the entire spectrum of habitats in a watershed.

SUBCOMMITTEE DISCUSSION

The Subcommittee was appreciative of the efforts of the authors in developing and presenting this working paper. Considerable discussion was stimulated by this working paper and the accompanying review. The draft working paper is a valuable contribution to our understanding of coho production processes and data needs for stock assessment. Areas of disagreement between the authors and the reviewer were discussed but not resolved. The Subcommittee noted that there does not appear to be consensus among coho researchers about the role of multiple juvenile coho rearing habitat types nor the relationship between coho productivity and these habitat types. The authors' hypothesize that access to multiple habitat types by juveniles allows buffering of productivity. The Subcommittee noted that the evidence for this was not presented in the working paper.

The authors were asked to:

- clarify the document by clearly separating statements of hypotheses from the accepted facts about coho (in particular serial versus parallel use of habitat types),
- identify what data/studies are required to test these hypotheses,
- identify what juvenile coho habitat data should be routinely documented for B.C. streams/lakes/rivers,
- identify what measurements are required to determine productivity and current stock status?
- resubmit a revised working paper at the spring 1993 meeting.

This working paper identified a need to integrate our understanding of habitat capacity, assessment, and inventory with coho stock assessment. The common objectives of both disciplines include the need to determine the quantity and quality of habitat suitable for coho, productive capacities of these habitats, and escapement levels necessary to reach productive capacities. To this end, the Subcommittee endorses the need for a workshop on productive capacity to organized by the Habitat Management Unit of Fisheries Branch and held in 1993. The working paper under review draws heavily on data from a small west coast Vancouver Island stream. The Subcommittee noted that research programs on coho productivity in B.C. have been going on for several years and are not yet completely reported. Studies of the factors affecting coho productivity have been supported by Pacific Salmon Treaty implementation funds since 1985. The Subcommittee will be requesting a working paper on the factors influencing coho productivity from the appropriate researchers.

SUBCOMMITTEE RECOMMENDATIONS

1. The authors should revise their draft working paper in consideration of the Subcommittee discussion and reviewers comments and resubmit for the Spring 1993 meeting.

2. A more general working paper on factors affecting coho productivity is required.

APPENDIX 1

List of participants at the Salmon Subcommittee Meeting. November 16-18, 1992.

Members:

1. Don Anderson, SCD (absent)
2. Sandy Argue, PP&E
3. Al Cass, BSB
4. Carol Cross, SEP
5. Peter Delaney, Hab. Mgmt. (absent Nov. 18)
6. Robin Harrison, FR&YD
7. Mike Henderson, BSB (absent)
8. Jim Irvine, BSB (absent Nov. 18)
9. Ron Kadowaki, BSB
10. Skip M^{c}Kinnell, BSB, Chairman
11. Dave Meerburg, FRB, Ottawa
12. Dave Peacock, NCD (absent)
13. Brian Riddell, BSB (absent)
14. Art Tautz, MELP, Province of B.C. (absent Nov. 18)
15. Chris Wood, BSB

Authors:

Dave Blackbourn, BSB
Tom G. Brown, BSB
Charles Scrivener, BSB
Brent Hargreaves, BSB
Sandy McFarlane, BSB (absent)

Reviewers:

Blair Holtby, BSB
Keith Thomson, UBC (absent)
Jake Rice, BSB
Kim Hyatt, BSB
Wilf Luedke, SCD (absent)

APPENDIX 2

LIST OF SUBMITTED WORKING PAPERS
SALMON SUBCOMMITTEE, NOVEMBER 16-18, 1992

STOCK ASSESSMENTS

1. New fisheries for hake in Barkley Sound, B.C. and implications for salmon stocks. - N.B. Hargreaves and G.A. (Sandy) McFarlane.

METHODOLOGIES

2. Two examples of methods used in forecasting stock abundance and adult migration behaviour in some stocks of southern pink and sockeye salmon. - D. J. Blackbourn

