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Pacific Stock Assessment Review Committee (PSARC) Annual Report for 1991

J. R. Irvine, A. D. Anderson, V. Haist, B. M. Leaman,
S. M. McKinnell, R. D. Stanley, and G. Thomas (Editors)

Biological Sciences Branch
Department of Fisheries and Oceans
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Canadian Manuscript Report of

Fisheries and Aquatic Sciences 2159

March 1992

PACIFIC STOCK ASSESSMENT REVIEW COMMITTEE

(PSARC)

ANNUAL REPORT FOR 1991

by

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S. M. McKinnell, R. D. Stanley, and G. Thomas[2] (Editors)

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ABSTRACT

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

This report summarizes activities undertaken by the Pacific Stock Assessment Review Committee (PSARC) during 1991. During this year 43 reviewed Working Papers and 27 unreviewed papers and updates were presented at meetings of the five PSARC Subcommittees (Salmon, Invertebrate, Groundfish, Herring, and Data and Systems). In this annual report, an overview by the Chairperson of the PSARC Steering Committee is followed by six PSARC Advisory Documents which summarize the Working Papers, reviewers comments, subcommittee discussions, and Steering Committee comments.

RÉSUMÉ

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

Le présent rapport fait le point sur les activités du Comité d'examen de l'évaluation des stocks du Pacifique (PSARC) pour l'année 1991. Quarante-trois documents de travail révisés et 27 documents et mises à jour non révisés ont été présentés lors des réunions des cinq sous-comités du PSARC (saumon, invertébrés, poissons de fond, hareng et données et systèms). Ce rapport annuel contient un survol des activités, rédigé par le président du Comité directeur du PSARC, et six documents consultatifs résumant les documents de travail, les observations des réviseurs, les travaux des sous-comités et les observations du Comité directeur.

Section I - Chairperson's Report for 1991

Historical Overview of PSARC

This is the sixth annual report of the Pacific Stock Assessment Review Committee (PSARC). The report summarizes the seventh year of operation for this committee, which provides scientific advice for the management of Pacific fisheries resources. 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 for stock assessments was formalized within the Pacific Region. This review process began with groundfish, herring, and shellfish. In 1986, the first terms of reference for PSARC were approved. In 1986, PSARC 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, the terms of reference for PSARC were revised and these changes are expected to be finalized in 1992.

PSARC Organization

PSARC is a committee within the Department of Fisheries and Oceans, Pacific Region that assesses and reviews the status of stocks, 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 whose membership for 1991 is listed in Table 1. The PSARC Chairperson is appointed by and reports to the Resource Management Executive Committee - Pacific (RMEC), a subcommittee of the Regional Executive Committee.

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 (Herring, Salmon, Invertebrate, Groundfish, and Data and Systems) as illustrated in Figure 1.

Steps in the Generation of PSARC Annual Reports

Each subcommittee holds one or more meetings annually at which a list of stock assessment documents proposed to be presented for future meetings is discussed. Stock assessment documents (Working Papers) are prepared prior to subcommittee meetings and reviewed by at least one individual prior to the subcommittee meeting. The reviewer is normally external to the Subcommittee and may be external to the Department of Fisheries and Oceans. At the subcommittee meeting, Working Papers and unreviewed assessment documents (Fishery Updates) are presented. 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 (Fig. 2).

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. Individual subcommittees may also publish their finalized stock assessment documents.

Summary of 1991 PSARC Activities

In 1991, six major subcommittee meetings were held (Table 2) resulting in the six Advisory Documents contained in this annual report. At these meetings, 43 Working Papers and 27 unreviewed reports and updates were presented (Tables 3 and 4). The reader is referred to the Advisory Documents for summaries of: Working Papers, reviewers' comments, subcommittee discussions, and Steering Committee comments. A brief overview of some of the more important points contained in these Advisory Documents, particularly those recommendations made by the Steering Committee, follows.

The first Salmon Subcommittee meeting (21-22 May) and the 13 June Steering Committee meeting resulted in PSARC Advisory Document 91-1. In addition to the chairman's report summarizing activities of the subcommittee during 1990, three stock assessments were presented: west coast of Vancouver Island chinook, methods for assessing 1989 Strait of Georgia sport fishing regulation changes, and 1991 late South Thompson sockeye salmon. The first assessment, like others in previous years, identified serious problems with the quality of salmon escapement data, and made several suggestions to improve these data for chinook returning to the west coast of Vancouver Island. Problems with data quality were also identified in the second assessment, and were expected to reduce the ability of the Department to detect moderate changes in harvest rates as a result of regulation changes. In the third Working Paper, several methods to forecast returns of sockeye salmon to the South Thompson River were presented and recommendations to improve these methods were provided by the subcommittee.

PSARC Advisory Documents 91-2, 91-3, 91-4, and 91-5 were produced following meetings on 26-28 August, 29-30 August, 4-5

September, and 6 September of the Invertebrate (Shellfish), Groundfish, Herring, and Data and Systems Subcommittees, respectively, and subsequent discussions by the Steering Committee on 19-20 September. An important point which was common to each of the marine species Advisory Documents (i.e. 91-2, 91-3, and 91-4), was the identification of a lack of clear management objectives for many of the important fishery stocks. The RMEC recommended that PSARC coordinate a workshop to deal with this issue.

At the Invertebrate Subcommittee meeting, 10 Working Papers were presented, seven unreviewed papers, and 16 Fishery Updates (Tables 3 and 4). PSARC Advisory Document 91-2 identified additional information needs for the geoduck fishery. The Steering Committee recommended that the Invertebrate Subcommittee consider scheduling detailed assessments of major stocks on a staggered basis, similar to the Groundfish Subcommittee.

At the Groundfish Subcommittee meeting, 12 Working Papers were presented (Table 3). A variety of issues were raised and recommendations documented in PSARC Advisory Document 91-3. The Steering Committee recommended that the subcommittee evaluate potential effects of different possible levels of marine mammal predation on Georgia Strait lingcod. The Steering Committee also took note of the Groundfish Subcommittee's recommendation that details of investigations leading to changes in assessment methodology and results be included in assessment results. The Steering Committee considered that this should be a general principle for all subcommittees and that comparison of results from new and old methodologies should be presented whenever assessment methods change.

Seven Working Papers and three unreviewed papers were presented at the Herring Subcommittee meeting (Tables 3 and 4). Major issues and recommendations are documented in PSARC Advisory Document 91-4. The Steering Committee expressed a concern that the roe fishery catch exceeded the quota in almost every year and area. The Steering Committee also noted that the assumption of average recruitment adopted for the west coast Vancouver Island stocks was inconsistent with procedures used in past years.

In addition to a Chairperson's report, four Working Papers and one unreviewed paper were presented by the Data and Systems Subcommittee (Table 3) in PSARC Advisory Document 91-5. This document makes the point that there are not sufficient numbers of people within the Pacific Region who are adequately skilled in survey design and methodology and modelling, and steps should be taken to remedy the situation.

