Pacific Stock Assessment Review Committee (PSARC) Annual Report for 1993

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(Editors)

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PACIFIC STOCK ASSESSMENT REVIEW COMMITTEE

(PSARC)

ANNUAL REPORT FOR 1993

by

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TABLE OF CONTENTS

ABSTRACT

Humphreys, R.D., S.M. McKinnell, D. Welch, M. Stocker, B. Turris, F. Dickson and D. Ware (Editors). 1994. Pacific Stock Assessment Review Committee (PSARC) Annual Report for 1993. Can. Manuscr. Rep. Fish. Aquat. Sci. 2227: iv + 182 p.

This report summarizes activities undertaken by the Pacific Stock Assessment Review Committee (PSARC) during 1993. During this year, 33 reviewed Working Papers and 17 unreviewed Fishery Updates and draft working papers were presented at meetings of the five PSARC Subcommittees (Salmon, Invertebrates, Groundfish, Herring and Data and Systems). In this annual report, an overview by the Chairperson of the PSARC Steering Committee is followed by 5 PSARC Advisory Documents which summarize the Working Papers, reviewers' comments, subcommittee discussions and Steering Committee comments.

RÉSUMÉ

Humphreys, R.D., S.M. McKinnell, D. Welch, M. Stocker, B. Turris, F. Dickson et D. Ware (éditeurs). 1994. Comité d'examen de l'évaluation des stocks du Pacifique - Rapport annuel de 1993. Can. Manuscr. Rep. Fish. Aquat. Sci. 2227; iv + 182 p.

Ce rapport décrit les activités du Comité d'examen de l'évaluation des stocks du Pacifique (CEESP) au cours de l'année 1993. Au cours l'année, trente-trois documents de travail (relus) et dix-sept rapports et documents de travail (non relus) ont été présentés aux réunions des cing sous-comités du CEESP (Saumon, Invertébrés, Démerseaux, Hareng et Informatique). Ce rapport débute par un tour d'horizon du président du comité directeur du CEESP suivi de cinq documents consultatifs dans lesquels sont résumé les documents de travail, les commentaires des experts, les discussions des sous-comités et les commentaires du comité de direction du CEESP.

Section I - Chairperson's Report for 1993

This is the seventh annual report of the Pacific Stock Assessment Review Committee (PSARC). The report summarizes the eighth year of operation for this committee, which provides scientific advice for the management of Pacific fisheries resources. This year the PSARC terms of reference (Appendix 1) were amended (Item 10) to ensure that advice and recommendations contained in PSARC Working Papers are reviewed by managers responsible for Regional stock assessment and fisheries management programs and their Directors prior to release of the documents to the public.

Process for the Provision of PSARC Advice

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

There are five PSARC Subcommittees: Herring, Salmon, Invertebrate, Groundfish and Data and Systems. Each subcommittee holds one or more meetings annually. Stock assessment documents (Working Papers) are prepared prior to subcommittee meetings and are reviewed by at least one individual before these meetings. Pre-meeting reviewers are normally external to the subcommittee and may be external to the Department of Fisheries and Oceans (DFO).

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.

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, division, section, program or individual is assigned responsibility for each major recommendation made. RMEC meeting minutes record the assignment of responsibility.

Summary of 1993 PSARC Activities

In 1993, six major subcommittee meetings were held (Table 1) resulting in the five Advisory Documents contained in this annual report. At these meetings, Working Papers (Table 2), unreviewed reports and updates were presented. In addition, the Invertebrate Subcommittee held a joint stock assessment workshop with invertebrate scientists in Washington State. Summaries of Working Papers, reviewers' comments, subcommittee discussions and Steering Committee comments are contained in the Advisory Documents.

The Salmon Subcommittee met on 20 to 22 April to review seven Working Papers and prepare a Subcommittee Report which was subsequently presented at the 12 May Steering Committee meeting, resulting in PSARC Advisory Document 93-1. The seven Working Papers summarized in the Advisory Document include reports on sockeye stocks of the Stikine River (Tahltan Lake sockeye), Fraser River (Quesnel Lake sockeye) and Skeena River. There are also reports on Cowichan River coho, Fraser River pinks, Skeena River steelhead and an evaluation of the Strait of Georgia chinook salmon conservation program.

PSARC Advisory Document 93-2 was produced following a meeting of the Data and Systems Subcommittee on 3 May and a subsequent review of the Subcommittee's Report by correspondence with Steering Committee members. PSARC Advisory Documents 93-3, 93-4 and 93-5 are the products of meetings on 27-30 July, 30 August-2 September and 7-9 September of the Groundfish, Invertebrate and Herring Subcommittees, respectively, and subsequent discussions with the Steering Committee on 22-24 September. In addition, the Data and Systems Subcommittee held a second meeting on 9 September and produced a report which was presented for review by the Steering Committee at its 22-24 September meeting. The Steering Committee found that there was inadequate information contained in the report to permit evaluation of the Subcommittee's advice and recommendations. This report will be revised and resubmitted for review at the next meeting of the Steering Committee.

At the 3 May meeting of the Data and Systems Subcommittee, the Subcommittee focused its attention on reviewing the current status of FMISST (Phase I), the current status of several regional or national database initiatives, issues concerning the correction and/or modification of data in existing stock assessment data bases and a number of other data and systems issues that needed to be examined in preparation for future work of the Subcommittee.

The Groundfish Subcommittee reviewed 11 Working Papers in 1993 (Table 2). Major assessments were conducted on slope rockfish and Pacific cod. The Subcommittee drew attention to the need for caution in setting yield options for Pacific hake on the basis of the 1992 U.S. hydroacoustic survey biomass estimates, which were considerably higher than predicted by previous assessments. The Subcommittee also recommended that a pessimistic view of the status of Hecate Strait and west coast Vancouver Island Pacific cod stocks be adopted and urged managers to exercise caution in assigning harvest levels for these stocks. Lingcod stocks in the Strait of Georgia were reported to be at an extremely low level of abundance and the Subcommittee recommended a complete closure for both commercial and sport fisheries in 1994 (Advisory Document 93-3). Subsequent to the review of this advice by the Steering Committee and by RMEC, the Recreational Fisheries Division raised concerns about the validity of using CPUE data as an index of lingcod abundance from a fishery for which the management regime had changed considerably in the past few years. A meeting was held on 14 December 1993 to discuss these concerns. Scientific staff agreed that the sport CPUE index was being used in a coarse manner. However, those present concurred that the Strait of Georgia lingcod stock is severely depressed compared to historical levels, and there is a conservation concern with this stock. There was also full agreement that there was no evidence that removals at the levels prosecuted by the sport fishery in 1992 and 1993 were doing further damage to the stock. But, the potential removals by the sport fishery could diminish or even preclude the ability of the spawning stock to rebuild, even if the stock experienced improving levels of recruitment. A full assessment of inshore lingcod will be conducted in 1994.

The Invertebrate Subcommittee's work was presented in the form of 5 Working Papers and numerous unreviewed Fishery and Science Updates (Table 2). In addition to a number of recommendations regarding changes to the stock assessment process and additional work required on several stock assessment issues, the Steering Committee recommended or endorsed the recommendation of a number of specific management actions. The Steering Committee endorsed the Subcommittee's recommendation that the Marina Island geoduck fishery be closed until stocks rebuild and that the coastwide quota for geoducks in 1994 be set at 2,245 tonnes. In regard to red sea urchins, the Steering Committee repeated its 1992 recommendation that harvests be capped in the North Coast until surveys are completed and results reviewed. In the absence of further information, the quota should be maintained at 5,400 tonnes. The Steering Committee also noted that abalone abundance has not rebuilt on the Central Coast and recommended that the fishery remain closed until there is evidence of substantial stock rebuilding.

Nine Working Papers were presented at the Herring Subcommittee meeting (Table 2). Major issues and recommendations are documented in PSARC Advisory Document 93-5. Some changes were made to the two analytical assessment models used to estimate herring biomass, resulting in slightly lower biomass estimates over the years 1972-1993. Managers were cautioned that the predicted continued decline in the Queen Charlotte Islands stock appears to have been correct. Consequently, the recommended catch of 1050 t would only satisfy the requirement for native food fish and 93% of the 1993 spawn-on-kelp fishery allocation. This year's assessment of West Coast Vancouver Island stock status was more optimistic than the previous year's assessment. However, in light of poor prospects for the 1992 and 1993 year-classes due to the effects of El Nino, the Steering Committee advised managers to exercise caution in assigning quotas for this stock in 1994. The Steering Committee also advised managers that although the West Coast of Vancouver Island is now treated as one stock, harvest should be distributed as widely as possible throughout the assessment region.

All PSARC Subcommittees as well as the Steering Committee were under new chairpersons in 1993. The contributions made by the retiring chairpersons are gratefully acknowledged.

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

Table 1. Major PSARC Meetings Held During 1993

Date	Meeting	Location
16-17 February	Joint WA-BC Invertebrate Meeting	Brinnon, Washington
16 February	Groundfish	PBS
20-22 April	Salmon	IOS
03 May	DSSC	VanHQ; Room 3B
06 May	Invertebrates	VanHQ; Room 4D
12 May	Steering Committee	PBS Seminar Room
10 June	PSARC/RMEC	VanHQ; Exec.Bdrm
27-30 July	Groundfish	Nanaimo
30 Aug.- 2 Sept.	Invertebrates	Nanaimo
7-9 September	Herring	New Westminster
9 September	DSSC	Nanaimo
22-24 September	Steering Committee	PBS Nanaimo
4 and 12 October	RMEC	VanHQ; Exec.Bdrm
15 November	Invertebrates	PBS, Nanaimo
16-18 November	Salmon	(Postponed until Feb. 1994)
14 December	Groundfish	PBS, Nanaimo

Table 2. List of PSARC Working Papers and Fishery Updates Reviewed During 1993.

SALMON SUBCOMMITTEE

Working Papers

S93-01	Review of the spawning escapement target for Tahltan Lake sockeye salmon. Wood, Morley, Johannes, Johnston and Etherton.
S93-02	Recommended target escapement levels for Quesnel Lake sockeye stocks. Welch, Shortreed, Stockner, Hume, Morton and Williams.
S93-03	Stock assessment of Mesachie Lake coho salmon with comments on Cowichan Lake coho salmon. Holtby.
S93-04	An evaluation of enumeration methods to estimate spawning escapements of Fraser River pink salmon. Cass and Whitehouse.
S93-05	Recent changes in catchability of sockeye salmon in the Skeena River gillnet test fishery and the impacts on escapement estimation. Cox-Rogers and Jantz.
S93-06	Migration timing and harvest rates of the steelhead populations of the Skeena River system. Ward, Tautz, Cox-Rogers and Hooton.
S93-07	1992 evaluation of the conservation program for chinook salmon in the southern Strait of Georgia; 1988-1991 (excludes Fraser River stocks). Riddell and Kronlund.

GROUNDFISH SUBCOMMITTEE

Working Papers

G93-1A	Inshore lingcod stock assessment for 1993 and recommended yield options for 1994. Murie, Richards and Yamanaka.
G93-1B	Offshore lingcod stock assessment and recommended yield options for 1994. McFarlane and Leaman.
G93-02	Pacific cod stock assessments for 1993 and recommended yield options for 1994. Stocker and Hand.

G93-03 Flatfish stock assessments for 1993 and recommended yield options for 1994. Fargo.

G93-04 Sablefish stock assessment for 1993 and recommended yield options for 1994. Saunders, McFarlane, Stocker and Leaman.

G93-05 Pacific hake stock assessment for 1993 and recommended yield options for 1994. Saunders and McFarlane.

G93-06 Spiny dogfish. Thomson.

G93-07 Walleye pollock stock assessment for 1993 and recommended yield options for 1994. Saunders.

G93-08 Slope rockfish assessments for 1993 and recommended yield options for 1994. Richards.

G93-09 Interim shelf rockfish assessment for 1993 and recommended yield options for 1994. Stanley.

G93-10 Inshore rockfish stock assessment for 1993 and recommended yield options for 1994. Yamanaka and Richards.

INVERTEBRATE SUBCOMMITTEE

Working Papers

I93-01 Effects of repeated digging on sub-legal sized manila clams, ***Tapes philipinarum***. Bourne, Heritage and Noakes.

I93-02 Intertidal clam survey at Savary Island, B.C. Adkins and Joe.

I93-03 Survey of geoduck population density at Marina Island, 1992. Campbell, Harbo and Heizer.

I93-04 1993 review of experimental prawn fishing in Howe Sound. Boutillier.

I93-05 Quota options and recommendations for the 1994 geoduck clam fishery. Harbo, Thomas and Hobbs.

Draft Working Papers

1. Sea Urchin Survey of Kitasoo Statistical Sub-areas

   Authors: G. Jamieson, K. Cripps and L. Greba

2. Sea Urchin Survey of Heiltsuk Statistical Sub-areas

   Authors: G. Jamieson, and W. Sandoval

3. Sea Urchin Survey of Haida Gwaii Statistical Sub-areas

   Authors: G. Jamieson, G. Martel and R. Jones

4. Preliminary Biomass Estimates and Quota Options for North Coast Red Sea Urchins.

   Authors: A. Campbell, G. Jamieson, D. Heritage and ...

5. Abalone Resurvey in Aristazabal Island, the Estevan Group and Banks Island, June 1993

   Author: G. Thomas

Fishery Updates

1. Intertidal clams. Dickson and Hobbs.
2. Geoducks. Harbo, Thomas and Hobbs.
3. Horse clams. Harbo and Hobbs.
4. Red sea urchins. Thomas, Heizer and Hobbs.
5. Green sea urchins. Harbo and Hobbs.
6. Crabs. Heizer and Joyce.
7. Euphausiids. Adkins.
8. Sea cucumber. Thomas and Heizer.
9. Scallops. Harbo, Hobbs and Bourne.
10. Shrimp. Ackerman.
11. Octopus. Adkins.
12. Goose barnacles. Adkins.
13. Prawn. Adkins.

HERRING SUBCOMMITTEE

Working Papers

H93-01	Stock assessment for British Columbia herring in 1993 and forecasts of the potential catch in 1994. Schweigert and Fort.
H93-02	Herring spawn index analysis. Schweigert, Hay and Fort.
H93-03	Herring stock structure on the west coast of Vancouver Island. Hay, Perry and McCarter.
H93-04	A comparison of the assumptions underlying the age-structured and escapement models for B.C. herring stock assessment. Tanasichuk, Hay, Schweigert and Ware.
H93-05	British Columbia herring stock production analysis. Ware, Schweigert and Tanasichuk.
H93-06	Hydroacoustic herring survey results from Hecate Strait, November 30-December 10, 1992. W.E. Ricker Cruise 92HER. McCarter, Hay, Withler and Kieser.
H93-07	Offshore herring distribution and recruitment forecast for the southwest coast of Vancouver Island, August 1993. Ware and Tanasichuk.
H93-08	Forecasting year-class strength from juvenile surveys. Haegele.
H93-09	Larval herring abundance and biomass in Georgia Strait and the west coast of Vancouver Island. McCarter, Hay and Miller.
H93-10	Egg loss from herring spawns. Schweigert and Haegele.

Appendix 1. PSARC Terms of Reference

Terms of Reference[2]
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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[2]Approved June 1993

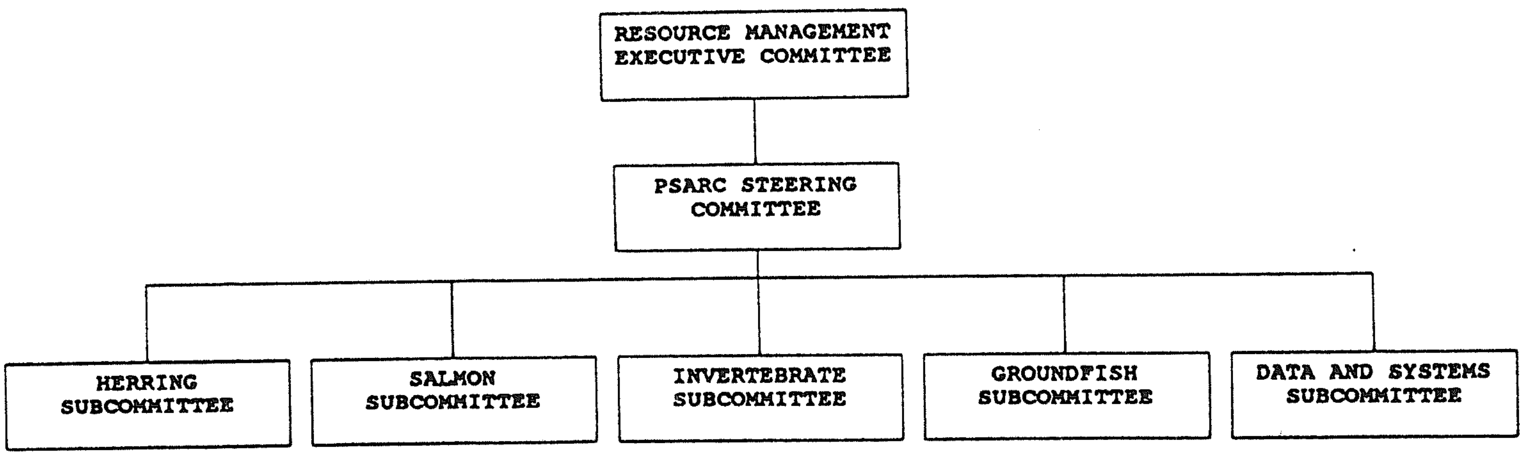

Figure 1. Relations between PSARC Resource Management Executive Committee, PSARC Steering Committee, and PSARC Subcommittees.

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 a Working Paper requested by the Subcommittee must be completed and accepted by the Subcommittee Chairperson within 45 days of the Subcommittee meeting. PSARC Working Papers are not to be publicly released until RMEC has approved the Advisory Document. The released Working Paper should contain revisions as needed to address concerns of the Subcommittee, Steering Committee and RMEC. When urgent issues require exceptions to this process, Working Papers can be released if approved by the chair of the Subcommittee, the chair of the Steering Committee and the Directors of the relevant Branches. 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 2. Past and Present Chairpersons of the PSARC Steering Committee and Subcommittees

PSARC Steering Committee

1985	D. Schutz
1986-88	M. Stocker
1989-90	S. Farlinger
1991-93	J. Irvine
1993-	R.D. Humphreys

Salmon Subcommittee

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

Groundfish Subcommittee

1986-90	A. Tyler
1990-93	B. Leaman
1993-	B. Turris & M. Stocker

Invertebrate Subcommittee

1986-87	R. Harbo
1987-89	N. Bourne
1989-91	G. Thomas
1992-93	D. McKone
1993-	F. Dickson

Herring Subcommittee

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

Data & Systems Subcommittee

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

Appendix 3. 1993 PSARC Steering Committee Membership

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Dr. D. Ware, Chairperson
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Section II - PSARC Advisory Documents

PACIFIC STOCK ASSESSMENT REVIEW COMMITTEE

PSARC ADVISORY DOCUMENT 93-1
MAY 1993

BIOLOGICAL ADVICE ON PACIFIC SALMON

CONTENTS PAGE

I. STEERING COMMITTEE REPORT

At its meeting on 12 May 1993, the PSARC Steering Committee reviewed the Salmon Subcommittee Report which follows. Seven 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 1992 Salmon Subcommittee contains sections on: recommendations from PSARC Advisory Documents 92-1, 92-6, 91-1, 91-6, 90-1 and 90-5; performance of 1992 forecasts; and proposed work plans for the Salmon Subcommittee for the remainder of 1993 and beyond. Due to lack of time at the May Steering Committee meeting, the list of proposed Working Papers was distributed to the Steering Committee members for consideration and comment by June 3, 1993.

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.

S93-1 Review of the spawning escapement target for Tahltan Lake sockeye salmon. Wood, Morley, Johannes, Johnston and Etherton.

- **The Steering Committee endorses the three Subcommittee recommendations (page 15). It is the Steering Committee's understanding that if run strength does not exceed the target escapement level of 20,000 there would be no additional spawners available as broodstock.**

- **The Steering Committee also wishes to point out that 20,000 is not necessarily a conservative level as stated in the Subcommittee report.**

S93-2 Recommended target escapement levels for Quesnel Lake sockeye stocks. Welch, Shortreed, Stockner, Hume, Morton and Williams.

- **The Steering Committee requests an explanation of what is meant by "substantially below expectation" in Recommendation 2 (page 19).**

- **The Steering Committee agrees with the first part of Recommendation 4 (page 19), but questions the statement regarding "potential for interactions with the subdominant year" in the last part of the recommendation.**

S93-3 Stock assessment of Mesachie Lake coho salmon with comments on Cowichan Lake coho salmon. Holtby.

- **The Steering Committee endorses the need to find out why the Cowichan coho have declined. However, we need more details re specific, testable hypotheses. These can then be ranked and cost estimates developed. Science Branch should respond to these queries.**

S93-4 An evaluation of enumeration methods to estimate spawning escapements of Fraser River pink salmon. Cass and Whitehouse.

- **The Steering Committee has serious concerns about the validity of the Fraser River pink salmon escapement data and endorses, therefore, the Subcommittee's recommendation for the formation of a working group to examine the problem and recommend changes for the 1993 season. The Steering Committee further recommends that the working group conduct its work as quickly as possible and report back to the Steering Committee.**

S93-5 Recent changes in catchability of sockeye salmon in the Skeena River gillnet test fishery and the impacts on escapement estimation. Cox-Rogers and Jantz.

- **The Steering Committee recommends that the Subcommittee's proposed review of the potential factors affecting the Skeena River gillnet test fishery be referred to the group tasked with the development of the Skeena River Integrated Watershed Management Plan (Peacock, Wood et al).**

S93-6 Migration timing and harvest rates of the steelhead populations of the Skeena River system. Ward, Tautz, Cox-Rogers and Hooton.

- **The Steering Committee recommends that steelhead issues be identified in the Skeena River Integrated Watershed Management Plan being developed by Peacock, Wood et al.**

S93-7 1992 evaluation of the conservation program for chinook salmon in the southern Strait of Georgia; 1988-1991 (excludes Fraser River stocks). Riddell and Kronlund.

- **The Steering Committee notes that MRP funding has been reduced and wishes to advise the RMEC that if voluntary head sampling is eliminated, as is currently envisioned, evaluation of the sport fishery will not be possible. This is true not only for chinook but also for coho. We are at the point of collapse in terms of chinook and coho assessments.**

II. SALMON SUBCOMMITTEE REPORT

1. CHAIRMAN'S REPORT FOR THE 1992 SALMON SUBCOMMITTEE

This report provides a summary of the Salmon Subcommittee activities during 1992. The primary sources of detailed information are the PSARC Advisory Documents 92-1 and 92-6. These reports, prepared for the Pacific Stock Assessment Review Committee (PSARC), were reviewed by the PSARC Steering Committee then presented to the Regional Management Executive Committee (RMEC). The Chairman's report comments on additional topics considered by the Subcommittee in addition to working papers, reports the accuracy of the 1992 abundance forecasts for selected major salmon stock/stock complexes, identifies outstanding topics or recommendations from previous Advisory Documents, and concludes with information on the status of the Subcommittee's membership.

In 1992, the Salmon Subcommittee submitted two reports reviewing 13 working papers. The reports consider various topics related to salmon stock assessment and also included the Salmon Subcommittee Chairman's report for 1991.

During 1992, special and/or *ad hoc* meetings of the Subcommittee were called to address issues that could not be considered during the normal meeting schedule. Teleconferences were scheduled to review the overall evaluation of the Lower Georgia Strait chinook rebuilding program, and to review an updated exploitation rate analysis for Georgia Strait coho stocks to determine if advice provided in a working paper in 1988 was still appropriate. Finally, a special stock assessment planning workshop of the Subcommittee was held from September 8-11.

In anticipation of changes to DFO regional fisheries management and assessment activities, the PSARC Subcommittees were asked to insure that the technical basis for fisheries management recommendations and advice was available to the public. A process of working paper revision, acceptance and distribution was needed for authors of PSARC Salmon Subcommittee working papers. Authors are now required to revise their working papers in consideration of comments made by the Steering Committee, the Subcommittee, and reviewers, both internal and external to the Department. Revised documents that are formally accepted by the Subcommittee are available for release to the public upon request to the Chairman of the Subcommittee. The working papers are not citable in the scientific literature unless they are upgraded to Journal, Technical, or Manuscript status.

Major recommendations in PSARC Advisory Document 92-1

Five working papers were reviewed at the 1992 Spring Salmon Subcommittee meeting in Vancouver.

Advice for Fisheries Management

Fraser River chum salmon - The Steering Committee supported the Subcommittee's recommendation that the escapement target of 700,000 be increased to a minimum escapement above 800,000 naturally spawning chum salmon.

Skeena River coho - The Steering Committee supported the Subcommittee's recommendation for a minimum spawning escapement of 36,000 coho as measured at the test fishery to August 24 but there was concern about whether such a small change from 33,000 to 36,000 was detectable. The Steering Committee agreed that it would be useful for the test fishery to continue through the end of the first week in September.

Evaluation of the Lower Georgia Strait chinook conservation program -The Steering Committee supported the recommendation that the native harvest in the Squamish River be reduced but acknowledges the difficulties implementing the recommendation.

Skeena River summer steelhead trout - The Steering Committee agreed 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 emphasized the importance of verifying assumptions in this model for the Skeena watershed. The Steering Committee accepted the spawning levels for substocks of Skeena River steelhead provided in the Subcommittee report as provisional rebuilding targets. The Steering Committee supported the recommendation that a model to develop fishery management options for fisheries on mixed populations of steelhead with differing productivities is required. The working paper should consider the development of an assessment strategy to determine whether management objectives have been achieved.

Information and Research Needs

Fraser River chum salmon - The Steering Committee agreed 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 was unsure whether appropriate data are available to do the analysis and recommends that, if the assessment is undertaken, enhancement effects on run timing be considered. The Steering Committee agreed that a request for estimates of the contribution of enhanced Fraser River chum to Washington fisheries should be made. The Steering Committee was unwilling to support chum escapement estimation programs on the Harrison, Stave, or Chilliwack rivers without additional information on the costs of these programs.

Skeena River coho - The Steering Committee was concerned that more stock specific information was needed. Estimates of the escapement and the in-river harvest of tagged fish are desirable.

Evaluation of the Lower Georgia Strait chinook conservation program - The Steering Committee strongly endorsed the recommendation that a statistical method for comparing harvest rate changes, based on coded wire tag recoveries, be developed. The Steering Committee agreed that pooling harvest rates over fisheries to increase sample sizes is appropriate and that the 1984-1987 base period appears better for comparing the effects of management and enhancement than the single year 1987. The Steering Committee agreed that the feasibility and costs of producing a habitat assessment and report for the Squamish, Nanaimo, and Cowichan rivers should be undertaken. The Steering Committee added a recommendation that the apparent high levels of pre-spawning mortality of hatchery and wild chinook should be investigated and the effectiveness of the three facilities designed to rebuild LGS chinook populations should be evaluated.

Skeena River summer steelhead trout - The Steering Committee encouraged the initiation of research programs to test assumptions of the habitat based model in the Skeena River.

Evaluation of the 62 cm. size limit for Georgia Strait chinook - The Steering Committee agreed that the analytical approach used in the working paper should be developed further.

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

Major recommendations in PSARC Advisory Document 92-6

Three working papers were reviewed at the November 1992 Salmon Subcommittee meeting.

Advice for Fisheries Management

Barkley Sound fisheries affecting salmon - A working paper on hake/mackerel fisheries in Barkley Sound and the implications for salmon management was not accepted by the Subcommittee. The three fisheries of concern were the summer hake fishery, a proposed winter fishery for resident hake in Barkley Sound, and a proposed mackerel fishery in Barkley Sound. Some recommendations concerning these fisheries had previously been provided by Science Branch to Fisheries Branch without the benefit of review by PSARC. Revisions to the working paper, as submitted, would be substantial. The Subcommittee was unwilling to request substantial revisions to the working paper without direction from the Steering Committee. The Subcommittee did suggest that the issue of by-catch, particularly salmon, in the summer hake fishery should be the first priority. The Steering Committee supported the concept of three separate working papers of the 3 fisheries provided there was sufficient concern. The issue was taken to the RMEC. Science Branch accepted responsibility for pursuing this further.

Information and Research Needs

The Subcommittee noted that an assessment of the resident winter hake population in Barkley Sound was required to assess the impact of a proposed fishery on that stock. The salmon interceptions and potential interceptions in the summer hake fishery should be a first priority.

Outstanding recommendations from PSARC Advisory Document 91-1, 91-6

1. The Steering Committee recommended the need to document forecasting methods for Fraser River sockeye on a single stock basis.

6. The Steering Committee supported the Subcommittee's request to establish a working group to examine alternative methodologies for assessing coho salmon. A number of issues, including the need for additional analyses to support the interim floor escapements for Fraser River coho, were suggested for the working group to consider.

   The Steering Committee requested that a working paper be submitted to the Salmon Subcommittee to evaluate sockeye fry growth and abundance following the very high escapement to Meziadin Lake in 1991 and to review the basic assessment data needed for Nass River sockeye.

Outstanding recommendations from PSARC Advisory Document 90-1, 90-5.

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.

   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.

   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.

1.5 The RMEC endorsed recommendations concerning the need and proposed program to improve the quality and consistency of salmon escapement data.

Salmon stock assessment planning workshop

A three-day workshop was held at the Institute of Ocean Sciences in September, 1992 to develop lists of important salmon stocks/stock complexes in the Pacific Region, to develop a system for prioritizing salmon stocks for assessment, to score each of the stocks/complexes according to the scheme, and to develop prioritized lists (by Division) to be used for developing schedules for salmon stock assessments. Before developing the schedules, the Subcommittee recommended that the draft plan be presented to the Steering Committee and the Regional Executive for approval.

The Steering Committee discussed the report at their meeting in late September 1992. They endorsed the process and the draft priority lists but recommended that these be reviewed by the regional advisory planning committees (APC) for comment. The Subcommittee chairman received a memo from South Coast Division recommending that the priority of two chum stocks should be lowered. There has been no formal response from the North Coast Division. Fraser River and Yukon Division does not have an APC, however, the lists were circulated within the division and revised scores to various criteria were received by the chairman and implemented.

Because of stock assessment reorganization and other uncertainties in the Region, the planning process has not proceeded further. The lists were, however, used for guidance in scheduling some of the assessments for spring 1993 and subsequent meetings.

Forecast Performance - 1992

Species	Stock	1992 Forecast Return (,000)	Average Absolute Variation % (Years)	1992 Observed Return (,000)	1992 Deviation (%)
Sockeye	Fraser River (1988 cycle)	5,900	n/a	6,150	-4.1
	Barkley Sound	1,000	15 (5)	1,100	-1
	Area 9 (Rivers)	659	64 (7)	849	-22
	Area 10 (Smith)	595	40 (8)	932	-36
	Skeena River	2,300	42 (11)	3,300	-30
	Nass River	330	66 (1)	980	-66
Pink	Skeena River	n/a			
	Area 8	8,808	21 (1)	7,253	21
	Southern B.C. Even Year	2,787	65 (12)	3,120	11
Chum	Area 8	648	95 (8)	241	148
	S.B.C./John.St. Fraser River	4,008	35 (23)	4,500	11
Chinook	S.B.C./Big Qualicum Hat.	n/a			

Publication Record

The Salmon Subcommittee reports from the 1992 meetings were published in:

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.

Subcommittee Membership

A.W. Argue replaced G. Berezay as Program Planning & Economics Branch representative. Members are listed in Appendix 1 of the Subcommittee report.

2. REVIEW OF WORKING PAPERS

S93-1 Review of the spawning escapement target for Tahltan Lake sockeye salmon. Wood, Morley, Johannes, Johnston and Etherton

Working Paper Summary

Tahltan Lake, located near Telegraph Creek, British Columbia, supports the largest single population of sockeye salmon in the Stikine River watershed. Tahltan Lake sockeye are caught in both Alaskan and Canadian fisheries, and their management is governed by the Pacific Salmon Treaty. Specific management objectives and in-season management plans are developed during annual meetings of the joint Canada-U.S. Transboundary Technical Committee. The Transboundary Technical Committee originally adopted an escapement goal for Tahltan Lake of 30,000 (acceptable range 20,000-40,000), but after reviewing data presented here, considers that this target is too high. Accordingly, this report was submitted to PSARC to ensure that there is scientific justification for reducing the escapement target for sockeye spawning naturally in Tahltan Lake.

In PSARC Working Paper S90-7, Wood and Johnston documented the status of sockeye production in the Stikine River, including Tahltan Lake. Their analysis indicated that the optimal spawning escapement was around 20,000 spawners, but the Salmon Subcommittee of PSARC did not consider it prudent to reduce the escapement target without more data. Since then, additional data have been collected as part of a study to evaluate the joint Canada-U.S. fry planting enhancement program. Furthermore, the escapement target issue has become important because the existing escapement goal now constrains the availability of Tahltan Lake broodstock for joint Canadian-U.S. enhancement projects in Tahltan and Tuya lakes.

Recent Trends in Sockeye Production

The 1992 total catch and total return of Tahltan Lake sockeye was the highest on record (59,346 and 119,253 fish, respectively). Total returns have increased steadily since 1988, the year of record lowest returns.

Harvest rates have been relatively stable from 40-50% since the signing of the Pacific Salmon Treaty in 1985, with the exception of 1988 when unexpectedly low returns resulted in a harvest rate of 73%. The poor returns from 1987-1989 resulted mainly from poor smolt-to-adult survival (Wood and Johnston, PSARC Working Paper S90-7).

Total smolt migrations (age 1+ and 2+ combined) have generally increased since 1984. Smolt production was augmented significantly in 1991 and 1992 by hatchery-incubated fry which were planted into Tahltan Lake in 1990 and 1991.

Stock-Recruit Analysis of Total Returns

For all brood years for which total return data are available (1975-1986), the three highest returns originated from escapements of less than 30,000, the current escapement target, although in two of these years escapements were within the proposed target range (>20,000) (Fig. 1). A Ricker function provides a significant fit to these data ($p=0.03$), with escapement explaining 38% of the variation in ln(recruits/spawner). The optimum escapement corresponding to the Ricker function is approximately 15,000.

Factors Limiting Sockeye Production

Egg-to-age 1+ smolt survival, approximated by ignoring age 2+ smolts, declines abruptly for escapements beyond 20,000 spawners (Fig. 2). Clearly, freshwater survival accounts for the relatively poor returns from escapements exceeding 20,000. However, further analysis was required to determine whether freshwater survival is limited during incubation or lake residence.

The favourable survival of planted fry provides strong evidence that wild smolt production is limited by events prior to fry plants (i.e. during incubation or emergence). Record wild smolt production occurred in 1990, originating from an escapement of only 6,100, despite the planting of 1.04 million hatchery-incubated fry. Similarly, record overall smolt production (wild + planted), and above average wild smolt production from an escapement of 11,600, occurred the following year after planting 3.58 million hatchery-incubated fry.

Analyses of smolt size and zooplankton standing crops confirm earlier conclusions that food supply has not limited wild smolt production. Mean smolt size has not decreased significantly in recent years despite increased smolt migrations. The record high recruitment of wild and planted fry in 1991 produced a record number of age 1+ smolts of about average size. Zooplankton abundance and mean length in Tahltan Lake has changed little since 1987 despite a three-fold increase in sockeye fry density from 1989-1991; zooplankton biomass has declined only slightly. Moreover, high (30-90%) proportions of cladocerans have persisted in the zooplankton forage base despite the increased fry recruitment. The only indication of increased cropping pressure by sockeye fry is a seasonal decline in the proportion of daphnids in zooplankton samples from August to September in 1990 and 1991. These observations indicate that the carrying capacity of Tahltan lake has not yet been reached at current levels of sockeye fry recruitment.

Stock-Recruit Analyses of Fry Recruitment

All of the preceding analyses indicate that wild smolt production in Tahltan Lake is limited by wild fry recruitment, prior to the planting of hatchery-incubated fry, and not (yet) by density-dependent processes during lake residence. It is appropriate, therefore, to determine the optimal escapement target for wild sockeye by examining the relationship between wild spring fry recruitment and spawning escapement. We calculated best, minimum and maximum estimates of wild fry recruitment from historical wild smolt counts, using the best and extreme estimates of lacustrine mortality derived from data for planted fry. We also fitted Ricker recruitment functions to each set of fry recruitment data and estimated the corresponding escapements that would provide maximum and optimum fry recruitment.

Results were very similar for all three data sets, and the Ricker functions explained 65-78% of variation in ln(fry recruitment/spawner) (Fig. 3). Maximum fry recruitment was predicted from escapements of about 20,000 for all three Ricker curves; optimum fry recruitment was predicted from escapements of 15,000-16,000 assuming 2% fry-to-adult survival, and 18,000-19,000 assuming 5% fry-to-adult survival. Smolt-to-adult survival has averaged 6.7% (range 1.5-18.5%) for brood years 1982-1987, which implies an average spring fry-to-adult survival rate of about 2% (range 0.4-5.6%) using our best estimate of lacustrine survival (30% during the first year).

Discussion

Two separate stock recruitment analyses indicate that sustainable yield from naturally spawning Tahltan lake sockeye will be maximized at escapements from 15,000-19,000 spawners. These analyses are meaningful because escapements have varied over a very wide range -- from 15% to 390% of the estimated optimum. Admittedly, both analyses are based on relatively short time series (9-12 yr.) which can cause optimum escapements to be underestimated. The analysis of total adult returns may also be biased because it is based in part on catch data of unknown reliability. In contrast, the escapement data, smolt counts, and planted fry recruitment are considered to be very reliable. Moreover, stock-recruit analyses of spring fry recruitment were relatively unaffected by assuming a wide range in values for lacustrine mortality, and smolt-to-adult survival. It is also reassuring that two different approaches yielded very similar estimates of optimal escapement, and that these estimates were very similar to estimates from previous analyses with only 6-10 years of data.

The conclusion that wild smolt production is limited by wild fry recruitment seems reasonable because all sockeye in Tahltan Lake spawn within the lake itself, not in tributary streams. Some high quality spawning habitat must exist because egg-to-spring fry survival has been very high (40-60%) at low spawning densities. However, observations during spawning and broodstock collection suggest that the extent of high quality spawning habitat is rather limited so that average incubation success could decrease quickly as spawning escapements increase.

We conclude that the most appropriate escapement target for naturally-spawning Tahltan Lake sockeye is 20,000 spawners. This is a significant reduction from the current goal of 30,000 (range 20,000-40,000). The recommended target is based on extensive data collected since 1984, whereas the original goal was based on "professional judgement" and very limited data available in 1985.

Reducing the escapement target for Tahltan Lake will have important implications for sockeye enhancement activities in the Stikine River. Additional spawners available as broodstock could provide an additional 5-10 million fry available for planting into Tahltan and Tuya lakes. This raises two concerns: First, excessive densities of planted fry could over-graze the forage base in these lakes, causing changes to zooplankton community structure that could be difficult or impossible to reverse, and that would be detrimental to the survival of wild sockeye in Tahltan Lake. Second, broodstock selection procedures, or inadvertent artificial selection during hatchery-incubation could lead to genetic changes and loss of diversity in the wild Tahltan Lake population, especially if the hatchery-reared component becomes predominant in adult returns to Tahltan Lake.

Reviewer #-1 (Internal)

The reviewer noted that on the whole, the conclusions reached seem reasonable given the length of the time series of available data and that the returns from the large 1991 and 1992 broods should help identify the density-dependent effects suggested by the authors. The reviewer agreed that the evidence suggests that lake rearing capacity is not limiting, rather that limited spawning habitat limits production. The reviewer recommended that the escapement target could be confirmed with additional research to determine the spawning habitat and that direct measurements of egg survival, or the quality of the incubation environment might yield an independent estimate of the optimal escapement based on the amount of high quality habitat. Finally, the reviewer noted that selection for certain traits (e.g., run timing) is more of a concern than loss of diversity in broodstock sampling.

Subcommittee Discussion

One of the central discussion items was the need for brood stock acquisition and incubation standards and their application. It was pointed out that there are current brood stock selection standards that are followed for the Tahltan. There are no long term guidelines for monitoring genetic changes.

There were lengthy discussions on the variability in the stock recruitment analysis and the merits of changing the escapement target in light of this uncertainty. The strength of the analysis is the apparent accuracy of the stock specific catch, spawning escapement, fry and smolt information, and the consistency in the indications of optimum escapement among all of the assessments. There are clear indications that the current incremental fry production from 30,000 versus 20,000 spawners is very minor and therefore the risk in the target escapement reduction is minimal. There is also a buffer currently since the 'lost' escapement is directly converted to increased fry production through supplemental enhanced fry production.

One concern discussed was the loss of potential 'adaptive management' stock recruitment data by moving to a lower fixed escapement target. If there are no management changes then only a modest change in escapement distribution would be anticipated. This may not be the case if terminal harvests were implemented, however the information base strongly indicates that the higher escapement ranges do not need to be probed further.