3. Coho freshwater habitats in coastal B.C.:multiple life strategies - T.G. Brown and C. Scrivener

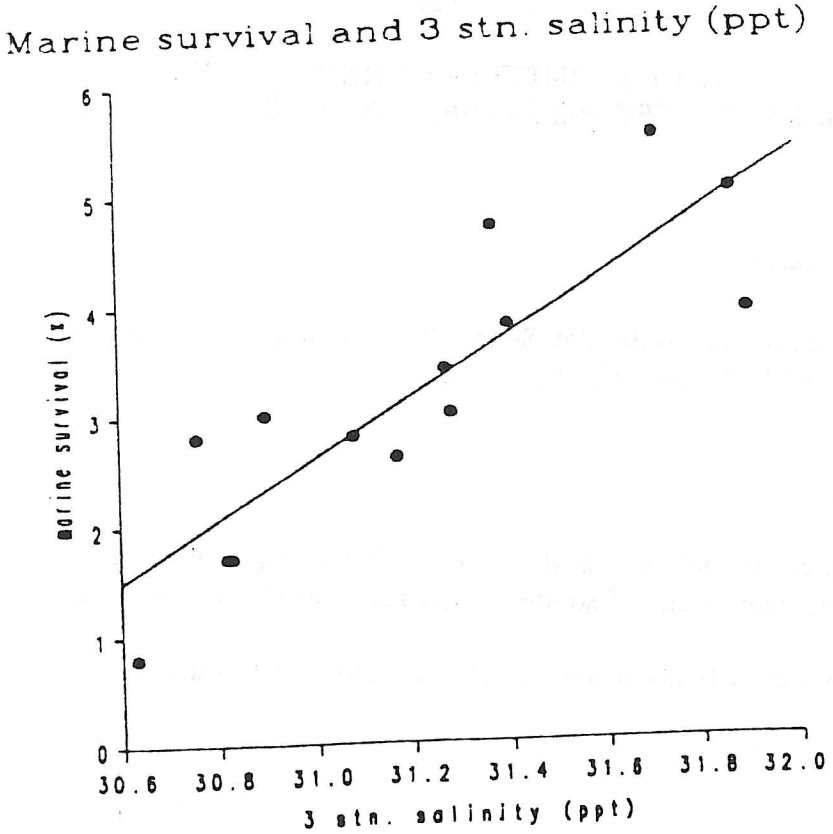


Figure 1.

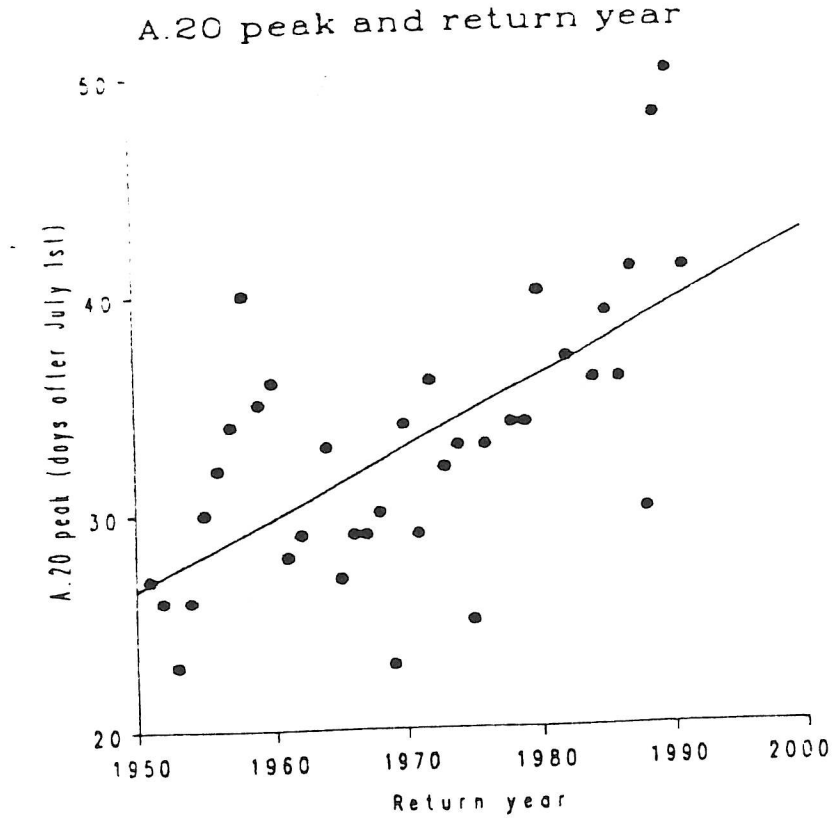
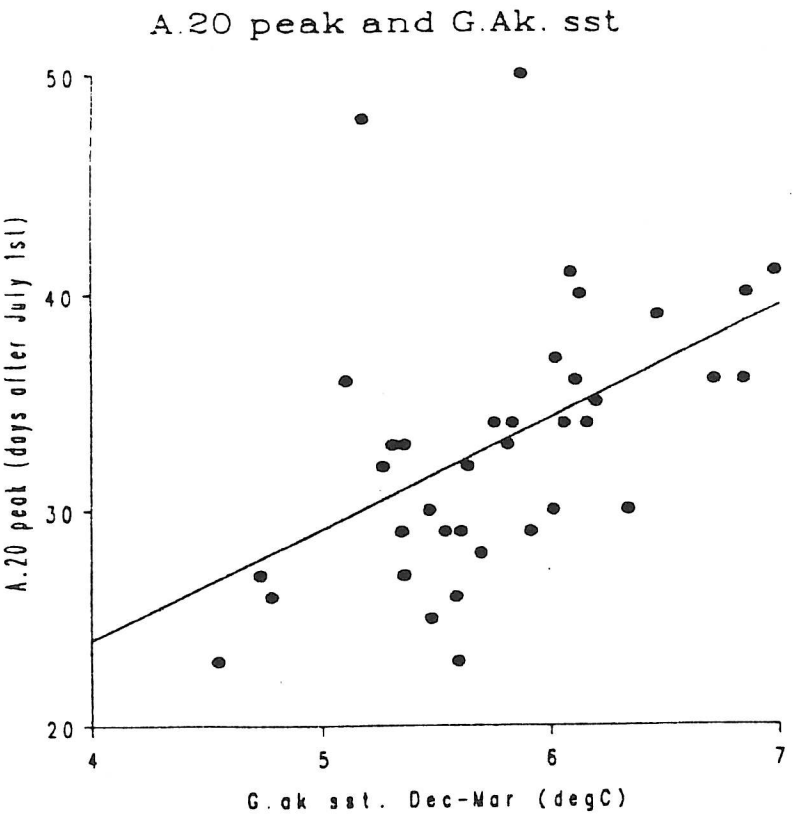