In the fall (19-21 November) meeting of the Salmon Subcommittee, six Working Papers were presented including two by the Provincial Ministry of Environment (Table 3). Further involvement with respect to steelhead by Provincial Staff is encouraged within the PSARC process. In PSARC Advisory Document the Steering Committee supported the establishment of a working group which would examine alternative assessment methods for coho salmon. A comprehensive review of the chinook rebuilding program is needed for the next meeting of the Salmon Subcommittee. The Steering Committee agreed that harvest rates and escapement targets for Nass River sockeye should not be changed at this point, but that more study and data analysis are needed.

During 1991 Mr. A. D. Anderson completed his term as Chairperson of the Salmon Subcommittee and was replaced by Mr. S. McKinnell while Mr. G. Thomas finished his term as Chairperson of the Invertebrate Subcommittee and was succeeded by Dr. D. McKone. Contributions made by the retiring Chairpersons are acknowledged with gratitude.

This document represents the efforts of the stock assessment community in the Pacific Region, especially those authors listed in Tables 3 and 4. The reviewers of the Working Papers also made a major contribution. All these people are thanked for their efforts.

The role of stock assessment within the Pacific Region is increasing. We have a continuing need to improve the quality of information for most major fishery stocks. During 1992 it is expected that the role of PSARC will expand to meet increasing expectations.

Table 1. 1991 PSARC Steering Committee Membership

Dr. J. R. Irvine, Chairperson
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Ms. V. Haist, Chairperson
PSARC Herring Subcommittee
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Mr. S. McKinnell (after September)
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Dr. B. Leaman, Chairperson,
PSARC Groundfish Subcommittee
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Mr. Greg Thomas, Chairperson
PSARC Invertebrate Subcommittee
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Mr. Rick Stanley, Chairperson
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Table 2. Major PSARC Meetings Held During 1991

1. Salmon Subcommittee (PBS, Nanaimo)............................May 21-23
2. Steering Committee (PBS, Nanaimo)...............................June 13
3. DSSC SubCommittee (555 W. Hastings)............................June 18
4. RMEC (555 W. Hastings) ....July 2
5. Invertebrate Subcommittee (Coast Bastion, Nanaimo).............Aug 26-8
6. Groundfish Subcommittee (PBS, Nanaimo)....................August 29, 30
7. Herring Subcommittee (New West.)..........................September 4, 5
8. DSSC Subcommittee (PBS, Nanaimo)............................September 6
9. Steering Committee (PBS, Nanaimo)......................September 19, 20
10. RMEC (555 W. Hastings)....................................September 26
11. Salmon Subcommittee (PBS, Nanaimo).......................November 19-21
12. DSSC Subcommittee (PBS, Nanaimo)...........................November 29
13. Steering Committee (PBS, Nanaimo)...........................December 9
14. RMEC (555 W. Hastings)................................January 7 (1992)

Table 3. Reviewed PSARC Working Papers prepared during 1991.

WORKING PAPER NUMBER	TITLE	AUTHOR(S)
	(SALMON SUBCOMMITTEE)	
S91-01	Chairman's Report for the 1990 Salmon Sub-committee	A.D.Anderson
S91-03	Evaluation Framework for Assessing 1989 Strait of Georgia Sport Fishing Regulation Changes	P.J. Starr A.W. Argue
S91-04	Stock Status Information for Chinook Salmon Along the West Coast of Vancouver Island	B.E. Riddell T. Shardlow P.J. Starr
S91-05	1991 Late South Thompson Stock Sockeye Salmon Forecast	G.A. Smith W.S. Saito
S91-06a	A method of estimating the commercial catch and escapement of steelhead trout (Oncorhynchus mykiss) at the mouth of the Skeena River.	C.R. Spence A.R. Facchin A.R. Tautz R.S. Hooton
S91-06b	Run timing and target escapements for summer-run steelhead trout (Oncorhynchus mykiss) stocks in the Skeena River system	C.R. Spence R.S. Hooton
S91-07	Stock status information for coho salmon (Oncorhynchus kisutch) in upper Johnstone Strait. (An assessment of distribution in Canadian fisheries and time trends in the natural spawning population.)	T. Shardlow
S91-09	Advice for establishing a floor escapement goal for Fraser River coho salmon (follow-up to PSARC Working Paper S89-28)	R. Kadowaki N. Schubert
S91-10	Evaluation of the 1988 and 1989 Strait of Georgia sport fishing regulation changes for the years 1989-1990	P. Starr
S91-11	Assessment of the status of Nass River sockeye salmon (Oncorhynchus nerka).	M. Henderson A. Cass C. Wood D.Rutherford R. Diewert L. Jantz

Table 3 Continued

WORKING PAPER NUMBER	TITLE	AUTHOR(S)
	(INVERTEBRATE SUBCOMMITTEE)	
I91-1	Blue Mussel (*Mytilus edulis*) mortalities in British Columbia	G. Jamieson
I91-3	On growth and mortality of geoduck clams (*Panope abrupta* (or How fast do all 'ducs go to heaven ?)	D. Noakes
I91-4	Commercial sampling of intertidal clams in Baynes Sound, June - July, 1990	R. Harbo
I91-6	Size at maturity and fecundity of the abalone, *Haliotus kamtschatkana* (Jonas), in Northern British Columbia.	A. Campbell
I91-7	Leslie Analysis of logbooks from the dive fishery for abalone, *Haliotus kamtschatkana*, in British Columbia, 1977-1990	R. Elner
I91-8	Assessment of the area 124 shrimp, *P. jordani*, trawl fishery	J. Boutillier
I91-9	Megalopal spacial distribution and stock separation in Dungeness Crab	G. Jamieson
I91-10	Crab morphometry by geographical location and the appropriateness of a 110 mm escape ring regulation in British Columbia	G. Jamieson
I91-11	Prawn Assessment using the Shrimp by Trap Logbook.	J. Boutillier C. Wallace
I91-12	Market sampling of sea cucumber in 1990	S. Heizer
	(GROUNDFISH SUBCOMMITTEE)	
G91-2	Lingcod	L. J. Richards K. L. Yamanaka
G91-3	Pacific cod	A. V. Tyler C. M. Hand
G91-4	Flatfish	J. Fargo

Table 3 Continued

WORKING PAPER NUMBER	TITLE	AUTHOR(S)
G91-5	Sablefish	M. W. Saunders G. A. McFarlane
G91-6	Pacific hake	M. W. Saunders
G91-7	Spiny Dogfish	B. L. Thomson
G91-8	Walleye pollock	M. W. Saunders
G91-9	Slope rockfish	L. J. Richards
G91-10	Shelf rockfish	R. D. Stanley
G91-11	Inshore rockfish	K. L. Yamanaka L. J. Richards
G91-12	Pacific hagfish	C. M. Neville R. J. Beamish
G91-13	Pacific halibut	B. M. Leaman
	(HERRING SUBCOMMITTEE)	
H91-1	Stock Assessment for British Columbia herring in 1991 and forecasts of the potential catch in 1992	V. Haist J. Schweigert
H91-2	Genetic and non-genetic aspects of Pacific herring stock identification in the Strait of Georgia	J.F. Schweigert
H91-3	Movement of herring in Georgia Strait as indicated from tagging studies	C.W. Haegele
H91-4	Distribution of herring larvae in the Strait of Georgia in April of 1989 and 1990 and implications for homing and stock structure	D.E. Hay P.B. McCarter
H91-5	The distribution and timing of spawning as a basis for recognition of herring stocks in B.C.	D.E. Hay
H91-6	Growth and size-at-age in B.C. herring	R.W. Tanasichuk D.M. Ware
H91-8	Delineating Strait of Georgia herring stocks using growth and reproductive characteristics	R.W. Tanasichuk