There was discussion of the need for guidelines about the use of surplus spawners and/or use of a limited number of spawners. Should enhancement take precedence over natural production in all cases?

Subcommittee Recommendations

1. Reduce the spawning escapement target for naturally-spawning sockeye in Tahltan Lake to 20,000 which reflects a conservative (high end of the range) interpretation of the stock-recruitment analyses.

2. The Pacific Salmon Commission, through its Transboundary Technical Committee should develop and document a plan to evaluate Tahltan Lake sockeye productive potential through adaptive management of fry out-plants. Continued fry, smolt and zooplankton sampling will be required to evaluate the program.

3. Confirm that the current SEP broodstock selection and incubation guidelines for safeguarding the genetic diversity of the natural population are being followed, and establish long term guidelines for monitoring genetic change in the Tahltan sockeye population.

S93-2 Recommended target escapement levels for the Quesnel Lake sockeye stock. Welch, Shortreed, Stockner, Hume, Morton and Williams.

In the fall of 1992, the PSARC Steering Committee recommended that the Salmon Subcommittee request two documents on Fraser sockeye: 1) Carrying capacity of sockeye in Fraser River lakes, and 2) an assessment of Horsefly sockeye and recommendations for 1993 escapement. After discussion between the proposed major authors (Drs. Stockner and Welch) the consensus was that there was sufficient overlap to warrant a single document.

Working Paper Summary

Stock size and recruitment of Quesnel Lake sockeye has grown exponentially over time (Fig. 4). During this period of rebuilding from very low initial levels, the dominant cycle line has rebuilt to the point where, in 1989, a total of nearly 12 million sockeye returned. However, despite these large increases in returns, there is still no evidence of density-dependence in the stock-recruitment relationship for the Horsefly system (the major spawning ground within the Quesnel watershed) (Fig. 4).

Large sockeye returns provide significant economic benefits to Canada. However, if the level of returns should outstrip the rearing capacity of the lake, then sharp reductions in subsequent recruitment could result. This has occurred in some Alaskan sockeye populations, where a collapse in sockeye production occurred following repeated years of high escapements. This collapse was also followed by a change in zooplankton community structure, one less favourable to sockeye production. Rebuilding Quesnel sockeye production should be carried out cautiously, in such a manner as to gain the most scientific information, while at the same time minimizing the risk of collapse and impacts on the fishing communities. To this end a wide range of biological data was reviewed to assess what changes have occurred in Quesnel Lake, and to compare these changes with those that have occurred in Shuswap and Chilko lakes, two interior lakes on the Fraser system that also contain large sockeye populations.

The main conclusions from this review of available data are that some significant changes to the zooplankton community of Quesnel Lake did occur in 1986 and 1990, when fry from the dominant cycle line were present in the lake. For example, *Daphnia* biomass was significantly reduced in 1986 and 1990 when compared with other years (Fig. 5, *top*). However, these changes were qualitatively similar to those changes also observed in Shuswap Lake, a system where the general consensus is that significant over escapement to the lake has not yet occurred (Fig. 5, *bottom*). Other changes in zooplankton were identified in Quesnel Lake, some greater than and some less than the changes observed in Shuswap Lake. These changes, taken together, suggest that the lake may now be approaching its rearing capacity. However, the observed changes provide little specific guidance as to what the appropriate escapement level should be.

Several limnologically based models of sockeye fry production in Quesnel Lake were presented. These models were based on Alaskan models but were modified to account for some of the marked differences in the limnology of Fraser River and Alaskan lakes. These models indicated that an escapement of roughly 2.1 million sockeye would be optimal, but the uncertainty in these estimates is currently difficult to quantify. The models did, however, indicate that some increase in escapement over 1989 levels (1,871,000 spawners) could be justified, particularly in light of the smaller return levels expected over the following three off-cycle years.

Some further evidence that an increase in escapement over 1989 levels was warranted comes from changes in sockeye smolt or pre-smolt size with escapement level (Fig. 6). It is widely agreed but not well documented that sockeye must attain at least a body weight of 2 grams in order to successfully smolt and leave fresh water. Quesnel Lake sockeye have in the past attained a size of about 3 grams as presmolts in the fall, irrespective of escapement level. In comparison, pre-smolt sizes in Shuswap lake are currently much closer to the two gram limit, and spring smolt sizes in Shuswap (before spring growth) and Chilko lakes range from 2-4 grams (Fig. 6).

For these reasons, it was concluded that an increase in escapement levels over the 1989 level was possible. It was recommended that a target escapement level of 2.3 million sockeye be set for the Quesnel Lake system in 1993, a 20% increase over the 1989 escapement level. This will allow some prudent testing of the potential for further production increases.

Preamble to the reviews

This working paper was discussed by the Subcommittee on two separate occasions. Once at the regular Subcommittee meeting and once again via teleconference to deal with a problem in the original working paper that was discovered following the regular Subcommittee meeting. The escapements to Quesnel Lake rivers other than the Horsefly River were not considered in the authors' original draft of the working paper where a target of 2.0 million spawners had been proposed. However, the working paper had been written in such a way as to suggest that they had been considered. Therefore, all three reviewers and the Subcommittee members present interpreted the proposed target escapement of 2.0 million spawners as a probing (rebuilding/information generating) increase of about 0.35 million (from 1.64 in 1989) spawners. With the revelation that non-Horsefly River systems had not been included, the 2.0 million target represented only a small increase over the 1989 total escapement to Quesnel Lake (1.87 million spawners). The reviewers' comments below presumed a proposed target of 2 million spawners.

Reviewer - #1 (Internal)

The reviewer noted that the target escapement of 2 million sockeye requires clarification if the sex ratio is not (or will not be) 1:1. The reviewer noted that there was not convincing evidence that 2 million should be the target, however, it represented a significant increase (approx. 400 thousand) over the target in 1989 and this, the reviewer felt was desirable. The reviewer found no evidence in the working paper that the stock is in danger of collapse from escapement at this level in 1993. The reviewer noted that habitat based estimates of optimal escapement to the Horsefly are potentially very useful but require substantially more work before they can be used to establish goals. The reviewer had specific comments about what could be included in such a document.

The reviewer recommended that efforts to establish the size and abundance of fall fry and spring smolts should be continued or pursued. The reviewer was concerned about the reliability of the fall fry abundance estimates and how the authors might address this. The reviewer recommended that the zooplankton studies would be useful but second in priority to work on fish size and abundance.

Reviewer - #2 (External)

The reviewer noted that the target escapements are as accurate as they can be given the available data, however, more consistent data or more data are needed to provide more convincing and accurate escapement estimates. The reviewer noted that of the two major factors controlling fry production (spawning/rearing area or food availability), the reviewer believes the latter to be limiting but that there are only a marginal number of years of data on which to base the conclusion. The zooplankton standing crop appears to be lower in dominant years, but with so little data, it is not possible to determine whether the apparent differences between years results from natural interannual variation or sockeye fry density. The reviewer noted that the authors may wish to examine what zooplankton biomass is required to maintain fry growth. The reviewer recommended that the authors attempt to measure that variable most directly related to fry growth and survival - zooplankton productivity, rather than using indicators lower in the trophic structure. Finally, the reviewer noted that the authors suggest overwinter survival may be the key to the success of a brood year yet there are no recommendations to test the hypothesis.

Reviewer - #3 (Internal)

Again, the reviewer believed the recommendation was for the Horsefly system, not Quesnel Lake. Unlike Reviewer-#2, this reviewer believed that spawning habitat limitations, not food supply, was the major factor to consider in establishing an escapement target. The reviewer also noted that the evidence presented did not suggest that spawning levels should be restricted to 2 million spawners. This reviewer also supported better efforts to resolve and clarify the fall acoustic estimates of sockeye fry abundance and size. The reviewer did not wholly support the notion that the zooplankton community structure is undergoing significant declines resulting from increased sockeye fry predation and noted that there is no sign of inhibited sockeye growth at greater fry densities. The reviewer commented that Quesnel Lake can easily support current sockeye fry densities and that lakes of much lower annual productivity support similar densities. This reviewer agreed in spirit with the recommendation of reviewer-#2 in supporting the need to emphasize studies at the critical trophic level for sockeye rather than the authors current focus of modelling primary productivity and nutrients. The reviewer also provided an extensive list of points for authors to consider in the text of their working paper.

Subcommittee Discussion

The Subcommittee noted that an adult sockeye escapement goal, once established and met, is subsequently influenced by interannual variation in egg to fry survival. This can create substantial variation in within lake fry abundances from the same number of spawners in different years. The stock-recruitment data, if considered independently, did not provide any evidence of a density-dependent relationship. This would suggest that large increases in escapement could be supported. The habitat based estimates of target escapements were greater (by 20% at the low end of the range) than the 1989 Quesnel Lake escapement (1.9 million). Unfortunately, the habitat estimates were not sufficiently documented to give the Subcommittee confidence in using them. Much of the discussion of lacustrine limitations to sockeye survival was based on the observation that zooplankton standing crops were lower in dominant cycle years, and that a 2 g smolt was assumed to be the minimum acceptable size for Quesnel Lake. Smolts from the 1989 return averaged about 3 grams. The reviewers and the Subcommittee noted that there is both controversy and little evidence for a broadly applicable relationship between sockeye smolt size and smolt to adult survival in Fraser lakes. The reviewers disagreed in what might limit production in Quesnel Lake. In part, this disagreement arose because the data are not sufficient to readily conclude what limits production in Quesnel Lake. Some felt there was evidence to suggest that the recent high escapements for the 1989 cycle year were approaching capacity. The 1993 return will provide some information on the success of the 1989 brood year. The Subcommittee considered that the target escapement, once established, should remain unchanged unless significant deviations from historical patterns are observed. The method for determining the 'breakpoints' for changing the goal should be the subject of additional study.

The authors suggested, without supporting documentation, that there is the potential to increase production through fertilization of Quesnel Lake. One reviewer supported this and two did not based on the information presented in the working paper. The working paper clearly lacked sufficient data to assess the requirement to fertilize Quesnel Lake and recommended that this be the subject of a separate working paper. The Subcommittee noted that, if fertilization was recommended in the future, it would not be required until 1994. The working paper should be jointly authored with fisheries managers such that the working paper would include a harvest plan for taking the increased production.

Subcommittee Recommendations

1. The Subcommittee recommends a target escapement of 2.3 million sockeye spawners (assuming a 1:1 sex ratio) to Quesnel Lake in 1993.

2. Because the success of the returns from the 1989 escapement level will not be known until this summer, and because none of the data examined provide a clear-cut indication of what escapement level is advisable biologically, it was also recommended that contingency plans be drawn up to reduce target escapement levels to a level intermediate between the 1985 and 1989 escapement levels, should returns to the Quesnel system in 1993 be substantially below expectation (strong evidence of density dependent effects in the lake).

3. Programs are required to determine whether lake carrying capacities are limiting sockeye production. Zooplankton and limnological monitoring of Quesnel Lake should continue and the cost and feasibility of obtaining smolt abundance estimates should be examined.

4. Without further confidence in the estimates of spawning habitat and lake rearing capacity, substantially higher escapement levels should not be pursued because of the potential for interactions with the subdominant year.

5. Escapement targets above 2.3 million should not be considered in the absence of a comprehensive management and harvest plan for weak stock and overlapping species considerations.

S93-3 Stock assessment of Mesachie Lake coho salmon with comments on Cowichan Lake coho salmon. Holtby.

Working Paper Summary

This working paper was prompted by a decline in escapements to Mesachie Lake and other tributaries to Cowichan Lake in the last several years, and especially in 1992. The Cowichan system has been one of the largest producers of coho salmon in B.C. with average escapements estimated to be in excess of 40,000 historically (Aro and Shepard 1967). The objectives of the working paper were to document trends in escapement and other indicators of stock status for the Mesachie Lake coho population and other populations in the upper Cowichan, and to compare trends in the Cowichan Lake populations with recent observations for other southern Strait of Georgia and Fraser River populations.

The approaches to estimate escapements used in this study were:

Measured or estimated	Years	Methods
Recent escapements to Mesachie Creek	1986-1989,1991,1992 1990	Fence count Area Under Curve (AUC), peak live count & carcass count expansions
Historical escapements to Mesachie Creek	1941-1944 1976,1977 1984	Point observations & timing model using Oliver Creek fence counts. AUC estimates AUC, peak live count & carcass count expansions.
Recent escapements to Robertson side channel, Patricia, Oliver, Shaw, Richards and Rotary Park Creeks	1986-1992	AUC estimates
Index of escapement or egg-fry survival index of fry abundance.	1987-1992	Numbers and growth of juvenile coho moving through Mesachie fence.
Proportion of applied tags in reporting fisheries. Tag distribution in fisheries. Smolt survivals and exploitation rates.	1988/9 - 1992/3 (return years)	Application of CWT at Mesachie Creek, recovery in fisheries and spawning ground estimates of tag return.

Escapements: Escapements to Mesachie Creek have decreased over the last decade (Figure 7). There has been a marked decline since 1990. The recent decreases contrast with stable escapements extending back over 50 years. The marked declines observed at Mesachie in 1991 and 1992 have been observed at all of the surveyed sites in the Cowichan (Fig. 8).

Fry indices: The number of fry moving through the Mesachie Creek fence has declined since 1989 (Figure 9). The apparent growth of the fry has increased simultaneously and is significantly correlated with fry numbers. The author concludes that the trends in fry numbers probably indicated declining fry abundance in the upper Cowichan. The number of fry, however, is not correlated with escapements. Numbers decreased even with stable or increasing escapements suggesting that egg-fry survival, and hence stock productivity, has been decreasing since 1986.

Proportions of released tags in reporting fisheries (survival to the fishery): Smolt survivals to the fishery of Mesachie Lake coho have declined over the last 5 years (see Table below). Similar declines were seen for Chilliwack River coho and possibly Eagle River, but not at other VCE, Lower Fraser River, and Thompson River sites. In fact, no general patterns in smolt survival are apparent. This lack of generality suggests that the factors responsible for varying survivals are localized, possibly in the rivers or their estuaries.

Proportions of released tags in all reporting fisheries for various stocks on Vancouver Island and in the Fraser and Thompson Rivers. Locations and their codes are: MSCH-Mesachie Creek (341), BIGQ-Big Qualicum hatchery (100), QUIN-Quinsam hatchery (106), SALM-Salmon River, Langley (248), CHILL-Chilliwack hatchery (107), EAGLE-Eagle River hatchery (156), THOM-Thompson River NCDP (188), and RCRK-Robertson Creek hatchery (104). Data from fed-fry releases were excluded.

Brood Year	MSCH	BIGQ	QUIN	SALM	CHILL	EAGLE	THOM	RCRK
1982	-	0.042	0.061	-	0.143	-	-	0.013
1983	-	0.075	0.050	-	0.078	-	-	0.025
1984	-	0.055	0.064	0.084	0.122	0.016	-	0.016
1985	0.056	0.013	0.062	0.144	0.149	0.032	-	0.010
1986	0.033	0.008	0.072	0.092	0.096	0.046	0.006	0.033
1987	0.037	0.031	0.064	0.085	0.081	0.020	0.073	0.057
1988	0.022	0.041	0.027	0.049	0.063	0.002	0.058	0.031
1989	0.018	0.042	0.046	0.071	0.042	0.015	0.061	0.030

Smolt survivals and fisheries exploitation: Overall smolt survival (catch & escapement) has declined over the last five years (Fig. 10). The fisheries exploitation rate has varied but shows no directional change. The decreased escapements since 1986 are consistent with the decrease in smolt survivals over the same period, and were not associated with any change in the exploitation rate of reporting fisheries.

Changes in smolt survivals cannot be easily ascribed to changes in ocean conditions; those changes may be due to habitat alteration in the river or the estuary that are reducing smolt survivals before they enter the ocean. For example, in the fall of 1987, Fielden and Holtby (1987) reported very large numbers of smolts apparently overwintering in Somenos Lake (a tributary of the lower Cowichan River). Those smolts may have originated in the upper watershed, (i.e. the fall smolt run), since at least two Mesachie Creek tags applied in the fall were recovered in Somenos Creek. For unknown reasons, in the three years following, no juvenile coho could be found in Somenos Lake (B. Holtby, unpubl. data). There is some evidence that debris is important during smolt migration (McMahon and Holtby 1992), apparently serving as short-term refuges. The widespread diking that has occurred in the lower Cowichan River has probably led to extensive degradation of the estuary as a nursery area over the past few decades. Further research into habitat use by coho of various life stages in the lower Cowichan is warranted.

In summary, escapements to all censused Cowichan coho populations have declined rapidly over the last decade with particularly severe declines in the last two years. **The declines appear to be associated with decreasing smolt survivals and decreased freshwater productivity.**

Reviewer - #1 (Internal)

The reviewer agreed that Mesachie Creek escapements have declined during the past 3 years and that there is cause for concern. The reviewer had little confidence in the estimates derived for the 1940's. The reviewer considered that recent escapements were very low and likely indicative of a substantial decline from earlier years. The reason(s) for the decline were not clear. The reviewer was concerned whether the in-river fishery, the Cowichan Bay fishery, and/or marine mammal predation have increased significantly in recent years. The reviewer noted that quantifying habitat loss in the lower Cowichan might be worth pursuing as there is historical data on the status of the estuary in 1975.

Reviewer - #2 (External)

The reviewer noted that improvements are required in the introduction to clarify the objectives of this working paper. The reviewer noted that another possible explanation for the observed decline in escapements might result from highly mobile spawners that do not home well. The author agreed that the study of a smaller system (than the Cowichan) might be more tractable. Overall, the reviewer felt that this was a creative attempt in an area that is traditionally very difficult to gather reliable data. The reviewer felt that the interpretations were conservative and agreed with the conclusions and recommendations. The major summary recommendation of the reviewer was to clarify many aspects of the description of the methodologies used by the author.

Subcommittee Discussion

The Subcommittee agreed that escapements to all censused Cowichan coho populations have declined rapidly over the last decade with particularly severe declines in the past two years. Although a reviewer and the author disagreed about how much confidence could be placed in the 1940's estimates of escapement to study streams, the author pointed out that, from field note books and similar sources, there was sufficient reason to believe that staff in the 1940s acted diligently in their efforts to count fish in Oliver Creek. Therefore, the estimates are reasonable. The Subcommittee had no cause to disagree with the author on this point.

Nothing in the data presented for reporting fisheries appears to explain the escapement declines since the late 1970s. The effect of freshwater and estuarine habitat loss is unknown. The magnitude and effect of the unreported fisheries (in-river sport and aboriginal) may be substantial and is of concern to the Subcommittee.

There is a need to know the cause for the decline in order to avoid manipulating fisheries if it would not be effective in reversing the trend. As an option, the author suggested studying smaller systems with similar ocean distributions to index what might be occurring in the Cowichan. A comprehensive study of the Cowichan would require additional commitments of people and funds but perhaps there is little alternative to evaluating causes of declining coho production.

Subcommittee Recommendations

1. Recognizing that the Cowichan River has been a major producer of coho salmon that has experienced substantial declines in escapements to study streams, and aware of the unique ocean distribution of this stock, the Subcommittee recommends that a comprehensive study of the factors limiting coho production in the Cowichan watershed and estuary be developed.

S93-4 An evaluation of enumeration methods to estimate spawning escapements of Fraser River pink salmon. Cass and Whitehouse.

Working Paper Summary

This document evaluates methods presently used to estimate the abundance of spawning populations of Fraser River pink salmon. There is concern about the ability of the current Fraser River tagging program to produce reliable estimates of pink salmon spawner abundance.

Spawning escapements are estimated primarily by mark-recapture experiments conducted every odd-numbered year.

Weekly tagged to untagged ratios in recovery samples were calculated for mainstem and tributary releases of pink salmon and compared to the distribution of weekly counts of untagged fish. Simulation studies were used to evaluate the trends in the observed tagging data and to evaluate the effects of violating model assumptions on the subsequent estimates of spawner abundance. Factors affecting the accuracy of the estimate were assessed using tagging data for 1989 and 1991.

Apart from the absolute magnitude of recent large escapement estimates, particularly in 1991, problems are also suggested by the temporal and spatial differences in the tagged to untagged ratio in the recoveries (Fig. 11). Two explanations can easily account for variation in weekly distributions of tagged:untagged recoveries: 1) disproportionate tag application rates, and 2) differences in behaviour of tagged and untagged fish (including tagging mortality). Disproportionate tagging alone will not substantially affect the accuracy of the escapement estimates (Fig. 12). Differences in behaviour of tagged and untagged pinks will bias estimates of escapements. The bias can potentially result in pronounced over-estimates of spawning escapements. Simulation results incorporating a tagging mortality rate of 2% per day, can result in a two-fold positive bias in estimates of spawning escapements (Fig. 13). Geographic differences in recovery rates of tagged pinks can only be explained by behavioral differences that result from tagging and will almost certainly result in a biased estimate of spawning escapement. The tagged/untagged ratio is lowest in the Thompson River, where pink salmon have the furthest to travel.

Reviewer - #1 (Internal)

The review had no substantive comments but raised a few minor points for authors to consider.

Reviewer - #2 (External)

The reviewer believed the authors did a good job of exploring the potential sources of bias in the pooled Petersen method currently used. The pooled Petersen estimate will be a valid estimate of the population size under the four common situations:

(a) a constant proportion of the carcasses are dead pitched in each recovery week.
(b) a constant proportion of the run is marked in each release week.
(c) there is a complete mixing of the release groups, i.e., a fish that enters to spawn in week 1 is just as likely to die in week 4 as a fish that enters to spawn in week 3.
(d) tagging happens to be applied so that the number of tagged fish that die in week j is a constant proportion of the number of untagged fish that die in week j.

Condition (a) is unlikely to be true, because pitching is likely limited by the size of the crew and cannot expand and contract with the number of carcasses present. Condition (b) is unlikely to be true because the nets are likely to become saturated. Condition (c) is unlikely to be true on physiological grounds. Condition (d) is unlikely to be true because releases must be planned with perfect prior knowledge of the run distribution and stream life distribution.

Consequently, it is unlikely that the pooled Petersen estimate employed is unbiased. However, as shown by the authors, the size of the bias may be small for certain violations of the assumptions but may be large for other violations. Because the data is collected and recorded in such a fashion that the stratified Petersen estimator (the Darroch estimator) can easily be used, The reviewer further recommends that this estimator also be used to estimate the spawning escapement. If the results from the stratified Petersen and the pooled Petersen are similar, then one is more confident that the violations of (a)-(d) are having little effect on the estimates. As well, simulation studies, similar to those performed by the authors, should be conducted to investigate the possible biases in the stratified Petersen caused by tagging mortality, non-closure, etc.

Subcommittee Discussion

The Subcommittee accepts the working paper (subject to revision) and the recommendations. The authors should undertake an analysis to compare a stratified Peterson estimator with the results from the current pooled Peterson estimator to determine whether the results are in agreement. The authors should undertake an analysis with the existing data to determine if the disproportional tagging accounts for the problems with recovery patterns.

Subcommittee Recommendations

1. There is evidence that the method of developing Fraser River pink salmon escapement estimates based on a pooled Peterson mark-recapture model provided biased estimates in 1989 and 1991. Mindful of the importance of having accurate escapement estimates, and concerned about the substantial funding to the existing enumeration program, a working group should be established immediately. The major functions of the working group will be to re-design the 1993 enumeration program, develop methods to test the assumptions of the new design, and to advise on the need for reanalysis of historical mark-recapture data. The working group may wish to consider acquiring expert assistance in mark-recapture statistical design.

S93-5 Recent changes in catchability of sockeye salmon in the Skeena River gillnet test fishery and the impacts on escapement estimation. Cox-Rogers and Jantz

Working Paper Summary

The Skeena River gillnet test fishery is used to monitor sockeye and pink salmon escapement during the management season (June-September). As a secondary function, the test fishery is also used to monitor the relative abundance of chinook, coho, chum, and steelhead passing into the Skeena River. In recent years, large underestimates in the annual test fishery estimates of sockeye escapement have occurred. This has created concern about the reliability of the test fishery as an index of abundance for all species.

Without the large 1985 sockeye escapement, there is little or no relationship between the annual test fishery index and sockeye escapement (Fig. 14). The reason for inability of the test fishery to index escapement is not well understood. Although catch per effort in the test fishery is assumed to be directly proportional to passing abundance for all species (eg. $C/f=qN$), this is only true if catchability (q) remains constant. Analysis of test fishery data from 1970-1991 reveals that sockeye catchability in the test fishery is actually variable, and has declined over time coincident with larger returns of both sockeye and pink salmon (Fig. 15). Three factors appear to be influencing catchability in the test fishery: gear saturation, size selectivity, and access of fish to the net.

Because sockeye catchability varies in the test fishery, predicting appropriate values of q, for in-season use, has been very difficult. While the effects of gear saturation on sockeye catchability may be partially removed, the best way to account for size selective effects on catchability is less clear. Although sockeye catchabilities can be estimated in-season using the relationship between sockeye catchability (q) and mean length in the test fishery, the relationship shows considerable variability, and will produce estimates that are imprecise. Further study is required to clarify the effects of size selectivity on catchability for all species sampled in the test fishery.

The factor with the greatest potential to influence catchability in the test fishery may be accessibility. Net design, river hydrology, fish behaviour, drift topography, and seal predation are all likely affecting catchability in the test fishery. Unfortunately, these factors are not easily controlled. If the intention is to maintain the existing test fishery on the Skeena River, then studies to examine the influence of these factors on catchability are required.

In general, the Skeena River gillnet test fishery provides relatively inaccurate estimates of sockeye escapement into the Skeena River. For other species, accuracy is unknown. No simple way of "fixing" the test fishery is apparent, as improving accuracy basically means improving the way that catchabilities are assessed and estimated in-season. While it may be possible to improve accuracy somewhat using the methods outlined in this report, sockeye

escapement estimates will still be biased. For 1993, it might be best to simply use recent trends in test fishery catchability for estimating escapements in-season. Over the long term, however, it may be more useful to examine other techniques for assessing escapements into the Skeena River. Echo sounding has proven to be a reliable method for estimating escapements on the Fraser River (Jim Cave, Pacific Salmon Commission, pers. comm.).

Reviewers - #1 (External)

The reviewers noted that the paper was not titled correctly and suggested a change to "Recent changes in catchability of sockeye salmon in the Skeena River gillnet test fishery and the impacts on escapement estimation." The reviewers noted that the working paper requires further development. The reviewers highlighted the need to examine the issue of gillnet selectivity more thoroughly and to examine changes in net specifications and materials during the recent period of the test fishery. The reviewers identified that apparent stanzas (before and after $\approx$1983) in the relationship between CPUE and escapement. Seasonal trends in the relationship between catch-per-effort and abundance, or catchability should be investigated. In summary, there are problems with the Skeena River gillnet test fishery, but the document does little other than identify the problem. Some of the problems may be resolved with existing data but others would require experimental work.

Reviewer - #2 (External)

The reviewer felt that the working paper should have focused more on the recent characteristics that could account for the current problems with indexing escapement. The reviewer found the description of the test fishery too brief to provide readers with a complete overview of the test fishery. A number of minor points were raised but the major comments of the reviewer concerned the authors' suggestion to implement a hydroacoustic estimation system. The reviewer felt that this would have some of the same problems as the test fishery (the need for calibration) and some new problems (species identification). Therefore the reviewer suggested that a mark-recapture program up-river from the test fishery might be desirable.

Subcommittee Discussion

The major issue is the underestimate of sockeye escapement. The inability to accurately index other species is also a problem. The working paper clearly identified the problem but the potential reasons are many and varied: fish behaviour, hydrology, predation, and gear saturation, gear selectivity, etc.

Subcommittee Recommendations

1. A working group should be established to review the potential factors affecting the Skeena River gillnet test fishery, to examine and analyze the available data, and to provide recommendations to the Department on the feasibility of improving the existing test fishery. The working group could consist of DFO staff and external consultants.

2. The working group should initially address the immediate management problem of developing a better estimate of q by accounting for factors such as run timing, species composition, the commercial fishery data, etc.

S93-6 Migration timing and harvest rates of the steelhead populations of the Skeena River system. Ward, Tautz (MELP), Cox-Rogers (DFO) and Hooton (MELP).

Working Paper Summary

Migration timing and stock specific harvest rates of Skeena river steelhead trout were examined in relation to the harvest of Skeena sockeye salmon. Summer-run steelhead overlap in their migration timing with sockeye to a significant degree. A previous PSARC Working Paper S92-6(8) estimated habitat carrying capacity and allowable harvest rates for the main Skeena River summer-run steelhead populations. This study compares estimates of steelhead harvest with the rates associated with MSY for each stock. Steelhead harvest in Area 4 was also considered in relation to harvests in Alaska and Canadian approach waters.

Sockeye run timing was reconstructed by adding catches to escapement at Tyee for 1980 to 1991. Sockeye runs peaked on July 24 (day 205) ±5 days. Since catch data for steelhead is unreliable, a method was developed using Tyee test fishery catches for sockeye (Fig. 16) and steelhead from 1956 to 1991. A curve-fitting procedure was used to estimate the steelhead peaks relative to sockeye. On average, sockeye peaked on July 22 (day 203) and steelhead on August 7 (day 219), a difference of 16.5 days.

Stock-specific run timing for steelhead was based on tag recoveries from several studies and racial analysis of catch (Cox-Rogers 1985). Coded-wire tags and Floy tags were recovered in fisheries of Alaska, Areas 3 and 4, at Tyee, or at the Skeena bar. CWT data were used for estimating the variances (distribution of the runs) of individual populations as well as relative differences in timing of some individual stocks. Differences in adjusted mean recovery dates indicated that steelhead stocks vary in timing relative to each other. Results of scale studies agreed with the conclusion of a timing peak between week 31 to 33 and differences of up to two weeks between peaks for specific stocks. Run timing patters differed depending on analyses of floy tag recoveries, CWT recoveries, or scale pattern analysis.

Area 4 harvest rates for sockeye were calculated by DFO for each statistical week. These weekly rates for the years 1986 to 1990 were applied to steelhead for the same years. The pattern of fishing varied from year to year, with the peak week of harvest in week 30 (week ending July 26). The fishing pattern was non-symmetrical, with higher rates occurring more frequently during the latter half of the sockeye migration. Depending upon relative run size and timing of individual stocks, overall harvest rates were between $\pm 10\%$ of the overall sockeye harvest rate. (Fig. 17). Mean harvest among steelhead stocks varied from 33% to 42% in the Area 4 general model.

Sensitivity analysis using the mean harvest rate from 1986 to 1990, average steelhead timing, and a 17-day difference to sockeye timing indicated that changes in the steelhead timing peaks or normal curve shapes had little impact at normal levels of variability. The worse case was for individual stocks with narrow timing curves. To estimate overall steelhead exploitation, it was necessary to add rough approximations of the exploitation from Alaska and Canadian approach waters (25%) and the river (6%) to the harvest in Area 4. Exploitation up to Tyee was approximately 56%. The total exploitation rate on these summer steelhead populations is estimated to be 62% but the accuracy of this estimate is unknown.

Based on model analyses, several steelhead populations of the Skeena River appear to be over-exploited. Low productivity stocks such as the Sustut and Morice would be well below of their target escapement at MSY given equilibrium conditions (Fig. 18). Other smaller, less productive populations not included in this analysis would be likewise affected. Only the most productive stocks (e.g., Babine) are likely to be able to sustain spawning population levels above MSY.

Reviewer - #1 (Internal)

The reviewer believed this to be a useful first step in estimating exploitation rates for steelhead returning to the Skeena River, however, key assumptions about harvest rates and productivities of steelhead stocks require validation before the results can be accepted. The reviewer noted that although sockeye harvest rates may be an index of steelhead harvest rates, this analysis requires knowledge of the magnitude of the harvest rate which is unavailable. The link to sockeye harvest rates requires support or testing. The reviewer noted that this methodology will not be effective in assessing the steelhead release program because the harvest rate assumption is violated if the program is effective.

Reviewer - #2 (External)

The reviewer noted that the largest fishery on the north coast of B.C. (Skeena/Nass sockeye fishery) could be the subject of major changes without presenting any information on the relative sizes of the steelhead populations that are threatened by current harvest levels. The reviewer noted that the CWT data does not support the statement that there is consistency in the stock-specific pattern of recovery within a year. The reviewer noted that harvest rate reductions in fisheries other than Area 4 (eg. Area 3-1, in-river) should be explored.

Subcommittee Discussion

Discussion centred on the uncertainty surrounding two major assumptions in the working paper: (1) the assumption that steelhead were harvested at the same rate as sockeye in commercial fisheries, and (2) the estimated width and variability of steelhead run timing distributions. The Subcommittee requested that the degree of uncertainty in the analysis be made more explicit by incorporating ranges or stochastic processes in the assumptions. It was suggested that in reality, harvest rates, run timing, marine survival, and age at return are all variable whereas in the original analysis these were each represented by a single "reasonable" value to compute resulting equilibrium escapement levels. Random variation in sequential processes could result in wide probability distributions for resulting escapements. The authors acknowledged that this was true, but pointed out that although such variation could delay a decline in steelhead abundance, it would have little effect on the ultimate equilibrium stock level.

The authors also acknowledged that particular assumptions in the analysis could not always be substantiated, but pointed out that some version of their analysis must apply, and that the real issue was whether the assumptions were reasonable. The Subcommittee agreed that the authors' approach was a reasonable one possible under the circumstances. Discussion continued on the degree of proof required before action would be taken to protect steelhead from over exploitation. Recent Endangered Species Act (U.S.A.) modelling studies indicate that action should be taken as soon as possible to maximize benefits from conservation programs. The Subcommittee also acknowledged that the authors had calculated MSY harvest levels for steelhead to make their analysis less controversial; in fact, benefits to steelhead sports fishermen would be maximized by maximizing catch opportunity (not sustainable yield) by reducing harvest rates below the MSY level.

The Subcommittee examined the summary conclusions of the paper. In the absence of accurate long term steelhead catch and escapement data, the use of sockeye harvest rates, adjusted for differences in run timing, is an acceptable alternative for estimating steelhead harvest rates. Using this approach, the estimate of exploitation rate for Skeena steelhead (all fisheries), is approximately 60%. The accuracy of this estimate is unknown. Run timing analysis indicates that the aggregate steelhead run is approximately 2 weeks later than the aggregate sockeye run. Using simulation techniques it was demonstrated that for current weekly fishing patterns, steelhead harvest rate was relatively insensitive to shifts in run timing. Of the 13 steelhead stocks defined in PSARC S92-6(8), 10 are likely experiencing harvest rates in excess of the previously estimated MSY harvest rates. The model suggests a differential impact among stocks, and indicates the potential for severe over harvesting of Upper Sustut and Morice River stocks.

Subcommittee Recommendations

[Chairman's comment] The Subcommittee had no specific recommendations other than to note that the Steering Committee concerns reported in Advisory Document 92-1 for verifying steelhead models are applicable to this working paper as well.

S93-7 1992 evaluation of the conservation program for chinook salmon in the southern Strait of Georgia; 1988-1991 (excludes Fraser River stocks). Riddell and Kronlund.

Working Paper Summary

Introduction

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 to all natural chinook populations in the lower Strait of Georgia (LGS, excluding Fraser River chinook stocks) to target levels by 1998. These populations include all chinook producing rivers on the east coast of Vancouver Island, beginning with the Cowichan River in the south, and ending with 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 was focused on chinook populations in the Cowichan, Nanaimo, and Squamish rivers. The program consisted 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.

Two previous PSARC working papers (Starr 1991, Starr and Argue 1991) focused on developing an evaluation framework for regulation changes in the Strait of Georgia sport fishery (GSPT). Subsequently Riddell et al. (1992) extended the evaluation to all five fisheries affected by the conservation program and examined production from the enhancement initiatives. The current working paper completes the 1992 assessment by addition of the depletion analysis recommended by the Salmon Subcommittee, and by addressing reviewers comments regarding the exploitation analysis (Irvine et al. 1992). This paper builds on analyses and recommendations accepted in Riddell et al. (1992) and does not repeat analyses unless modified since that paper.

Revisions to the Exploitation Rate Analysis

Preparation of CWT Data

All tag recovery data were assembled as described by Starr and Argue (1991, Appendix 4: 1.0) up to and including the 1991 catch year. Detailed descriptions of the procedures and assumptions used in estimating coded-wire tag (CWT) recoveries in the GSPT were presented by Starr (1991). All Strait of Georgia CWT sport recoveries are based on the voluntary return of heads from adipose-clipped chinooks, by participants in the sport fishery. All other CWT recovery data used were from the coast wide sampling program of commercial landings. Cohort analysis of tag codes and the calculation of harvest rate indices used the procedures described in Starr and Argue (1991), regardless of the fishery being considered.

Changes to CWT data since Riddell et al. (1992)

Several changes to the CWT data have been implemented since the exploitation rate assessment in 1992.

The 1991 Quinsam CWT recoveries from the spawning escapement have been corrected. Escapement recoveries in the CWT database from the Quinsam/Campbell system are not expanded to total return of tags. This expansion must be conducted externally to the access programs using data from the key stream reports. For 1991, this data was provided by R. Semple (pers. comm. DFO, Vancouver, B.C.).

During 1992, estimates of recoveries since 1983 in the GSPT fishery have been stratified into three sub-areas to more accurately reflect stock compositions. The sub-areas used are northern Strait of Georgia (GSPTN, statistical areas 13-16), southern Strait of Georgia (GSPTS, statistical areas 17-19A, 29), and Juan de Fuca (JFSP, statistical areas 19B+ including area 20 out to Sheringham Point). Expansion of recoveries was conducted within sub-areas and total recoveries summed over sub-areas. This re-stratification of CWT data has been completed for all CWT data used in this analysis. For data collected previous to 1983, methods described in Starr (1991) have been maintained. Recoveries in the Juan de Fuca sub-area are not included in this assessment since statistical sub-area 19B+ was excluded from this conservation program.

To more accurately reflect harvest changes in the GSPT since the early 1980's (and to address previous comments from reviewers), age 2 CWT recoveries have been incorporated into the exploitation rate analysis.

To increase the stock/age strata used in the exploitation rate analysis, cohort analyses have been completed for Puntledge River summer chinook salmon. Total escapement and tags recovered have been reviewed from enhancement files and fishery officer reports back to 1975. Puntledge fall chinook were also examined but were not included since the stock has declined to extremely low numbers since the late 1980's.

All tag data available by recovery strata have been accepted in this analysis. Starr (1991, page 5) presented criteria to select strata for inclusion in the exploitation rate analysis. These criteria were established to reduce variability in the analysis caused by random sampling or recovery errors. However, these criteria effectively eliminate strata with small numbers of estimated recoveries. Fewer tag recoveries over time are occurring as the objective to reduce exploitation is realized and because compensatory increases in the numbers of tags released has not occurred. Consequently, establishing an arbitrary lower limit for recovery data, the analysis may bias the assessment by eliminating strata.

U.S. tag codes used in the exploitation rate analysis by Starr (1991) have not been included in this analysis. The tagging in these stocks was inconsistent in the base period and harvest rates in the fisheries of interest are low.

Calculation of the Harvest Rate Index

Estimation of the index was described by Starr and Argue (1991, Appendix 2: 3.0). The index is the age and fishery-specific exploitation rate for selected chinook stocks divided by their base period values and combined over the stocks used in a fishery. Several methods for combining stocks may be used (simple average of the stock and age-specific values, weighting the values by the actual exploitation values, or summing exploitation rates and then dividing by the base period average value). In this assessment, the stock and age-specific exploitation rates have been summed and then the index calculated. When fisheries are combined, stock and age-specific exploitation rates are summed over fisheries before the index is calculated.

Exploitation Rate Analyses

The basic data of the exploitation rate analysis are the observed recoveries of coded-wire tag groups by age and fishery strata. As in Riddell et al. (1992) small numbers of recoveries for some stock, age, and fishery strata remain a concern with this analysis. Exploitation rate analyses were presented by fishery (Figure 19) but the recommended assessment would be for inclusion of all four fisheries in one fishery index (consistent with recommendations last year, Figure 20). Further, base periods for comparison with recent annual exploitation rates were: 1979-1982 for evaluation of the Pacific Salmon Treaty chinook rebuilding program, and 1984 through 1987 for the LGS conservation program (as per recommendations in PSARC Advisory Docu. 92-1).