Figure 2.


A.20 peak and G.Ak. sst
A.20 peak (days after July 1st)
50
40
30
20
4
5
6
7
G.ak sst. Dec-Mar (degC)

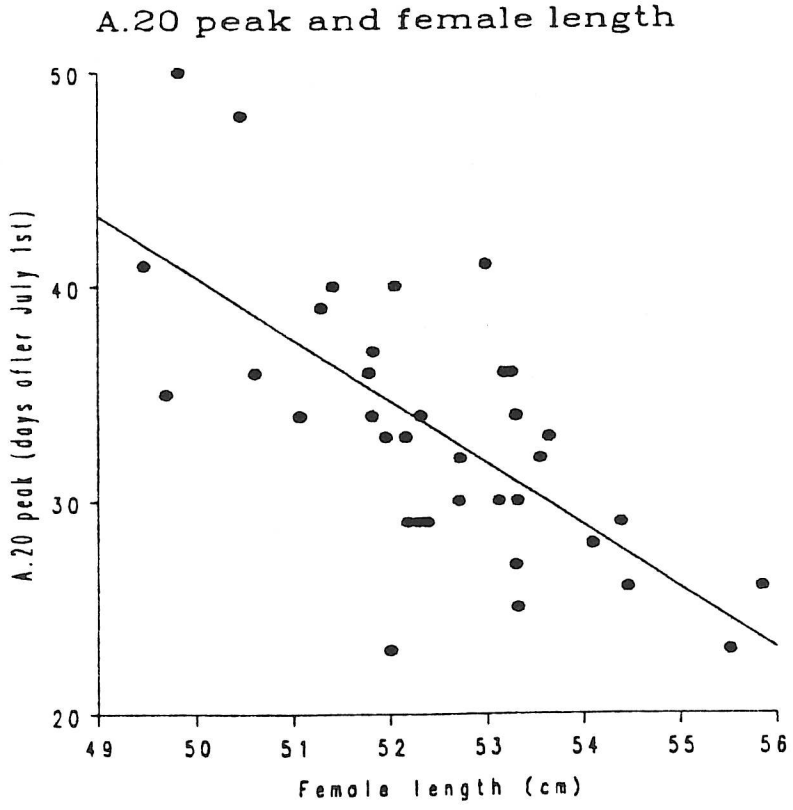

A.20 peak and female length
A.20 peak (days after July 1st)
50
40
30
20
49
50
51
52
53
54
55
56
Female length (cm)

Figure 3.