Table 3 Continued

WORKING PAPER NUMBER	**TITLE**	**AUTHOR(S)**
	(DATA AND SYSTEMS SUBCOMMITTEE)	
D91-1.	Study Plan of Shellfish Logbooks	D. Noakes S. Somjee R. Stanley
D91-2.	Progress report of FMISST study with respect to stock assessment databases	M. Birch
D91-3.	Survey methodology for intertidal and subtidal invertebrates	S. Farlinger
D91-4.	Regional Modelling Group	R. Stanley

Table 4. Unreviewed PSARC Reports and Fishery Updates prepared during 1991.

TITLE	AUTHOR(S)
(HERRING SUBCOMMITTEE)	
Offshore herring distribution and recruitment forecast for the lower west coast of Vancouver Island, August 1991	D.M. Ware R.W. Tanasichuk
Hydroacoustic herring survey results from Hecate Strait December 3-15, 1990. *W. E. Ricker* Cruise 90HER2	P.B. McCarter P. Withler D.E. Hay R. Kieser
1991 in-season tagging results and recommendations	S. Farliner B. Armstrong V. Haist
(INVERTEBRATE SUBCOMMITTEE)	
Preliminary report of a study on geoducks near Gabriola Island during 1990-91	A. Campbell
Results of a preliminary survey of geoduck beds in the north coast	S. Farlinger
Analysis of CPUE data from geoduck logbooks using the Leslie method	A. Campbell R. Elner
Results of the 1990 WCVI clam survey	S. Heizer
Preliminary report of intertidal clam surveys in 1991	N. Bourne D. Heritage G. Cadwell
The effects of repeated digging on sublegal-sized manila clams, <u>Tapes philippinarum</u>	N. Bourne D. Noakes D. Heritage
Review of DFO Pacific Region euphausiid studies	D. Mackas
(DATA AND SYSTEMS SUBCOMMITTEE)	
Sampling analysis for halibut bycatch observer program.	R. Stanley J. Fargo

Table 4 Continued

TITLE	**AUTHOR(S)**
(INVERTEBRATE SUBCOMMITTEE FISHERIES UPDATES)	
Molluscs	
Geoducks	R. Harbo G. Thomas S. Heizer
Horse Clams	R. Harbo
Intertidal Clams	F. Dickson
Razor Clams	S. Farlinger
Mussels	G. Thomas
Oysters	N. Bourne
Scallops	N. Bourne
Octopus	S. Heizer
Squid	S. Heizer
Crustaceans	
Crab	M. Joyce
Prawn	B. Adkins
Plankton	B. Adkins
Gooseneck barnacles	B. Adkins
Echinoderms	
Green sea urchins	R. Harbo
Red sea urchins	R. Harbo G. Thomas
Sea cucumbers	S. Heizer G. Thomas

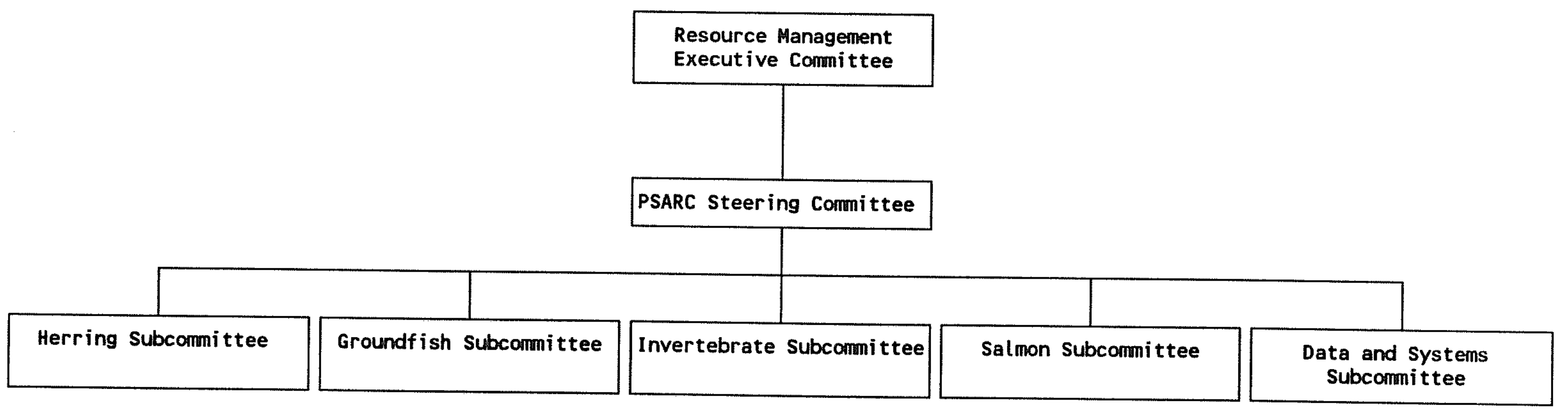

Figure 1. Relations between PSARC Resource Management Executive Committee, PSARC Steering Committee, and PSARC Subcommittees.