Exploitation rates for 1979 through 1991, by stock and age, in the combined fisheries [SCTR(S. central troll), GSTR(Georgia Strait troll), JSN(Johnstone Strait net), and GSPT(Georgia Strait sport)] were:

	BQR	BQR	BQR	BQR	QUI	QUI	QUI	QUI	PNT	PNT	PNT	PNT
Year	Age 2	Age 3	Age 4	Age 5	Age 2	Age 3	Age 4	Age 5	Age 2	Age 3	Age 4	Age 5
79	0.1091	0.3234	0.2961	0.2763	0.0142	0.0241	0.0186	0.1240	0.1306	0.3177	0.3710	0.4500
80	0.0998	0.3527	0.3581	0.1364	0.0070	0.0230	0.1158	0.3333	0.0809	0.3071	0.3356	0.0000
81	0.1205	0.3770	0.5160	0.4857	0.0029	0.0114	0.1107	0.3419	0.1221	0.3399	0.5431	0.4000
82	0.1403	0.2053	0.2602	0.2857	0.0111	0.0054	0.0531	0.2755	0.1493	0.2324	0.2760	0.0000
83	0.1639	0.4224	0.4699	0.1304	0.0089	0.0364	0.0491	0.1878	0.1264	0.2814	0.2877	0.7000
84	0.1322	0.4360	0.4923	0.0000	0.0059	0.0137	0.0920	0.0983	0.0645	0.3538	0.1515	0.0000
85	0.0613	0.1918	0.1718	0.0000	0.0060	0.0218	0.0443	0.1384	0.0998	0.1327	0.1667	0.0000
86	0.0521	0.3111	0.4264	0.0000	0.0064	0.0321	0.0717	0.0926	0.0385	0.3291	0.2381	0.0000
87	0.0585	0.1760	0.2923	0.1220	0.0031	0.0189	0.0423	0.0619	0.0606	0.1141	0.0843	0.0000
88	0.0507	0.2112	0.2162	0.0000	0.0049	0.0102	0.0307	0.0979	0.0311	0.3333	0.0294	0.0000
89	0.0850	0.2178	0.3254	0.0000	0.0109	0.0465	0.0949	0.1618	0.0865	0.2405	0.7143	0.0000
90	0.0647	0.2274	0.2301	0.0000	0.0046	0.0136	0.0563	0.0433	0.0388	0.0172	0.1507	0.0000
91	0.0734	0.2410	0.3684	0.1176	0.0000	0.0072	0.0420	0.0519	0.0713	0.2232	0.0000	0.4167
Base	0.1174	0.3146	0.3576	0.2960	0.0088	0.0160	0.0745	0.2687	0.1207	0.2993	0.3814	0.2833

The "Base" values from this data are simple averages of the 1979-1982 exploitation rates. These values indicate the proportion of the total exploitation by stock and age, in a year, that is attributable to these four fisheries. Based on the consistency of data in the base period and the numbers of tags observed, three stock and age strata were eliminated from the harvest rate index calculations: age 2 and 3 Quinsam, and age 5 Puntledge.

Harvest rate reductions for the combined fisheries averaged 45% during the past four years compared to the 1979-82 base period (Index value = 0.55). The 1984-87 index parallels the 1979-82 index but the average index value for the 1984-87 base was 0.91, less than half of the minimum target reduction.

Depletion Analyses

A classical depletion analysis relates the capture of a fixed fraction of a population at successive points in time to the cumulative capture over time, and uses this trend to estimate the initial population size (i.e., at the start of the fishing year). Traditionally, constant catchability is assumed so that a straight line is used to describe the relationship between a fishing rate (eg. catch per unit effort) and cumulative fishing mortalities. The analysis in this paper is based on a general model developed by Walters (Hilborn and Walters 1992) and described by Starr and Argue (1991, Section 2.2 and Appendix 3). Once estimates of the initial population size and total fishing mortality are determined, harvest rate can be estimated for any year and the change in harvest rate between years examined. **The method does not depend on the recovery of CWT, and thus provides an alternative and independent assessment to the exploitation rate analysis. Note, however, that this method can only be applied to the Strait of Georgia troll and sport fisheries (individually or combined) and does not allow examination of all five fisheries under the chinook conservation program.**

Starr (1991, section 2.2.1) proposed to adjust for the size limit changes over time by estimating the initial population in terms of encounters rather than catch. Catches by fishery would be expanded by the proportion of the population above the size limit. However, after thorough examination of the computer code used by Starr (1991), it is apparent that *encounters per unit effort* (EPUE) was regressed on *cumulative encounters*, and not cumulative removals from the population. The encounters represent the fish vulnerable to the fishery, all of which will not be removed. The result is that the slope of the regression line does not represent catchability, and the X-intercept does not represent initial population size. Simulation studies presented indicate that the true initial population size can only be correctly estimated if the actual fishing mortality is accumulated over time; this also requires that the proportion vulnerable is accurately known.

The procedures to estimate the initial population size and, subsequently, the harvest rate have been corrected. However, the harvest rates estimated (see following table) remain quite similar between years, and to those in Starr (1991). These depletion model (static or linear model compared) estimates of harvest rates do not indicate any obvious reduction or trend following the conservation actions, with the exception of reduced 1991 sport rate. This reduction is consistent with the reduced fishing effort in 1991. Effort in 1991 was reduced 28% relative to the average effort between 1987-1990.

Comparison of harvest rate calculations for Model A (EPUE vs. cumulative encounters, Starr 1991) against Model B (CPUE vs. cumulative mortalities, this analysis) for 1987 to 1991. The static depletion model was used with the #2 Georgia Strait model length at age data and a shaker mortality of 0.3 (as used in Starr 1991).

Year	Model	Initial Pop.	Sport H.R.	Troll H.R.
1987	A	163948	46.12	23.57
	B	150421	50.41	27.89
1988	A	102453	51.99	18.67
	B	97915	54.50	21.20
1989	A	201887	51.03	16.16
	B	204123	50.47	15.98
1990	A	170422	42.81	20.01
	B	160981	49.50	23.39
1991	A	227735	44.56	16.15
	B	229495	44.22	16.02

Discussion

This assessment and that presented by Riddell et al. (1992) indicate that harvest controls and enhancement are contributing to increased spawning escapements (see following table) and reduced harvest impacts on LGS chinook salmon. The harvest reductions were, however, to be implemented as equal reductions (at least 20% in each fishery) in five fisheries: south central B.C. troll (Areas 10,11,110,111 only) and the Strait of Georgia troll fisheries, Johnstone Strait seine fishery, Strait of Georgia recreational fishery, and Native fisheries in each indicator river. Based on the exploitation rate analysis, the average harvest rate index for 1988-91, determined by combining the 4 ocean fisheries, is only approximately half of the 20% target (relative to a 1984-87 base period), but the reduction compared to the 1979-82 base period is much larger (45%) and consistently below the base period average. It is apparent though that troll and net fisheries have compensated for the sport fishery. Riddell et al. (1992) also noted that the Native fishery in the Squamish River is not consistent with the objective to reduce harvest rates. Terminal harvest rate in this fishery has more than doubled compared to the base period.

The depletion analysis presented by Starr and Argue (1991) was to provide a direct method to estimate the annual harvest rates in the Strait of Georgia sport and/or troll fisheries. While the review of the depletion analysis indicates that Starr's (1991) estimates of the initial population sizes were incorrect, the corrected values remain similar to his and the harvest rate changes between years were small. The authors, however, are concerned that the rather simple static depletion model was not an adequate assessment of harvest rate dynamics in these fisheries.

Further, since the statistical errors about the harvest rates estimated by either method have not been developed, we are unable to test whether the difference between methods are statistically meaningful or whether the harvest rate changes over time are significant. Consequently, the authors recommended that the depletion analysis be re-developed within a statistical framework that deals with the sources of statistical error and allows for statistical inferences.

The authors also recommended that biological sampling for age composition in fisheries and size-at-age in the total population of chinook in the Strait of Georgia be continued. Simulation analyses of the depletion analysis demonstrated the necessity of accurately determining the proportion vulnerable and accounting for annual variation in this proportion. Processing of this information should also be prioritized so that the data are available for assessments in the late fall following the fisheries. Further, the present process of relying on voluntary tag returns in the GSPT should be replaced with random sampling for tags, or another quantitative recovery process.

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 (broodstock, 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
1992*	10893	2447	1823	15163

* 1992 data are preliminary and under review

1979-1982 Average 10,780
Escapement target 21,560

Reviewer - #1 (Internal)

The reviewer noted that the chinook stocks chosen to represent the lower Georgia Strait are from the western (upper) part of the Strait, whereas the management actions may have a greater effect on the indicator stocks (Cowichan, Squamish) in the southeastern part of the Strait. The authors are required to make the assumption that harvest rates are equal for all stocks in the fishery and this may not be the case. The reviewer highlighted the authors' comment that they are unable to determine whether the harvest rate changes over time are statistically significant for either the exploitation rate or depletion analyses. The reviewer noted that many of these recommendations or concerns had appeared in previous PSARC working papers but that progress was slow.

The reviewer recommended that all analyses to date should be included in a single document and included some specific suggestions for the authors to bring attention to the conclusions that can be drawn to date, the weaknesses, and recommendations for additional work to strengthen the program.

Reviewer - #2 (External)

The reviewer was asked to focus on the assessment of the depletion analysis. No substantive comments were offered.

Subcommittee Discussion

The Subcommittee noted that based on information and analyses presented by the authors, the depletion analysis should be withdrawn from the overall evaluation until the matter of statistical uncertainty in the depletion analysis and the apparent lack of sensitivity of the method is adequately addressed.

The estimation of harvest rates in the Georgia Strait sport fishery continues to be a problem, in most part, because there is no direct sampling of the sport fishery. Unlike the commercial fisheries, the exploitation rate analysis for the sport fishery relies on a voluntary head recovery program without a statistical sampling design. The lack of a direct CWT sampling program for the Georgia Strait sport fishery and the variability in the data (not explicitly considered in the analyses) make it difficult to interpret the indices for each fishery.

The Subcommittee suggests that a single document on the status of the LGS chinook rebuilding program should be updated annually for review by the Subcommittee. Although the Subcommittee failed to accept Working Paper S92-1, the Subcommittee noted that the important aspects of the study could be included in the overall assessment.

Subcommittee Recommendations

The Subcommittee has requested that the authors of the 1992 update combine this working paper with the 1991 overall assessment (S92-5) to provide a synthesis of current and previously reported information on the LGS chinook conservation program. The following recommendations are the result of merging of previous recommendations from S92-5 with those presented in S93-7.

1. The Subcommittee recommends that a statistical method for comparing harvest rate changes, based on coded wire tag recoveries and/or the depletion method, be developed to test whether the observed trends in harvest rate are significant. The statistical basis for the depletion method should be given second priority to the exploitation analysis using coded wire tags.

2. The overall progress in harvest control should be assessed by pooling 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 actions under the LGS conservation program is preferred to the use of the single year, 1987.

3. The Department should evaluate increasing the sampling for coded wire tags in the South Central troll and Georgia Strait troll fisheries for use in the exploitation analysis to determine the compliance of those fisheries with harvest rate reductions.

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.

6. Additional research will be needed to understand the dynamics of the Georgia Strait sport fishery and to more critically evaluate harvest rates in this important fishery. The present process of relying on voluntary tag returns should be replaced with random sampling for tags, or some similar statistically reliable process.

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Appendix 1. List of participants

April 20, 1993 - Subcommittee members

S. Argue	
B. Humphreys	
S. M^cKinnell, Chairman	
C. Wood	
D. Peacock	
D. Meerburg	
B. Riddell	
C. Cross	
A. Tautz	
D. Anderson	
A. Cass	
B. Mason	(for P. Delaney)
M. Henderson	(Fraser pink escapement evaluation only)
R. Kadowaki	(absent)
R. Harrison	(absent)

Authors

C. Wood
D. Welch
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S. McKinnell	
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D. Peacock	
D. Meerburg	
B. Riddell	
C. Cross	
A. Tautz	
D. Anderson	
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B. Mason	(for P. Delaney)
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R. Kadowaki	(absent)
C. Cross	(absent)
R. Harrison	(intermittent due to AFS)

Appendix 2. List of Recommended Working Papers.

Fall 1993

Robertson Creek chinook assessment and forecast for 1994.

The potential effects of predation on chinook smolts in Barkley Sound during the 1992 El Nino require examination. A complete analysis of all cwt for Robertson Creek chinook in Barkley Sound streams is required as only hatchery rack recoveries have been considered in previous assessments.

Area 23 sockeye assessment and expectations.

PSARC has not reviewed the status of this important stock in many years. Considerable data have been added to the assessment database since then. The potential effects of predation related to the 1992 El Nino year need to be examined.

Feasibility of undertaking coho and chinook salmon habitat assessments.

In the fall, 1992, the Subcommittee endorsed a salmon/habitat workshop. Issues related to habitat concern in the Squamish and the Nanaimo Rivers (LGS, etc) and a recommendation to use the Cowichan as a tractable watershed for such a study was considered.

Skeena River/Kitimat chinook.

Outstanding Subcommittee request for an assessment of Kitimat chinook has been expanded to include the Skeena River. GSI results from stock identification programs needs to be reported. There is a need to develop natural stock escapement indicators.

Nass River chinook.

Review of a contractor report from LGL.

Update of the Skeena coho assessment.

A more detailed review of historical and recent cwt recoveries is required for PSC. There is a need to determine the feasibility of using weekly recoveries of cwts by statistical area (including Alaska) to provide run timing information on Skeena River coho salmon.

Assessment of Queen Charlotte Island coho.

There is a need to determine whether QCI coho are overexploited.

Evaluate the management change for Statistical Area 2W chums.

Changes are being considered to move from a fixed escapement to an exploitation rate management regime. There is a need to evaluate the consequences of this change.

Review of the in-season management model for Skeena sockeye.

A new stock specific in-season management model is being constructed by NCD staff.

Lake fertilization potential for Quesnel Lake.

Authors of S93-2 suggested that Quesnel Lake was an ideal candidate for fertilization without providing the information needed to assess the suggestion. In consideration of the potential for large numbers of sockeye fry in Quesnel Lake following the 1993 return, a working paper supporting the need to fertilize Quesnel Lake should be developed.

Spring 1994

Update on the Lower Georgia Strait chinook rebuilding program.

To provide senior management with an annual status report on progress toward rebuilding goals for chinook salmon in the lower Georgia Strait.

Assessment and target escapement for 1994 Adams River/Shuswap Lake sockeye.

1994 is a dominant cycle year for Adams River sockeye.

Escapement estimate and review of the effectiveness of the proposed new design for estimating pink salmon abundance in the Fraser River.

The Subcommittee recommended that a new tagging method be developed for estimating pink salmon escapements to the Fraser River.

Assessment of Georgia Strait coho.

Outstanding request.

Area 25 chinook salmon assessment.

A fishery is developing on Conuma chinooks, a stock for which little biological information exists. There is a generally increasing interest in the Gold River generally and there are concerns about interceptions.

Evaluation of the clockwork system for in-season chum run size assessments.

A review of the clockwork system.

Comparison of the commercial and test fishery sampling to develop stock composition estimates for Johnstone Strait chum fishery.

How do chum stock mixture estimates from a test fishery compare with samples taken directly from the commercial fishery?

Assessment of the run reconstruction methodology for Skeena/Nass River sockeye fisheries.

The existing methods are used extensively in Nass agreements.

Status of Rivers/Smith Inlet sockeye stock status.

Ongoing request.

Assessment of Meziadin Lake sockeye.

The Subcommittee endorsed study of the large escapement (appox. 250,000) to Meziadin Lake in 1991 and recommended that a working paper be prepared. Since then an even larger escapement (c. 600,000) was recorded in 1992. The impacts of these escapements need to be reported to PSARC.

Assessment of contractor reports on historical reconstructions of Nass sockeye and chinook stocks.

Work produced by contractors has not been formally reviewed by PSARC.

Assessment of non-Babine Skeena sockeye stock status.

AFS priority

Assessment of central coast Area 6,7, and 8 sockeye stock status.

AFS priority

Assessment of QCI sockeye stock status.

AFS priority

Assessment of Babine Lake sockeye populations.

First priority from stock assessment planning.

Fall 1994

Fraser River pink salmon carrying capacity.

I. Williams

Early Stuart sockeye assessment - Henderson.

This paper is proposed in consideration of the recent attention focused on this sockeye population complex.

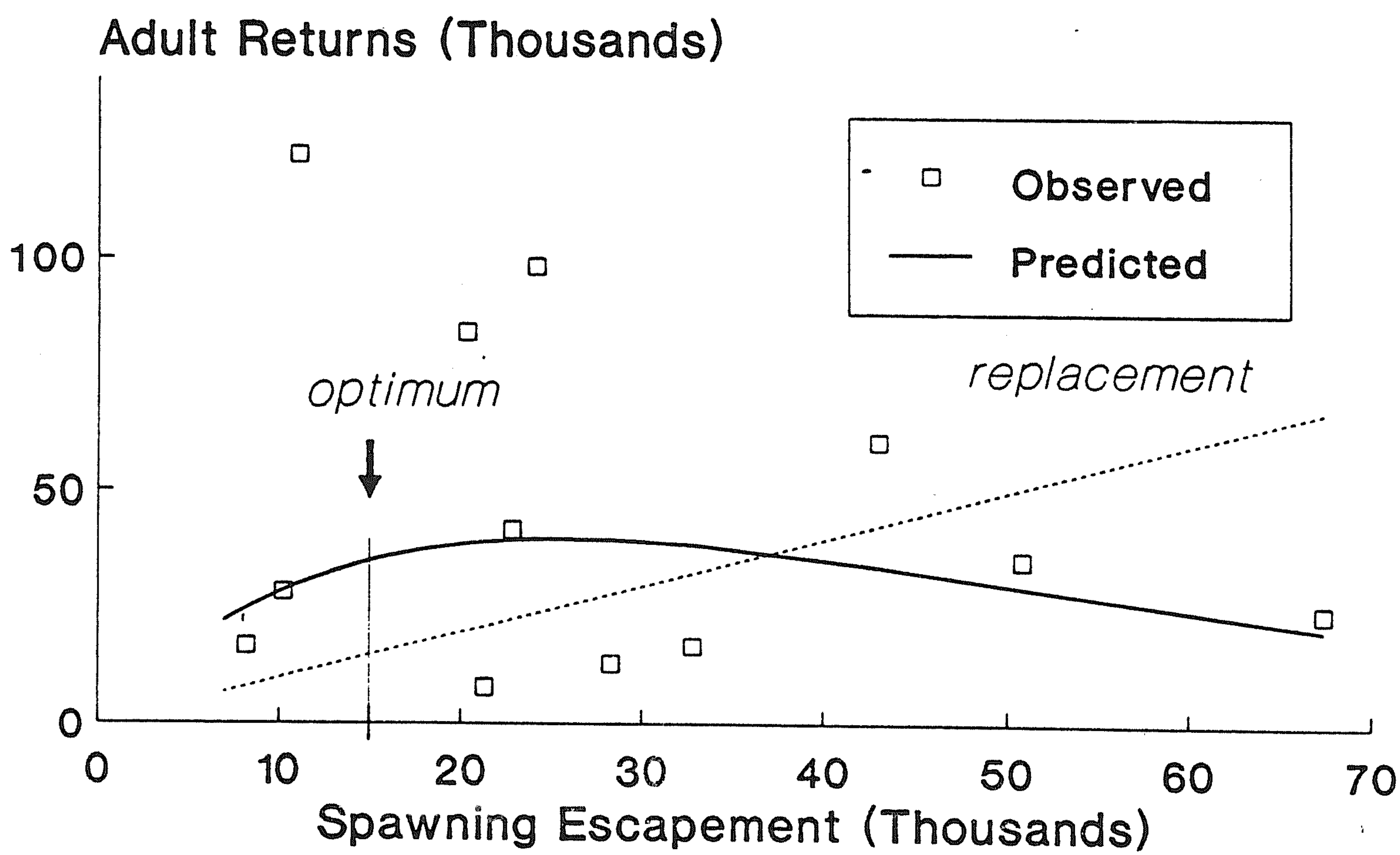
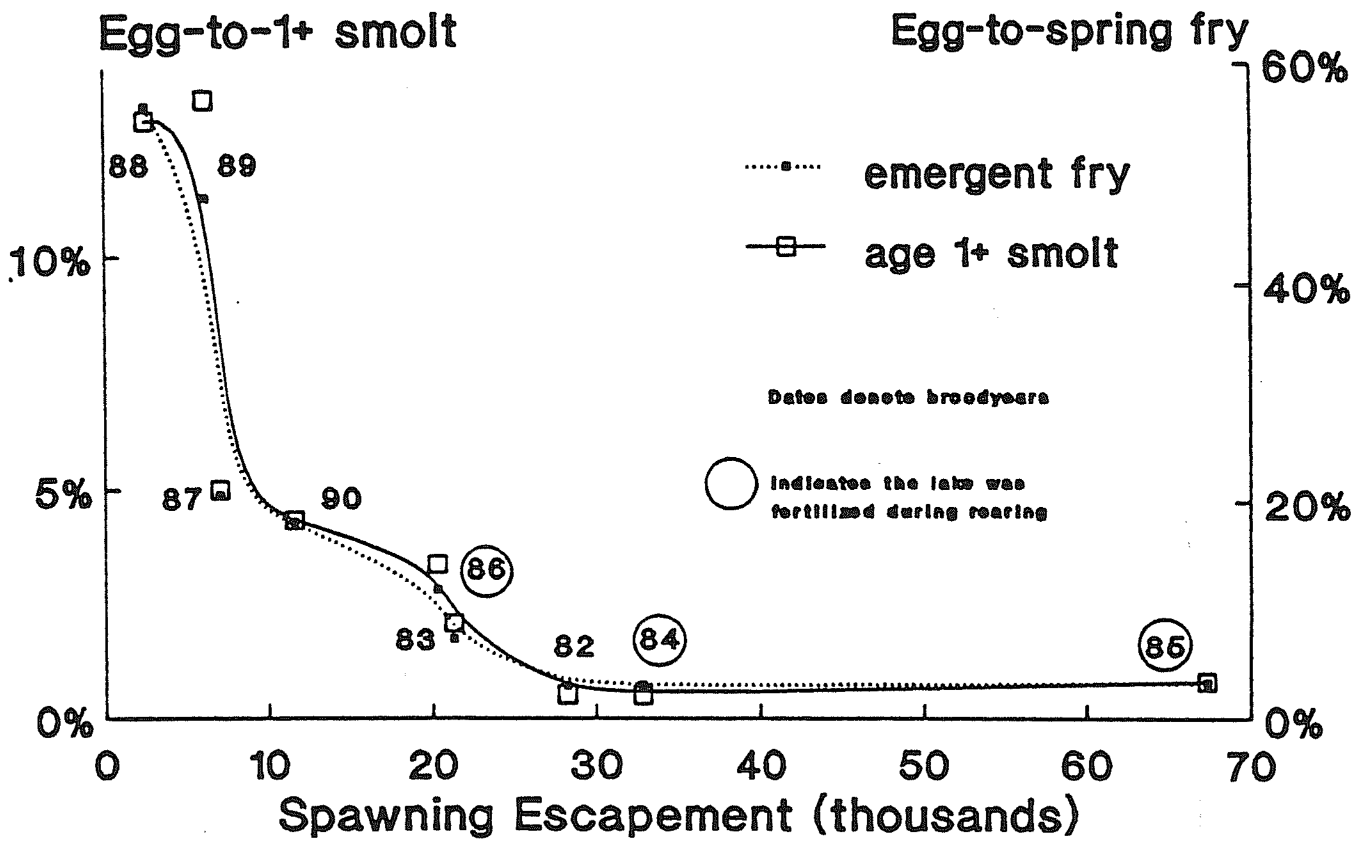


Figure 1. Tahltan Lake sockeye salmon. Stock-recruit analysis of adult returns.



Survival to 1+ smolt is minimum estimate because 2+ smolts are ignored. Spring fry estimated from 1+ & 2+ smolt counts

Figure 2. Tahltan Lake sockeye salmon. Freshwater survival of wild fish.

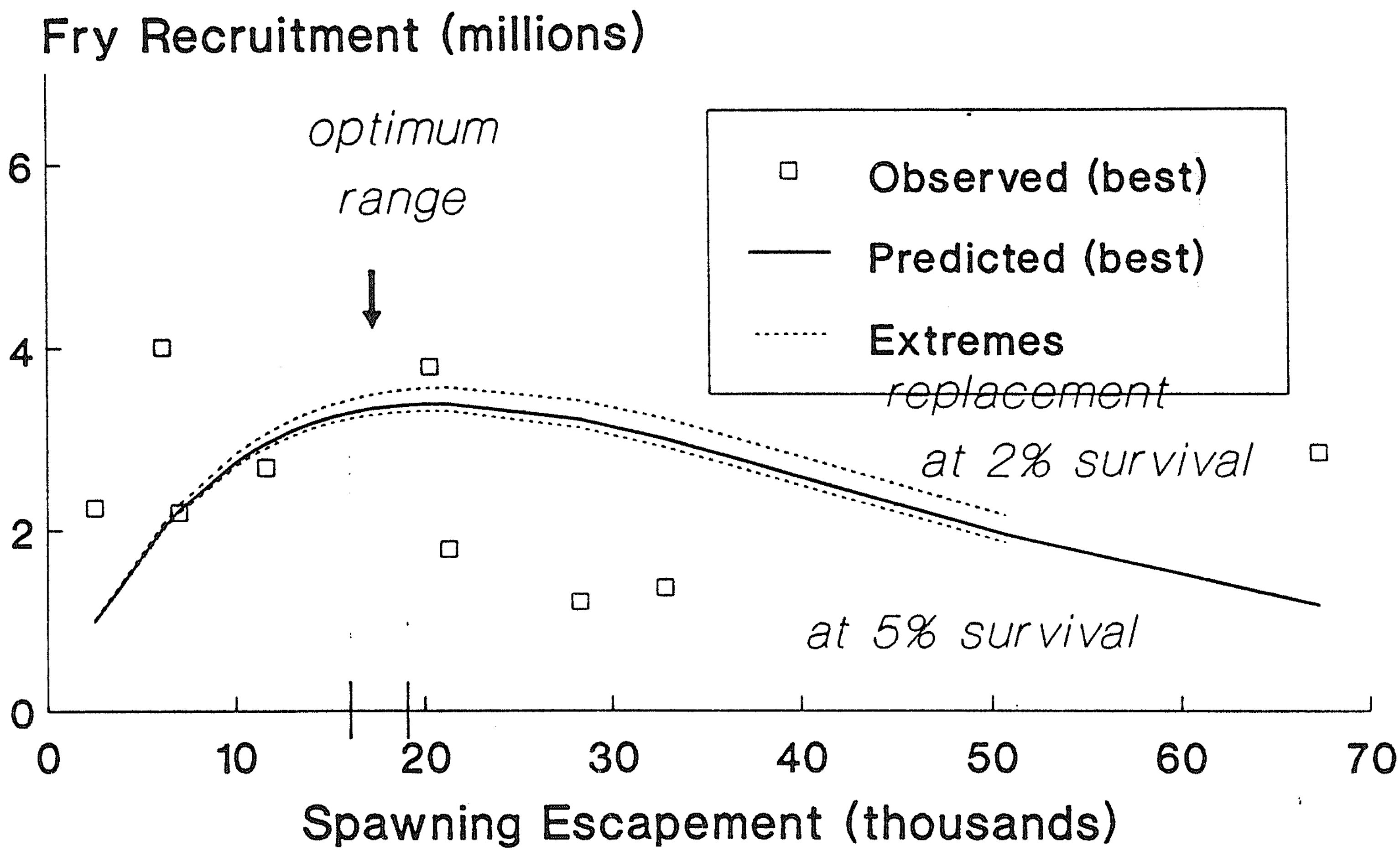
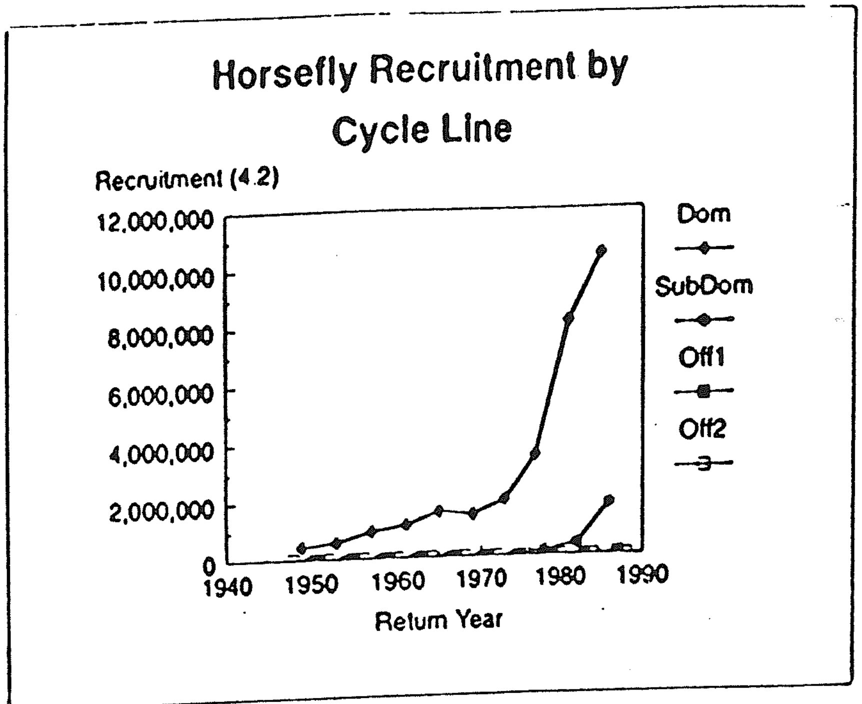


Figure 3. Tahltan Lake sockeye salmon. Stock-recruit analyses of wild fry recruitment.



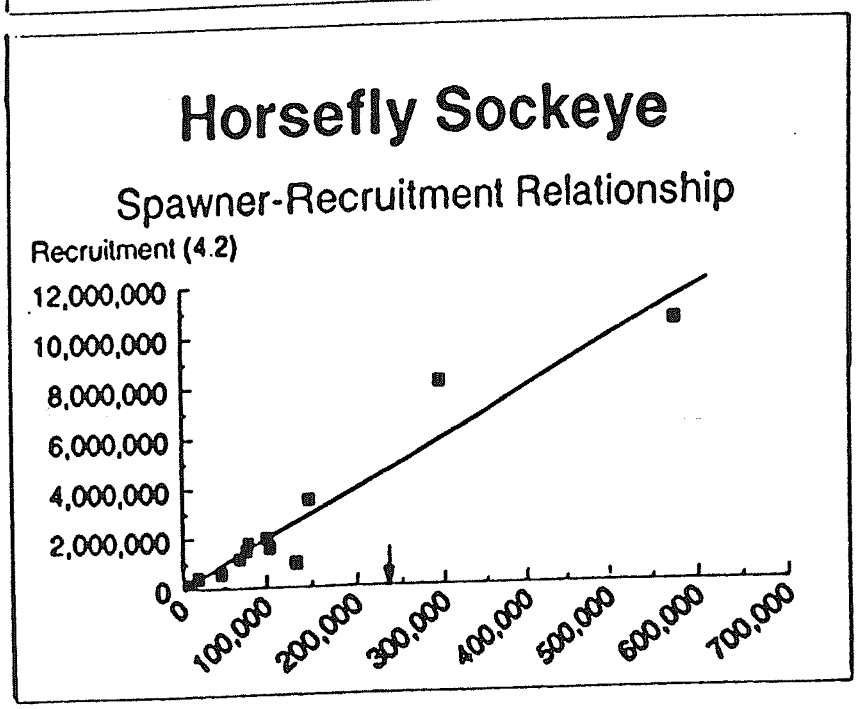
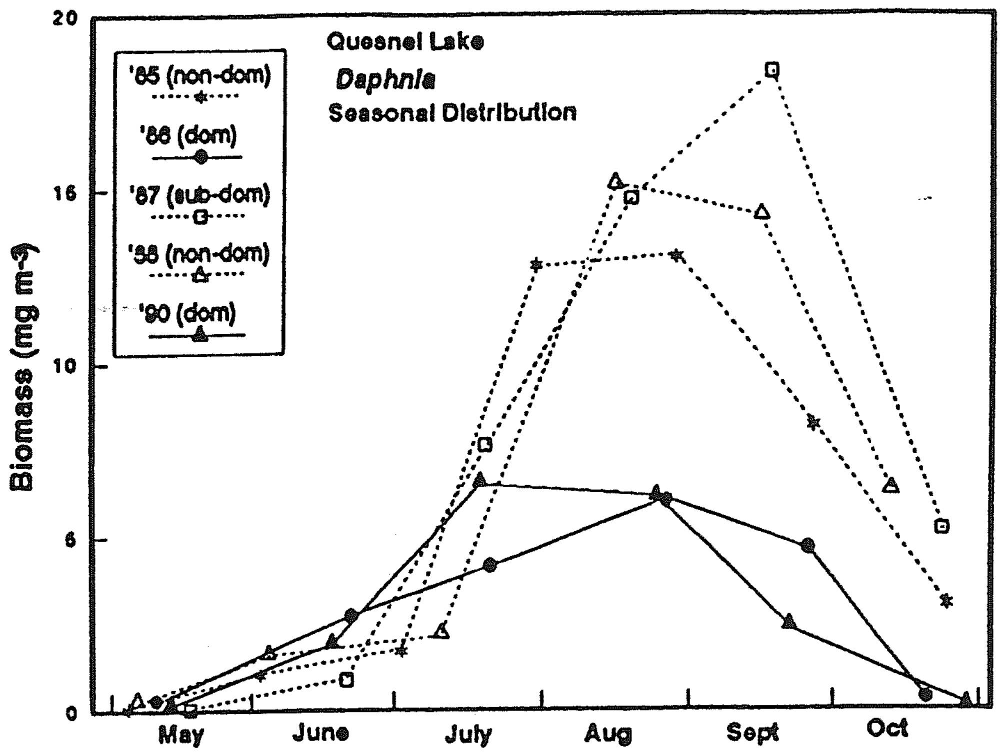


Figure 4. Quesnel Lake sockeye salmon. Stock-recruitment relationship for the Horsefly River system.



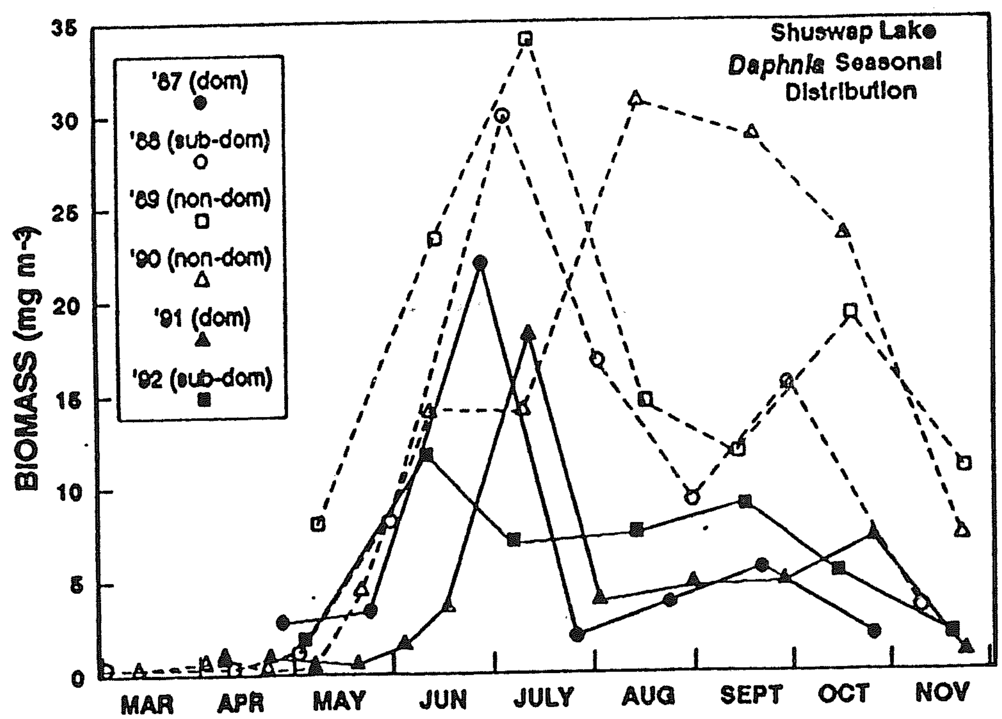


Figure 5. Quesnel Lake sockeye salmon. Changes in Daphnia biomass in Quesnel Lake (top), and comparison with changes in Daphnia biomass in Shuswap Lake.

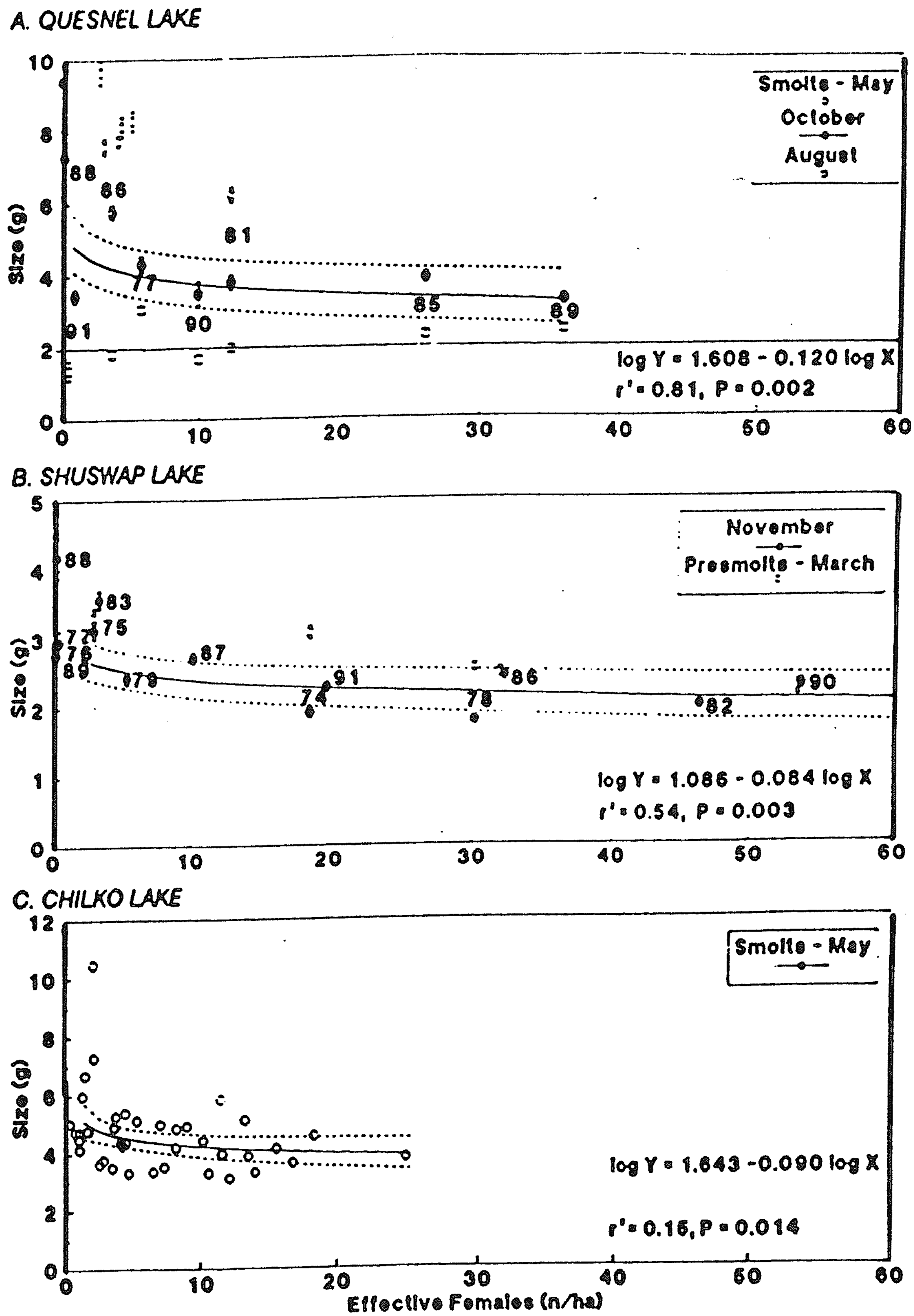


Figure 6. Quesnel Lake sockeye salmon. Changes in sockeye smolt and pre-smolt size with escapement level and comparisons with smolt and pre-smolt sizes in Shuswap and Chilko lakes.

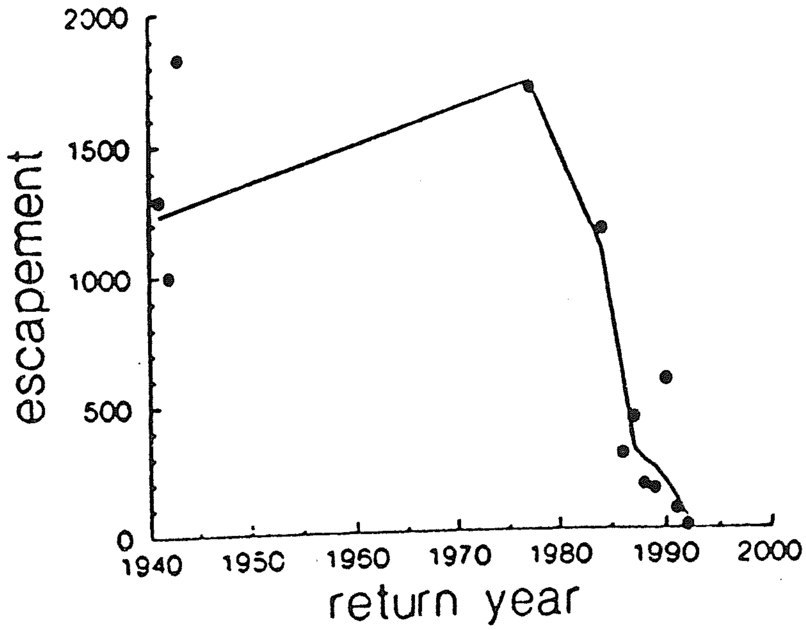


Figure 7. Mesachie Lake coho salmon. Estimated escapements to Mesachie Creek. The solid line is a LOWESS smoothing function. Suspect estimates for 1944 and 1976 have been excluded.

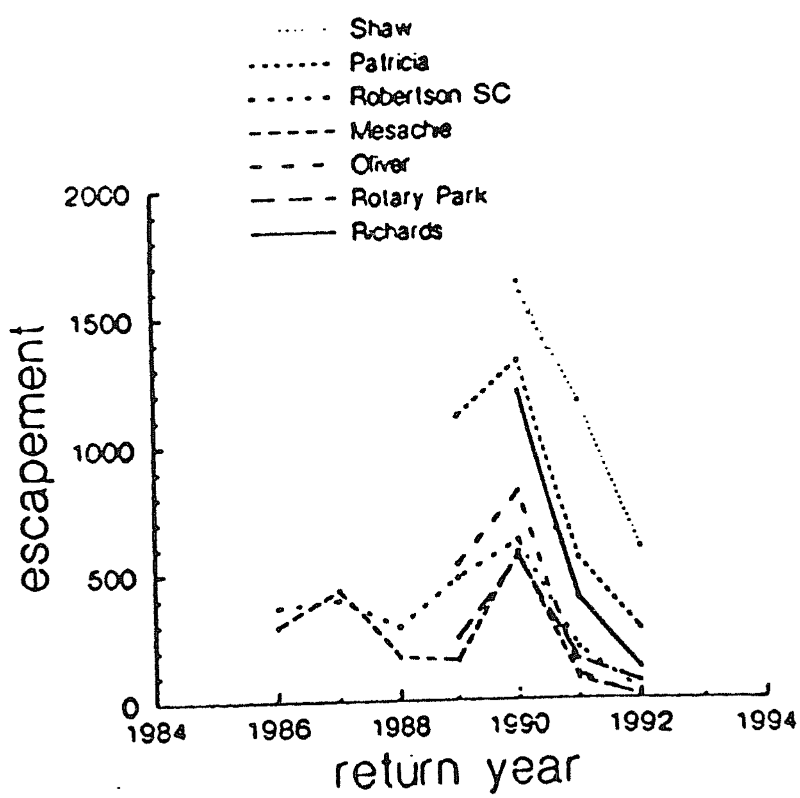


Figure 8. Mesachie Lake coho salmon. Recent escapements to Cowichan streams. Except for Mesachie, all estimates are AUC estimates.

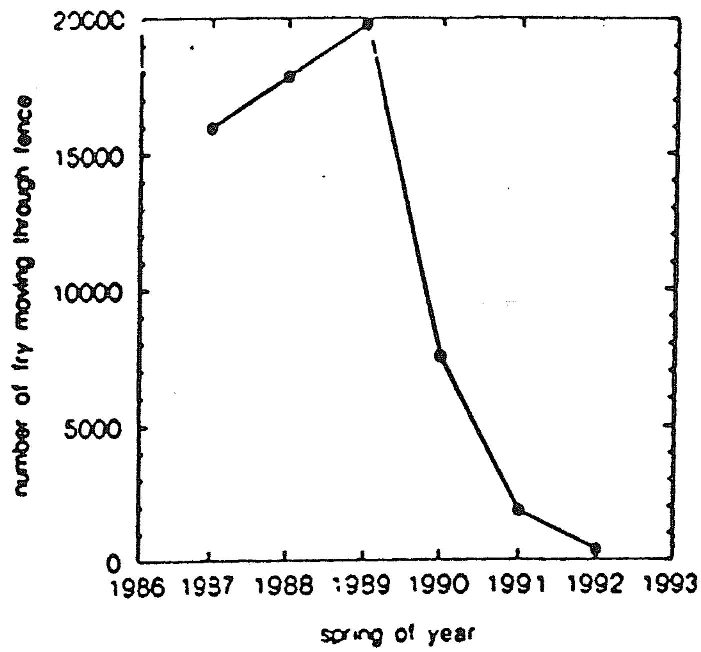


Figure 9. Mesachie Lake coho salmon. Numbers of coho fry moving through the fence during the spring. Numbers moving upstream and downstream have been summed.

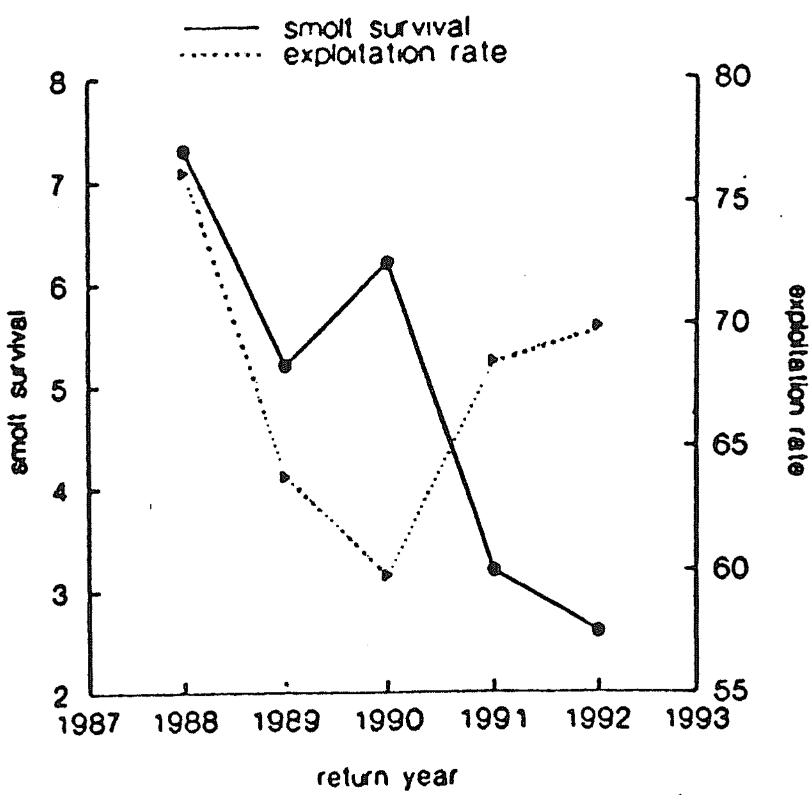


Figure 10. Mesachie Lake coho salmon. Smolt survival and fisheries exploitation rate for Mesachie Creek coho.

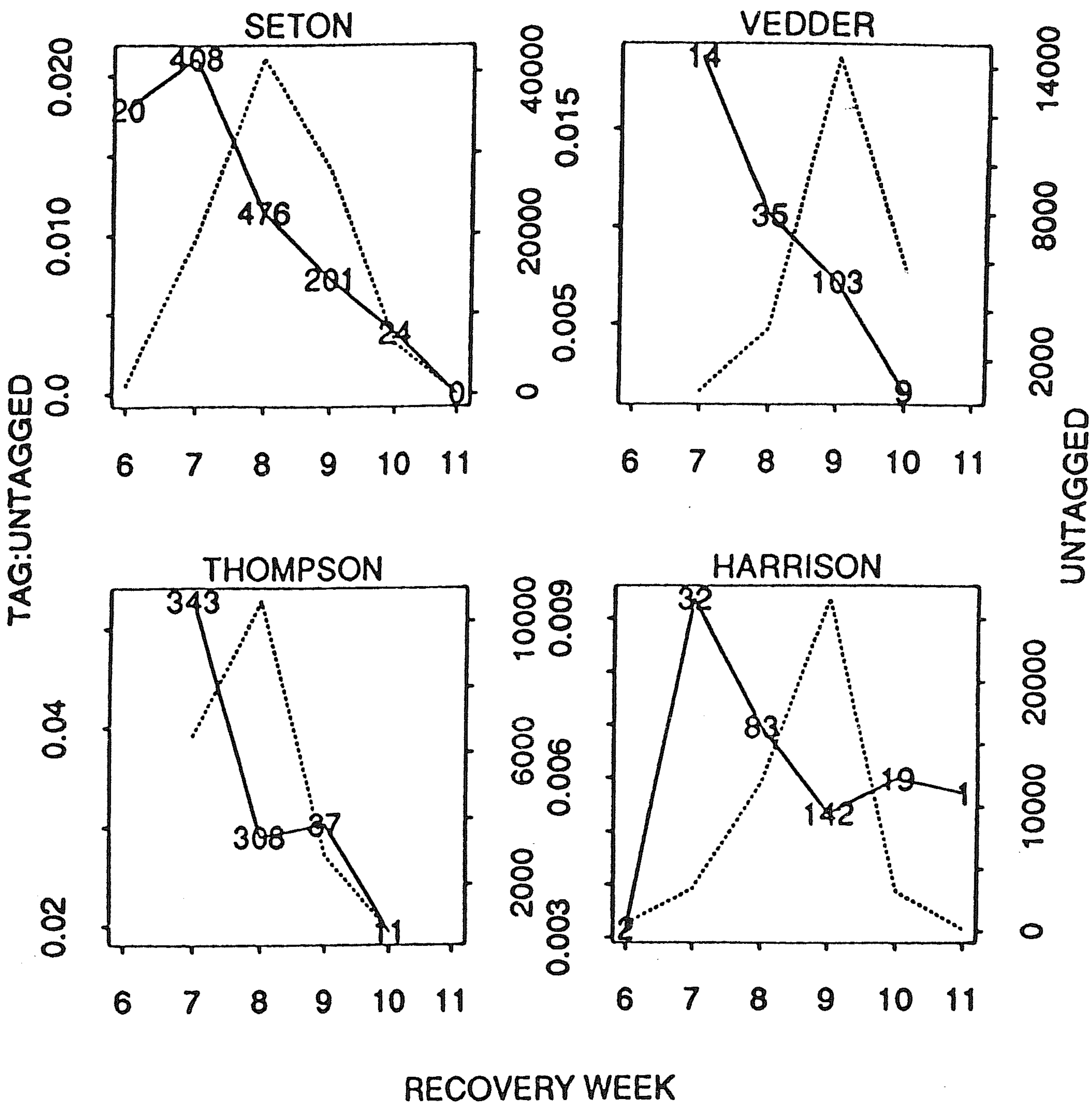


Figure 11. Fraser River pink salmon.

Comparison of tagged/untagged ratios (m/u) in recovery samples by recovery wk from Fraser R tributary releases in 1989. Solid = tagged/untagged ratios. Dashed = untagged. Data labels are sample sizes of tag recoveries.

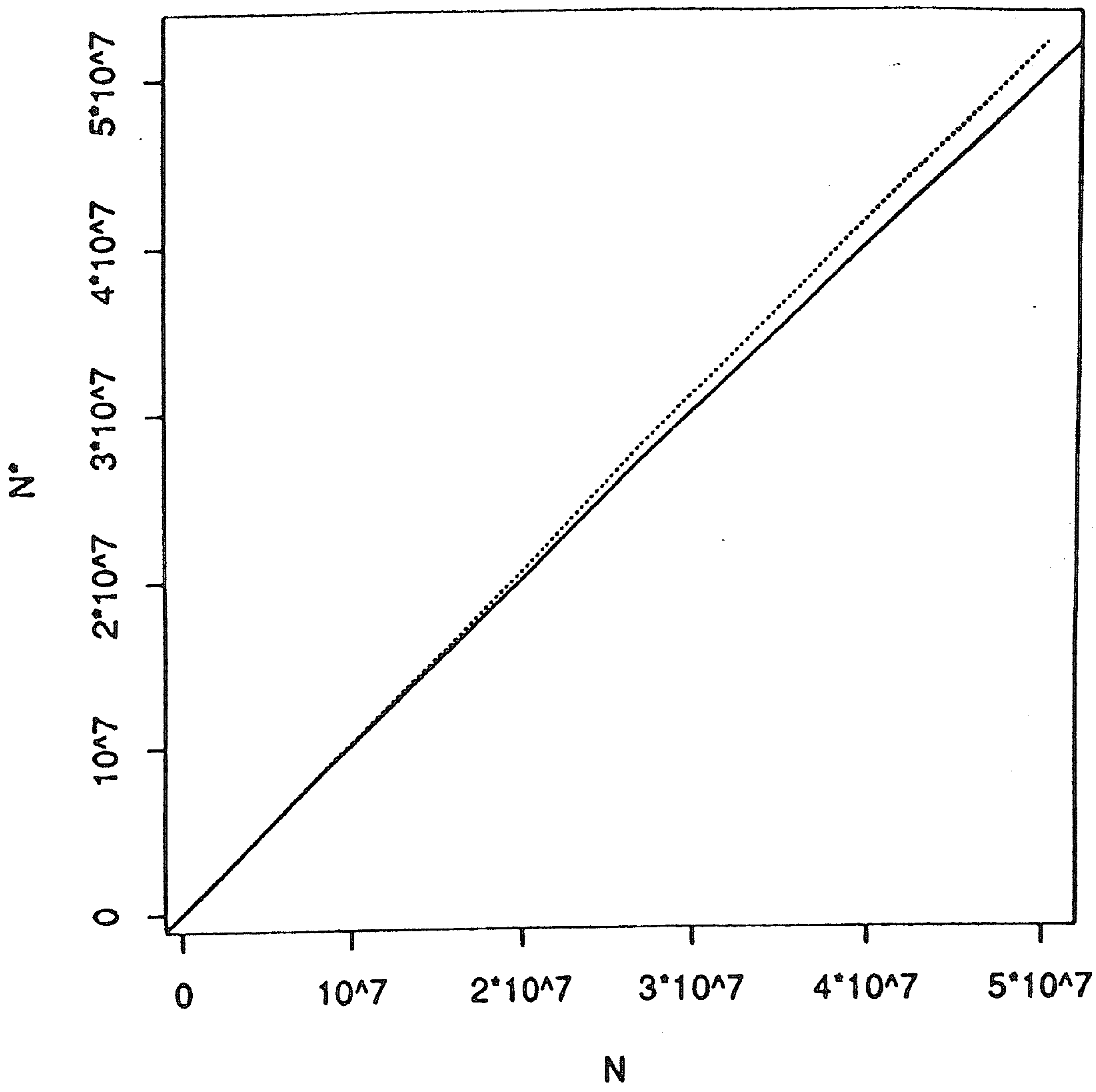


Figure 12. Fraser River pink salmon. Results of simulations to measure the effect of disproportionate tagging on estimates N* of population size N. Solid Line = 1:1 line. Dotted Line = Lowess fit.

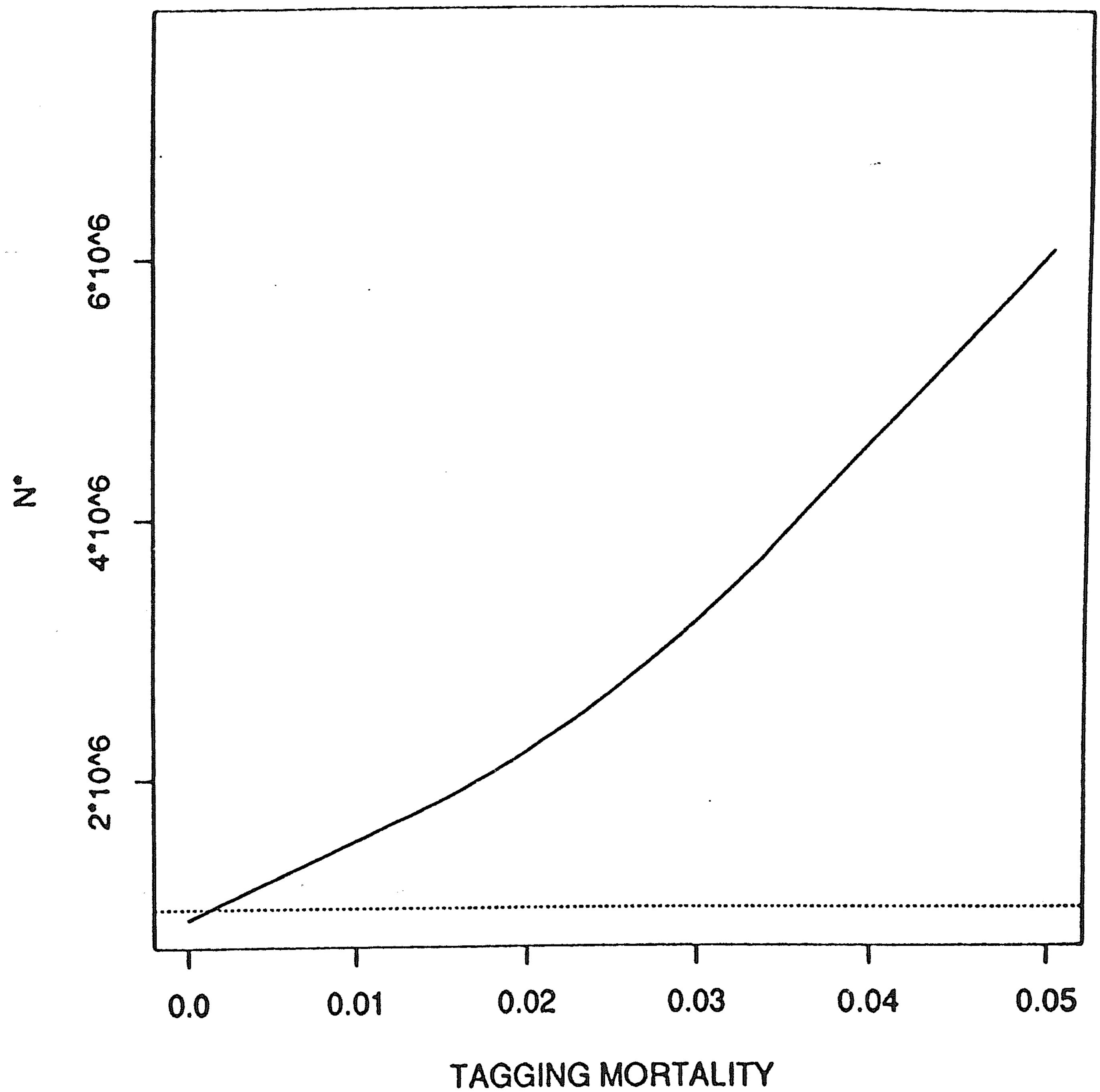


Figure 13. Fraser River pink salmon. Simulation results shiwing the relationship between tagging mortality rate/day and the estimated population size N* where the true population N = 1 million pinks.
Solid Line = Lowess fit. Dotted Line = True N.

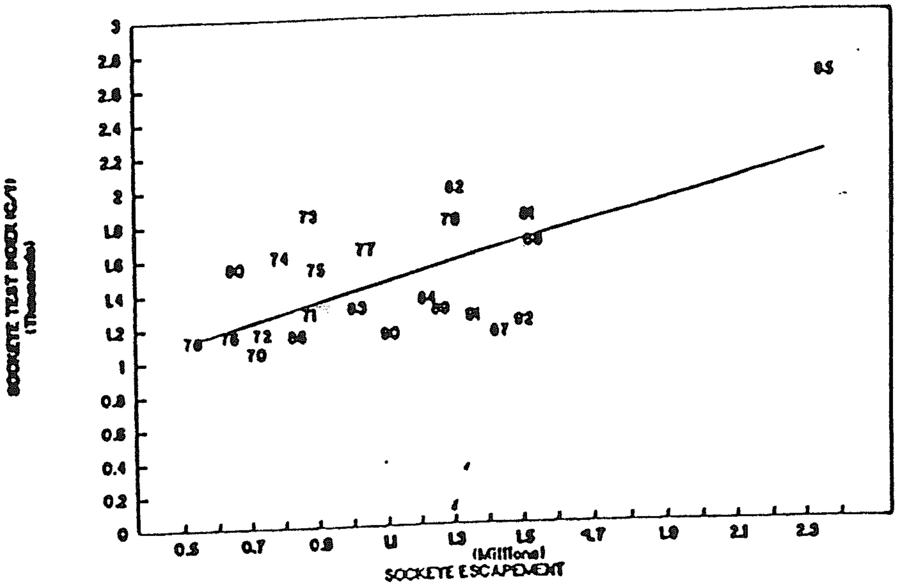


Figure 14. Skeena River sockeye salmon. The relationship between the seasonal sockeye test index (C/f), and actual sockeye escapement, for sockeye sampled in the Skeena River gillnet test fishery from 1970-1992: ($y = 5.76E-4(x) + 822.14$, $r^2 = 0.39$).

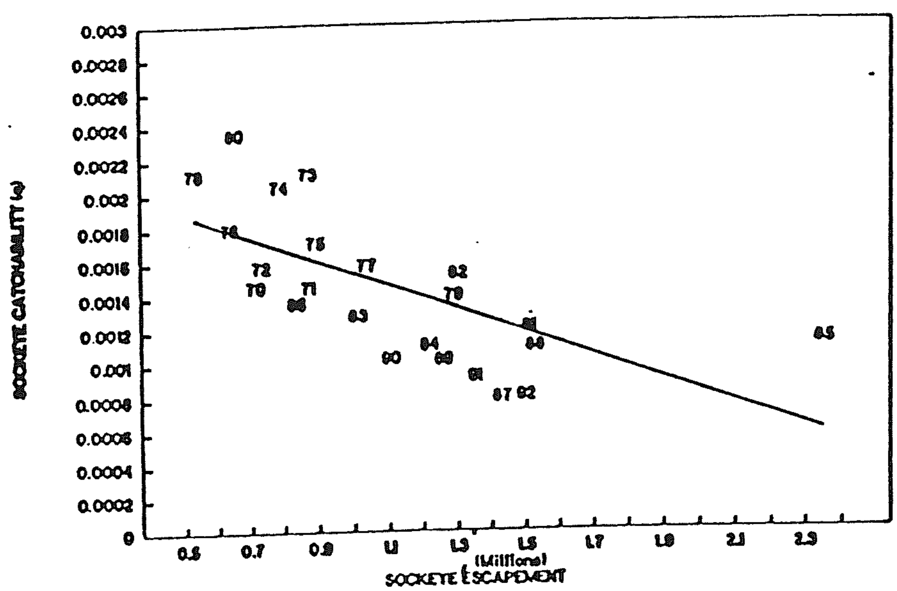


Figure 15. Skeena River sockeye salmon. The relationship between seasonal sockeye catchability (q) and actual sockeye escapement for sockeye sampled in the Skeena River gillnet test fishery from 1970-1992: ($y = -7.33E-10(x)+2.24E-3$, $r^2 = 0.47$).

TIMING CURVE FITTED TO TEST FISHERY DATA 1990

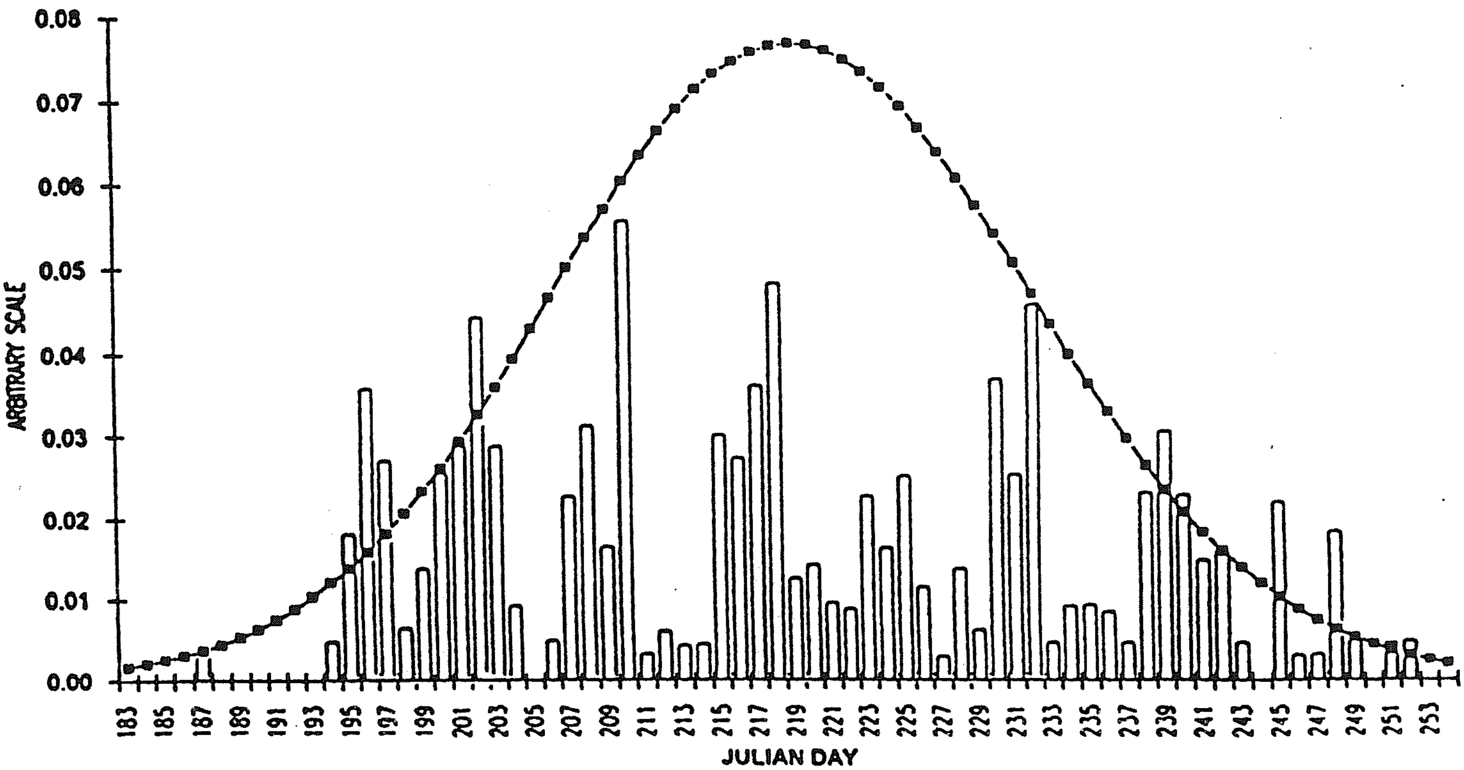


Figure 16. Skeena River steelhead. Fitted curve for Tyee escapements. Bars represent daily escapements, normal curve represents catch and escapement.

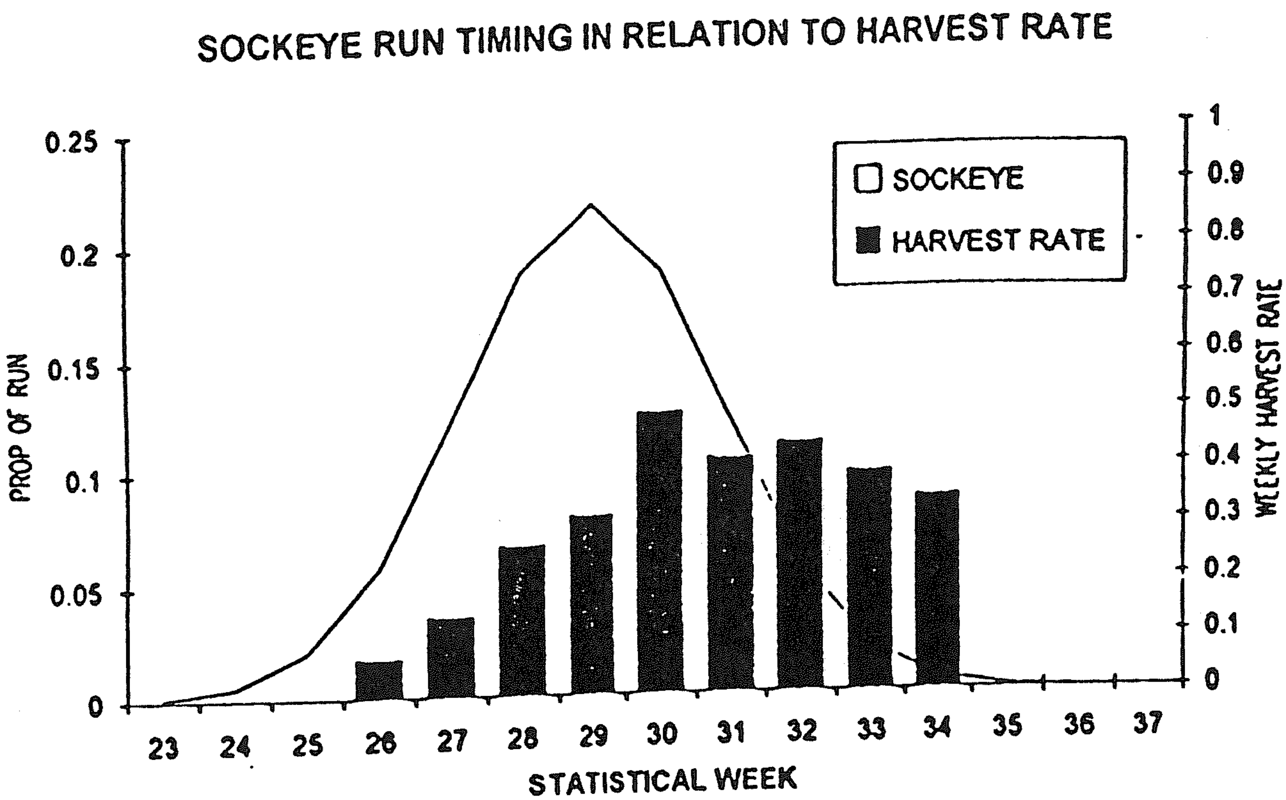


Figure 17. Skeena River steelhead. Average weekly harvest rates of Skeena River sockeye salmon in Area 4 for the years 1986 to 1991 and the estimated sockeye run timing. Week 31 is the week ending August 2.

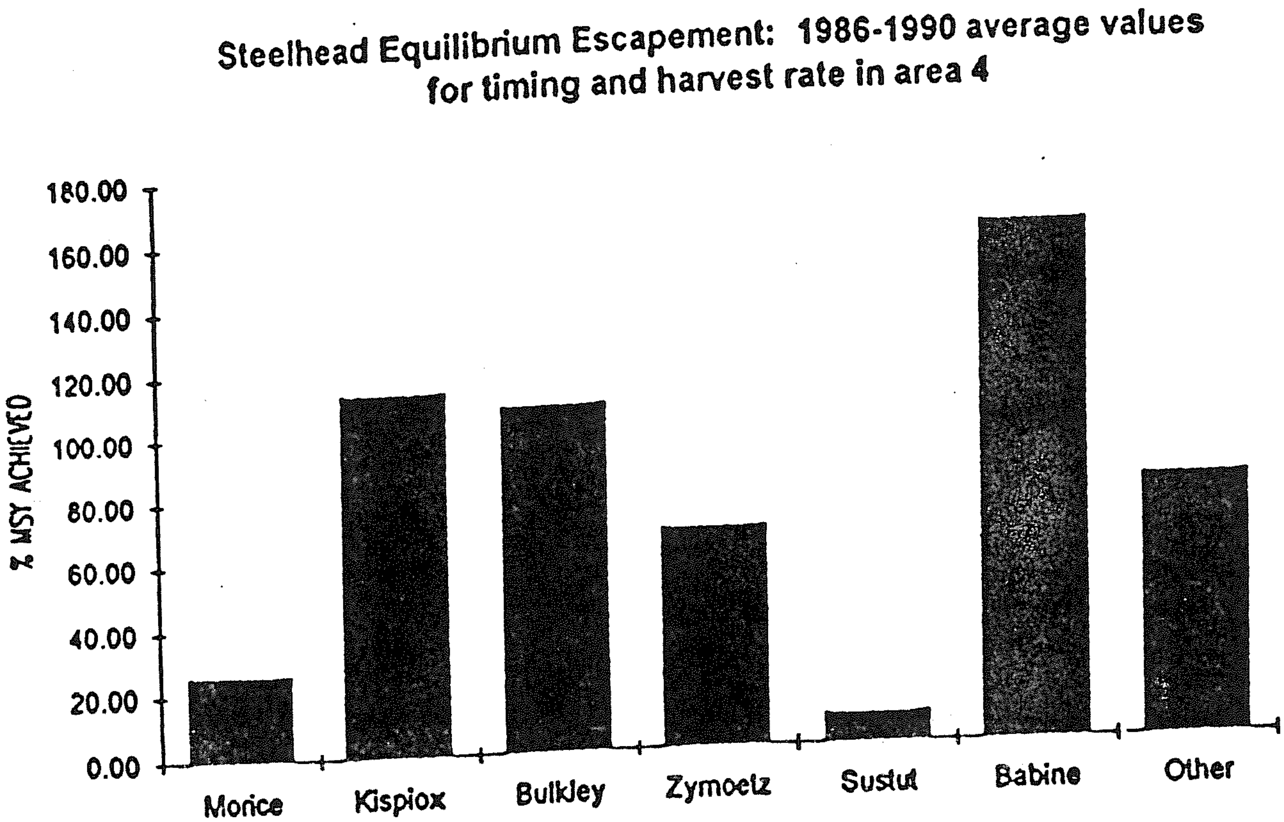


Figure 18. Skeena River steelhead.

Prediction of equilibrium spawning stock size of Skeena River steelhead populations expressed as a percent of their spawning stock size at Maximum Sustained Yield (MSY), given exploitation rates simulated in a general harvest model of Area 4 and considering harvest in all fisheries.

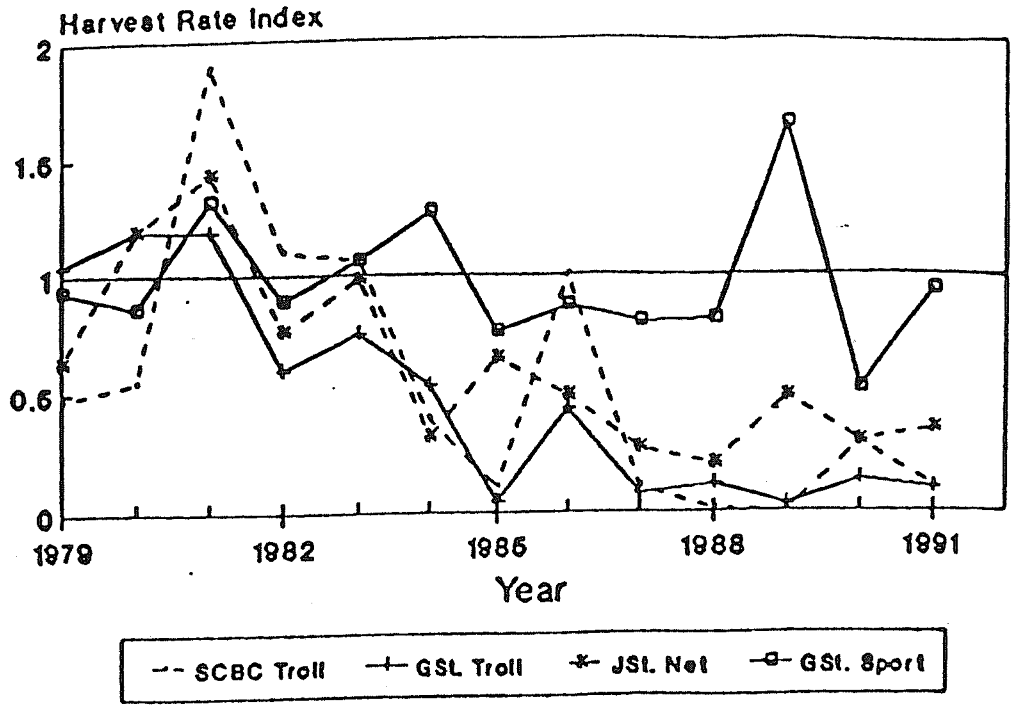


Figure 19. Southern Georgia Strait chinook salmon. Harvest rate trends in four fisheries relative to the 1979-82 base.

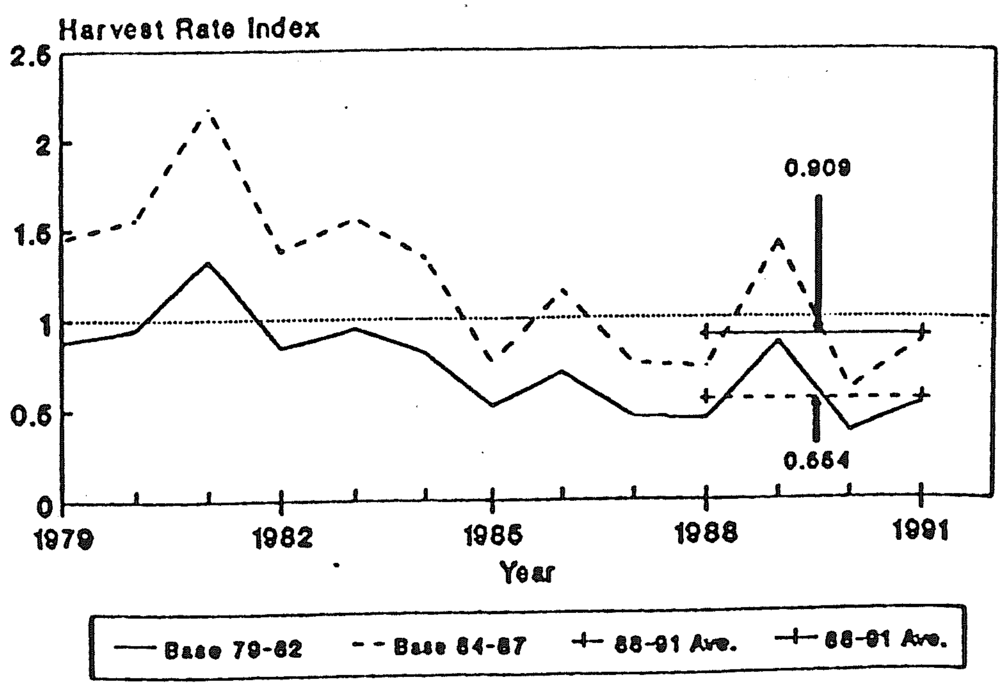


Figure 20. Southern Georgia Strait chinook salmon. Harvest rate reductions in the combined fisheries compared to the 1979-82 and 1984-87 base periods.

PSARC STOCK ASSESSMENT
REVIEW COMMITTEE

PSARC ADVISORY DOCUMENT 93-2
MAY 1993

DATA AND SYSTEMS SUBCOMMITTEE REPORT

CONTENTS

I. STEERING COMMITTEE REPORT

The PSARC Steering Committee met 12 May 1993 but was unable on that date to review the Data and Systems Subcommittee (DSSC) Report due to insufficient time. The draft report was appended to the draft minutes of the May 12th meeting and members of the Steering Committee were encouraged to review and comment on the report. Consequently, the following recommendations were made:

1. The Steering Committee concurs with DSSC's favourable response to FMISST's "Business Case & Phase I Report" and endorses DSSC's recommendation that a review team be struck to examine the FMISST recommendations for herring and groundfish and to develop an implementation plan.

2. The Steering Committee agrees that there is clearly a need to have a uniform Regional data coding standard in order to facilitate the stock assessment process and endorses the DSSC's intent to have a Working Paper on Regional coding standards prepared for the fall meeting of the DSSC.

3. The Steering Committee recommends that Science Branch investigate the feasibility of developing a salmon escapement data base system that includes a method of recording changes to the database and a means of including multiple estimates of the same number developed using multiple techniques.

4. The Steering Committee is encouraged by the DSSC's report that herring, groundfish and salmon biological data base Working Papers will be completed by fall 1993. The Steering Committee also acknowledges and concurs with the Marine Fish Division's response to the request for similar information with respect to shellfish, i.e. that, due to the magnitude of the job and the scarcity of resources, the work will be scheduled over a longer timeframe.

5. The Steering Committee shares the concern of the DSSC regarding the potential loss of valuable data bases held personally by DFO investigators who may never have taken the time to provide adequate documentation of the collected data. The Steering Committee recommends, therefore, that Science Branch EDP staff as well as ISD staff take the lead in developing a system to facilitate the archival and documentation of these data bases and that line managers in Science Branch, Fisheries Branch and SEP ensure that the system that is developed is implemented by their respective staffs.