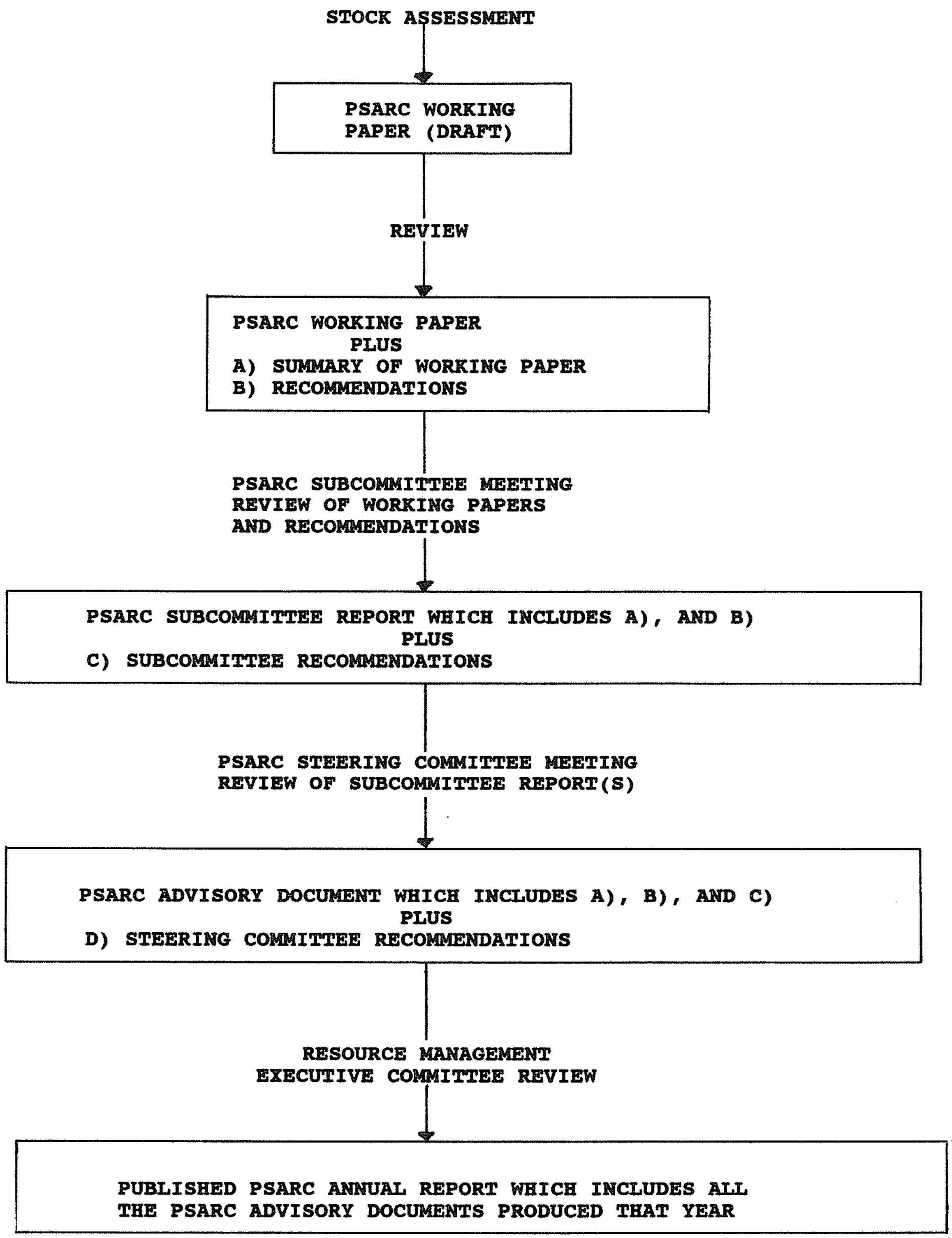

Figure 2. Steps in the generation of PSARC annual reports.

Section II- PSARC Advisory Documents

PACIFIC STOCK ASSESSMENT REVIEW COMMITTEE

PSARC ADVISORY DOCUMENT 91-1
JUNE 1991

BIOLOGICAL ADVICE ON PACIFIC SALMON

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I. STEERING COMMITTEE REPORT

At its meeting on June 13, 1991, the PSARC Steering Committee reviewed the Salmon Subcommittee Report as contained in this document. The Salmon Subcommittee considered four working papers which are summarized in this document.

The Chairman's Report for the 1990 Salmon Subcommittee contains sections on: status of recommendations from PSARC Advisory Documents 90-1 and 90-5; performance of 1990 forecasts; and proposed work plans for the Salmon Subcommittee for the remainder of 1991 and 1992.

The Stock Assessment Section contains one chapter providing stock status information for West Coast of Vancouver Island (WCVI) chinook. The Methodologies Section contains chapters dealing with: methods for assessing 1989 Strait of Georgia sport fishing regulation changes and; methods of forecasting the 1991 return of South Thompson sockeye salmon.

FISHERY IMPACTS

The 1990 returns of the eleven salmon stocks for which return abundances were forecasted in Advisory Document 90-1 were within the range of previously observed forecast deviations. A notable variation, larger than expected, occurred for the Smith Inlet sockeye forecast. Summary information on the forecasts and observed returns is presented in Table 1.1 of the Subcommittee Report.

The return of Fraser River sockeye was larger than forecasted due principally to the Chilko, Horsefly, and Late Stuart runs. The observed return listed for Barkley Sound sockeye is presented with a range. The spawning escapement was recorded as 320,000. Preliminary in-season estimates of the mortality of sockeye delayed within Alberni Inlet, as a result of warm low water flows and other environmental conditions, ranged from 100,000 to 200,000. For the purpose of forecast performance a mortality of 100,000 is listed.

STEERING COMMITTEE RECOMMENDATIONS

Each chapter of the Subcommittee Report contains advice for fisheries management and/or recommendations to improve stock assessments. Many of these recommendations should be acted upon directly by the responsible Branch and Division. Major recommendations are arrayed in two categories: Advice for Fisheries Management, and Information Needs.

A) Advice for Fisheries Management

1) Stock status information for WCVI chinook salmon was reviewed (Chapter 2 in the Subcommittee Report). The

Steering Committee supported four of five of the recommendations made by the Subcommittee with only minor wording changes. Significant changes were made to the other recommendation, the fourth in the following list. The Steering Committee recommendations are as follows:

a) Harvest controls to increase escapements to WCVI chinook populations should be continued and exploitation reduced further, where possible, to rebuild the naturally spawning populations.

b) The natural stocks in Area 26 (Artlish, Tahsish, and Kaouk) are the only remaining natural stocks which have been annually surveyed and which have, until recently, had reasonable numbers of chinook to enumerate. We strongly recommend standardized escapement surveys be designed and maintained in these systems, including increased monitoring and biological sampling, and that these stocks be preserved as minimally disturbed natural stocks.

c) Implement a program to survey chinook spawning populations on the WCVI to establish a baseline of escapement information. Index stocks for Statistical Areas 23 and 24 should be established. Annual escapement surveys should be revised so that a few high priority streams are regularly surveyed, biological samples (sex, age, size) are collected annually, and habitat impacts and survey effort are recorded.

d) Consideration should be given, once additional information is obtained, to revising the WCVI indicator stock group (Artlish, Tahsish, Kaouk, Gold, Burman, Tahsis, Marble, and Leiner) presently used by the Chinook Technical Committee. Rebuilding within the Pacific Salmon Commission (PSC) program was intended to be for naturally spawning chinook stocks. Therefore, for the enhanced populations (latter five in the above list), an attempt should be made to partition the contribution of the enhanced component from natural production.

e) Procedures should be established so that annual spawner enumeration forms (i.e., B.C. 16's) are completed more fully and consistently. The established reporting requirements should include; B.C. 16's, visitation logs and methods used to estimate the final escapement. Comments on the effects of serious environmental events should be included and reports of enhancement activities within the river must be detailed.

B) Information Needs

1) The methods used to forecast the 1991 return of sockeye salmon for the South Thompson River system (Chapter 4 of the Subcommittee Report) were reviewed. The Steering Committee supported the Subcommittee recommendations that:

a) The 1991 forecast method be re-assessed to investigate the significant bias over time in forecasts based on the sibling and spawner recruit models;

b) The reliability of the estimate for the 1988 pre-smolt abundance in Shuswap Lake be reviewed;

c) The relation between smolt size and survival over time in Shuswap lake be examined;

d) The 1958 brood year point in the spawner-recruit model be investigated in terms of the data reliability as well as the implications of removing the point from the regression.