6. The Steering Committee agrees that direct advice on experimental design and reliability of stock assessment programs is an important aspect of the stock assessment process that is often overlooked and recommends that the DSSC undertake an evaluation of the requirements for putting a rigorous system in place that would ensure the statistical defensibility of proposed stock assessment programs prior to funding.

II. DATA & SYSTEMS SUBCOMMITTEE REPORT

1. INTRODUCTION

A meeting of the Data and Systems Subcommittee (DSSC) was held on 3 May 1993. The meeting focused chiefly on reviewing (i) the current status of FMIST (Phase I), (ii) the current status of several regional or national initiatives related to database (DB) issues and the relevance of DSSC initiatives in this area, (iii) recently identified issues concerning the correction and/or modification of data in existing stock assessment data bases, (iv) the status of working papers being prepared for the Fall DSSC meeting, (v) issues concerning "privately" held data bases collected by DFO employees, and (vi) whether all major aspects of the current PSARC-DSSC mandate were being satisfactorily met with the existing review process.

2. CHAIRMAN'S REPORT FOR THE 1993 DATA & SYSTEMS SPRING SUBCOMMITTEE MEETING

(i) FMISST - PHASE I.

DSSC was brought up to date on the recently completed "Business Case & Phase I Report" prepared by Fisheries Management Information Systems (FMIS) study team members (April 1993) led by Margaret Birch. There was general agreement that there were significant potential benefits to the department in terms of reduced PY time involved in data entry and processing, as well as improving the speed and accuracy of the current process.

DSSC agreed to strike a review team to examine the FMISST recommendations for herring and groundfish. Reviewers will be asked to assess FMISST with respect to (1) Priorities, (2) Whether the process is on-track and will deliver what DFO needs to improve stock assessments, (3) Whether a set of short, step-wise projects should be implemented, and (4) Whether an FMISST-style review of salmon and shellfish should be completed. The reviewers will be asked to report in time for the Fall DSSC meeting. Because of the importance of this issue to regional priorities, the Steering Committee should consider whether they wish to see external reviewers brought into the process (e.g. CAFSAC, or non-DFO experts). Appropriate external reviewers were not identified during discussions.

(ii) NATIONAL & REGIONAL DATA BASE STANDARDS.

There are significant differences in data base coding standards used within the Pacific region. The nearest approximation to a regional standard for recording fish species is the "Hart codes". These use the page number on which a fish species is described in the book "Pacific Fishes of Canada" (1973). The advantages of maintaining this code as a *de facto* standard are that it is widely used and it has recently been updated for fish species (Gillespie 1993). The disadvantages are that there is no simple mechanism for coding new fish species, or for coding marine mammals, birds, and plants for incorporation into data bases. In addition, as the original numeric coding was based on text pagination, extensions and additions to the code will be awkward, and the code is only used by DFO Pacific, and no other agency.

Considerable time was spent discussing this issue. No consensus was reached, but the advantages of moving to a single unified standard were generally accepted within the committee. For example, in the event of an oil or contaminant spill, a unified data base standard would allow rapid identification by DFO of how much total catch was reported from a given geographic area surrounding the spill, and a rapid breakdown of what species and fisheries would likely be most impacted. Information from disparate data base systems could also be rapidly amalgamated, because there would be no difference in coding standards, and displayed in GIS or other systems to allow better assessment of what options were possible or what potential problems could still arise.

The DFO National Standards Committee is apparently likely to mandate a species coding for information transfer ***between*** regions, but apparently will ***not*** mandate use of a species coding standard ***within*** regions. In contrast, the National Standards Committee is likely to mandate a nation-wide gear code.

Species coding for inter-regional data transfer will probably be based on the US NODC coding system, an established system which provides a continent-wide coding standard. This coding system also provides an established path for registering new species within the code, and ensuring that they are immediately applicable continent-wide. Its drawback from a regional perspective is that the code is large (12 digits) and, more importantly, will require change from the way existing groups do their business.

The option therefore will exist to adopt the NODC species codes, thereby eliminating concerns about inter-regional data transfer or the addition of new species. Adopting this standard allows the use of a stable coding system (now nearly 15 yrs old), and will allow DFO to take advantage of existing NOAA technical support for the standard at little direct cost to DFO. Because one of the architects of this system was from Alaska, it is also likely that the vast majority of species codes required in the Pacific region are already present in the code. The drawback is that mandating compliance by all user groups will initially require a significant investment of DFO time in order to revise existing data bases.

Adoption of clear coding standards will clearly save DFO scarce resources. However, although the need to have a uniform standard was clear during our discussions, it was not clear how to go about identifying ***the*** regional standard, or where responsibility for this decision lies. However, there is a need for an individual or small group to develop standards that will facilitate the stock assessment process, and eventually improve access by native and outside user groups to DFO data bases, in line with current DFO Reform policy.

Accordingly, DSSC has requested that Peter Kho act as co-ordinator in developing an inventory of species and gear codes used in the region. At a minimum, groups developing new data bases need to use existing data base codes. DSSC has directed that a Fall Working Paper be prepared documenting what codes are in use and their associated problems, and providing recommendations as to what should be done within the region. This Working Paper can then act as a focus for establishing regional coding standards.

(iii) MODIFYING EXISTING DATA BASES.

A recent example came to light of a request being sent in to change escapement estimates in the SEDS data base. In the specific case discussed, the request for modification was justified. However, the broader questions of tracking changes to the data base over time, and determining authorization for making these changes, is much less clear. This issue will be of increasing importance to DFO as aboriginal and other groups play a larger role in providing escapement estimates and other stock assessment-related data that may be of varying quality. The issue is also of importance in other data bases, where multiple records of the same or similar observation also occur.

The chief issue is not whether changes to DFO data bases are "right" or "wrong". The major issue is whether or not changes to data are properly recorded so that it is possible to track the changes that occur over time, and why. During discussion it became clear that staff were in the past given a clear directive by senior management that *only one number* for one quantity should exist in a given salmon escapement record (e.g. the value for Black Ck. coho escapement for 1991), even if several independent estimates were available.

From a scientific viewpoint, this approach is simply wrong. Over time it will tend to undermine the quality of DFO's stock assessments. No one number can be correct, and the best technical approach is generally to combine all of the available data by statistically weighting them for differences in data quality. The present system of revising data bases to keep only the best number is clearly wasteful of DFO resources. We need to keep track of all of data. However, in light of DFO reform this issue of maintaining multiple numbers will need to be handled with some sensitivity, because special interest groups (SIGS) will have the potential to access DFO data bases and do their own stock assessments.

The existence of multiple numbers could be an embarrassment because the public would have difficulty understanding how SIGS could arrive at different conclusions from DFO's scientists when they use the same data. The FMISST recommendation is to maintain all numbers, but to also record the synthetic summary. DFO policy could presumably be developed to ensure that only summary values are released externally. However, the primary issue at present is that in a number of key data bases no system is currently in place to ensure capture and tracking of *all* the raw data or logging of all subsequent changes that occur. This failure needs to be rectified as quickly as possible.

(iv) STATUS OF FALL WORKING PAPERS

Working papers were previously requested by DSSC on herring, groundfish, salmon, and shellfish biological data bases. These were to be completed by the Fall of 1993. The DSSC reviewed progress on these papers and the direction the authors were taking to comply with the

DSSC's requests. Herring, groundfish, and salmon working papers appear to be on track, and addressing the main directives. A memo from the Marine Fish Division Head has been received which raised concerns about the request for a review of shellfish data bases, because of the amount of work that would be required to collate and review the very diverse data sources used in shellfish stock assessment. A review of shellfish logbooks was proposed as an alternative, plus reviews of a few species-specific shellfish data bases each year.

The consensus of the DSSC was that a review of shellfish logbook programs was welcome, as would any submission concerning stock assessment databases. However, DSSC requests clarification on the form of the suggested report vis-á-vis previous DSSC submissions on shellfish logbooks (Noakes, Stanley, & Somjee 1991; Jamieson, Hobbs, & Harbo 1992).

With respect to the request for a review of biological databases for shellfish, the DSSC recognizes the difficulties in meeting this request by the shellfish group. The DSSC hopes that the project can be included in 1994/95 workplans, and submitted in the spring of 1994. At that time the submissions for Salmon, Herring, and Groundfish will have been completed, and may serve as a guide for authors of the shellfish paper. Advice from the PSARC Steering Committee is clearly needed prior to committing to a specific plan of action.

(v) "PRIVATELY" HELD DATA BASES

DSSC is aware of a number of "privately" held data bases that are maintained in the region. These involve data collected with DFO funds, but which are maintained by individual investigators on micro computers. In most cases the principle investigator is the most appropriate individual to maintain and update these data bases, and the current system is probably cost-effective. However, in many cases DFO's long-term needs may not be met by the current "*laissez-faire*" system. It is not clear what level of backup and archival of these data sets is occurring, nor is the existence of many of these data sources even systematically recorded.

A more fundamental issue involves ensuring that these data bases remain usable and do not simply get lost upon retirement of individual investigators. In many cases, the investigator may have a deep understanding of the nature and use of personally-held data bases, but may never have taken the time to provide adequate documentation of the collected data. Unlike paper records, which can be filed in archives, micro-based data files are not straight-forward to archive at retirement, and in any case could be impossible to extract in a few years. System standards change, ensuring that past storage formats will not be supported. Detailed information about the problems and nature of the data collection may never have been written down. Finally, the integrity of magnetic storage systems degrades with time, so that the data bases may become irrecoverable - even if they are discovered.

The region needs to carefully consider this issue. Over the next decade a substantial number of employees will be retiring. These people will be the first generation that routinely used micro computer software to store, analyze, and disseminate their carefully collected data. In earlier years, investigator's field notebooks and typewritten data tables were contributed to

DFO's archives at retirement. These holdings can be retrieved. In contrast, it is far from clear how a small hard drive, that may in some cases contain several million dollars of investment, should be archived, much less how other individuals are to be able to sort through the thousands of files that may be stored there, in order to find useful data.

DFO needs to carefully consider these issues. Microcomputer data bases are useful and are here to stay. However, there will be a large number of retirements over the next decade. Perhaps time should be specifically set aside within the workplanning exercise to require those individuals near retirement to identify, summarize, and document their most essential data holdings. It is unlikely that all but a few highly motivated individuals will voluntarily take the time to do this properly. There is significant potential for DFO data holdings and investments to be damaged if the issue is not addressed in a timely fashion.

(vi) THE DSSC MANDATE

The DSSC is charged with providing the scientific and technical basis for PSARC advice on matters concerning fisheries statistics, sampling of commercial catches, and biological surveys. *Technical* advice to PSARC on issues related to data is currently being carried out. However, within the PSARC framework, and DFO in general, there is no overall scientific review of the experimental design and reliability of many of DFO's programs.

Some programs reviewed within the species committees of PSARC may, depending upon reviewer's expertise, touch on the issue of whether or not sampling and program direction will provide statistically valid answers (the scientific basis for stock assessment advice). However, direct advice on these issues is often lacking, and usually comes only after significant funds are spent on collecting data, not before.

In Alaska, staff biometricians are apparently required to review and advise all programs during the workplanning stage, and sign off as to the statistical defensibility of the proposal *prior to funding*. Such a rigorous process is not currently implemented in DFO's Pacific Region. At this point it is unclear whether such an expanded role for either DSSC or some other committee is appropriate, nor is it clear where the manpower to implement such a process would come from. However, there could be significant savings to the region if statistically weak projects could be identified prior to implementation.

The DSSC counterpart organization in CAFSAC (SSSS) does involve itself more heavily in these issues. However, the DSSC does not feel that it is appropriate at this time to make a specific recommendation as to whether or not an expanded role is needed. However, the issue is important, and does need to be given careful consideration by both the PSARC Steering Committee and senior management.

3. LITERATURE CITED

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Noakes, D.J., R.D. Stanley, & S Somjee. 1991. A review outline of shellfish logbook programs. PSARC DSSC Discussion Paper 91-1. 5 p.

Jamieson, G.S., R. Harbo, and K. Hobbs. 1992. Review of the use of logbook data in invertebrate fisheries research and management. PSARC I92-08. 39 p.

APPENDIX I.

LIST OF PARTICIPANTS, DSSC SPRING (3 MAY, 1993) MEETING.

Present:

Carol Cross, SEP, Vancouver
Camille Gosselin, Vancouver
Lorena Hamer, BSB, Nanaimo (PBS)
Leroy Hopwo, OB, Nanaimo
Bob Humphreys, OB, Nanaimo (PSARC Chair)
Peter Kho, Louis Lapi, BSB
Bill Shaw, BSB, Nanaimo
Rick Stanley, BSB, Nanaimo
D. Welch, BSB, Nanaimo (Chair)

Absent:

Don Radford, OB, Prince Rupert

PACIFIC STOCK ASSESSMENT REVIEW COMMITTEE

PSARC ADVISORY DOCUMENT 93-3
SEPTEMBER 1993

GROUNDFISH

CONTENTS PAGE

I. STEERING COMMITTEE REPORT

PSARC Steering Committee met 22 September 1993 at the Pacific Biological Station in Nanaimo to review the Groundfish Subcommittee Report. The Steering Committee supports the recommendations of the Subcommittee and wishes to highlight the following:

Degradation of CPUE: Steering Committee noted that there are a number of problems with CPUE obtained from commercial fisheries. Steering Committee encourages assessment biologists to develop fishery-independent indices of stock status, particularly for slope and shelf rockfish, inshore lingcod, and sablefish.

Inshore lingcod: Steering Committee stresses the fact that the recommendation that lingcod fisheries be closed, and that a review by the Marine Mammal Section on marine mammal predation on lingcod be carried out, has been made on at least two occasions. Indices of abundance have continued to decline.

Pacific Cod: There is considerable uncertainty about the stock status of Pacific Cod. The Steering Committee supports the view that a low to mid range stock status is more likely than an optimistic view.

Flatfish: Steering Committee advises that managers should exercise caution in the harvest of Petrale Sole and limit the catch to the lowest possible level. Steering Committee notes that flatfish are scheduled for a major assessment in 1994.

Pacific Hake: Steering Committee reviewed new information presented by the Subcommittee on Pacific Hake. This new information (updated recruitment index) led to substantial increases in the yield options for 1994. Steering Committee notes that the increase in available yield is strongly dependent on the acceptance of the 1992 survey estimate. Since there are scientific concerns with this estimate, the Steering Committee recommends caution in assigning yield options.

Inshore Rockfish: In the Subcommittee Report, it was noted that there was a lack of processing and analysis of hook and line rockfish data. Therefore, Steering Committee recommends that the 1993 logbook data (start of limited entry) be processed, and that logbook data from previous years be examined for their utility. Steering Committee recommends the implementation of a user-pay logbook program for 1994.

Aggregate Species Management: The Steering Committee supports the Subcommittee's request that if aggregate species management is accepted, that assessment scientists need clear guidelines from managers as to the kinds of advice needed.

Port Monitoring: The Steering Committee endorses the need for the implementation of a port monitoring program.

In addition, the Steering Committee recommends the following:

(i) Definitions of low, sustainable, and high risk should be clearly articulated. Risk levels need to have a temporal basis in their definitions.

(ii) Steering Committee requests that future Groundfish Subcommittee Reports overviews on current conditions (summary table), include a summary of trends in changes in stock status for all species, and where possible, reasons for changes.

II. GROUNDFISH SUBCOMMITTEE REPORT

BIOLOGICAL ADVICE ON MANAGEMENT OF BRITISH COLUMBIA GROUNDFISH FOR 1994

This document contains synopses of stock conditions and management recommendations for the major groundfish stocks off British Columbia. It also contains summaries of reviewers comments and summaries of reviews of 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. Some shorter-lived groundfish species (e.g. Pacific cod) may require more frequent assessment updates. This year major assessments were conducted for slope rockfish (Pacific ocean perch, redstripe rockfish, yellowmouth rockfish and rougheye rockfish) and Pacific cod.

Marine Fish Division staff conduct their assessments using a multi-year data base of fishery statistics and biological sampling, and a variety of assessment tools including several catch-at-age models, age-independent biomass dynamic models, and yield-per-recruit models. Stock assessments are assigned to reviewers by the Subcommittee 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 reviewer. Assessments and recommended yield options are then reviewed by the Subcommittee as a whole, which includes representatives from Science Branch, Fisheries Branch, and Program Planning and Economics Branch. The Subcommittee must reach a consensus on any recommendations presented in assessments before submission to the PSARC Steering Committee.

1993 WORKING PAPER TOPICS AND AUTHORS

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, G. A. McFarlane, M. Stocker and B. M. Leaman
Pacific hake - M. W. Saunders and G. A. McFarlane
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

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	Very 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*

* depending on specific stock.

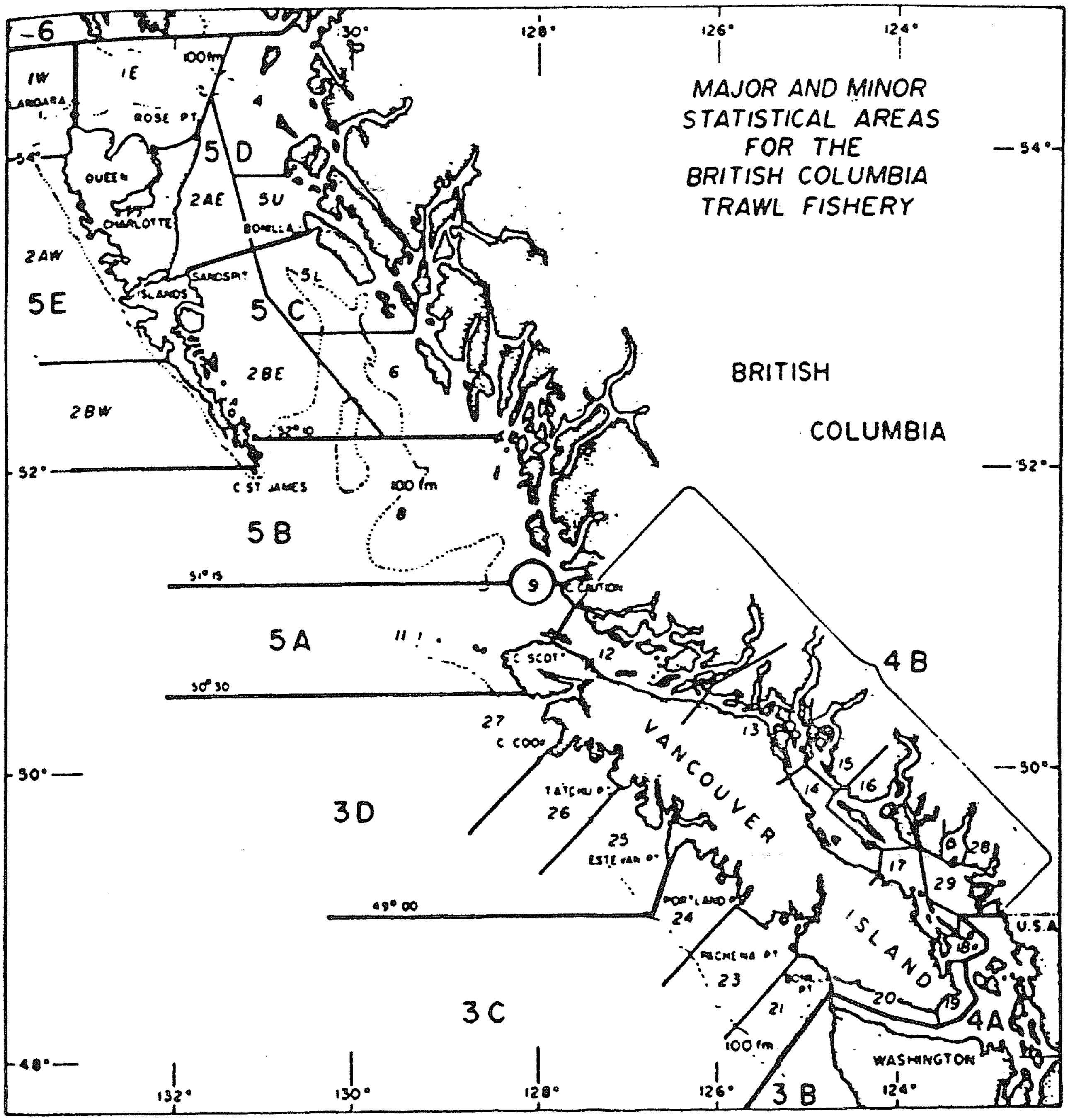

Figure 1. Major and minor statistical areas for groundfish fisheries on the west coast of Canada.

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 qualitative in that they incorporate neither a formal calculation of probability, nor a precise definition of consequence. Rather, they attempt to convey the degree of uncertainty associated with various yield options. For a detailed description of yield options see Leaman and Stocker (1993).

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

MAJOR SUBCOMMITTEE CONCERNS

Offshore hake - Coastwide and Canadian zone estimates of Pacific hake made in 1993 were considerably higher than predicted by previous assessments. A total of 2,921 Kt of hake coastwide were found by the U.S. hydroacoustic and bottom trawl surveys combined. Yield recommendations depend critically on the expanded area coverage of the 1992 hydroacoustic survey. U.S. scientists have suggested the cause for the increase is a deep scattering layer found sea-ward of the normal survey boundaries and that the previous surveys have missed fish. While there was certainly hake in this scattering layer the proportion of hake is uncertain. Calibration on this layer which was deeper than previously surveyed with this equipment was not precise. Caution is recommended in adopting yield options until more information is available to clarify this result.

Pacific cod - The Subcommittee agrees with the external reviewer's comments that the effects of changes in the mean size of fish be included into the assessment of the Hecate Strait and west coast Vancouver Island Pacific cod stocks. These analyses were expected to result in decreased low risk yield options for both stocks. Based on these analyses, the Subcommittee thought that within the range of possible stock conditions, a pessimistic view of stock status was much more likely than an optimistic view of stock status. Managers are urged to exercise caution in assigning harvest levels for these stocks.

Strait of Georgia lingcod - The lingcod stock in the Strait of Georgia was assessed using commercial and sport fisheries data. These declines indicate that the Strait of Georgia lingcod stock is at an extremely low level of abundance. A complete closure for both commercial and sport fisheries in 1994 is necessary to prevent further stock depletion.

Degradation of CPUE - Several assessments noted that changing fishery regulations (trip limits) and frameworks (IQ systems) erode the value of traditional indices of abundance, such as CPUE. Assessment biologists should develop fishery- independent indices of stock status. In addition, managers should consider the impact on traditional fishery-based indices of stock status, whenever they are considering changes to management strategies or regulations.

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. All indices indicate a decrease in abundance of lingcod. In particular, the commercial CPUE is less than 50% of values prior to 1984 and the sport CPUE is less than 9% of the value for 1984. These declines indicate that the Strait of Georgia lingcod stock is at an extremely low level of abundance. A complete closure for both commercial and sport fisheries in 1994 is necessary to prevent further stock depletion.

The reviewer noted that analysis and conclusions of the 1993 stock assessment for inshore lingcod is unchanged from previous years. As such, the review comments are directed primarily towards clarifying the meaning of some sentences.

The Subcommittee concurs with the stock assessment and the recommendations presented for Strait of Georgia lingcod for 1994. There is concern that the bycatch mortality from the capture and handling during commercial and sport fishing, and marine mammal predation, may impede or even preclude stock rebuilding. In light of this concern, the Subcommittee repeats the request for a review by the Marine Mammal Section on the marine mammal predation on lingcod, that was made last year. The Subcommittee would like to see continued work on the various sources of mortality and comments that although this sport fishery will remain small with respect to landings, it will remain a high profile fishery as part of the complex issues related to managing the Strait of Georgia Basin.

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 and personnel 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. This problem was examined through comparison of independently observed lengths at age with those calculated from fish samples aged in 1987 and again in 1992. This work indicates that ages estimated in recent years underestimate previously estimated ages by approximately one year. Until this discrepancy is resolved in the historical data series, 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 increases in CPUE off Vancouver Island are associated with a substantial decline in fishing effort. CPUEs off the northwest coast of Vancouver Island and in Queen Charlotte Sound are relatively stable. 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 also presented. 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 stated that the analysis and conclusions of the 1993 stock assessment for offshore lingcod is unchanged from previous years. The review comments were directed primarily towards clarification of meaning although questions regarding the appropriateness of the inclusion of previous analyses and the extent of the final recommendations were raised.

The Subcommittee concurred with the reviewer's comment that, there was concern about the present biomass trajectory of the Area 3C and Area 5A/B stocks, and the current record levels of fishing effort. The patterns were not marked enough to justify a major reanalysis during an interim assessment year. Yield options from the most recent full assessments are still considered appropriate. The Subcommittee encourages resolution of ageing discrepancies for this stock.

The Subcommittee noted that the possibility that the use of 25% qualification in association with decreased trip limits for other species may have contributed to the apparent increase in effort.

Pacific cod

Pacific cod stock assessments were presented for four areas on the British Columbia coast. The basis for the assessment in each area varies in relation to the available information. No new analysis has been conducted for the Strait of Georgia stock. Regulation does not appear to be necessary for this stock. Major new analysis have been conducted for this year's west coast of Vancouver Island stock. Our estimates from catch-at-age analysis indicate that fishing mortality rates are at above average levels, and the effort is far above average levels. The abundance estimated with different modelling tools (including a Bayesian stock assessment method) is around average. Yield recommendations are based on a one year projection from the Bayesian procedure. Low risk, sustainable and high risk yields are 650 t, 2170 t and 5880 t respectively. It is recommended that the winter closure be resumed, and that a catch level not greater than 2200 t be applied in 1994. The winter closure is to protect cod when they are particularly vulnerable as they concentrate within a very limited area for spawning. The Queen Charlotte stock is not assessed for yield potential. This fishery remains small and is of low management priority. Major new analysis have also been conducted for the Hecate Strait stock.

Survey and commercial fishery abundance indices indicate a decrease in relative abundance in recent years. Our estimates indicate that fishing mortality and fishing effort in Hecate Strait are above average levels. The abundance estimated with different modelling tools is below average levels. Yield recommendations are based on a one year projection from a Bayesian procedure. Low risk, sustainable and high risk yields are 1670 t, 3850 t and 7790 t respectively. It is recommended that a catch level of less than 4000 t be applied in 1994.

Some general points about this Working Paper upon which many of the detailed comments of reviewer 1 are based are presented. The authors have not captured the key feature of the Bayesian approach to presenting information to managers. This document actually gives the manager less information on which to base decisions than was presented in previous documents. There are too few details of the methods presented, given that this is a major update of the assessment.

Reviewer 2 (external) suggests that generally the document is well organized and presents information in a fashion that should be reasonably easy for management staff to use. It would be useful to have a historical overview near the start of the paper, reviewing the entire catch history of the fishery and any major changes that have occurred in the spatial distribution of fishing, particularly with regard to depth and concentration on spawning/nonspawning aggregations.

The analytical methods used are state of the art. Probably the new Bayesian VPA package should be used in preference to the older packages and the Paloheimo (1980) method, so that one can look at uncertainty about M and about recent changes in catchability. Also, one should use the BP program for Bayesian aggregate CPUE/catch analysis rather than the Hilborn/Punt program.

The main concern with the whole analysis is the heavy reliance on commercial CPUE data for the Bayesian and Paloheimo methods. It has been pointed out for many years that the qualified CPUE method that is used for cod is not an appropriate way to construct an index that is proportional to stock size. Using any qualification scheme is a guarantee of biasing the index upward when stock sizes are low, and it also links the assessed trend in cod relative abundance to changes in relative abundance of other species like rock sole.

The Subcommittee agrees with the external reviewer's comments that the effects of changes in the mean size of fish be included into the assessment of the Hecate Strait and west coast Vancouver Island Pacific cod stocks. These analyses are expected to result in decreased low risk yield options for both stocks. Based on these analyses, the Subcommittee thought that within the range of possible stock conditions, a pessimistic view of stock status was much more likely than an optimistic view of stock status.

Flatfish

Flatfish stocks were assessed in 1993 using standardized landing statistics. Landing statistics for rock sole, English sole and Dover sole (Area 5C-E) were standardized using a multiplicative model accounting for the effect of changing vessel horsepower on CPUE. Petrale sole stocks were determined to be at low levels while rock sole, English sole and Dover sole stocks were at average to high levels. Landings for rock sole and English sole in Hecate Strait are at historical highs during the last two years. The strong 1984 rock sole year-class continued to contribute to fishery production in 1992 but landings for these stocks have levelled off. Yield should decrease over the next two to three years as recruitment declines. Recruitment has increased for Hecate Strait English sole and landings in 1992 increased significantly from 1991 because of this. CPUE for Area 5CDE Dover sole decreased in 1992 from 1991 while CPUE for Area 3CD Dover sole remained at a level similar to that observed for 1991.

The reviewer agreed with the methods used and the yield options presented in these interim assessments. It is recommended for future full assessments that the author consider using catch at age or surplus production models to assess 5A rock sole and investigate the potential use of U.S. triennial bottom trawl survey data in assessments of 3C flatfish.

The Subcommittee comments that the harvest of petrale sole should be limited to the lowest practical level, however, there is no biological basis for recommending a specific trip limit, nor any evidence that imposition of trip limits would benefit the stock.

For 3C-3D Dover sole, there is no evidence of a decline in abundance, as inferred from CPUE, since 1988 when landings from this fishery first became significant.

With the exception of the two stocks discussed above, the Subcommittee concurs that the interim assessment does not provide any basis for revising the yield recommendations of the previous assessment.

Sablefish

The sablefish stock off the west coast of Canada is estimated to be in good condition. Nominal estimates of coastwide CPUE remained high in 1992 and biomass estimates, based on survey trap catch rates in 1989, 1990 and 1991, indicated that total biomass was between 54.0 Kt and 61.7 Kt while exploitable biomass was between 44.0 Kt and 50.8K. These values are above comparable estimates reported in the early 1980s. A Bayesian implementation of a simple age and sex-structured model estimated virgin biomass (B_0) to have been 120 Kt and produced estimates of 4510 t for MSY and $F_{0.1}$ of 4100 t. The Bayesian approach has several interesting properties but requires additional development. The present version shows undesirable sensitivity to survey estimates of abundance and estimates of recruitment. Yield options remain unchanged from the previous assessment. They range from 2900 t for the low risk option to 5000 t for the high risk option.

Reviewer 1 endorses the cooperative study with industry, the continuation of the trap surveys and the larval surveys. It is recommended that future assessments concentrate more on analysis of the biological and tagging data and ensure that biological sampling is consistent in space and time to allow the monitoring of trends, especially trends in mean age and size. These variables can be reasonable indicators of level of recruitment and total mortality in the absence of reliable fishery information.

Reviewer 2 (external) suggests that generally the document is well organized and easy to follow. The main concerns are with the interpretations. In future, it would be helpful in organizing the document to have (1) a subsection near the front, or in the catch history description, reviewing historical changes in depth and north-south patterns of fishing effort--these come in later in interpretation of the CPUE series, but really belong right up front; and (2) reduction in the tabular data presentation on spatial details of the catch/effort history--include the highlights of these in the description of changes, but don't present the details as though they were of equal importance to the catch/CPUE/survey data actually used in assessment.

Some concerns about the data interpretation were: (1) recent changes in CPUE should not be viewed with "cautious optimism"; recent increase in CPUE is obviously related to changes in place/time/type of fishing, and is too rapid to be in any way related to stock changes; (2) Why not analyze the inseason CPUE changes for hot-spot depletion? Such depletion estimates would also give you minimum stock size estimates for more valued fishing areas; (3) the estimated area fished per trap for the survey estimate appears to be assumed in order to give stock estimates that agree with older consensus based on VPA, etc.; (4) the Bayes analysis should also be done leaving out the trap CPUE data entirely; (5) since strong-weak year-classes are already seen in the age composition data at least a few years before each cohort becomes fully vulnerable, why not concentrate on improving the age selectivity estimates for young ages as a way of getting lead time on year class changes.

The Subcommittee concurs with the yield options presented in the stock assessment.

The Subcommittee recommends, however, that the assessment document be augmented to reflect modifications to the trap index as suggested by the external reviewer. The Subcommittee had some concern that the stock might be lower than previously thought, particularly since the CPUE time series may not accurately reflect stock abundance. However, there is insufficient information to justify modification of yield options at this time.

Pacific hake

The fishery in the Strait of Georgia continues to develop with 20,686 t landed during 1992, the highest annual catch ever reported. The stock is estimated to be in good condition based on preliminary results of a hydroacoustic survey conducted during March 1993 that found a total of 245 Kt throughout the Strait of Georgia. These estimates are higher than previous surveys conducted during 1981 and 1988. The survey had a strong showing of 1 and 2 year-olds suggesting that recruitment to this stock may be good over the next several years. The yield options for the Strait of Georgia remain unchanged from the previous assessment conducted using Virtual Population Analysis (VPA) and a forward simulation model that indicated that yields up to 14,000 t may be sustainable.

Since 1968, more Pacific hake have been landed from the offshore stock than from any other species in the groundfish fishery on Canada's west coast. Coastwide catches of Pacific hake decreased from 322 Kt in 1991 to 295 Kt in 1992 a result of declining available yield. The all-nation-catch in the Canadian zone was 86,370 in 1992, down from 104,522 t in

1991. In the absence of an allocation procedure, the combined Canadian and U.S. harvests in 1990, 1991 and 1992 have exceeded recommended yield levels. The approach taken in this assessment is similar to that of the previous one, using catch-at-age analysis tuned to independent Canadian and U.S. survey estimates to assess the current status of the stock, and using an age-structured forward simulation model to examine long-term (equilibrium) production and short-term (look ahead) yield options. Overall abundance as indicated by stock synthesis runs, is declining as the strong 1980 and 1984 year-classes move through the fishery. Hydroacoustic surveys were conducted by U.S. and Canadian researchers during 1992. The estimates coastwide and in the Canadian zone were considerably higher than expected based on previous assessments. A total of 2,921 Kt of hake coastwide were found by the U.S. hydroacoustic and bottom trawl surveys combined. Canadian and U.S. surveys found 932 Kt and 1,101 Kt of hake in the Canadian zone, respectively. U.S. scientists have suggested the cause for the increase is a deep scattering layer found sea-ward of the normal survey boundaries and that the previous surveys have missed fish. While there was certainly hake in this scattering layer the proportion of hake is uncertain. Calibration on this layer which was deeper than previously surveyed with this equipment was not precise. Caution is recommended in adopting yield options until more information is available on the size of the offshore biomass, and its relationship to potential yield from the stock. Yield options for three possible fishing strategies and three risk levels are presented with available yields for 1994 ranging from 198 Kt to 463 Kt. These are considerably higher than 1993, a result of the increase in abundance estimated by the 1992 survey.

The reviewer stated that this is an interim assessment, but the significant changes in the assessment for the offshore stock warranted an extensive review. The catch of the Strait of Georgia stock has been increasing and now approaches the quota. While the catch remains below the quota, it is reasonable to direct assessment work to higher priority stocks. However, if demand continues to increase, then yield options for this stock should be re-evaluated. One reason cited for not conducting a major revision is the poor quality of the early catch-age data; this problem cannot be resolved easily. The assessment describes the alternative information available for this stock from hydroacoustic surveys. The survey data alone should provide sufficient information to develop (at least) approximate yield ranges. Given the cost of these surveys, more direct use of the resulting data could be made in future assessments.

The assessment of the offshore hake highlights a significant departure from previous assessments. Recommended yields are substantially higher than in previous years at a time when stock abundance is declining. Yield recommendations depend critically on the results of the 1992 hydroacoustic survey. Difficulties are encountered in tuning the analytical age-structured model because of variations in the survey abundance estimates due to non-comparability of methods and coverage over the years. Furthermore, survey biomass estimates are stated without estimates of associated error. Yield ranges are based on forward simulations which vary the recruitment, but fix all other model parameters at their estimated values. Thus, these yield options give a misleading sense of model certainty. A substantial increase in yield, based solely on a change in area coverage during the most recent of six surveys is not justified. In the interim, a minor increase in quota is probably justified. A minor increase could be accommodated either by phasing in the increase to a higher level or by accepting the low risk option provided in the paper.

The Subcommittee agrees with the recommendations proposed for Strait of Georgia Pacific Hake.

The Subcommittee agrees the analyses conducted are reasonable and done correctly, given the survey and catch. The Subcommittee strongly supports the concerns raised by the author and reviewer that the results of the analysis are dependent upon the results of the U.S. coastwide triennial survey. The Subcommittee noted that there are three principal concerns with the 1992 U.S. hydroacoustic survey: 1) coverage was expanded from the 350 m contour to the 1000 m contour, and thus considerably more area was surveyed than in earlier years, 2) species composition of the offshore deep scattering layer surveyed acoustically was inadequately determined, and 3) calibration of the acoustic system becomes less precise in deeper waters, and only limited calibration was conducted in deeper waters on this survey. The Subcommittee recognizes that the low risk option represents a substantial increase to the quota from 1993 but recommends the adoption of this level for 1994.[3]

Spiny dogfish

A summary of fishery statistics was provided showing catch and effort patterns for B.C. and Washington fisheries for the years 1979-1992. Directed effort towards spiny dogfish remains market dependent as the profitability of the fishery is considered to be marginal. Yield options developed using a deterministic age-structured simulation model are unchanged from recent years at 9,000-15,000 t for the offshore stock and 4,000-6,000 t for the Strait of Georgia-Puget Sound stock. Catch levels in both areas remain below the low-risk harvest levels.

As an interim assessment, the methodology, interpretation, and yield recommendations for spiny dogfish remain unchanged from the 1992 stock assessment document. Based on the level of fishing, changes in the basis of the assessment are not warranted for the 1993 assessment.

The Subcommittee and the reviewer endorsed the yield recommendations contained in the working paper. The Subcommittee noted that information on bycatch in other fisheries where dogfish are caught (e.g., shrimp trawl) would be a valuable addition to future assessments. The Subcommittee also requested additional text to clarify the best understanding of the relative contribution of dogfish in the Canadian zone to the coastwide totals. The reviewer drew attention to the fact that, although the fishery for dogfish is now relatively minor, the assessment of dogfish is also important concerning its impact as a predator on other species of assessment concern. The Subcommittee acknowledged this concern but noted that investigation of such relationships constituted a major new research initiative, and that fisheries management had not requested assessment advice in such an ecological context.

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[3]Subsequent to this Subcommittee report new information was made available on this stock. Please refer to I. Steering Committee Report.

Walleye pollock

The 1992 walleye pollock catch in the Canadian domestic fishery decreased from 2658 t in 1991 to 1364 t in 1992. The 1992 incidental catch in the joint-venture and foreign hake fisheries increased to 1437 t from 383 t in 1991. No new analyses were conducted for this assessment. Low to high risk yield options for the Strait of Georgia, based on Gulland's MSY model with revised mortality estimates, are 1300 and 2700 t, respectively. Yield options are not proposed for stocks off the west coast of Vancouver Island, Queen Charlotte Sound and in Dixon Entrance/Hecate Strait.

1993 is an interim assessment year for walleye pollock and the author may choose to address some of the reviewer's detailed comments in the 1994 major assessment. It is suggested that when using the Gulland estimate MSY=a(M)(B), the constant "a" remain fixed at 0.4 when deriving both the low and the high risk yield options for the Strait of Georgia. The document infers that the March 1993 hydroacoustic survey may underestimate the biomass of pollock in the Strait of Georgia. The implications of this for the major 1994 assessment could be stated.

The subcommittee recommends that the Gulland constant (a) value be set at 0.4 for both the low and high risk yield analysis and that natural mortality estimates of M=0.2 be used to develop the yield options for the Strait of Georgia walleye pollock stock. The subcommittee accepts the revised yield options using these parameter values.

Slope rockfish

Slope rockfish covered by this assessment are Pacific ocean perch and redstripe, yellowmouth, and rougheye rockfish. Detailed data are available for Pacific ocean perch in the Queen Charlotte Sound region only. A major assessment update is presented for this region, including a re-examination of CPUE as an abundance index and a catch-age analysis based on 1963-92 data. We show that the management strategy of variable trip limits has altered the catch-effort pattern in the rockfish fishery, with the consequence that CPUE has questionable value as an abundance index. However, no recent fishery-independent data are available; the last biomass survey in Queen Charlotte Sound was conducted in 1984. Without a suitable index for 'tuning' the catch-age analysis, the age structure data are equally consistent with a continuation of the stock decline in Goose Island Gully or a complete recovery from foreign overharvesting during the late 1960s and early 1970s. We choose 30,000 t as a high risk estimate of the 1992 exploitable biomass, consistent with a 1.5 fold increase in catchability between 1963-92 and with use of the 1965-84 surveys for tuning. A policy of a fishing mortality rate equal to the natural mortality rate (0.05) provides a yield range of 350-1,800 t for Goose Island and Mitchell's Gullies. A catch-age analysis for Moresby Gully resulted in low-high risk yield estimates of 1,500-3,400 t. Given the uncertainties associated with this assessment, we recommend a moderate increase only in the coastwide quota until stock recovery can be confirmed by future surveys and analyses. Interim coastwide yield options for other species (excluding the experimental Area 5E-N) were derived from plus or minus 25% of the 1986-92 mean catch. Yield options for redstripe rockfish remain unchanged from previous assessments because of concerns over catch reporting.