2) The evaluation framework for assessing 1989 Strait of Georgia sport fishing regulation changes has been reviewed (Chapter 3 of the Subcommittee Report). The Steering Committee acknowledged that due to the large inherent variability in biological systems, one cannot be expected to make statistically defensible conclusions in short time periods even with good data measurements and analysis. The ability to detect moderate changes in harvest rates as a result of regulation changes will be low. If it is determined that it is not possible to statistically defend the evaluation of the regulation changes, it may be necessary to re-frame questions in terms of available data which would be more statistically defensible.

The Steering Committee accepted in principle the first three recommendations on general advice provided in the Subcommittee Report: (1) As data used for evaluation is expected to come under close review and should be defensible statistically, there is a need to improve the precision of data; (2) As measured parameters include natural variability, there is a requirement for evaluation procedures to develop dynamic (stochastic) models to account for variability; and (3) To avoid putting the resource at risk, the development of evaluation procedures should be part of the management planning process.

The Steering Committee agreed with the Subcommittee Report regarding the next two recommendations for this Working Paper:

a) The Marine Tagging and Catch at Age methods should be dropped and that the evaluation be conducted using the Exploitation Rate and Depletion methods.

b) The evaluation in a) must include a sensitivity analysis to possible ranges of assumptions and variability should be incorporated into parameter estimates where possible.

The Steering Committee also supported the following recommendations of the Subcommittee. However, implementation of these are subject to program priorities and available resources:

c) Additional exploitation rate indicator stocks, such as Cowichan chinook, should be added. A fence to collect CWT information could be installed in the autumn of 1991. This implies a long term commitment to the quantitative evaluation of the chinook returning to this river. A permanent fence for enumeration should be considered.

d) The chinook (age 2 and older) population in the Strait of Georgia be sampled to determine length frequency distributions for each age class.

e) As the current voluntary return program for CWT's by sport fishermen in the Strait of Georgia is inadequate for the purposes of this evaluation framework, a scientifically sound method for sampling of CWT's in the Strait of Georgia sport fishery should be developed.

f) The statistical methodology used for analysis of CWT data be developed and improved.

The Steering Committee acknowledged, as recommended by the Subcommittee:

g) The need to maintain a core biological sampling program for chinook in the commercial troll and sport fishery.

h) The need to perform an evaluation of additional enhancement put in place to buffer the natural LGS chinook stocks. Additional enhancement is a major component, along with the regulatory measures, to rebuild these stocks.

OUTSTANDING TASK FROM ADVISORY DOCUMENT 90-1

The Subcommittee reported on the review and evaluation of the computer model simulation for the WCVI troll fishery. The Subcommittee identified the need for further work and recommended this be accomplished by the establishment of a Regional Modelling Group.

The Steering Committee and the RMEC supported the recommendations in principle, subject to the Biological Sciences Branch's assessment for the provision of staff to the modelling group.

This recommendation was not acted upon in 1990. The staff who will establish the modelling group have yet to be assigned. The Steering Committee again identified the need to complete this task. There is a pressing need to bring together and develop modelling expertise.

PROPOSED WORKING PAPERS FOR 1991/92

The Salmon Subcommittee proposed a number of Working Papers and a schedule to the end of 1992. The Steering Committee made one change requiring the completion of the Nass River Sockeye paper for the autumn 1991 meeting. This change is reflected in the following table.

PSARC SALMON SUBCOMMITTEE PROPOSED WORKING PAPERS AND SCHEDULE FOR 1991 and 1992.

	TITLE	AUTHOR(S)
	AUTUMN OF 1991 MEETING	
1.	Skeena River Steelhead, Stock Status	R. Hooton (MOE F&W)
2.	Johnstone Strait Coho, Stock Status	T. Shardlow R. Kadowaki
3.	Smith Inlet Sockeye, Stock Status Update and Revision of Escapement Goal	R. Goruk K. Hyatt
4.	Fraser River Coho, Development of a "Floor" Escapement Approach	R. Kadowaki N. Schubert
5.	Lower Georgia Strait Chinook, Evaluation of Sport Fishing Regulation Changes	P. Starr (Working Group)
6.	Nass River Sockeye, Stock Status	M. Henderson L. Jantz
	SPRING 1992 MEETING	
7.	Fraser River Sockeye, Stock Identification	A. Cass C. Wood PSC Staff
8.	Prediction Methods for Forecasting Chinook Returns	P. Starr
9.	Fraser River Chum, Stock Status	M. Joyce
10.	Skeena River Coho, Stock Status and Management Recommendations	R. Kadowaki, et al
11.	Information Requirements for Major stocks	To be assigned (Workshop)
12.	Kitimat River Chinook, Stock Status	D. Peacock B. Snyder
13.	Troll Fishery Model Development	To be assigned (Modelling Group)
	AUTUMN 1992 MEETING	
14.	Fraser River-Strait of Georgia Coho, Update of Stock Status (1989-1991)	To be assigned (Working Group)

II. SUBCOMMITTEE REPORT

INTRODUCTION

The Salmon Sub-committee met at the Pacific Biological Station, Nanaimo, B.C. on May 21 and 22, 1991. The Sub-committee considered 4 working papers, including a Chairman's report, on stock assessments, methodologies and forecasts. A list of participants, and a list of working papers are appended (Appendix 1, 2). The objectives of this meeting were:

1. to review the assessments, methods, and advice provided in each working paper;

2. to develop consensus on stock status and advice, and

3. to identify program and/or information needs.

This report provides a synopsis of the working papers, reviewers' comments, and the Sub-committee's advice and recommendations.

1. CHAIRMAN'S REPORT FOR THE 1990 SALMON SUBCOMMITTEE (Working Paper S91-1)

1.1 INTRODUCTION

This report provides a summary of the Salmon Sub-committee activities during 1990. In this regard, information is provided on the Sub-committee's two reports of 1990 (PSARC report 90-1 and 90-5) and the actions taken on major recommendations. These reports, prepared for the Pacific Stock Assessment Review Committee (PSARC), were presented to the Steering Committee and then to the Regional Management Executive Committee (RMEC). These reports summarized recommendations of the Sub-committee as PSARC Advisory Documents 90-1 and 90-5. This report also; comments on the accuracy of the 1990 abundance forecasts for eleven major salmon stocks, comments on the publication of assessments presented in 1990, identifies topics needing continued work, provides an outline for future activities, and concludes with information on the status of the Sub-committee's membership.

1.2 SUB-COMMITTEE ACTIVITIES, 1990

In 1990, the Salmon Sub-committee submitted two reports summarizing 26 working papers. These papers have been prepared by staff from the; Biological Science Branch, Fisheries Branch, Resource Enhancement Branch and Program Planning and Economics Branch. In the spring of 1990, the Sub-committee's report (PSARC REPORT 90-1) addressed: stock assessments of the Kitimat Arm

Chinook in preparation for the Canada/USA Salmon Treaty discussions, stock status of Stikine River Sockeye and an updated assessment and conservation concerns for Harrison River Chinook; the approach used to estimate the numbers of enhanced fish in the naturally spawning escapement, the forecast methods and accuracy of forecasting the abundance of salmon returns; four special issues for Fraser River Sockeye regarding the experimental rebuilding of selected stocks, interim escapement goals, optimal harvest rates, capabilities for stock identification and the potential for assessing the effects of lake fertilization in Chilko Lake. As well, the Sub-committee reported on its review and evaluation of troll fishery management models and identified concerns and the need to collect accurate escapement data. In the autumn of 1990, the second report (PSARC REPORT 90-5) addressed an approach for improving salmon spawning enumeration. Each of these reports presented recommendations concerning the status of Pacific Region's salmon stocks, data needs, fisheries management actions, and research programs.

The Sub-committee and the Steering Committee have identified a concern about how to monitor progress on the implementation of recommendations. To assist, the following information on the status of recommendations is provided.

1.3 MAJOR RECOMMENDATIONS IN PSARC ADVISORY DOCUMENT 90-1. (Recommendations are referenced by the numbering system on pages V to VIII of Document 90-1).

A) Advice for Fisheries Management

1. Stock status information regarding the Stikine River Sockeye was presented and five recommendations made.

   The Steering Committee and RMEC endorsed the recommendations. The Fraser River Northern B.C. and Yukon Division has the assignment of responsibility for implementing the recommendations.

   This completes the Sub-committee's task.

2. An updated assessment and conservation concerns for Harrison River Chinook were presented and three recommendations made.

   The RMEC endorsed the recommendations as restated by the Steering Committee.

   The Biological Science and Resource Enhancement branches are to continue the disease monitoring programs. The Fraser River Division is to initiate a process to develop an implementation plan, the establishment of a target date for increasing escapements and monitoring the resulting recruitment.

This completes the Sub-committee's task.

3. While the Steering Committee recognized the need for documentation and development of forecasting methods, it only recommended the continuation to document methods for Fraser River sockeye returns and on a single stock basis.

   Methodologies for forecasting the 1991 return of the Late South Thompson sockeye will be presented to the Sub-committee at its spring meeting as Working Paper S91-05.

4. The Sub-committee made four recommendations regarding approaches to achieve increased production from Fraser River sockeye runs. These recommendations were reformed by the Steering Committee.

   The Steering Committee and RMEC accepted the biological advice regarding the opportunity to test cyclic dominance and increased production. However, considering the implications of implementation, the managers requested an information session with the Sub-committee for the purposes of a complete understanding. This information session concluded; the exploitation rate reduction to implement the adaptive management plan would not be considered for 1991, to maximize fry production on the 1991 cycle from the Horsefly channel, and that consideration will be given to implementing the plan on the late timing segment of the 1992 run with a comprehensive consultation approach.

   The Sockeye Task Force has the assignment of responsibility regarding these concluded recommendations as well as the formal analysis of potential costs and benefits for the interactive stocks under the rebuilding scenarios of the plan.

   This completes the Sub-committee's task.

B) Information Needs

1. The Sub-committee recommended that the working paper for the Assessment of Kitimat Arm Chinook Stocks be resubmitted with particular attention on some components.

   The Steering Committee endorsed the recommendation and the RMEC requested that particular focus be given to the exploration of active management in the terminal area (Sub-committee's recommendation #2).

   The North Coast Division plans to present this working paper to the Sub-committee at its Spring 1992 meeting.

2. A method for evaluating the reliability of escapement counts for WCVI Spawning chinook was recommended.

   The Steering Committee and the RMEC supported the recommendation and the need for further work.

   Stock Status information will be presented to the Sub-committee at its spring meeting as Working Paper S91-04.

3. The Sub-committee identified concerns regarding the quality of spawning escapement data.

   The Steering Committee and the RMEC acknowledged the concerns and supported the recommendations for the formation of an Assessment Priorities Working Group and the review and revision of material with the intent of upgrading escapement enumeration techniques. The use of inspection logs as mandatory for all personnel was not supported.

   The Sub-committee developed this topic further and reported in PSARC REPORT 90-5.

4. The Sub-committee reported on the review and evaluation of the computer model simulation for the WCVI troll fishery. The Sub-committee identified the need for further work and recommended this be accomplished by the establishment of a Regional Modelling Group.

   The Steering Committee and the RMEC supported the recommendations in principle, subject to the Biological Science Branch's assessment for the provision of staff to the modelling group.

   It is unclear as to who has the responsibility to establish the modelling group and the status of the assessment for staff to be assigned.

C) Research Needs

1. The Sub-committee continued the evaluation for accuracy and precision in identifying Fraser River sockeye stocks by scale pattern analysis alone. The Sub-committee recommended a formal working group, consisting of appropriate PSC and DFO staff, be established to develop a consolidated approach. This approach would incorporate additional/other stock identification characteristics and considerations.

   The Steering Committee and the RMEC supported the recommendation, including the need to present a working paper to the Sub-committee in the spring of 1991.

The working group was not established and a working paper will not be presented at this spring's meeting.

The Sub-committee will need to develop plans to address this task.

1.4 MAJOR RECOMMENDATION IN PSARC ADVISORY DOCUMENT 90-5. (Recommendation is referenced by the numbering system on page 1 of Document 90-5).

A) Information Needs

1. The Sub-committee addressed the recommendations from PSARC Advisory Document 90-1 concerning the need to improve the quality and consistency of salmon escapement data and made two recommendations.

   The Steering Committee supported the need and proposed program and recommended an enhanced version of the options presented. The RMEC endorsed this.

   The Sub-committee now needs to develop plans accordingly.

1.5 OUTSTANDING RECOMMENDATION FROM PSARC ADVISORY DOCUMENT 89-5 (Recommendation is referred to by the numbering system on page 1 of Document 89-5)

A) Advice for Fisheries Management

1. The Steering Committee endorsed the recommendation of the Sub-committee to replace the present escapement goal for Fraser River coho and further supported pursuing the concept of a "floor" escapement for adaptive management.

   A working paper is scheduled for presentation to the Sub-committee at the Autumn 1991 meeting.

1.6 STOCK ABUNDANCE FORECASTS

The 1990 returns of the eleven salmon stocks for which return abundances were forecasted in Advisory Document 90-1 were within the range of previously observed forecast deviations. A notable variation, larger than expected, occurred for the Smith Inlet sockeye forecast. Summary information on the forecasts and observed returns are presented in Table 1.1 (deviations are calculated as; forecasted return, minus the observed return, divided by the observed return).

The return of Fraser River sockeye was larger than forecasted due principally to the Chilko, Horsefly and Late Stuart runs. The observed return listed for Barkley Sound sockeye is presented with a range. The spawning escapement was recorded as 320,000. Preliminary in-season estimates of the mortality of sockeye delayed within Alberni Inlet, as a result of warm low water flows and other environmental conditions, ranged from 100,000 to 200,000. For the purpose of forecast performance a mortality of 100,000 is listed.