Reviewer 1 (external) noted that the assessment includes a significant update of the status of the major Pacific ocean perch stocks in the region. The author employs a statistical catch-age modelling approach, similar to the stock synthesis approach used at the Alaska Fisheries Science Center, National Marine Fisheries Service. The major sources of data and analytic procedures used in the POP assessment are well documented and clearly laid out. The author conducted an excellent assessment with the available data. Overall, the document is well organized, clearly written, and the results valid. The following comments/suggestions may provide food for thought in future iterations of the POP assessment.

A high priority should be given to developing and generating alternative fishery-independent abundance indices to help tune the catch-age analysis, particularly for the Moresby Gully stock. Reviewer 1 questioned deeply discounting the sigmoidal catchability results. The author's justification for a maximum increase in catchability of 1.5 is questionable. A domed-shape selectivity function may be more appropriate with the data used in this assessment, particularly with the fishery data.

Reviewer 2 indicated that the presentation was clear and logical, and that no additional analysis was required. With regard to the two catch-age analyses for Pacific ocean perch, the major concern is that the author has equated catchability with fishing power. The author has suggested that although the model implies that catchability in Goose Island Gully may have increased dramatically, this cannot be possible because fishing power cannot have increased that much. The author has not considered the possibility that the biomass distribution may have altered such that an increasing proportion of the biomass is concentrated on the preferred trawl grounds. If this were the case, catchability could have increased considerably more than 1.5 times, and currents stock size would be even lower than suggested. A second concern involves what the author feels should be the future directions of slope rockfish assessment. The reviewer agrees with the author that the catchability problem and the lack of fishery-independent indices are what limits the assessment.

With respect to the minor species, reviewer 2 suggest the author provide a further rationale for using the average of the last 5 years of landings as the recommended quota.

The Subcommittee agrees with the recommendations proposed for POP. Because of the difficulty in interpreting CPUE in recent years, where trip limits were imposed, the Subcommittee concurs with the author and reviewers that fishery independent indices are needed (including possibly a survey). The Subcommittee recommends that the yield options for redstripe rockfish remain unchanged from 1993 because of the concern over species catch reporting.

Shelf rockfish

Interim assessments were presented for eight shelf rockfish stocks. Assessment methodology was reviewed in the previous document. Quota recommendations for silvergray, yellowtail, and canary rockfish are unchanged from the previous year. For silvergray rockfish in PMFC Areas 3C+3D (Vancouver Island), 5A+5B (Queen Charlotte Sound) and 5C+5D (Hecate Strait), the recommended yield ranges 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 respectively. However, owing to continued declines in CPUE for all three silvergray rockfish stocks and the 3C+3D canary rockfish stock, we recommend that managers be conservative within the recommended yield ranges for these four stocks. Widow rockfish is assessed as one coastal stock. The recommended yield range is changed from 500-2200 t to 1100-2150 t. We include a more detailed discussion of comparability between the U.S. and Canadian fishing experience. Yield recommendations for the yellowtail rockfish stock of PMFC Area 3C (south Vancouver Island) is combined with the northern Washington fishery (PMFC Areas 3C-US and 3B). The recommended yield is unchanged from the previous document at 1000-2000 t for the combined U.S. and Canadian yield. The yield recommendation for the remaining yellowtail rockfish fishery (PMFC Areas 3D-5E) is unchanged at 2500-4900 t.

The reviewer indicated that this was a very soundly done interim assessment, containing all the information appropriate for an interim update. This interim assessment does not recommend changes in upper and lower limits of yield options for any shelf rockfish stocks except widows. For many stocks the assessment does advise that conservative selections be made from the ranges advised in last year's assessment. The author should indicate whether he feels those admonitions of caution require even more conservative decisions by managers than were made last year.

The core of the widow assessment hinges on the assumed similarity between the Canadian fishery prior to 1993 and US fishery prior to 1983. The part of the Canadian fleet which lands most of the widows disagrees strongly that the parallel is a close one. In consideration of work reviewed with the author and to be included in revisions to the assessment document, the reviewer believes that the assessment deals adequately with the matter, however our advice on this stock is still very weak. PSARC cannot reject a higher value for the high risk sustainable level than is advised in the present document.

Two items warrant follow-up for the next interim assessment. Because we are giving meaning to small changes in CPUE, the relationship between trip limit and CPUE estimates should be explored for at least a couple of stocks where data are most suitable. This could be examined as a focused analytical project, without entailing a major reassessment for next year. Also, the author mentions the intent to initiate fishery independent indices of stock status. Such an initiative should be pursued.

The Subcommittee and the reviewer complimented the author for selection of appropriate material for presentation in an interim assessment. The Subcommittee endorsed the yield recommendations with the exception that the high-risk yield estimate for widow rockfish should be set at a level near the average catch over the last five years. The Subcommittee also agreed that future documents should strive to incorporate interpretation of the effects of the most recent management actions and quotas. The Subcommittee held an extensive discussion on the value of CPUE as an index in shelf rockfish assessments and endorsed the need for development of alternative indices of stock status, where possible.

Inshore rockfish

Landings from the hook and line rockfish fishery have declined since 1992 in response to the implementation of a limited entry fishery coastwide and area quotas. In general, the stock condition is poor in the Strait of Georgia, and unknown in other areas. Yield levels (tonnes) for each statistical area were determined, as in the past two years, by multiplying ratios of catch to habitat (tonnes per km^2) by the size of the rockfish habitat within each statistical area (km^2). In 1993, areas of low slope, mud/sand bottom were identified from hydrographic charts and removed from the habitat areas used to determine yields.

The reviewer noted that the 1993 interim inshore rockfish stock assessment requires a more detailed description of the derivation of 1994 yield options. Use of harvest log data is suggested as a source for more accurate catch density estimates for future assessments.

The Subcommittee and the reviewer endorsed the yield recommendations. The Subcommittee also requested some alteration of the data presentations to facilitate comparisons of quotas and catches. The Subcommittee reviewed the status of logbook data processing for the Z-N licence fleet and repeated its previous requests to have these data made available in machine readable form for analysis as soon as possible. The Subcommittee noted that a user-pay program to include logbook data processing of the Z-N logbooks is scheduled for implementation in 1994. The Subcommittee also requested that the IPHC logbook data and data from fishing lodges and charter boat operations be investigated as additional sources of information on stock status.

ADDITIONAL SUBCOMMITTEE DISCUSSIONS

1. Biological Objectives Working Group update

The Subcommittee was presented with a review of the status of the working group. Membership of this group was finalized on July 14, 1993 and the group has had one meeting to-date. Tasks identified for the working group are: 1) provide a definition of conservation, 2) identify biological management objectives, and 3) outline a framework for dealing with socio-economic objectives.

The working group will also review the work of other similar committees in different jurisdictions to determine what has been concluded. The working group's schedule is to provide a final report to the PSARC Steering Committee in December 1993.

2. Report on Fisheries Management Information Systems Study Team (FMISST) recommendations and implementation plan

A brief review of FMISST was provided. Phase I, a review of existing systems including diagnosis of current information systems, has been completed for the groundfish and herring fisheries. The review provides for a plan to co-ordinate groundfish data among all users and a biological system is being designed with a completion date of December 15, 1993. It was felt that if the FMISST program was implemented, there would be better utilization of resources and improved data quality. The Subcommittee felt that the FMISST program for groundfish data should be implemented regardless of plans for other fishery data bases.

3. Nature of Science advice in light of Conservation Councils and reorganization

The Subcommittee was briefed on the request by the Steering Committee that Science Branch undertake a review of the structure and function of the East coast Conservation Council process. Information regarding the terms of reference, council objectives, mandate and scope, size and structure and make-up of the Conservation Council on the East coast were presented.

4. Aggregate Species Management

An update on the status of using aggregate species management as a means of managing the groundfish fishery was presented. If this approach is accepted, assessment scientists need some clear guidelines from managers as to the kinds of advice needed. Changes must be made to current legislation to address contradictory regulations regarding trip limits and a prohibition on discarding. A no-discarding regulation was to have been in place for 1994 but will not be before 1995 because of difficulties in changing legislation. Rockfish might be the first group to be managed on an aggregate basis.

5. Accounting for unreported catch

The Subcommittee stressed the importance of clarifying an industry misconception of how unreported catch is accounted for in assessments. It was stated that catch numbers are not added into assessments to account for unreported catch. Unreported catch will show up over time as mortality (either fishing or natural). It would not be possible to partition this mortality into fishing versus natural mortality.

6. Port Monitoring

An update on the progress towards a port validation of landings program was presented. The proposed start-up date of July 1, 1993 has been postponed due to several unresolved problems such as determining how the program will be financed and administered, determining a level of coverage acceptable to both DFO and industry and the legalities of randomly applying coverage of less than 100%.

The Subcommittee felt that work must continue towards the implementation of this program as it will only benefit the quality of data used for the management, assessment and enforcement of the groundfish fishery.

7. Oceanographic and Ecological knowledge in assessments

The Subcommittee was apprised of a memo from the ADM of Science to Science Branch requesting inclusion of the effects of major environmental and ecological influences in the assessments. The Subcommittee felt that additional discussion was needed to determine how this information could be best incorporated into assessments, but that staff should start to routinely incorporate this information into annual assessments.

LITERATURE CITED

Leaman, B. L. and M. Stocker (Eds.). 1993. Groundfish stock assessments for the west coast of Canada in 1992 and recommended yield options for 1993. Can. Tech. Rep. Fish. Aquat. Sci. 1919: 407 p.

TABLE 1.
RECOMMENDED YIELD OPTION SUMMARY

The recommended yield options for 1994 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	Low risk yield 650 t Sustainable yield 2170 t High risk yield 5880 t
5A/B	Pacific cod	No options proposed
5C/D	Pacific cod	Low risk yield 1670 t Sustainable yield 3850 t High risk yield 7790 t
5E	Pacific cod	No options proposed
Coastwide	Petrale sole	No options proposed
4B	Flatfish	No options proposed
3C/D	Dover sole	Low risk yield 1300 t High risk yield 2000 t
5A	Rock sole	Low risk yield 250 t High risk yield 500 t

AREA	SPECIES	YIELD OPTIONS
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 11000 t High risk yield 14000 t
3C	Pacific hake	Yield options to be announced at a later time, when joint arrangements with U.S. completed
Coastwide (including U.S. waters)	Spiny dogfish	Low risk yield 9000 t High risk yield 15000 t
4B (Strait of Georgia)	Spiny dogfish	Low risk yield 2000 t High risk yield 3000 t
4B	Walleye pollock	Low risk yield 1300 t High risk yield 2700 t
3C-5E	Walleye pollock	No yield options are proposed
Coastwide (Area 3C to 5E-S)	Pacific ocean perch	Low risk yield 3400 t High risk yield 5700 t
5A/B	Pacific ocean perch	Low risk yield 350 t High risk yield 1800 t
5C/D	Pacific ocean perch	Low risk yield 1500 t High risk yield 3400 t

AREA	SPECIES	YIELD OPTIONS
Coastwide (Area 3C to 5E-S)	Redstripe rockfish	Low risk yield 950 t High risk yield 2570 t
Coastwide (Area 3C to 5E-S)	Yellowmouth rockfish	Low risk yield 1100 t High risk yield 1850 t
Coastwide (Area 3C to 5E-S)	Rougheye rockfish	Low risk yield 500 t High risk yield 900 t
5E(N)	Pacific ocean perch	Experimental fishing area
5E(N)	Yellowmouth rockfish	Experimental fishing area
5E(N)	Rougheye rockfish	Experimental fishing area
5E(N)	Redstripe rockfish	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 1100 t High risk yield 3000 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

Table 2A. 1994 recommended yield options (t) by statistical area for red snapper.

Statistical Area	1994	
	Low	High
Strait of Georgia		
12	21	32
13	7	11
14	11	16
15	6	9
16	5	8
17	3	5
18	4	6
19	7	10
20	10	15
28	2	2
29	5	7
grouped quota	31	48
West Coast		
21,121	27	36
23,123	117	157
24,124	96	128
25,125	61	82
26,126	42	56
27,127	85	113
grouped quota	127	169
Queen Charlotte Islands		
1,101	101	135
2,102,130,142	185	247

Table 2A. (cont'd)

Statistical Area	1994	
	Low	High
grouped quota	286	382
North Coast		
3,103	7	9
4,104	21	28
5,105	30	40
grouped quota	52	69
Central Coast		
6,106	69	93
7,107	93	125
8,108	64	85
9,109	19	25
10,110	25	33
11,111	118	158
grouped quota	187	251

Table 2B. 1994 recommended yield options (t) by statistical area for rockfish.

Statistical Area	1994	
	Low	High
Strait of Georgia		
12	68	103
13	22	33
14	22	33
15	13	20
16	13	19
17	19	29
18	13	19
19	19	29
20	11	17
28	11	17
29	25	39
grouped quota	181	270
West Coast Vancouver Island		
21,121	10	13
23,123	32	44
24,124	46	62
25,125	22	30
26,126	20	27
27,127	25	34
grouped quota	155	210

Table 2B. (cont'd)

Statistical Area	1994	
	Low	High
Queen Charlotte Islands		
1,101	16	21
2,102,130,142	52	70
grouped quota	68	91
North Coast		
3,103	4	5
4,104	44	59
5,105	62	82
grouped quota	66	87
Central Coast		
6,106	104	139
7,107	76	101
8,108	157	209
9,109	5	7
10,110	38	51
11,111	44	60
grouped quota	120	161

REVIEWER ASSIGNMENTS FOR GROUNDFISH STOCK ASSESSMENTS

TITLE	AUTHORS	REVIEWERS
Inshore lingcod	Murie, Richards, Yamanaka	Thomson
Offshore lingcod	McFarlane, Leaman	Thomson
Pacific cod	Stocker, Hand	Leaman, Walters
Flatfish	Fargo	Saunders
Sablefish	Saunders et al.	Fargo, Walters
Dogfish	Thomson	Murie
Walleye pollock	Saunders	Yamanaka
Pacific hake	Saunders, McFarlane	Richards
Slope rockfish	Richards	Stanley, Ito
Shelf rockfish	Stanley	Rice
Inshore rockfish	Yamanaka, Richards	Hand

RAPPORTEURS ASSIGNMENTS FOR GROUNDFISH STOCK ASSESSMENTS

ASSIGNMENTS	RAPPORTEURS
Inshore lingcod Offshore lingcod Flatfish	Hand, Stanley
Slope rockfish	Yamanaka, Rice
Pacific hake Walleye pollock Pacific cod	Thomson, Fargo

Sablefish	Murie, Richards
Inshore rockfish Shelf rockfish Spiny dogfish	McFarlane, Leaman
Additional Subcommittee discussions	Adams, Zyblut

PARTICIPANTS AND REVIEWERS AT THE GROUNDFISH SUBCOMMITTEE MEETING
July 27-29, 1993

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J. Fargo	BSB, Assemblage Management Section, Nanaimo
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B. Humphreys	PSARC Chairman, South Coast Division, Nanaimo
B. Leaman	BSB, Marine Fish Population Dynamics Section,
Nanaimo	
G. McFarlane	BSB, Marine Fish Population Dynamics Section,
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B. Turris, Co-chair	FB, Commercial Fisheries Division, Vancouver
N. Venables	BSB, Marine Fish Population Dynamics Section, Vancouver
C. Walters	Fisheries Centre, UBC
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, 1982-1992.

Species	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1982-91	1992[b]
English sole	559	532	812	692	452	755	879	1,041	1,266	1,171	699	1,336
Rock sole	745	668	525	430	454	887	1,960	2,066	2,264	3,414	1,000	3,109
Petrale sole	367	439	417	336	416	445	790	952	1,066	793	523	597
Dover sole	914	871	1,148	963	1,167	633	1,281	2,149	2,382	2,217	1,151	2,735
Rex sole	74	49	219	205	87	83	145	140	134	59	114	93
Starry flounder	168	66	170	66	54	65	110	123	143	146	97	146
Turbot	525	323	369	764	895	1,193	375	609	2,635	2,286	769	3,559
Other flatfish	220	199	141	161	215	232	147	50	51	87	142	204
Pacific cod	4,810	4,505	3,465	2,342	3,650	13,917	11,015	9,149	6,463	11,914	5,932	10,344
Lingcod	4,162	3,755	3,688	5,668	3,827	3,591	3,462	3,980	5,219	5,385	3,735	4,356
Sablefish	3,976	4,414	3,855	4,275	4,668	4,719	5,770	5,493	5,038	5,531	4,221	5,225
Pollock	924	1,070	800	1,895	577	1,270	1,111	443	939	2,597	903	3,532
Hake	2,826	3,122	4,600	6,055	6,802	13,275	6,054	8,682	10,609	23,175	6,203	28,316
Ocean perch	5,983	5,655	6,698	6,069	5,914	6,335	6,929	6,004	5,761	4,331	5,535	4,052
Other rockfish	5,093	7,024	8,512	11,709	19,040	18,177	20,399	18,437	22,885	19,428	13,128	22,183
Misc. species	141	156	175	192	245	344	353	172	122	143	190	161
Hagfish	-	-	-	-	-	-	66	829	213	23	111	2
Dogfish	3,875	3,274	2,510	2,815	3,289	3,801	5,483	2,780	4,194	3,126	3,202	2,335
Animal food	65	94	161	309	255	188	130	127	17	tr.	135	tr.
Reduction	450	321	244	214	175	210	581	353	210	380	276	540
Total	35,877	36,537	38,509	45,160	52,182	70,120	67,040	63,579	71,611	86,204	48,062	92,825

[a] Does not include catches from joint-venture fisheries, see Table 2.

[b] Preliminary data.

Table 4. Joint-venture catches[a] (t) of groundfish from International Area 3C -- southwest coast of Vancouver Island in 1992.

Nation	Species	Quota (t)	Catch (t)
Poland	Hake	40,300	39,843
	Pollock	incidental	1,003
	Rockfish	incidental	542
	Other	incidental	1
China	Hake	6,200	6,091
	Pollock	incidental	104
	Rockfish	incidental	122
	Other	incidental	tr.
Japan	Hake	23,500	23,723
	Pollock	incidental	396
	Rockfish	incidental	444
	Other	incidental	–
Total	Hake	70,000	69,657
	Pollock	incidental	1,503
	Rockfish	incidental	1,108
	Other	incidental	1

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

PACIFIC STOCK ASSESSMENT REVIEW COMMITTEE

PSARC ADVISORY DOCUMENT 93-4
SEPTEMBER 1993

INVERTEBRATES

CONTENTS PAGE

I. STEERING COMMITTEE REPORT

The PSARC Steering Committee met on September 23, 1993, at the Pacific Biological Station, Nanaimo, to review the Invertebrate Subcommittee report. In general, the Steering Committee endorses the recommendations made by the Subcommittee. The Steering Committee wishes to emphasize the following points and recommendations:

Highlights

1. The Steering Committee compliments the Subcommittee for developing new projects on red urchins, following the Steering Committee's 1992 request. These projects will require continued resources over the next few years to ensure their completion. In general, concrete results are difficult to achieve because of limited resources (staff and funds), shifting priorities within DFO and industry and the large number of species or species groups.

2. The Steering Committee shares the concerns of the Subcommittee that changes in the operation of the intertidal clam fishery and the increased demand for clams could be deleterious to clam stocks. **The Steering Committee recommends that the Subcommittee prepare a working paper reviewing intertidal clam recruitment processes in the Strait of Georgia. The Steering Committee further recommends that minimum size limits remain in place and depuration harvests not be expanded, pending completion of the review.**

3. The Steering Committee endorses the recommendation of the Subcommittee on geoduck aquaculture. Monitoring will be necessary to evaluate the biological benefits of experimental permits issued for aquaculture. Because of the longevity and slow growth of geoducks, the evaluation will require a minimum ten-year period to complete.

4. The Steering Committee notes that specific quotas for 1994 (e.g. geoducks) were identified by the Subcommittee. **The Steering Committee recommends that future assessments submitted to the Subcommittee provide a yield range that incorporates uncertainty in the yield estimate.**

5. The Steering Committee supports the regional DFO committee formed to recommend policy on marine protected areas. **The Steering Committee recommends that reports prepared by this committee be submitted to the PSARC Invertebrates**

Subcommittee for review. In particular, the concept of marine protected areas relates to current Subcommittee recommendations on green sea urchins and intertidal clams.

6. The Steering Committee commends the Subcommittee for placing a higher priority on logbook processing. **The Steering Committee recommends that the Subcommittee continue this work and initiate analyses of logbook data.**

7. In future, the Subcommittee should report landings separately for the North and South coast areas.

Geoducks

The Steering Committee endorsed the recommendation of the Subcommittee that Marina Island be closed to geoduck fishing until stocks rebuild. The Steering Committee notes that the Subcommittee specifies 50 percent of the originally estimated biomass as a minimum cutoff for harvesting. 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. The Steering Committee further notes that managers have been directed to be conservative for this stock.

The Steering Committee endorses the 1994 coastwide quota of 2,245 t; the 7.7% reduction from the 1993 quota relates to an improvement in data quality.

The Steering Committee recommends that user fees be applied to stock assessment and that management and contribution agreements with native groups acknowledge this need.

Intertidal clams

The Steering Committee endorses the recommendations of the Subcommittee. The resources previously allocated to the redigging project could now be redirected to other higher priority work, e.g. review of clam recruitment processes. The Steering Committee notes that management is currently compromised in this fishery by the large number of participants.

The Steering Committee notes that the Savary Island clam survey recommended by the Subcommittee has now been completed. However, the results are not yet available.

Prawns

The Steering Committee endorses the Subcommittee's recommendations.

Red sea urchins

The Steering Committee repeats its 1992 recommendation that harvests be capped in the North Coast until surveys are completed and results are reviewed in a working paper presented to the Subcommittee. In the absence of further information, the quota should be maintained at 5400 t (the 1993 quota).

The Steering Committee notes the need to reconcile the survey methodology with the assessment analyses. Therefore, the Steering Committee endorses the recommendation of the Subcommittee that a working paper be prepared for the spring PSARC meeting that evaluates survey methodology.

Abalone

The Steering Committee notes that abalone abundance has not rebuilt on the Central Coast and recommends that the fishery remain closed until there is evidence of substantial stock rebuilding. The Steering Committee endorses the need identified by the Subcommittee to review survey methodology. **The Steering Committee also recommends that alternatives be examined if no natural stock rebuilding occurs within the next few years.** Aquaculture and enhancement are possibilities. Further, **the Steering Committee recommends that the Subcommittee develop guidelines for determining the stock level at which the fishery can be reopened.**

Sea cucumbers

The Steering Committee notes the problems of assessing species such as sea cucumbers for which basic biological data are lacking. However, **the Steering Committee recommends that research be directed to higher priority species (e.g. urchins) at the present time, unless outside sources of funding are available.**

II. INVERTEBRATE SUBCOMMITTEE REPORT

BIOLOGICAL ADVICE ON MANAGEMENT OF BRITISH COLUMBIA INVERTEBRATE FISHERIES FOR 1994

Introduction

The Invertebrate PSARC Subcommittee met three times in 1993: February 16-17, 1993 at Brinnon, Washington in a joint meeting with Washington State Department of Fisheries, May 6, 1993 in Vancouver and August 30 to September 2, 1993, at Nanaimo. The August/September meeting addressed advice and recommendations for management of invertebrate fisheries in 1994 and identified research needs and concerns for invertebrate fisheries. Five working papers, four science updates and 13 fishery updates were reviewed

(Appendix 1). Other business and future workplans for review in 1994 were also addressed.

This report is a summary of advice and recommendations resulting from these meetings and provides the basis for advice to the Regional Executive Committee for development of 1994 Management Plans and stock assessment research required for invertebrate fisheries.

Subcommittee Membership

Frances Dickson assumed the chair from Doug McKone effective December, 1992. Bill Heath, Ministry of Agriculture, Fisheries and Food will be joining the subcommittee as a new member at the next meeting. A list of 1993 participants is appended (Appendix 2).

Management Framework

Invertebrate fisheries are managed by a variety of regulations and management techniques depending on the biology of the animal, the fishing gear utilized, the advice received from client groups and the status of stock information on the particular species (Appendix 3).

Catch Trends

Invertebrate landings have increased rapidly since 1990 and preliminary 1992 landings show an increase of 23 percent over 1991 largely due to increases in urchin and crab landings (Table 1). The geoduck clam fishery continues to be the highest landed value species in 1992 but red sea urchin landings doubled again over 1991 landings due to increased landings in the north coast. Crab landings reached 3,300 t, the highest recorded landings on record. Prawn landings continue to increase on an annual basis.

A total of 1427 personal fishing vessel licences and 1948 personal fishing licences without vessels were issued for invertebrate fisheries in 1992. The landed value of invertebrate fisheries was about $59.7 M (including oysters, $4 M) in 1992, a 29.3 percent increase over the previous year (Table 2). Geoduck values increased phenomenally averaging $2.54/lb due to live market sales and accounted for $16.1 M in 1992; the most valuable invertebrate fishery.

Summary of Major Recommendations:

We have made some progress on echinoderm research. Research on echinoderms was identified as a priority for 1993 in order to obtain information on growth, mortality and recruitment for all commercially harvested species. Major work was initiated on red sea urchins using funds from cooperative program. Other studies are ongoing and will take some time to complete before working papers can be prepared and reviewed.

Recommendation 1. **Research on sea cucumbers and green urchins is still required and resources need to be obtained from cooperative resources or redirection of other departmental resources.**

The study on effects of repeated digging on sub-legal sized manila clams did not demonstrate any deleterious effects on survival of these clams. However, the Subcommittee noted that the harvesting techniques used were not representative of commercial harvesting practices and that it is not possible, therefore, to discount possible effects at this time.

Recommendation 2. **Further research on redigging is not recommended at this time.**

It was noted in the study that there was significant wild recruitment to the study area which was on a clam tenure and that the majority of production will be resulting from management of wild sets. Harvest of undersize clams on leases may further reduce spawning stocks which are contributing to adjacent areas. Similarly, depuration harvests are removing spawning stocks from areas which previously formed reproductive refuges.

Recommendation 3. **The Subcommittee recommends that before either a relaxation in minimum size limits for clam farmers or before depuration harvests are expanded and encouraged, a review of the recruitment process be completed on a large geographical scale, e.g. Strait of Georgia.**

Recommendation 4. **The Subcommittee recommends that experimental management techniques such as quotas and open and closed beaches could be used to investigate recruitment dynamics in the Savary Island fishery, but noted that this will be difficult with the uncontrolled effort present in the fishery. Effort limitation would be beneficial to clam stocks and fishery management.**

Recommendation 5. **The Subcommittee recommends a 1994 coastwide geoduck quota of 2,245 t, a 7.7 percent reduction from 1993. As well, the current period of three year rotational harvests should be reviewed to see if changes are warranted. Alternative harvesting strategies should also be reviewed.**

Recommendation 6. **The Subcommittee recommends that, if geoduck aquaculture and enhancement proceeds, it should do so only on an experimental basis, recognizing that it will be impossible to evaluate the biological consequences of culture activities for at least ten years after initiation of the work, due to slow growth rates.**

The 1993 abalone survey in the Central Coast is considered to be an uncalibrated index of relative abundance; there has been no apparent recovery of legal or pre-recruitment abalone abundance since the 1989 survey despite the closure implemented in December, 1990.

Recommendation 6. **The Subcommittee recommends that calibration of abalone survey methodology remains a research priority prior to reopening of the fishery.**

The Subcommittee reviewed the red sea urchin fishery update and a draft working paper. The surveys done cooperatively in 1993 with all user groups were reviewed.

Recommendation 7. **The Subcommittee recommends that a comprehensive review of methodologies and collected data be completed to evaluate survey design and identify appropriate modifications before sampling is conducted in future years.**

Due to uncertainty from sources including bed area sizes, densities, transect placement, analyses used and the natural mortality estimate, the Subcommittee could not calculate a more reliable quota for the north coast. However, the analyses do not raise significant concern that the existing quota of 5400 t threatens the resource.

Recommendation 8. **The Subcommittee, therefore, recommends this quota be maintained for 1994 and that it be apportioned geographically to encourage spreading of harvest among beds.**

Recommendation 9. **The Subcommittee recommends further analysis of abalone data and writing of several working papers.**

Papers and Recommendations by Fishery

A. GEODUCK

Two working papers and a fishery update were reviewed by the Subcommittee.

I93-03 Survey of Geoduck Population Density at Marina Island

Summary:

A survey of geoduck density was conducted around Marina Island during June-July, 1992. The purpose of the study was to determine geoduck density, an approximate original density and biomass and the level of optimal sampling of geoduck populations at Marina Island. Bed 101 (74.3 ha) on the northern half of the island was thoroughly surveyed but bed

102 (236 ha) on the southern half was only partially surveyed. The beds were surveyed by divers who counted geoduck necks showing above or at the substrate surface in $5m^2$ consecutive quadrats along strip-transects, 18-118 m long spaced about 100 m apart. Average densities were calculated and adjusted for proportion of geoducks "showing" and the original densities prior to commercial fishing were estimated. For the whole of Marina Island, it was estimated that 819.4 t (0.248 geoducks/m^2) were removed or 52% of the original biomass of 1568.2 t (0.475 geoducks/m^2); these removals have occurred since 1978 in 12 seasons of fishing.

As a result of the survey, recommendations were made on spacing of variable length transects for future surveys. In addition, due to the large removal (52% of original biomass), it was recommended that Marina Island be closed to commercial fishing for geoducks until stocks rebuild. It was also recommended that additional surveys are required for bed 102 and other beds to obtain a wide range of geoduck densities, to determine whether an overall variance - mean density relation is generally applicable for future surveys of geoduck density.

Reviewers comments:

There were two reviewers, including an external reviewer, of this paper. Both reviewers thought the objectives were clearly stated and data obtained were appropriate to deal with the objectives. The techniques, conclusions and management recommendations are well supported by data and analyses. One reviewer questioned a probable positive relationship of geoduck bed distributions with depth and the other reviewer wondered whether show factors had been estimated.

The authors agreed with most of the reviewers' comments and suggestions. They did not agree with the recommendation concerning the apparent relationship between geoduck distribution and depth. The objective was to compare high and low density of geoducks regardless of depths to get as much difference in variance and main relationships as possible, i.e. depth did not matter in this regard. There is a biomass effect of commercial fishing in the area which most likely largely occurs in shallower waters. With respect to geoduck show factors, the statistical analysis developed enables geoduck beds to be optimally sampled and is still valid. Show factors may effect densities, but errors will always be on the side of conservation.

The paper was accepted by the Subcommittee subject to revisions which included expansion of the purpose of the study to address the context of the study, verification of quota options as calculated from fishers' logbooks and discussion of mean weights used in the study and the reason for using these.

Subcommittee Recommendation

The Subcommittee recommends that Marina Island be closed to geoduck fishing until the stocks rebuild; this closure will likely be required for a minimum of 10 years with a survey required every five years.

Harvest of geoduck beds is presently restricted to 50 percent of the original estimated virgin biomass of the given bed at a one percent annual harvest yield.

I93-05 Quota options and recommendations for the 1994 geoduck clam fishery.

Summary:

The commercial fishery for geoduck clams began in British Columbia in 1976 and has landed over 53,346 t over the period 1976 to 1993. Individual Vessel Quotas (I.V.Q.'s) have been in effect since 1989. The total coast calculated quota is divided by 55 licences for an annual I.V.Q. The north coast, southern inside waters and the west coast of Vancouver Island were then divided by the I.V.Q. to determine the number of area licences. Some minor adjustments were made to have whole numbers of quotas in an area. Some minor exploratory area quotas were set in the north with designated existing areas to harvest if no new stocks were found.

To determine the 1994 quota options, the hectares of known commercial fishing areas were measured and original densities were reduced from earlier years to 0.7 geoduck/m^2 (from 1 geoduck/m^2) for southern inside waters, 1.4 geoducks/m^2 (from 2 geoducks/m^2) for the west coast of Vancouver Island and densities of 1 to 3.5 geoducks/m^2 for beds in the north coast (from 3.5 to 5 geoducks/m^2). Conservative yield options of 1% were recommended for all areas in 1994.

There is concern that the fishery is depleting the most accessible stocks of the highest quality geoducks. Some fishing areas have been lost due to contamination. Some harvest sites with minor landings have been eliminated from area calculations and other beds were reduced in their estimate of area following consultation with fishing representatives in 1993.

For the south coast, 503 beds measured 12,742 ha (256 beds inside for 7251 ha and 247 beds on the W.C.V.I. for 5491 ha). In the north, a total of 291 beds measured 3155 ha (148 beds in the Q.C.I. for 1204 ha; 37 beds in the Prince Rupert district for 617 ha and 106 beds in the Central coast district for 1334 ha). These data include areas fished up to and including 1991. The average density of geoducks in northern harvest beds is estimated to be greater than in the south.

A range of biomass estimates, harvest rates to date and reduced quotas set for the 1994 fishery are provided.

Reviewer's Comments

The reviewer was only able to undertake a cursory review of this paper because of its length and time limitation, but commended the authors on the amount of information presented in this assessment. Suggestions made include a reorganization of the paper.

The reviewer pointed out that a very general stock assessment is applied and data usually required for stock assessment are largely absent. The reliability of density estimates should be stated. The reviewer suggests that reliability of original biomass estimates of geoducks on a bed by area is very uncertain and states that presenting ranges for quotas should be given that reflect the uncertainty of the data or, in some cases, they should be treated as developing fisheries.

The number of recommendations should be reduced and prioritized.

The Subcommittee accepts this paper subject to incorporation of revisions suggested by the reviewer and the Subcommittee.

Subcommittee recommendations:

1. **It is recommended that the 1994 coastwide geoduck quota be 2,245 t, a 7.7% reduction from the 1993 quota.**

2. ***It is recommended that the current period of rotation be examined and consideration be given to increasing it to a longer period. A review of alternative harvesting strategies should be conducted to determine if other strategies are appropriate.***

3. ***It is recommended that industry and Native Groups be encouraged to cooperate in geoduck stock assessment surveys, using the methodology developed by DFO.***

4. ***The Subcommittee recommends that, if geoduck aquaculture and enhancement work proceeds, it should only proceed on an experimental basis. It is recognized that it will be impossible to evaluate the biological consequences of culture activities for at least 10 years after initiation of the work.***

B. INTERTIDAL CLAMS

Two working papers and a fishery update were reviewed by the Subcommittee.

I93-01 **Effects of repeated digging on sub-legal-sized manila clams, *Tapes philipinarum*.**

Summary

The frequency for harvesting intertidal clam beds has been discussed on previous occasions. Conclusions from most studies indicate digging clam beaches has advantages and disadvantages for clam stocks.

A two-year experiment was undertaken to determine the effect of different harvesting frequencies on survival of sub-legal sized manila clams. Marked manila clam seed was

planted at a density of $500/m^2$ in experimental plots that measured 3 x 3 m in the Baynes Sound, British Columbia area. The plots were randomly divided to give the following digging regime:- four subplots were dug four times in each of two years; four subplots were dug twice in each of two years; four subplots were dug once in each of two years; four subplots were dug four times in the second year; four subplots were dug twice in the second year; four subplots were dug once in the second year; eight subplots served as controls. At the end of the experiment the plots were carefully dug and the number of marked clams recorded.

The overall survival of marked clams for all plots was 7%. ANOVA showed there was no significant difference when the number of marked clams was compared by treatment, i.e. frequency of digging. A two-way ANOVA used to compare the effect of treatments and plots showed no significant differences between treatments but a marginally significant effect of plots. From the analysis we conclude that overall survival was low and not affected by the frequency of digging.

The lack of significant difference between treatments (digging frequencies) could be due to several factors including:- manila clams are hard shelled and are able to resist breakage, they are buried at shallow depths, and harvest is by rakes and scrapers which do not dig deeply into the substrate. Digging is probably not as damaging to sub-legal sized manila clams as it is to other deeply buried species, although repeated digging could seriously affect habitat of the substrate for settling larvae and early juveniles.

Reviewer's Comments

One reviewer stated that the experimental results presented in the paper support the conclusion that digging frequencies up to four times/year have no demonstrable deleterious effect. However, the reviewer suggests that this conclusion would be better supported if the discussion focused on the analysis of variance results.

The second reviewer expressed a number of reservations concerning the study and resulting conclusions. It was suggested that the digging methods used in the survey did not mimic commercial conditions, therefore, the results could not demonstrate commercial fishery effects. It was also suggested that an ANOVA be performed on the data and that analytical methods and results be presented in the document. The authors have addressed the reviewer's comments.

Subcommittee Recommendations

The Invertebrate Subcommittee accepted the document, but noted that the study showed a nonsignificant relationship between digging frequency and survival with the treatments used. Results of the survey could not demonstrate deleterious effects on clam production, however, this may have been because "non-commercial" digging methods were used.

Because commercial fisheries on wild stocks are now of relatively short duration, other issues related to clam harvesting are of higher priority, and further study is not recommended at this time.

In this study, the majority of production observed in beach plots was from wild settlement. The study suggests that the majority of settlement on leases may be of wild origin and that lease production results primarily from good husbandry of natural sets. Harvest of undersized clams on leases may further reduce spawning stocks which are contributing to settlement on that lease and in adjacent areas. Similarly, depuration harvests remove spawning stocks from areas which previously were reproductive refuges.

The subcommittee recommends that, before either a relaxation in min. size limits for clam farmers or depuration harvest are accepted, a review of stock and recruitment relationships, on a larger geographical scale (Str. of Georgia), be completed.

Annual clam landings and days fishing have declined significantly in the open fishery in recent years. Participation in the fishery is now substantially oversubscribed, and both management and the clam resource would benefit by a reduction in fishing effort.

I93-02 Intertidal Clam Survey at Savary Island, B.C. - 1992

The objective of this paper was to rationalize the continued closure of the commercial clam fishery at Savary Island. Surveys of intertidal clams undertaken on Savary Island up to 1992 are summarized. This area supported a large commercial clam fishery up to 1989. Concerns about declining stocks and low levels of recruitment of manila and littleneck clams resulted in a closure of the fishery at Savary Island since 1990. Surveys at two sites in 1991 showed significant increases in the density of sub-legal sized manila clams. Surveys carried out in 1992 showed continued and significant increases in the density of sub-legal manila clams at two sites, with little change in abundance at the third site. Littleneck clams showed little change in population structure or density between 1990 and 1992 at any of the sites surveyed. Results suggest that the continued increase in the density and abundance of pre-recruit manila clams is attributed to a substantial settlement of manila clam spat in 1990 possibly correlated with the commercial fishery closure and increased survival of sub-legal size classes in the absence of harvest activity and possible associated mortality. Significant recruitment of legal sized manila clams is anticipated at two sites in 1993. A reopening of the commercial fishery is recommended if 1993 survey results confirm the presence of significant legal sized manila clams at Savary Island.

Reviewer's comments

In a previous review, two reviewers commented on a lack of clearly stated objectives for this paper. The hypothesis being tested was not clearly stated. Both reviewers requested more statistical rigour in the analyses of the data. One reviewer did not feel the evidence presented was convincing enough to reopen the fishery and suggested that management goals and objectives be clearly stated in the paper.

The authors have addressed the reviewers comments in the text and with new analyses. A Kruskal-Wallis single factor ANOVA and non-parametric comparison was used to test the significance of changes in mean densities.

Subcommittee Recommendations

1. **Savary Island should be surveyed in 1993. If the strong year class of pre-recruits found in the 1992 survey have recruited to legal size, a fishery is recommended for late in 1993.**

2. **The Subcommittee recommends that when the fishery reopens a post-fishery survey be undertaken to estimate the removal rate of the fishery as soon as possible to avoid confounding the results with potential natural mortality from winter kill.**

3. **Some experimental management techniques such as quotas and open and closed beaches could be used to investigate recruitment dynamics in this fishery, but this will be difficult with the uncontrolled effort that is present in the commercial clam fishery.**

C. PRAWNS

One working paper and one fishery update was reviewed by the Subcommittee.

I93-4 1993 Review of Experimental Prawn Fishing in Howe Sound

Summary

This document reviews the findings from the experimental prawn management areas in Howe Sound. It summarizes the effects of manipulating the timing and duration of the fishery on the catch with respect to the size of animals and the age classes exploited. In addition, a review of the dioxin closures in the area provided a unique data set from which to calculate a spawner /recruit relationship for the closed area and provide a point from which to evaluate the current spawner index management system used coast-wide.