1.7 PUBLICATION RECORD

The Salmon Sub-committee reports from the 1990 meetings were published in:

Farlinger, S., G. Thomas, D. Anderson, D. Chalmers, and A. Tyler [Editors]. 1991. Pacific Stock Assessment Review Committee (PSARC) Annual Report for 1990. Can. MS Rep. Fish. Aquat. Sci. 2095: 201p.

In 1990 there were 26 Working Papers submitted to the Sub-committee. Publication of some of these papers is unlikely because some are to be resubmitted for future meeting, others were intended for discussion purposes to establish plans or procedures for future work, and others were annual updates of forecasts. Of the remaining papers, two have been published:

Starr, P. J. and N. D. Schubert. 1990. Assessment of Harrison River chinook salmon. Can. MS Rep. Fish. Aquat. Sci. 2085: 47p.

Welch, D. W. and D. J. Noakes. 1991. Optimal harvest rate policies for rebuilding the Adams River sockeye salmon (Oncorhynchus nerka). Can. J. Fish. Aquat. Sci. 48: 526-535.

1.8 SUB-COMMITTEE'S FUTURE WORK PLANS

The previous sections of this report identified some topic requiring further work. Additionally, the Sub-committee in its February 1991 planning meeting proposed to the RMEC a number of topics and schedule to the end of 1992. This information is presented in Table 1.2.

1.9 SUB-COMMITTEE MEMBERSHIP

The current status of the Salmon Sub-committee membership to the Spring 1991 meeting is:

Don Anderson, Chairman
Fisheries Branch
South Coast Division
Nanaimo

Brian Riddell
Biological Science Branch
Pacific Biological Station
Nanaimo

Chris Wood
Biological Science Branch
Pacific Biological Station
Nanaimo

Ron Kadowaki
Biological Science Branch
Pacific Biological Station
Nanaimo

Paul Starr
Biological Science Branch
Pacific Biological Station
Nanaimo

Gordon Berezay
Program Planning and
Economics Branch
Regional Headquarters
Vancouver

Al Cass
Biological Science Branch
Pacific Biological Station
Nanaimo

Dave Peacock
Fisheries Branch
North Coast Division
Prince Rupert

Robin Harrison
Fisheries Branch
Fraser River, Northern B.C. and Yukon Division
New Westminster

Kim West
Resource Enhancement Branch
Regional Headquarters
Vancouver

Dave Meerburg
Fisheries Research Branch
National Headquarters
Ottawa

The seat assigned to Dave Schutz as Coordinator of Biological Services, with Rick Semple serving as an alternate, is currently vacant. A replacement is to be appointed. Additionally the Steering Committee and RMEC supported the Sub-committee's request to have representation from Habitat Management. The Sub-committee needs to recommend a potential candidate and forward to Fisheries Branch.

The changes to the membership during 1990 and prior to the Spring 1991 meeting were; Terry Beacham was replaced by Al Cass, Ted Perry was replaced by Kim West, and Kaarina McGivney was replaced by Gordon Berezay.

Table 1.1. Performance of 1990 Forecasts for Selected Stocks.

Species	Stock	1990 Forecast Return	Average Absolute[1] Forecast Variability (Years)	1990 Observed Return	1990 Deviation
Sockeye	Fraser River (1986 cycle)	16,500,000	22% (7)	22,000,000	-25%
	Barkley Sound	324,000	4% (3)	320,000 - 420,000	+1% to 23%
	Smith Inlet	625,000	42% (6)	207,000	201%
	Rivers Inlet	750,000	73) (5)	819,000	-8%
	Skeena River	2,100,000	45% (10)	2,139,000	-2%
	Nass	426,000	51% (6)	232,000	+84%
Pink	Skeena	2,200,000	52% (9)	4,308,000	-49%
	Southern B.C. Even Year	4,692,000	67% (10)	7,472,000	-37%
Chum	Central B.C. Bella Coola	890,000	101% (6)	956,000	-7%
	Southern B.C. John. St. - Fraser River	2,835,000	37% (21)	3,225,000	-12%
Chinook	Southern B.C. Big Qualicum Hatchery[2]	6,800 Adults 3,600 Females[3]	N/A (2)	6,500 3,700	--

N/A indicated not available
[1]Absolute values of plus/minus range of historical forecasts. Deviations are calculated as forecasted return minus the observed return divided by the observed return.
[2]Forecast in numbers of total adults (male + female), escapement goal of female only based on 19 million eggs required and 5,000 eggs/female.
[3]Expected number of spawners

Table 1.2. PSARC Salmon Sub-committee proposed working papers and schedule for 1991 and 1992.

	TITLE	AUTHOR(S)
	AUTUMN OF 1991 MEETING	
1.	Skeena River Steelhead, Stock Status	R. Hooton (MOE F&W)
2.	Johnstone Strait Coho, Stock Status	T. Shardlow R. Kadowaki
3.	Smith Inlet Sockeye, Stock Status Update and Revision of Escapement Goal	R. Goruk K. Hyatt
4.	Fraser River Coho, Development of a "Floor" Escapement Approach	R. Kadowaki N. Schubert
5.	Lower Georgia Strait Chinook, Evaluation of Sport Fishing Regulation Changes	P. Starr (Working Group)
	SPRING 1992 MEETING	
6.	Fraser River Sockeye, Stock Identification	A. Cass C. Wood PSC Staff
7.	Prediction Methods for Forecasting Chinook Returns	P. Starr
8.	Nass River Sockeye, Stock Status	M. Henderson L. Jantz
9.	Fraser River Chum, Stock Status	M. Joyce
10.	Skeena River Coho, Stock Status and Management Recommendations	R. Kadowaki, et al
11.	Information Requirements for Major stocks	To be assigned (Workshop)
12.	Kitimat River Chinook, Stock Status	D. Peacock B. Snyder
13.	Troll Fishery Model Development	To be assigned (Modelling Group)
	AUTUMN 1992 MEETING	
14.	Fraser River-Strait of Georgia Coho, Update of Stock Status (1989-1991)	To be assigned (Working Group)

2. STOCK STATUS INFORMATION FOR CHINOOK SALMON ALONG THE WEST COAST OF VANCOUVER ISLAND (Working Paper S91-04).

2.1 INTRODUCTION

Chinook salmon along the west coast of Vancouver Island (Statistical Areas 22 - 27) have historically been important food sources for Native peoples and contributed to the off-shore troll fishery as it developed through the 1900's. This Working Paper summarizes exploitation and spawning escapement patterns for this stock but can only comment qualitatively on the status of the stock. Like most other chinook stocks in British Columbia, catch of this stock in ocean fisheries is unknown, except for hatchery chinook which have been tagged. Assessments for this stock are also complicated by spawning escapement records which are weaker than in other areas of B.C. due to the remoteness of most streams, very high rainfall (approx. 250 cm./yr) and extensive logging, and the involvement of enhancement programs in many of the streams. The latter complicates interpretation of the escapement trends which may change due to fishery management actions, environmental variation, and/or impacts of enhancement.