It was recommended that managers could increase the criterion for closures in various fisheries by setting a higher monthly index. Increased landings could be evident in the fishery within two years.

In addition, for commercial prawn areas which receive intensive effort that result in late spring closures, increased landings could be achieved by delaying the fishery to take advantage of spring and summer growth. The fishery should not last into November-December, when the 1+ animals recruit.

Summary of Reviewer's Comments and Subcommittee Discussions for Prawns

The recommendations were accepted by the Subcommittee. Additional details on methods and analyses and supporting details describing the derivation of the spawner index (SI) were requested. Management to the spawner index should continue.

The current spawner indices do not optimize yields. With our present assessment, fishery closures at higher index levels in areas will increase landings. Specific increases in SI are not recommended, but should be developed in discussion with industry on an area specific basis. Alternative management strategies were not discussed in the paper. Additional years of study (five or more) are required before quotas or limits on trap hauls could be reliably set. Estimates could be developed from logbooks, hail data and biological sampling.

Subcommittee Recommendations

1. **Continued biological sampling of the commercial catch is essential to any management program, since several year-classes are taken in the fishery.**

2. **Continued sampling in the closed area of Howe Sound is recommended to improve the analyses of the Spawner/Recruit relationship.**

Other recommendations for further studies were discussed following the prawn fishery update. The highest landings on record were reported in 1992, with highest CPUE. Alternative management and marketing strategies are required to maximize the value of this fishery, in which the price per pound has declined since 1989.

Analysis of biological sampling data for Area 12 is recommended to determine the benefits of early closures. An analysis of the benefits of the minimum size limit and mesh size restrictions implemented in 1988 should be carried out.

D. RED SEA URCHIN

A fishery update and four preliminary draft working papers were reviewed by the Subcommittee. The draft working papers could not be accepted as presented due to their preliminary nature, but instructions were given for additional analyses and working papers.

Subcommittee Discussion - (on Fishery Update)

Catches have continued to increase at an exponential rate to 1992 as a result of expansion in the North Coast. In 1993, the North Coast landings were capped at 5,400 t because of a concern of over-exploitation. A number of issues have been identified in this fishery which are outlined below:

Issue 1. There is still a general need for basic biological information in support of management of this species. Fishers continue to complain that the 100 mm minimum size limit is too restrictive as the 75 - 100 mm size category is the most desirable to market. Also, fishers and processors contest the 5,400 t ceiling in the North Coast, so that assessment data in support of a North Coast Quota is required. Some work has been initiated with the cooperation of native bands, industry, MAFF and DFO.

Issue 2. Under current management, the fishery has suffered from inconsistent supply, product dumping, spoilage and reduced safety attributed to short, intense openings. The Pacific Urchins Harvesters Association (PUHA) has submitted a proposal for I.Q.'s in this fishery which they claim will mitigate these problems. Some processors oppose I.Q.'s.

Issue 3. Several South Coast management areas had landings far in excess of the quota. In 1992, some areas have had quota reductions to compensate.

Issue 4. There continue to be problems with roe quality in the North Coast Fishery. Undersize urchins, which are more marketable due to a better roe quality, are being landed. As well, processors complain that product from virgin fishing areas have low roe yield and quality.

Issue 5. Another government agency, MAFF, has become involved in an advocacy role for the processors and fishers. MAFF appears to be supporting the industry request for larger quotas, despite DFO's concerns about the status of urchin stocks.

Draft Working Papers 1,2 & 3 Sea Urchin Survey of Heiltsuk, Kitasoo and Haida Gwaii Statistical Subareas

Summary

Three draft working papers were presented summarizing the three collaborative sea urchin surveys conducted in the North Coast in July and August 1993. Collaboration involved DFO, native bands (Haida, Kitasoo and Heiltsuk), Ministry of Agriculture and Fisheries (MAFF) and the Pacific Urchin Harvesters Association (PUHA). A total of 277 transects were surveyed in Areas 2, 6, 7 and 10, with the sizes of 18,704 sea urchins measured and the numbers of urchins in 6,335 square metre quadrates counted.

In the Haida Gwaii survey, large sea urchins from Area 2W were less frequent than in other statistical areas. Proportions above significant density and size thresholds were given by subarea.

Because this was the first year of extensive study in these statistical areas, the survey was to broadly characterize urchin density and size frequency rather than provided a detailed study of specific sites. A minimum of 22 m^2 was surveyed at each site, but site selection was not standardized within Subarea. Some potential bias in the data may exist.

Subcommittee Discussion

The Subcommittee commends the work done by all parties in collecting some of the most extensive data sets for invertebrate fisheries. This is a very positive step in the cooperative management of shellfish species.

The Subcommittee requests clarification of sampling methodologies in each paper. Transect selection within the statistical Subareas was not standardized or consistent. However, the survey methodology at each transect site was consistent and is based on modified methodologies previously used in DFO surveys. There was also concern that the survey did not cover the entire area identified as potential urchin habitat. In each report, the range of depths should be included in the tables.

A comprehensive PSARC review of methodologies and collected data is required to evaluate survey design and identify appropriate modifications before sampling is conducted in future years.

Recognizing that segregation by size has not been evident, bias identified in the sampling distribution would not bias the size distribution reported for each area. The Subcommittee, therefore, accepts the length frequency data presented. Whether absence of large (>140 mm) urchins in all three survey areas and the lower proportion of legal size (>100 mm) urchins in Statistical Area 2W is due to previous fishing effort or area specific growth rates cannot be determined.

Draft Working Paper 4 **Preliminary Biomass Estimates and Quota Options for North Coast Red Sea Urchins**

Summary

Based on the survey data collected in the cooperative red sea urchin surveys conducted by DFO, PUHA, the Haida, Kitasoo and Heiltsuk Native Bands and MAFF, a preliminary paper was presented.

Preliminary biomass estimates were made for the red sea urchin in northern B.C. (Statistical Areas 1-11, 102, 105, 106, 108) based on density and size frequency surveys conducted in July and August 1993. Estimated areas of commercial beds, based on known urchin harvest were calculated by the digitization of charts. Further analyses are required to verify the validity of the density estimates from the surveys.

Subcommittee Discussion

The Subcommittee and authors agreed there were several reasons the area calculations may not represent actual urchin distribution accurately. The calculations did not consider slope, clumping, congregations in narrow bands, etc. At this time, it cannot be determined whether the area estimates over- or under- estimate actual urchin habitat. Not all urchin areas have been fished, so collaborating data from commercial fishing areas may not be representative. Some areas were not digitized. Also, Estevan and bottom of Moresby were fished in 1993 and landings not included in paper.

The Subcommittee noted that estimated density is not a weighted average of the average density by Subarea. It expressed concern that Area 5 does not have density sampling and that densities from other areas may not be representative. It was noted that 30% of commercial landings come from Area 5.

In the calculations, current biomass of legal sized urchins is assumed to be virgin biomass. This assumption requires documentation. It was recommended that Table 7 be disaggregated on a site-specific basis. For areas not sampled, an average density could be used, but PSARC should state that quotas for areas not sampled are arbitrary.

Overall, the Subcommittee agreed that the data used in the analyses tabled at the meeting were the best data available. Nevertheless, the analyses contain substantial uncertainty from several sources, including:

1. The area estimates are based on only known areas, and known areas with low densities (as identified to DFO by commercial fishers). Areas they identified as speculative were not included, yet at least some of these areas support urchin populations. This source of uncertainty would make the area estimates conservative.

2. Within each polygon digitized, all area between 0 and 10 m was included. This practice probably overestimates urchin habitat, as urchins may not be present in the entire area.

3. Populations in unsurveyed areas are assumed to have average density, although selection of areas to be surveyed was opportunistic.

4. Allocation of transects within sites does not ensure the abundance data are representative of the sites.

5. The estimate of Natural Mortality is weak.

6. The analyses use a Scaling factor and a Correction factor which are weakly determined.

These uncertainties mean that the Subcommittee cannot, at present, calculate more reliable quota estimates for North Coast areas. Some of the sources of uncertainty can be addressed through further analyses of existing data. Useful analyses include making more accurate matches of areas sampled with areas digitized, calibrating survey data by depth for tides and inclusion of data from surveys to be conducted in coming months. Some important sources of uncertainty can only be addressed through additional directed research. Important projects include:- improving the definition of urchin habitat, possibly through use of aerial photography to identify suitable urchin habitat; field studies to evaluate (and modify as necessary) survey methods; and, refinement of life history parameters related to yield and survivorship.

Given the uncertainties, it is not obvious whether estimates of harvest presented are overestimated or conservative.

The Subcommittee recommends that the current quota should be maintained for 1994. The Subcommittee endorses apportioning the quota geographically, to encourage spreading harvest among beds.

Although the digitized bed areas presented at the meeting will be refined with further work, they are the best estimates of urchin habitat by area available at present.

The Subcommittee requests that the calculation of urchin habitat through digitization of coastline between 0-10 m be rewritten as a separate PSARC working paper. This paper should be prepared, reviewed, and discussed by teleconference as quickly as possible.

The Subcommittee also recommends further analysis of data presented and addition of new sampling data as surveys are completed prior to resubmission of the working paper. Areas to be reevaluated include applying average densities on a Subarea basis to determine total quota and analyses to ascertain whether densities are representative of total area surveyed.

The Subcommittee commended the present cooperative survey program for recording all other species observed. It recommends that such records continue to be made during future cooperative surveys.

E. GREEN SEA URCHINS

A Fishery Update was reviewed by the Subcommittee.

Subcommittee Discussion

The Subcommittee noted CPUE appears to be declining in this fishery and catches appear to be maintained by expansion into new fishing areas and harvest in marginal habitat surrounding previously fished areas.

The Subcommittee recommends that the pattern of decline in CPUE be investigated in more detail through an analysis of logbooks.

Because of the declines in CPUE and expansion of areas fished, the Subcommittee recommended that a cap be placed on removals, either through quotas or limitations on effort. It noted the existing program of limited vessel licenses has not been effective in limiting effort.

The Subcommittee also recommends establishment of long-term closures to protect broodstock. It stresses, however, that benefits of such areas, if any, would only be realized if the areas closed contained healthy populations in areas of good quality habitat, and if the closures were enforceable.

F. ABALONE

A preliminary draft working paper was reviewed by the Subcommittee.

Draft Working Paper 5 **Abalone Resurvey in Aristazabal Island, the Estevan Group and Banks Island, June, 1993.**

Summary

This report summarizes the fourth resurvey of Central Coast abalone areas. Previous surveys indicated a substantial decline in both legal and sub-legal sized abalone abundance, which resulted in a closure of all British Columbia user fisheries in 1990. The closure period was set for a period of a minimum of five years. The 1993 resurvey was important in evaluating whether the closure should be extended or whether the fishery could be re-opened if abalone populations had recovered. Survey procedures were the same as in previous surveys, allowing comparative interpretation of data.

Average density of legal size abalone continued to decline. An average density of 0.11 abalone/m2 observed in 1989 has decreased to 0.09 abalone/m2. While this difference is not significant, it demonstrates no apparent recovery of abalone numbers. Both 1989 and 1993 densities were significantly lower than the 1985 density of 0.33 abalone/m2. A similar pattern was observed for pre-recruit (94-101 mm length) abalone.

Subcommittee Recommendations:

1. **The Subcommittee accepts that there is no evidence of abalone stock rebuilding on the Central Coast.**

2. **Because of industry concerns with methodology, it is particularly important to**

calibrate any survey methodology to determine the relative abundance of abalone. This has not been adequately done with the survey methodology currently used, and hence it should be considered an uncalibrated index of absolute abundance. Survey methodology should continue to be a research priority.

3. **Because we expect industry to demand a review of the abalone closure, we request a review of the available stock information on the South Coast abalone.**

G. HORSE CLAM

A Fishery update was reviewed by the Subcommittee.

The Subcommittee recommends stock assessment work be undertaken on horse clams to be reported at the 1994 fall PSARC meeting. The assessment should include a description of depth, distribution, population estimates and yield modelling.

The Subcommittee also recommends continuation of the 1993 fishing plan with no expansion of the fishery until additional stock assessment data are available. All landings should be validated.

H. OCTOPUS

Fishery update was reviewed by the Subcommittee.

The Subcommittee recommends the initiation of a regulation amendment banning the use of deleterious chemicals for harvesting octopus in the intertidal zone.

I. SCALLOPS

A Fishery update was reviewed by the Subcommittee. There were no recommendations for action concerning this species group.

An interest has been expressed to undertake experimental dragging for weathervane scallops with gear recently developed in Alaska.

J. SEA CUCUMBERS

A Fishery update was reviewed.

The Subcommittee recommends that stock assessment work be carried out.

Sea cucumber management is by precautionary quota levels but the fishery continues to exceed quotas. We do not know the impact of the fishery on the stocks because we lack basic biological and stock assessment data on sea cucumbers.

K. SHRIMP

A Fishery Update was reviewed by the Subcommittee. It was noted that about 175 of 249 vessels are fishing. There has been a 17% decrease in landings in 1992 over 1991 which is reflective of market conditions, ie. lower price and lower landings primarily from the Tofino Ground. There is currently a world-wide market glut of shrimp.

ISSUE: concern about increase in catches and movement of vessels to Areas 13 to 15 from other areas.

The Invertebrate Subcommittee recommends analysis of logbook information and collection of biological samples for inshore fisheries.

L. EUPHAUSIID

A Fishery Update was presented for this fishery. The fishery continues to be managed to an annual ceiling of 500 t. for the Strait of Georgia and Mainland Inlets with an open season from November to March to minimize incidental catch of larval and incidental fish.

There is presently a market problem with U.S. buyer acceptance of B.C. product due to product spoilage in 1992. Preliminary advice from Science surveys in the area of the fishery show no declines in stock abundance; there is no biological reason to separate management of Jervis Inlet stocks from adjoining parts of Malaspina Strait.

M. GOOSENECK BARNACLES

A Fishery Update was provided for this fishery. Due to high landed value of product $11.90/kg in 1992, there is often more product harvested than the market can absorb resulting in some product wastage. There are problems with catch statistics for this fishery. There are reports of stock depletion in some areas in Area 26 where the Kyuquot Native Band has requested some short term closures. However, research to date indicates these closures may have to be as much as three to five years in duration, or as long as ten or more years as recruitment is variable.

No recommendation were made with respect to management of this fishery.

N. CRABS

Dungeness Crabs

A Fishery Update was provided and reviewed. Total Dungeness crab landings of 3276 t. are the largest on record, with the largest increase in catch of 450% over 1991 landings in the Queen Charlotte Islands. The decision to delay implementation of the 110 mm ring size in favour of implementation of soft shell closures has not been well received by the average fisher who is not favourably inclined to soft shell closures.

The Subcommittee recommends that Dungeness crab logbook information be analyzed with special regard to trap inventories.

King Crabs

Landings in 1992 were primarily from the North Coast. The size limit suggested of 178 mm (same as Alaska) met with opposition.

The Subcommittee recommends that as these stocks are at the southern limits of the range and there is no biological basis to support this size limit, the limit not be required in 1994.

VII OTHER BUSINESS

Biological Objectives Working Group

Jake Rice reported that when REMEC agreed to this Committee, Fisheries Branch had not appointed their representatives and did not appoint their salmon representative until July. Consequently, one meeting of the Working Group has been held and another is proposed for September.

Joint Meeting With Washington State Department of Fisheries

The Subcommittee noted that this meeting was useful to exchange data and information on management of fisheries and stock assessment but was not a suitable venue for a PSARC review of working papers. However, the use of reviewers from other government agencies was beneficial.

Working Papers for 1994

The Subcommittee developed a tentative list of working papers for review at 1994 meetings.

APPENDIX 1

List of Working Papers and Fisheries Updates submitted to the PSARC Invertebrates Subcommittee in 1993.

WORKING PAPERS

I93-01 Effects of repeated digging on sub-legal sized manila clams, *Tapes philipinarum*

Authors: N. Bourne, D. Heritage and D. Noakes
Reviewers: Rick Stanley, DFO
Jennifer Cahalan, State of Washington Department of Fisheries

I93-02 Intertidal clam survey at Savary Island, British Columbia

Authors: B. Adkins and J.J. Joe
Reviewers: Bill Wood, State of Washington Department of Fisheries
Jake Schewigert, DFO

I93-03 Survey of geoduck population density at Marina Island, 1992

Authors: A. Campbell, R. Harbo and S. Heizer
Reviewers: Ian Perry, DFO
Lynn Goodwin, State of Washington Department of Fisheries

I93-04 1993 Review of Experimental Prawn Fishing in Howe Sound

Author: J. Boutillier
Reviewer: J. Rice, DFO

I93-05 Quota Options and Recommendations for the 1994 Geoduck Clam Fishery

Authors: R. Harbo, G. Thomas and K. Hobbs
Reviewer: J. Fargo, DFO

Draft Working Papers

1. Sea Urchin Survey of Kitasoo Statistical Sub-areas

   Authors: G. Jamieson, K. Cripps and L. Greba

2. Sea Urchin Survey of Heiltsuk Statistical Sub-areas

   Authors: G. Jamieson, and W. Sandoval

3. Sea Urchin Survey of Haida Gwaii Statistical Sub-areas

   Authors: G. Jamieson, G. Martel and R. Jones

4. Preliminary Biomass Estimates and Quota Options for North Coast Red Sea Urchins.

   Authors: A. Campbell, G. Jamieson, D. Heritage and ...

5. Abalone Resurvey in Aristazabal Island, the Estevan Group and Banks Island, June 1993

   Author: G. Thomas

FISHERY UPDATES

1. Intertidal clams - F. Dickson and K. Hobbs
2. Geoducks - R. Harbo, G. Thomas and K. Hobbs
3. Horse Clams - R. Harbo and K. Hobbs
4. Red Sea Urchins - G. Thomas, S. Heizer and K. Hobbs
5. Green Sea Urchins - R. Harbo and K. Hobbs
6. Crabs - S. Heizer and M. Joyce
7. Euphausiids - B. Adkins
8. Sea Cucumber - G. Thomas and S. Heizer
9. Scallops - R. Harbo, K. Hobbs and N. Bourne
10. Shrimp - B. Ackerman
11. Octopus - B. Adkins
12. Goose Barnacles - B. Adkins
13. Prawn - B. Adkins

APPENDIX 2

List of Participants 1993

Fisheries Management

Frances Dickson	Chairperson
Greg Thomas	North Coast Division
George Cronkite	Fraser River Division
Marilyn Joyce	Fraser River Division
Rick Harbo	South Coast Division
Bruce Adkins	South Coast Division
Steve Heizer	South Coast Division
Kerry Hobbs	South Coast Division
Doug Brouwer	South Coast Division
Kip Slater	South Coast Division
Randy Webb	South Coast Division
Byron Koke	South Coast Division

Science

Jake Rice	PBS
Jim Boutillier	PBS
Neil Bourne	PBS
Alan Campbell	PBS
Dwight Heritage	PBS
Dave Mackas	IOS
Howard Powles	Ottawa

Bob Humphreys, Chairperson PSARC

Washington State Department of Fisheries - Staff from Brinnon Laboratory

APPENDIX 3

MANAGEMENT FRAMEWORK FOR INVERTEBRATE FISHERIES, 1993

SPECIES	LICENCES	QUOTA	SEASONS	COMMENTS
Geoduck	Limited entry. 55 licensed vessels. Licence conditions include notification, validation and catch reporting requirements. Validation costs funded by licence holders.	Two year plan set for 1992-93. 1993 quota is 5,309,500 lb. for IQs of 97,500 lb. (1/55 of coastwide quota). Quota not taken in 1993 cannot be carried to 1994.	Varies by area.	Three year rotational fishery. Quotas based on an annual yield of 1% of the virgin biomass.
Horse Clam	Limited to 55 vessels licenced to harvest geoducks.	Area 24 only: annual quota 250,000 lb.	Varies by area and only in areas open to geoduck harvesting.	Area 24 has been divided into 3 areas with a three-year rotation.
Green Sea Urchin	Limited entry. 49 licences. Notification required prior to commencement & termination of fishing trip.	None. Managed by size limit.	October 31 to February with area & seasonal openings.	Handpicking by divers only. Permanent area closures in marine protected areas.
Red Sea Urchin	Limited entry. 108 licences. Notification required prior to commencement & termination of fishing trip.	S. Coast quota: 1401.1t S. Coast quota overruns may be deducted from 1994 quotas. North coast quota: 5400t	South coast openings for 4 days per week. Three North Coast fishing periods: Jan-May, June-Aug, Oct-Dec	Rotational fishery. maximum size limit rescinded, minimum size limit remains in effect.
Gooseneck Barnacle	Not limited entry. 125 licences issued in 1992.	None.	All year.	Less than 10% of the stock is available for harvest due to harvest conditions or unsuitable size and quality.
Pink or Spiny Scallop (Drag or Trawl)	Not limited entry. A new Z licence "Z-R" in 1993. 63 licences issued in 1992 required to drag for scallops.	None. Managed by minimum size limit.	Permanent area closures.	

SPECIES	LICENCES	QUOTA	SEASONS	COMMENTS
Pink or Spiny Scallop by Dive	Not limited entry. 63 licences issued in 1992. Z-I licence is for handpicking only.	None. Managed by minimum size limit.	Permanent area closures.	
Plankton-Euphausiids	Limited entry. 19 licences.	Mainland inlets: 285t Other areas of Str. of Georgia: 215t Total annual quota: 500t.	Closed June 1 to Aug 15.	Licence limitation announced for 1993. Landings of 20,000 lb in 1988, 1989 or 1990 qualify.
Octopus by Trap	Not limited entry. 199 licences issued in 1992.	None.	Inshore: Apr to Dec subject to prawn closures. Offshore: all year. Seasonal closures for spawning.	In 1993 octopus will be a bycatch species for shrimp trawl and groundfish trawl fisheries.
Octopus by Dive	Not limited entry. 73 licences issued in 1992.	None.	All year with seasonal closures for spawning.	
Prawn/Shrimp by Trap	Limited entry. 273 licences.	Managed by time and area closures based on a minimum escapement of the spawner cohort. Minimum size limit and gear escapement regulations.	3-month seasonal closure: Jan - Mar.	Delayed openings in Howe Sound, Salmon/Sechelt Inlets, Saanich Inlet and Alberni Inlet. Trap limits in these areas. Fishing allowed only between ½ hr. before sunrise and ½ hr. after sunset.
Shrimp Trawl	Limited Entry. 249 licences.	NIL	All year, with in-season monitoring of shrimp counts. Area closures.	Bycatch: <u>Prawn</u>-not exceeding the greater of 2% or 5lb. of total weight of shrimp on board. <u>Squid</u>-not exceeding 2% of total weight of shrimp on board. <u>Octopus</u>-all incidentally caught octopus.
Squid	Not limited entry. 47 licences issued in 1992.	None.	Permanent area closures.	Select areas with a history of landings in Pacific Rim National Park will be open.
Crab	Limited Entry. 230 eligible to be issued.	Managed by size limit, not quota. Area- specific trap limits. Trap escapement regulations.	Area licencing, area closures due to softshell or allocation to aboriginal or sport fisheries.	Non-retention of females. Rot panel size for traps without hinged lids changed from 20 to 11 cm a side. Crab traps to be fitted with one escape holes at least 100 mm diameter.

SPECIES	LICENCES	QUOTA	SEASONS	COMMENTS
Clam	Not limited entry. 1814 licences issued in 1992.	Managed by size limit, not quota.	Seasonal openings & closures, staggered openings to maintain market supply. Closures for allocation to aboriginal and sport fisheries.	Area-specific licences, licence-holders to choose 1 of 7 areas. Ongoing federal-provincial consultation for changes to fishery management with all user groups.
Sea Cucumber	84 licences.	S. Coast quota 55 t. split weight (approx. 229,107 pieces). North Coast quota 183 t. split weight (approx. 762,500 pieces).	S. coast open Feb 2 & 3. If quota not taken, further openings will be called. N. coast opens Feb 2 & remains open until quota is taken.	S. coast quota (55t.) = 1/2 of 1992 quota.

Appendix 4. Landings of invertebrates in tonnes in British Columbia, 1981–1992

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992[1]
INTERTIDAL CLAMS												
Razor	30	68	31	101	90	142	142	155	117	114	117	55
Butter	120	103	77	131	252	159	69	134	92	109	42	132
Manila	317	597	1049	1677	1914	1894	3607	3908	2764	1456	982	939
Nat. Ln.	179	241	325	295	192	285	373	289	433	465	201	116
Mixed	161	155	280	410	478	371	87	27	159	339	137	107
TOTAL INTERTIDAL CLAMS	807	1164	1762	2614	2926	2851	4278	4513	3565	2483	1479	1349
GEODUCK	2704	3135	2636	3483	5370	5006	5734	4567	3985	3956	3333	2864
HORSE CLAM	51	321	21	7	6	96	355	325	115	124	110	2
SHRIMP	581	413	411	408	678	768	2644	2561	2299	1940	3265	2520
PRAWN	358	274	331	505	514	550	620	720	820	761	961	1042
CRAB	1317	895	960	1155	1165	1321	1631	1631	1522	2168	1887	3300
ABALONE	85	82	56	58	42	52	49	49	49	50	N/A	N/A
OCTOPUS		18	30	25	32	53	129	209	217	198	131	102
SEA URCHIN	116	160	986	1764	1815	2067	2223					
RED								2116	2658	3158	6945	12018
GREEN								444	609	475	607	984
SEA CUCUMBER				113	346	786	1722	1922	1144	870	490	455
SCALLOP		8	11	18	53	68	66	67	75	69	82	89
PLANKTON	19		47	103	131	166	130	247	360	530	450	266
SQUID		29	15	69	111	79	86	88	70	72	116	93
MUSSELS			tr	1	tr	2	2	3	4	1	tr	0
GOOSENECK BARNACLES					tr	2	32	49	30	37	40	32
OYSTERS		1579	2453	2897	3420	2864	3482	3702	3721	4547	4482	5000
TOTAL TONNES	6038	8078	9719	13220	16609	16731	23183	23213	21243	21439	24378	30116

[1] preliminary landings for 1992

Appendix 4 (con't). Landed value of invertebrates in thousands of dollars in British Columbia, 1981-1992

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992[1]
INTERTIDAL CLAMS												
Razor	24	55	24	123	95	127	126	137	124	130	129	82
Butter	42	36	33	55	138	75	40	63	44	53	34	81
Manila	323	611	1043	1813	2278	2762	6003	7175	6003	0.71	2574	2083
Nat. Ln.	195	263	329	311	202	327	474	359	589	-	327	190
Mixed	175	169	293	455	575	510	132	36	196	5567	238	179
TOTAL INTERTIDAL CLAMS	759	1134	1722	2757	3288	3801	6775	7771	6956	5750.7	3302	2615
GEODUCK	2434	2814	1818	2937	4605	4294	6184	9762	12967	10582	9659	16051
HORSE CLAM	42	235	12	5	6	63	309	300	144	274	119	2
SHRIMP	912	644	1073	1022	1180	1240	4609	2802	2985	2637	4430	2831
PRAWN	2019	1545	2138	3262	3379	3734	4326	5724	7083	7006	7728	8380
CRAB	3556	2345	2866	4558	4719	5661	6452	5555	5012	9311	8686	10987
ABALONE	721	696	462	530	442	734	973	1076	1170	1347	N/A	N/A
OCTOPUS		39	63	56	82	136	381	651	707	657	415	325
SEA URCHIN	34	56	358	712	763	1011	1276					
RED								1241	1631	1953	4187	8002
GREEN								584	1020	948	1795	4164
SEA CUCUMBER				22	94	236	768	961	998	1168	1029	1174
SCALLOP		17	24	56	95	212	244	285	316	317	387	415
PLANKTON	6	0	19	42	89	113	102	192	223	415	390	229
SQUID		22	21	84	184	127	132	113	94	81	148	135
MUSSELS		tr	tr	tr	0	tr	tr	tr	tr	1	tr	
GOOSENECK BARNACLES					1	4	211	479	343	413	418	382
OYSTERS		981	1554	2109	2613	2515	2548	2725	2938	3613	3465	4000
TTL VALUE ($000)	10483	10528	12130	18152	21540	23881	35290	40221	44587	46473.	46158	59692

[1] preliminary values for 1992

PACIFIC STOCK ASSESSMENT REVIEW COMMITTEE

PSARC ADVISORY DOCUMENT 93-5
SEPTEMBER 1993

HERRING

CONTENTS PAGE

I. STEERING COMMITTEE REPORT

The PSARC Steering Committee reviewed the Herring Subcommittee report on 23 September, 1993 at the Pacific Biological Station, Nanaimo. The Steering Committee supported the recommendations of the Subcommittee and wishes to highlight the following:

1) Some changes have been made to the two analytical assessment models. For the escapement model a new spawn index was developed that uses all past dive survey observations. The age-structured model has been recalibrated by using the estimated egg numbers from the escapement model as the spawn index. These changes have generally resulted in slightly lower biomass estimates over the years 1972-1993.

2) Last year's prediction that the Queen Charlotte Islands stock would continue to decline to a level close to the CUTOFF level appears to have been correct. The recommended catch of 1050 t, will only satisfy the requirement for native food fish and 93% of the 1993 spawn-on-kelp fishery allocation. This means that there is no surplus for the roe and bait fisheries.

3) Last year, concern was expressed about the status of the West Coast of Vancouver Island stock. At that time the Subcommittee recommended, in view of uncertainties in the model forecasts and concern about poor recruitment for 1993, that the quota be less than the 1992 catch. This years' assessment indicates that the 1993 run size was larger than expected. Therefore, it appears that the current stock levels would lead to the conclusion that a catch of 7,260 t could be supported in 1994. However, in light of poor prospects for the 1992 and 1993 year-classes (which will recruit to the fishery in 1995 and 1996) due to the effects of El Nino, the Steering Committee advises managers to exercise caution in assigning quotas for this stock for 1994. The Steering Committee also advises managers that although the West Coast of Vancouver Island is now treated as one stock, harvest should be distributed as widely as possible throughout the assessment region.

In addition the Steering Committee:

1) Supports the recommendations in Appendix 4 but wishes to emphasize the following:

i) Subcommittee Recommendation 2 stresses the importance of completing dive and surface spawn surveys. The Steering Committee noted the Subcommittee's concern regarding the 1993 herring spawn surveys. Deterioration of the spawn survey data base could lead to poor biological advice, or no basis for advice for the Prince Rupert District in future.

ii) For Recommendation 3, the Steering Committee urges the Subcommittee to complete by 1996, the evaluation of Strait of Georgia juvenile surveys as a tool for forecasting recruiting year-class strength.

iii) The Steering Committee endorses the inclusion of winter hydroacoustic data as auxiliary information for tuning the age-structured model in the QCI and PRD (Recommendation 5). However, statistical work on winter hydroacoustic surveys using existing data needs to be completed as quickly as possible to establish their usefulness as auxiliary information in QCI and PRD stocks.

2) Concurs with the Subcommittee that there is no basis for fishing minor stocks above a 20% harvest rate (this includes all sources of removal). DFO should also protect a minimum spawning biomass for minor herring stocks. Minor stock allocations should be tied to the user acquiring adequate biological and spawn data so minor stock biomass can be estimated more accurately. The Steering Committee also agrees with the Subcommittee that there is no guarantee that allocated quotas on minor stocks are sustainable.

3) It is believed that the bait fishery in Johnstone Strait and Strait of Georgia is largely harvesting minor stocks. In the 1992/93 fishing season, 300 tons of herring were allocated to sports bait and 62 tons for personal use bait. There is a concern that some of these minor stocks may be harvested more heavily than desired if additional allocations were to be made.

II. HERRING SUBCOMMITTEE REPORT

BIOLOGICAL ADVICE ON MANAGEMENT OF BRITISH COLUMBIA HERRING FISHERIES FOR 1994

PSARC HERRING SUBCOMMITTEE OBJECTIVES

The PSARC Herring Subcommittee met at the Inn at Westminster Quay during 7 to 9 September 1993 to reach a consensus on the status of herring stocks in 1993 and to forecast abundance and potential catch levels for 1994. 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, reviews and Subcommittee discussions of working papers (Appendix 5) are attached.

The 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 1992/1993, forecasts of abundance in 1993/94 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).

3. To discuss approaches for estimating the abundance of minor herring stocks from fragmentary data and to provide the Subcommittee's advice on harvesting levels for minor stocks.

Additionally, the Subcommittee was asked by the PSARC Steering Committee to consider the implications with respect to herring population dynamics of allowing catches to exceed the 20% guideline.

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, and juvenile abundance surveys.

5. CUTOFF (stock conservation).

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

Management Framework

The five major British Columbia herring stocks are currently managed by a fixed harvest rate policy in conjunction with a CUTOFF level. Cutoff levels have been set at 25% of the estimated unfished average biomass, as 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. If a 20% harvest rate will take the stock below CUTOFF, then the recommended quota is determined by subtracting the CUTOFF from the forecast run. If the forecast run is below CUTOFF, 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.

In view of the change in the West Coast of Vancouver Island assessment region, the CUTOFF was re-evaluated for the revised region. CUTOFF levels for the other stocks were also recalculated using a slight modification of the previous procedure. The only significant change was for the Central Coast, where a higher CUTOFF was derived from the new estimate of natural mortality (see P-9)

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. Total roe herring landings have averaged 39,200 t over the last five years.

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

		1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993[d]
QCI	PSARC[c]					2.2	0.0	2.7	7.1	4.6	3.6	3.5
	Quota	*	4.6	5.0	3.8	1.4	0.0	0.9	5.5	4.7	3.3	2.1
	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]	3.7
PRD	PSARC[c]					6.4	8.7	8.5	4.7	3.9	6.1	11.0
	Quota	*	4.0	5.0	6.4	5.4	7.5	7.3	3.5	2.6	4.2	5.4
	Catch	0.0	3.5	6.5	8.3	6.1	7.9	8.5	4.7	3.5	4.7	6.7
C.C.	PSARC[c]					4.6	4.8	9.7	8.6	7.6	7.5	14.0
	Quota	*	6.6	4.1	2.3	3.4	3.7	7.8	7.4	6.2	5.3	7.8
	Catch	5.6	7.2	5.2	3.3	3.6	4.5	9.4	8.4	8.9	7.3	10.7
GULF	PSARC[c]					10.6	9.3	9.9	11.0	14.0	11.8	18.3
	Quota	11.7	11.6	4.7	0.0	8.1	6.4	7.4	7.1	9.1	9.3	11.0
	Catch	16.4	10.2	6.2	0.2[a]	9.1	7.5	8.4	8.1	10.5	11.6	13.4
WCVI	PSARC[c]					9.7	7.9	10.5	7.2	6.8	5.8	3.4[e]
	Quota	4.5	4.5	0.0	0.0	9.4	8.1	10.3	7.2	6.7	2.9	2.7
	Catch	8.7	6.7	0.2[a]	0.2[a]	15.9	9.7	13.3	9.8	8.6	3.4	5.8
PSARC	Total[c]					33.5	30.7	41.3	38.6	36.9	34.8	50.2
Coast	Quota[f]	28.0	31.3	18.8	12.5	27.7	25.8	33.7	30.7	29.3	30.7	29.0
Total	Catch	38.8	32.6	24.4	15.6	36.7	29.9	41.7	40.0	38.5	35.4	40.3

* 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] 1993 catch data are hail estimates only.
[e] Catch recommended not to exceed that for 1992.
[f] Quota determined by Herring Working Group taking into account other mgmt concerns.

Stock Status and Forecasts for Major Assessment Regions

For northern B.C., the stock assessment regions used for the 1993 assessments are the same as those used in previous years. In the Queen Charlotte Islands, the assessment region extends from Cumshewa Inlet in the north to Louscoone Inlet in the south. The Prince Rupert District stock assessment region includes all of Statistical Areas 3 to 5. The Central Coast assessment region encompasses Area 7, Kitasu Bay in Area 6, and Kwakshua Channel in Area 8. As recommended by the Herring PSARC Sub-committee in 1991, the Strait of Georgia is considered a single stock complex which includes Deepwater Bay and Okisollo Channel in Area 13 and all of Areas 14 through 19. In 1993 the northern (Area 25) and southern (Area 23/24) West Coast of Vancouver Island assessment regions were combined into a single assessment unit (Area 23 to 25). The 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 Sub-committee 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. Evidence was presented at this year's Subcommittee meeting to show that there was no strong biological basis for maintaining a northern and southern assessment area off the West Coast of Vancouver Island (H93-3). Hence, these two areas were combined into a single assessment unit.

The assessment criteria are listed in Appendix Table 3 and the spawning stock biomass trends are plotted in Figures 1 and 2. To provide an overall estimate of stock abundance in 1993 and forecast abundance for 1994, 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 (i.e. Prince Rupert District). 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 1951-93 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 (minus the recommended catch) 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 six 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. Since then, catch levels peaked in 1990 at 7,800 t and have since been declining.

In general, the quality of the data available for the Queen Charlotte Islands in 1993 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, in some years. 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. According to diver observations, mortality of ponded herring in Section Cove was high in 1992, but light in 1993.

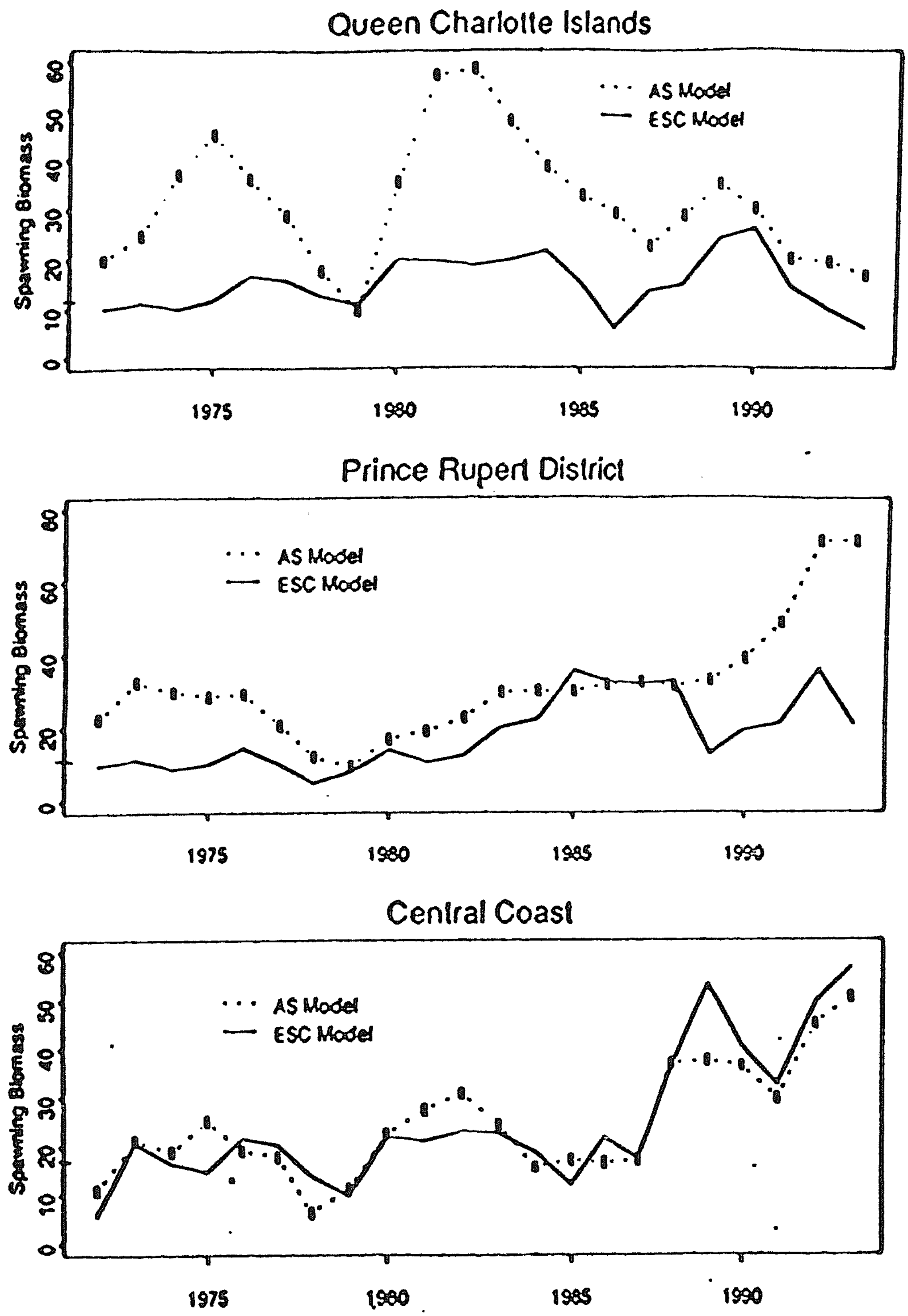

Fig. 1. Estimates of spawning stock biomass (tonnes x 1000) from age-structured and escapement model analyses for northern B.C. herring stock assessment regions, 1972-1993.

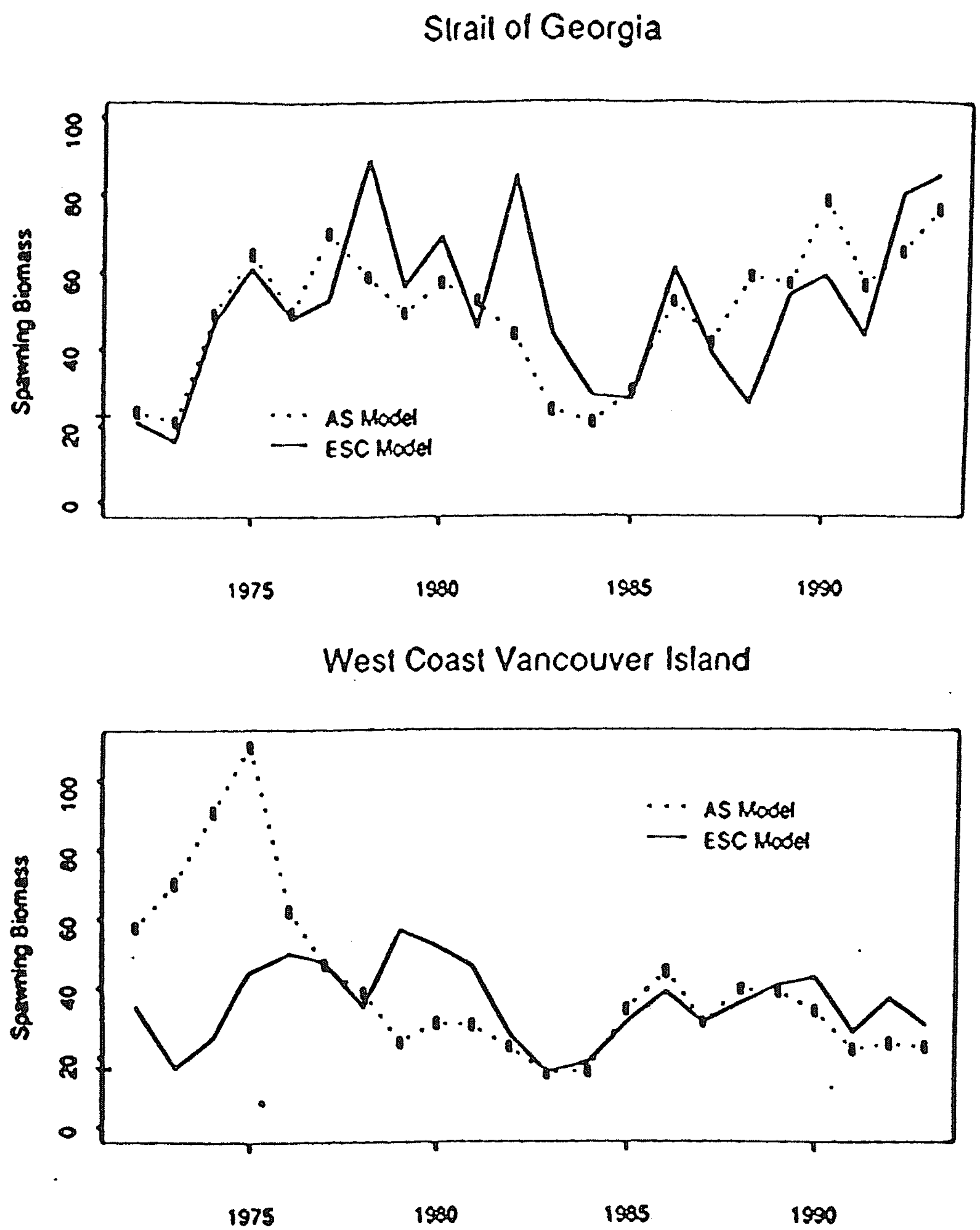

Fig. 2. Estimates of spawning stock biomass (tonnes x 1000) from age-structured and escapement model analyses for southern B.C. herring stock assessment regions, 1972-1993.

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 1992 to 1993 indicated by the Age-structured Model is less than that estimated by the Escapement Model. The spawn indices also suggest a decline in abundance for this area. Charter skippers perceptions of stock status in this area are that the stocks are declining. The winter hydroacoustic survey (H93-6) indicates a slight increase in overwintering stocks, but these stocks may represent a mixture of QCI and Prince Rupert District stocks.

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 was good. Early signs are that the 1990 year-class is below average. Since only 3 of the last 10 year-classes have been above average, the Sub-committee concluded that the stock was currently in a low productivity phase and, therefore, recommends that the poor recruitment option be selected for the 1994 forecast.

To forecast stock abundance for 1994, the Sub-committee adopted a 50:50 weighting of the forecasts from the two analytical models. Assuming poor recruitment for the 1991 year-class, the forecast pre-fishery biomass in 1994 is 12,350 t. Since the CUTOFF is 11,300 t, the recommended catch at the 20% target harvest rate is **1,050 t** (12,350-11,300 t). The Subcommittee noted last year that another year of poor recruitment to the Queen Charlotte Islands would bring the stock close to the CUTOFF level. This appears to have happened.

Prince Rupert District

During the period of the reduction fisheries, herring catches in the Prince Rupert District were generally in the range of 10,000 to 50,000 t annually. Since the beginning of the roe herring fishery, catches have not exceeded 9,000 t, and in 1983 no roe herring catch was taken from this area. For the past five years, annual roe herring harvests have been approximately 5,600 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.

Herring abundance in the Prince Rupert District decreased in 1993 as the good 1988 and 1989 year-classes passed their peak contribution to the stock. Both Age-structured Model and Escapement Model analyses indicate that current stock abundance is still high. However, the spawning stock abundance estimate from the Age-structured Model is unrealistically high (71,000 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. 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 (H93-6) indicate a decline in 1993. These estimates follow similar trends to those of the Escapement Model. Additionally, in-season sounding estimates in the Kitkatla area were down slightly in 1993. 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 evidence for a slight decrease in herring abundance in the Prince Rupert District in 1993. 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 1994, the forecast stock biomass is 34,100 t. This forecast yields a recommended catch of 6,820 t, at a 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 over the last five years have averaged 8,900 t.

Sampling intensity for age composition was similar to the levels obtained in recent years. 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 in 1994. The 1989 year-class was dominant in the seine catch during 1993, representing 64%, with the 1985 year-class representing another 10%. The 1985 and 1989 year-classes composed over 27% and 44% of the gillnet catch in 1993, respectively.

The spawn survey sampled all major spawning areas in 1993. 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 total length and spawn area indices were similar. The indices show an increasing trend since 1986 corresponding to 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 high.

Assuming average recruitment for the 1991 year-class, the forecast pre-fishery biomass in 1994 is 69,800 t. To achieve the target 20% harvest rate, the Sub-committee recommends a catch of 13,960 t in 1994. The large forecast catch 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. Over the last five years the harvests have been around 10,400 t.

The food, charity and bait landings are missing this year. With this exception, all the remaining catch was reported. Spawn survey coverage appears to be complete, with the majority of spawns surveyed by SCUBA methods; a few small spawns in Burrard Inlet and Sliammon were missed. 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 echo sounding stock estimate is down a bit from last year's record high, but agrees with the assessment model trends. Charter skippers and District staff perceptions were that the Strait of Georgia herring stocks are strong and at least as good as they were in 1992.

Both the Age-structured and Escapement Models indicate that the 1987 and 1989 year-classes in the Strait of Georgia are strong. In 1993, these two year-classes comprised 22% and 40% of the gillnet catch, respectively. Since the Strait of Georgia stock has produced four above average year-classes in the last six years, the Subcommittee concluded that the stock is in a high productivity phase and recommends the good recruitment option. This decision is also supported by the juvenile survey, which suggests a large 1991 year-class (H93-8).

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 good recruitment, the forecast pre-fishery stock biomass is 97,400 t, which yields a potential catch of 19,480 t.

West Coast Vancouver Island

During the period of the reduction fishery, catches from the West Coast of Vancouver Island reached nearly 70,000 t in the 1958/59 season. In general, catches were in the range of 10,000 to 25,000 t. During this period, annual harvests in the southern region (Area 23/24) exceeded harvests in the north (Area 25) for all but three years (51/52, 59/60, 62/63), often by large amounts. Since the roe fishery began in 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. In 1985 and 1986 the commercial fishery was closed along the entire West Coast of Vancouver Island due to serious concerns about stock abundance. The stock rebuilt and the 1987 harvest of nearly 16,000 t is the largest since 1978. However, harvests have declined since then and the decline has been quite rapid since 1989.

In 1992 the Subcommittee requested a Working Paper to review the basis for partitioning the herring on the West Coast of Vancouver Island into northern and southern stocks. The Working Paper (H93-03) reviewed tagging data, biochemical studies, morphometric studies and ecological data and noted that no evidence of genetic differences, some adult mixing and broad larval dispersion patterns suggest that the herring on the West Coast of Vancouver Island can be treated as a single stock for management purposes. The Subcommittee agreed, however, that because there are still some signs of local differentiation, such as predictable migrations, holding areas and some variation in spawning times, **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.** A new CUTOFF (18,900 t) was calculated for the combined stock assessment area.

The last strong year-class was produced in 1985; the 1989 year-class was average. The stock has declined since 1989 with the passage of the 1985 year-class through the fishery. The stock has been relatively stable for the last three years; the run size in 1993 (35,000 t) was a little better than forecast (31,000 t), which offset the catch overrun in 1993.

The Subcommittee adopted an equal weighting of the two analytical models to obtain a stock forecast for the West Coast of Vancouver Island stock. Based on an assumption of average recruitment, the forecast pre-fishery stock biomass is 36,300 t, which yields a potential catch of 7,260 t. The Subcommittee noted that this increase in the quota does not signal that the stock is rising; it appears to be stable, not increasing at this point. There is also some concern that the 1992 and 1993 El Nino conditions may cause below average recruitment in 1995 and 1996 (neither of two offshore surveys (H93-7) found any young-of-the-year herring, which would recruit in 1996). During the last four strong El Ninos, three of the year-classes produced during those events were poor (1940, 41, 58) and only one was of average strength (1983).

For each major stock, the recruitment assumption, the corresponding 1994 forecasts and the recommended catches (in tonnes) are summarized below (also see Appendix 3):

Stock Assessment	Cut Off	Recruitment Assumption	Forecast	Potential Yield
Queen Charlotte Islands	11,300	poor	12,350	1,050
Prince Rupert District	12,100	average	34,100	6,820
Central Coast	17,300	average	69,800	13,960
Strait of Georgia	22,500	good	97,400	19,480
West Coast Vancouver Island	18,900	average	36,300	7,260
TOTAL			249,950	48,570

Harvest Rate

With respect to the Steering Committee's request for an evaluation of the implications to herring population dynamics of allowing catches to exceed the 20% guideline, the Subcommittee noted that an earlier PSARC Herring Working Paper (H88-3) and primary publication has been prepared on this topic. The Subcommittee discussed this question briefly in the context of our discussion about minor stocks (below). The conclusions of the papers were that "the threat of the spawning stock decreasing below a predefined critical level is greater for high harvest rates. At harvest rates below 0.3 the probability is always less than 0.05" (Hall et al 1988. Can. J. Fish . Aquat. Sci. 45: 888-897). The Subcommittee recognizes that the 20% harvest rate is conservative, but this strategy also reduces the risk of having to close a fishery for conservation reasons.

Minor herring stocks

In view of the growing requests from AFB about minor herring stocks, the Subcommittee was requested to review our current policy on advice for minor stocks in light of current Departmental initiatives. The Steering Committee's request regarding the status of resident (minor) herring stocks in Johnstone Strait and the Strait of Georgia and the potential costs and benefits of increasing assessment effort on these stocks was considered in the general discussion of what the Sub-committee feels PSARC's policy should be for handling the growing number of requests for minor stock biomass estimates and appropriate harvest rates. After two special presentations at the Sub-committee meeting about the state of the minor stock spawn data base, discussion focused on three questions:

1) **How accurately can the biomass of minor herring stocks be estimated from the existing fragmentary spawn data?**

A precise definition of "minor" stock was not derived. For the purpose of this discussion, minor stocks are considered to encompass those outside the five major stock assessment regions. The Subcommittee concluded that existing spawn data can only provide minimum biomass estimates. Therefore, minor stock allocations should be tied to the user acquiring adequate biological and spawn data so the biomass can be estimated more accurately. The Subcommittee also noted that advice for minor stocks would likely be based on spawn data and possibly sounding information and, therefore, would be different from its advice for major stocks, which is based on age-structured information as well as spawn survey information.

2) **At what rate should the minor stocks be harvested?**

The Subcommittee concluded that there is no basis for fishing minor stocks above a 20% harvest rate (this includes all sources of removal). As we do for the major stocks, we should also protect a minimum spawning biomass. Any fishery on a minor stock should be based on the best biological information available.

3) **What are the risks associated with harvesting minor stocks?**

The Subcommittee noted that some minor stocks exhibit large fluctuations in abundance and, therefore, there is no guarantee that allocated quotas are sustainable. On the other hand, there is also no guarantee that foregoing catch by not fishing will sustain a minor stock. With respect to potential user interactions, the Subcommittee noted that some minor stocks may support local salmon sports fisheries. Some clients believe that these fisheries may be affected by fishery-induced changes in minor stock biomass. There is also a possibility that some minor stocks, which are currently being harvested by bait fisheries, may be harvested a second time.

Spawn-on-kelp mortality

Dennis Chalmers presented a report to the Subcommittee about the results obtained during the 1993 dive surveys on spawn-on kelp ponding operations. The dive teams have begun documenting mortality associated with the spawn-on-kelp operations. Last season, ponds in the Central Coast, QCI and the West Coast of Vancouver Island were monitored by divers. There was little mortality this year in Jedway and Section Cove (QCI), in contrast to last year, when high mortalities were observed in Section Cove. For the West Coast of Vancouver Island, ponds in Barkley Sound and Esperanza Inlet had little mortality; in Winter Harbour approximately 100 tonnes of dead herring were observed on the bottom of a pond in shallow (35 feet) water. This site was revisited in July. There is poor water circulation in the area where the pond was located. Large windrows of decaying herring were observed and there was no vegetation present. This site will be visited again this fall to assess conditions.

Appendix 1. 1993 PSARC Herring Subcommittee Working Papers.

No.	Title	Authors	Reviewers
H93-1	Stock assessment for British Columbia herring in 1993 and forecasts of the potential catch in 1994	J. Schweigert C. Fort	F. Funk (Alaska) C. Wood
H93-2	Herring spawn index analysis	J. Schweigert D. Hay C. Fort	B. McCarter J. C. Rice
H93-3	Herring stock structure on the west coast of Vancouver Island	D. Hay I. Perry B. McCarter	C. Haegele B. Leaman
H93-4	A comparison of the assumptions underlying the age-structured and escapement models for B.C. herring stock assessment	R. Tanasichuk D. Hay J. Schweigert D. Ware	C. Fort D. Welch
H93-5	British Columbia herring stock production analysis	D. Ware J. Schweigert R. Tanasichuk	J. Fargo S. McFarlane
H93-6	Hydroacoustic herring survey results from Hecate strait, November 30 - December 10, 1992.	B. McCarter D. Hay P. Withler R. Kieser	T. Mulligan B. Shaw
H93-7	Offshore herring distribution and recruitment forecast for the south west coast of Vancouver Island, August 1993	D. Ware R. Tanasichuk	C. Haegele B. Holtby
H93-8	Forecasting year-class strength from juvenile surveys	C. Haegele	B. Hargreaves D. Hay
H93-9	Larval herring abundance and biomass in Georgia Strait and the west coast of Vancouver Island	B. McCarter D. Hay D. Miller	I. Perry J. Schweigert
H93-10	Egg loss from herring spawns	J. Schweigert C. Haegele	R. Kronlund R. Tanasichuk
H93-FU	B.C. Herring Fishery Update 1992/93	L. Hamer	

Appendix 2. List of Participants

Name	Association
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
Jake Rice	DFO, Pacific Biological Stn, Nanaimo
Bob Armstrong	DFO, FB, South Coast Div., Nanaimo
Gordon McEachen	DFO, FB, Comox
Dennis Chalmers	DFO, FB, South Coast Div., Nanaimo
Laurie Gordon	DFO, Port Alberni
Lloyd A. Webb	DFO, FB, Vancouver
Bruce McCarter	DFO, Pacific Biological Stn, Nanaimo
Chuck Fort	DFO, Pacific Biological Stn, Nanaimo
Lorena Hamer	DFO, Pacific Biological Stn, Nanaimo
Bob Humphreys	DFO, South Coast Division, Nanaimo
Dan Ware (Chairman)	DFO, Pacific Biological Stn, Nanaimo
Sue Farlinger	DFO, Prince Rupert
Greg Thomas	DFO, FB, Prince Rupert
Howard Powles	DFO, Ottawa
Stuart Kerr	DFO, PPEB, Vancouver
Russ Jones	Haida Fisheries Program, Council of the Haida Nation
Don Hall	Nuu-chah-nulth Tribal Council, Port Alberni
Carl Haegele	DFO, Pacific Biological Stn, Nanaimo
Ed Safarik	Fisheries Council of B.C.

Appendix 3.1. Criteria used in the assessment of stock status for the Queen Charlotte Islands stock assessment region in 1993

Criteria	Status
1. Data Quality	
a) all catch reported	Yes
b) all spawn surveyed	Yes
c) consistent age composition	Yes, for most areas; 1989 year-class much stronger in Cumshewa.
2. Spawn and stock trends	
a) age-structures	Declining trend
b) escapement model	Declining trend
c) spawn indices	Declining; egg density lower than 1992
d) in-season echo-soundings	14,000-15,000 tons
e) winter echo-soundings	Increasing; however fish may be composite of North Coast and QCI spawners.
f) consistent trend info	Yes, excluding winter soundings
3. Perception of stock status	
a) charter skippers comments	Fish may have moved in at end of test fishing period; stock declining
b) district staff	Fish mainly in Skincuttle; stocks declining since 1989; poor recruitment
4. Recruitment trends	
a) age-structured model	1985 and 89 year-classes are the most recent good ones
b) escapement model	Same
5. Cutoff	11,300 t
6. Forecast weighted run size	
a) weighting	50:50
b) assuming-poor recruitment	12,350 t (Recommended)
average	14,950 t
good recruitment	21,050 t
7. Quota recommendation	1,050 t

Appendix 3.2. Criteria used in the assessment of stock status for the Prince Rupert District stock assessment region in 1993.

Criteria	Status
1. Data quality	
a) all catch reported	Yes
b) all spawn surveyed	Yes
c) consistent age composition	No, Different Dominant age-classes in Kitkatla and Port Simpson areas.
2. Spawn and stock trends	
a) age-structured model	N/A
b) escapement model	Decrease from 1992
c) spawn indices	Decline from 1992 but still above average
d) in-season echo-soundings	Big Bay-high but difficult sounding area; Kitkatla - average
e) winter echo-soundings	Down from 1992
f) consistent trend info	Yes
3. Perception of stock status	
a) charter skippers comments	Port Simpson better than 1992; Kitkatla down but better than average
b) district staff	Big Bay soundings strong with good gillnet catch rates; Kitkatla sounds good; historically poor correlation between sounding biomass estimates and those based on assessment models
4. Recruitment trends	
a) age-structured model	N/A
b) escapement model	1988 and 1989 year-classes strong
5. Cutoff	12,100 t
6. Forecast weighted run size	
a) weighting	0:100 (AS:ES)
assuming-poor recruitment	30,200 t
average recruitment	34,100 t (Recommended)
good recruitment	43,800 t
7. Quota Recommendation	6,820 t

Appendix 3.3. Criteria used in the assessment of stock status for the Central Coast stock assessment region in 1993.

Criteria	Status
1. Data quality	
a) all catch reported	Yes
b) all spawn surveyed	Yes, but over half by surface surveys
c) consistent age composition	Yes. 1989 year-class dominates.
2. Spawn and stock trends	
a) age-structured model	Biomass increasing
b) escapement model	Biomass increasing
c) spawn indices	Slight increase from 1992 high
d) in-season echo-soundings	Record high; increasing since 1985
e) winter echo-soundings	N/A
f) consistent trend info	Yes
3. Perception of stock status	
a) charter skippers comments	As good or better than 1992; fish found in Kildit
b) district staff	Stock appears strong
4. Recruitment trends	
a) age-structured model	Lower than 1992 high; 2 of the last 6 year-classes are strong
b) escapement model	Same.
5. Cutoff	17,300 t
6. Forecast weighted run size	
a) weighting	50:50 (AS:ES)
assuming-poor recruitment	66,450 t
average recruitment	69,800 t (Recommended)
good recruitment	80,150 t
7. Quota recommendation	13,960 t

Appendix 3.4. Criteria used in the assessment of stock status for the Strait of Georgia stock assessment region in 1993.

Criteria	Status
1. Data quality	
a) all catch reported	Food, charity and bait catch missing
b) all spawn surveyed	Yes. Small spawns in Burrard Inlet and at Sliammon missed
c) consistent age composition	Yes.
2. Spawn and stock trends	
a) age-structured model	High biomass
b) escapement model	High biomass
c) spawn indices	Record high since 1972.
d) in-season echo-soundings	58,000 tons maximum soundings; slight decline from 1992
e) winter echo-soundings	Difficult to estimate because of changes in fish distribution
f) consistent trend info	Yes, all evidence points to high stock level
3. Perception of stock status	
a) charter skippers comments	Stock is strong
b) district staff	At least as good as last 2 years; 28 nautical miles of spawn began the day after the fisheries
4. Recruitment trends	
a) age-structured model	4 above-average year-classes in the last 6 years
b) escapement model	Same
5. Cutoff	22,500 t
6. Forecast weighted run size	
a) weighting	50:50
assuming-poor recruitment	73,450 t
average recruitment	84,000 t
good recruitment	97,400 t (Recommended)
7. Quota recommendation	19,480 t; Good recruitment recommended based on recent recruitment Trends and juvenile surveys

Appendix 3.5. Criteria used in the assessment of stock status for the West Coast of Vancouver Island stock assessment region in 1993.

Criteria	Status
1. Data quality	
a) all catch reported	Yes
b) all spawn surveyed	No. Two spawns in Hesquiat Harbour, and spawns in Hotsprings Cove and Bajo Reef missed
c) consistent age composition	Yes.
2. Spawn and stock trends	
a) age-structured model	No change in last 3 years
b) escapement model	No distinct trend over last 3 years
c) spawn indices	Large increase in spawn length, with extensive spawn in Vernon Bay; small decline in spawn index from 1992.
d) in-season echo-soundings	19,500 tons in Barkley; Sydney Inlet fish left early to spawn in Hesquiat; 3000 tons in Esperanza; 2500-3000 tons in Nootka
e) winter echo-soundings	N/A
f) consistent trend info	Yes, except for minor deviation between biomass trends
3. Perception of stock status	
a) charter skippers comments	More fish seen than in 1992, but first wave spawners not sounded that year
b) district staff	No observed dramatic increase in soundings over previous years. Spawn intensity lower in Areas 23 and 24
4. Recruitment trends	
a) age-structured model	No good recruitment since 1988
b) escapement model	Same
5. Cutoff	18,900 t
6. Forecast weighted run size	
a) weighting	50:50
assuming-poor recruitment	29,400 t
average recruitment	36,300 t (Recommended)
good recruitment	50,150 t
7. Additional information	An estimate of 1994 recruitment from Ware & Tanasichuk (H93-7) is average. Preliminary results suggest 1992 and 1993 year-classes may be poor
8. Quota recommendation	7,260 t; Because there is no clear indication of stock increase, the Committee advises that the harvest not exceed the recommended quota. In addition, the effects of the 1992 and 1993 El Nino may cause below average recruitment in 1995 and 1996.

Appendix 4. 1993 recommendations for stock assessment and related activities.

1) **The Subcommittee felt that the divergence in model results adds to the uncertainty of the stock assessments in various regions and times. It recommends that the differences in the results of the assessment models 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. This topic was addressed in Working Paper H93-4; additional analyses are required to complete the work.

2) The quality of the 1993 spawn data shows some deterioration (a number of surface and dive survey spawn reports were incomplete). The Subcommittee is concerned that, because of re-organization, it is not clear who will conduct the 1994 herring spawn surveys. Further deterioration of the spawn data could lead to poor biological advice on stock status. **The Sub-committee wishes to emphasize to regional managers, the importance of completing the dive and surface spawn surveys in all areas, including those supporting minor stocks.**

3) **Because of our current inability to accurately forecast recruitment, preliminary results from the juvenile herring surveys in the Strait of Georgia show promise for providing forecasts of incoming recruitment to this stock. The Subcommittee recommends these surveys and associated analyses be continued.** The Subcommittee notes, however, that the ability of the surveys to forecast recruiting year-class strength cannot be evaluated fully until they have been conducted over a period of years when there has been substantial contrast in the strengths of year-classes produced by the stock.

4) **Since recruitment makes up a large proportion of the herring spawning biomass (30-49%), the Subcommittee recommends that a working paper evaluating the effect of environmental factors on West Coast Vancouver Island herring recruitment be prepared.** This work will eventually be extended to other stocks. The intent is to derive a probabilistic recruitment forecast that can be used in estimating yield.

5) **The Subcommittee recommends that the winter acoustic surveys of herring in QCI and PRD continue.** The objectives of this work are to provide fisheries-independent indices of stock abundance and annual trends. The results can be used as auxiliary information for tuning the age-structured model in these stock assessment regions.

6) **The Subcommittee recommends that the components of the revised spawn index (the egg index) should be investigated via bootstrapping to incorporate the empirical variability in the spawn data into biomass estimates and stock forecasts.**

7) **The Subcommittee was requested to provide advice on minor stocks. After much discussion (see section in report), it recommends that minor stocks not be fished above a 20% harvest rate. As for major stocks, the Subcommittee recommends that minimum stock levels be defined below which no harvesting should occur.**

8) **The Subcommittee recommends that next year's stock assessment document include all available catch, spawn and other biological information pertaining to the herring in Areas 2W and 27.** This information would assist in future management of these stocks.

9) **The Subcommittee recommends that a document be prepared that examines the criteria used for differentiating amongst herring stocks on the B. C. coast. The** objectives of the document will be to develop functional definitions and classify stocks for management purposes.

10) **The Subcommittee is concerned that there are significant discrepancies between the quantity of herring allocated and used by S-O-K operations. 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.**

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

H93-1. Stock assessment for British Columbia herring in 1993 and forecasts of the potential catch in 1994.
by J.F. Schweigert 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 forecasts stock levels for the 1994 fishing season. The methodology used to calibrate historical surface survey width and egg density estimates was changed significantly from last year's escapement model. However, the new procedure did not significantly change the estimates of stock abundance. There were no changes in the structure or parameterization of the age-structured model, but the model software was rewritten in C++ using AUTODIF to facilitate future modifications. One significant difference relative to last year's assessment is the use of the escapement model biomass estimate as the spawn index for the age-structured model, thus resolving an inconsistency which existed in past assessments. However, this change did not significantly change historical estimates of abundance by this model. The other major change in this year's assessment is the combination of the previous northern and southern assessment regions on the West Coast of Vancouver Island into a single assessment area as recommended by PSARC. As a result of this amalgamation, it was necessary to re-evaluate CUTOFF levels for the revised region. CUTOFF levels for the other stocks were also recalculated using a slight modification of the previous procedure. Stock forecasts by the two models are generally consistent except for the Prince Rupert District. Abundance levels declined in the Queen Charlotte Islands and Prince Rupert District and remained stable on the West Coast of Vancouver Island. Stocks in the Central Coast and Strait of Georgia increased during 1993 to very high levels.

Summary of reviews and Subcommittee discussions:

The reviewers felt that the document was well-written and used up-to-data methods consistent with contemporary fisheries stock assessment literature. The paper should provide graphs of residuals, or other tools, to describe the goodness-of-fit of the Age-structured model. The difference in results between the Age-structured and Escapement models for the Queen Charlotte Islands and North Coast should be addressed. Fishing and natural mortality should be modelled as discrete processes because fishing mortality occurs over a very brief period. Natural mortality should be modelled with more parameters to consider inter-annual and age effects.

The Subcommittee accepted this document and recommended that the Stock Assessment group test to see if the model fits the data better if only the roe fishery data are used as input. The Subcommittee discussed extending the timing of collection of age samples. A sensitivity analysis of this effect should be done and discussed at next year's meeting.

H93-2. Herring spawn index analysis.
by J. Schweigert, D. Hay and C. Fort.

A modification to the escapement model was developed which adjusts historical surface survey information on spawn width and intensity to comparable dive estimates of diver survey spawn width and egg density. The calibrations are based on a pooling system for spawning locations throughout the B.C. coast for which dive survey estimates of width are available. In addition, a predictive equation of egg density from egg layers was developed. Together, these data are used to provide modified estimates of spawning stock biomass for each assessment region. Another index of spawning per unit length of beach was developed to deal with requests for stock biomass estimates of smaller herring populations which occur outside the major assessment regions and for which currently no dive survey estimates exist. A variety of spawn indices were evaluated and all were highly correlated. We recommend the use of the modified egg deposition estimate developed here as the spawn index for application in the age structured stock assessment model.

Summary of reviews and Subcommittee discussions:

The new spawn index makes improvements by more finely resolving spawning locations and by combining diver and surface survey observations. However, there was no evidence that the new index was better. This working paper makes some good points, but requires more work to resolve the problem. It would be valuable to bring out conclusions more clearly. An analysis of the impact of new indices on past biomass indices should be done. The preferred index is weak because the variance in the data is not captured. Additional work should include transferral of the data and it's variability into the assessment models.

The Subcommittee concluded that this document makes a contribution and accepted it subject to revision.

H93-3. Herring stock structure on the West Coast of Vancouver Island.
by D. E. Hay, I. Perry and P. B. McCarter

This report reviews available biological information on herring stock structure on the West Coast of Vancouver Island. Reviewed subjects include studies on tagging, biochemical stock analyses, morphometric comparisons and ecological studies that include spawning areas and spawning times. Genetic studies indicate no meaningful differences among any herring examined. This conclusion applies over broad ranges for both Pacific and Atlantic herring, as well as for the West Coast of Vancouver Island. Biochemical and genetic techniques for stock separation have been available for more than 20 years and, to date, no significant differences have been found in any herring stocks. Summaries of new data on larval herring distributions also were presented. The data support the view that adjacent herring populations mix at the larval stage. The accumulated evidence supports the position that there is a biological continuum from Area 23 (Barkley Sound) to Area 25 (Nootka and Esperanza).

Appendix 5. Summary of working papers, reviewers comments and Sub-committee discussions - Con't

Summary of reviews and Subcommittee discussions:

This manuscript sheds little new light on the question of herring stock structure for the Lower West Coast of Vancouver Island. Tagging results were presented at earlier PSARC meetings. Studies found larvae offshore, but the proportion of total larvae they represent and their fate were not discussed. The time and location of spawning and biochemical and morphometric studies were discussed adequately. There was no evidence to support the hypothesis that juveniles imprint on their rearing areas. The greatest difficulty is that there has been little new work in this area. The paper appears to confuse the genetic concept of population and the management concept of stock. The paper also recommended that no more than 40% of the sounded biomass in a given area be harvested.

The Subcommittee accepted the paper with revision. It felt that the paper provides sufficient evidence that Areas 23, 24 and 25 be managed as one stock. However, the authors should remove the statement "that no more than 40% of the sounded biomass in a given area be harvested", for which there is no basis and, instead, should re-iterate the importance of spreading the catch over different fishing locations.

H93-4. A comparison of the assumptions underlying the age-structured and escapement models for B. C. herring stock assessment.
by R. Tanasichuk, D. Hay, J. Schweigert and D. Ware.

This report begins to compare the age-structured and escapement model outputs by examining the underlying assumptions for both models. Results indicate that biological sampling is somewhat biased because it concentrates on earlier spawnings and, therefore, can miss some smaller, younger fish. We found this bias to be greatest for North Coast herring, and it may explain (in part) the poor performance of the age-structured model in the North Coast. We found the fecundity assumptions made by the age-structured model to be out of date. The Escapement model currently assumes no egg loss, but should include egg loss estimates based on recent work. We acknowledge how difficult natural mortality is to estimate. However, we recommend that the discrepancy in methodolgies between assessment models in estimating natural mortality be evaluated.

Summary of reviews and Subcommittee discussions:

This paper presents some useful new findings, particularly with respect to apparently showing that current biological sampling practices may tend to lead to an over-representation of older and larger fish, thus distorting the sample statistics upon which the fishery depends. Alaskan herring biologists have come to the same conclusion. However, considerable work should be done before a number of observations and conclusions are recognized by PSARC. This includes documenting the effects of biases on key model outputs, selecting more appropriate tests for comparing age structures and time trends in age composition and providing support for some conclusions in the Working Paper. In addition, the escapement model should be evaluated as rigorously as the age-structured model was.

The Subcommittee felt that the work does not completely address the recommendations made at the 1992 PSARC meeting. More work needs to be done and the revised paper should be given at the 1994 PSARC meeting. The revision should include comparing the model-specific algorithms to see how they perform with the same model input.

**H93-5. British Columbia herring stock production analysis.
by D. M. Ware, J. Schweigert and R. Tanasichuk.**

The purpose of this paper is to summarize the estimated annual production characteristics for the major herring stocks from the 1974/75 to the 1991/92 fishing seasons. The production trends for the Prince Rupert District stock are not summarized here because the age-structured model does not produce reasonable biomass assessments for this stock. The paper uses the natural mortality rate estimated by the age-structured assessment model in the analyses, so the results are an extension of the output produced by this model. The factors which determine annual production are growth, recruitment, natural mortality and fish catch. The results are intended to summarize stock production and biomass trends in a format that may be more intuitively clear to DFO staff and clients who are interested in the status of B.C. herring stocks without being well versed in the quantitative aspects of the assessment models currently being used.

Summary of reviews and Subcommittee discussions:

This paper presents a clear, concise description of stock production trends for herring. The reviewers felt there should be some discussion about the possible causes for changes in stock productivity and why they appear to differ between north and south coast herring stocks.

The Subcommittee accepted the paper subject to the removal of the appendix tables and references to oscillations.

**H93-6. Hydroacoustic herring survey results from Hecate Strait, November 30 - December 10, 1992. W. E. Ricker Cruise 92HER.
by P. B. McCarter, D. E. Hay, P. Withler and R. Kieser.**

Pacific herring in Hecate Strait overwinter in two major areas: Browning Entrance on the mainland side of Hecate Strait and the inshore waters of Juan Perez Sound off the south-eastern Queen Charlotte Islands. We conducted an acoustic and fishing survey of these herring aggregations from November 30 - December 10, 1992 aboard the research vessel, W. E. RICKER. Total echo integration biomass estimates of midwater herring were 12,500 tonnes in the Browning Entrance area and 21,400 tonnes in the Juan Perez Sound area. Hydroacoustic estimates and model-based stock forecasts were similar in the Queen Charlotte Islands District but were significantly different in the Browning Entrance/Prince Rupert District. A compilation of 1985-1993 model-based stock forecasts and estimates are compared with acoustic survey estimates.

Appendix 5. Summary of working papers, reviewers comments and Sub-committee discussions - Con't

Summary of reviews and Subcommittee discussions:

This document sets out to develop methods for estimating herring abundance but only provides an estimate of abundance. Acoustic assessment may not be appropriate for herring if, as stated in the paper, herring are easily missed in an acoustic survey by either being too close to the surface or bottom. Confidence intervals should be calculated for the point estimates.

The Subcommittee accepts this paper. Next year's paper will include boot-strapped confidence estimates.

H93-7. Offshore herring distribution and recruitment forecast for the southwest coast of Vancouver Island, August 1993.
by D. M. Ware and R. W. Tanasichuk

A multispecies mid-water trawl survey of the La Perouse Bank region was conducted between August 4-12, 1993. Twenty-three tows were made to determine the species composition, diet and length and age compositions of the dominant pelagic fish species in the region. The distribution of herring on the offshore banks was unusual this year; we didn't encounter any large concentrations. Nine tows were made on the largest herring schools we found. Analysis of the length composition suggests that 48% (95% confidence interval = 39-57%) of the West Coast Vancouver Island stock will consist of age 2+ recruits in 1994. From age-structured model projections of the abundance of repeat spawners in 1994, we estimate that the 1991 year-class is a little below average strength (about 10,380 tonnes of recruit spawners in 1994). We caution, however, that due to the unusual oceanographic conditions and herring distribution pattern we are not as confident in the forecast this year as we have been in past surveys. There was a very poor showing of the 1993 year-class both in our survey, and in a DFO beam-trawl survey which covered the entire West Coast of Vancouver Island in July 1993.

Summary of reviews and Subcommittee discussions:

There was some concern about sampling age 2+ (recruit) herring. First, as the authors stated, fish distributions were unusual and may influence the accuracy of the forecast. It needs to be demonstrated that age 2+ herring react to oceanographic conditions as larger herring do. More herring samples should be collected to improve the database for estimating year-class strength. Finally, it is assumed that all fish are West Coast Vancouver Island fish, when it is generally accepted that Strait of Georgia fish mix with them. The authors should consider the implications of this in their forecasting. The predictive power of the influence of the selected environmental factors on year-class strength looks promising.

The Subcommittee accepted the paper with revision. The statistical analysis of limiting factors seems very promising and should be continued. It is not clear if the survey is capable of accurately measuring the percentage of a year-class when the adult stock is not dominated by a large year-class. DSSC should be asked to determine the sample size required to accurately estimate proportion-at-age. Proportion-at-age data should be transformed using the arc sine transformation before calculating the weighted mean.

H93-8. Forecasting year-class strength from juvenile surveys.
by C.W. Haegele

The nearshore surface waters of Georgia Strait were sampled with purse seines at night between May and October in 1990 to 1992. Pacific herring, the target species of the surveys, were the most abundant small fish. Herring cohorts occurred at about the same abundance from July until the following June. The 1991 year-class appeared to be about twice as abundant as either the 1990 or 1992 year-class and the recruitment of the 1991 year-class to the 1994 roe fishery should be above average. Herring were generally smaller in channels than on the open coast and frequently smaller nearshore than further from shore in the same location. The weight-at-length relationships were similar for the three years.

Summary of reviews and Subcommittee discussions:

This work has made significant progress in our understanding of the distribution and migration timing of juvenile herring. However, the interpretation and results for forecasting juvenile abundance is inadequate. This paper should be presented again in 1994 and include a comprehensive treatment of forecasting.

The Subcommittee accepted this report after revision. The forecast suggests that the 1991 year-class will be above average. The author is encouraged to pursue quantitative estimatation of year-class strength.

H93-9. Larval herring abundance and biomass in Georgia Strait and the West Coast of Vancouver Island.
by P. B. McCarter, D. E. Hay and D. C. Miller.

Larval herring in the Strait of Georgia and off the West Coast of Vancouver Island were surveyed to determine distribution patterns and relative abundance. Plankton tows were conducted each year during an eleven day period, approximately 3-6 weeks after major herring spawning activity. A total of 1457 tows were completed between 1989 and 1992. An additional 325 tows were conducted to assess the bathymetric distribution of herring larvae at different times of the day, night and tide. The surveys focused on near-shore and offshore surface waters from Victoria to Campbell River. This report briefly provides estimates of total larval abundance from these surveys and comparisons with estimates of egg and juvenile abundance. The purpose of the report is to show that the larval surveys provide a rough, but independent corroboration of the biomass estimates made by other methods.

Summary of reviews and Subcommittee discussions:

It may be a bit premature to conclude that larval surveys are not useful for predicting future recruitment or biomass trends. There were concerns about data analyses, for example, the definition of near-shore versus offshore, and between year differences in sampling times, which should be addressed.

The Subcommittee accepts this paper subject to revision.

H93-10. Egg loss from herring spawns.
by J. F. Schweigert and C. W. Haegele.

Herring spawn, birds and epibenthic invertebrates were sampled in Barkley Sound in 1988 and in Lambert Channel in 1989 and 1990 to determine egg loss and egg mortality. A generalized linear model assuming a Poisson error distribution and log-linear link between egg density and incubation day produced the best fit. The decline in observed egg density was 8% per day while the decline for egg densities estimated from visual observations of the egg layers and vegetative cover and type was 4% per day. Both birds and invertebrates were estimated to consume about 4% of the spawn. Thus, only about 12% of the estimated 69% egg loss over the 14-day incubation period is from predation. Most of the detached eggs may survive to hatching.

Summary of reviews and Subcommittee discussions:

The reviewers criticized the study design and data analysis. There was no way to estimate between-plot variability for a given quadrat along a transect. In addition, quadrats along transects were assumed to be replicates, therefore ignoring the variability due to quadrat locations along a transect.

The Subcommittee accepted this paper subject to revision which considers the referee's comments.