2.2 EXPLOITATION RATE AND PATTERNS

This assessment is heavily reliant on coded-wire tagged groups of chinook released from enhancement programs. Exploitation rates and patterns are estimated using a cohort analysis which includes procedures to estimate non-catch fishing mortalities (troll shakers, net drop-out, mortalities during chinook non-retention periods). The procedure for the cohort analysis was documented by the Chinook Technical Committee of the PSC (TCCHINOOK 88-2, Pacific Salmon Commission, 600-1155 Robson St., Vancouver, B.C.).

All the chinook stocks along the west coast of Vancouver Island, which have been coded wire tagged, have very similar catch distributions. The stocks are heavily fished in S.E. Alaska and northern British Columbia and to a much lesser extent along the west coast of Vancouver Island. WCVI chinook distribute northward from their stream of origin and are harvested at ages 2 through 6. Distributions in Figure 2.1 are unweighted averages of all years with total mortality data included. S.E. Alaskan fisheries (troll, net, and sport) account for between 46 and 60% of the harvest from these stocks (calculated after adjusting the Robertson Creek data for the terminal net catches). Fisheries in northern and central B.C. harvest between 24 and 39% of the catch. With the exception of the Marble River stock, 8 to 10% of the catch is estimated to be from recreational fisheries on the west coast of Vancouver Island, usually terminal fisheries in the inlets or Nitinat Lake. Migration timing of mature adults returning to the Conuma Hatchery (Area 25) seems to be about one month earlier than the other three stocks.

Conuma chinook are harvested in July versus mid to late August for the other three hatchery stocks.

The total exploitation rate on Robertson Creek chinook has ranged between 80 and 90%, but between 25 and 33% of this occurs in terminal fisheries (net and sport). Native harvest of Robertson Creek chinook in the Somass River has never been included in the exploitation calculations since coded-wire tags are not reported or sampled. Most chinook populations along the west coast of Vancouver Island don't have this degree of terminal fishing. To examine trends in exploitation rates on these stocks, the ocean exploitation rates for the Robertson Creek stock were calculated. Ocean exploitation rate is the fishing mortality in non-terminal fisheries divided by that fishing mortality plus the terminal fishing mortality plus the spawning escapement.

Two trends were evident: (1) ocean exploitation rates on reported catches for recent brood years (1984-86) declined by 15 percentage points compared to earlier brood years (1976-79 brood years used as a pre-Treaty base period); (2) changes in fishing regulations (increased size limits and increased non-retention periods) have increased the exploitation attributed to non-reported fishing mortalities by 5 percentage points. The net result is a decline in the ocean exploitation rate of about 10 percentage points in the past three brood years.

The time series of ocean exploitation rates from the Robertson Creek hatchery indicates that the total fishing mortality on that stock in ocean fisheries has been, on average, about 57% for the 1984-1986 brood years. This exceeds the total exploitation rate recommended by Hankin and Healey (1987) for maximum sustainable production in chinook stocks which mature at ages 3 to 6 (females are usually one year older than males) as in these WCVI stocks. Most of the indicator stocks do not have significant terminal exploitation although expansions to recreational fisheries are expected. On the basis of Hankin and Healey, we expect that total exploitation rates of about 50% are likely required to rebuild the naturally spawning chinook stocks on the west coast of Vancouver Island.

2.3 SPAWNING ESCAPEMENT EVALUATIONS

Two levels of evaluations were conducted: (1) examination of all the escapement records for streams in Statistical Areas 22 to 27 which have had chinook salmon recorded in them at least twice since 1953 (Serbic 1991), and (2) for the assessment of the chinook rebuilding program of the Pacific Salmon Commission (PSC), the consistency or reliability of escapement surveys within a stream (1975 - 1990) was examined; as per the index presented by Shardlow and McConnell (PSARC Working Paper S90-15). The intent of the index was to identify escapement information which is based on poor or inconsistent survey methods. All of the spawning escapements reported include brood stock used for enhancement since in many cases the number of fish removed has not been recorded, and the numbers are still relatively small compared to the total escapement. To determine the rebuilding status of WCVI chinook, the time trend in escapement to selected chinook streams (used aggregately as the index stock for this group of chinook populations) was evaluated as by the Chinook Technical Committee (TCCHINOOK 90-3, Pacific Salmon Commission, 600 - 1155 Robson St., Vancouver, B.C.).

Spawning chinook have been reported in 76 streams along the west coast of Vancouver Island since 1953 (Serbic 1991) and 15 of these populations were considered major chinook stocks (number of spawners > 500, Aro and Shepard 1967). However recently, escapement to 70% of these 76 streams has decreased substantially and/or escapement records have become so sporadic that the escapement of chinook is unknown (Table 2.1). Further, only 7 streams would now be defined as major stocks and significant enhancement programs are on-going in 6 of these 7 streams.

The salmon escapement records (B.C. 16's) seem to clearly indicate that the number of chinook populations has decreased substantially. However, the degree of production loss is unknown. **A major limitation in assessing the status of WCVI chinook is that the accuracy of escapement data can not be evaluated.** All of the estimates have been based on visual counts (although by several methods...walks, scuba swims, flights, etc.), the methods of extrapolating counts to total escapements are largely unknown, and there is no other information (terminal catches, test fisheries, etc.) which could provide an independent measure of accuracy to corroborate the escapement trend. Further, there has been a very high frequency of Fishery Officer changes which also tends to reduce our confidence in the data.

The use in the Pacific Salmon Commission of selected spawning populations as indicators of escapement trends reflects this uncertainty in escapement data. Shardlow and McConnell (South Coast Division, Fisheries Branch, DFO, Nanaimo, B.C.) reviewed stream visitation records maintained by field staff to select streams with known survey effort and methods. If the data were consistently collected between years, these escapement estimates were assumed to be our best estimate of the trend in escapements even though their accuracy remains unknown. An indicator stock group (ISG) of eight stocks from statistical Areas 25 - 27 were identified in 1990 (PSARC Advisory Docu. 90-1). Additional stocks from Area 23 and 24 were reviewed for inclusion this year. However, escapement monitoring and documentation was insufficient to warrant inclusion of additional stocks. Spawning escapements and the weighting index values for the indicator stocks are listed in Tables 2.2 and 2.3, respectively. The usefulness of the index in examining the consistency of escapement surveys is evident in Table 2.3. Index values vary substantially between years within streams.

Further, there is a clear time trend in the index values, more than doubling since 1986 compared to pre-1986 surveys. This would complicate interpretation of escapement trends if more chinook are now being observed per survey effort relative to previous years.

The Departmental policy for determining an interim escapement goal has been to double the average 1979-82 escapements. However, based on index values in Table 2.3, we do not recommend simply using the 1979-82 average for this ISG. The 1979-82 average would be heavily influenced by the reportedly large 1980 and 1982 escapements to the Marble River but these escapement values have very low index values. We suggest a base period of 1977-79 and 1981; resulting in an average escapement of 4705 chinook and an escapement goal of 9410 chinook. Later years were not included because of poor survey reliability in Areas 26 and 27 in 1983 and because chinook conservation actions had already begun in 1984. Using the evaluation criteria selected by the Chinook Technical Committee of the PSC, the WCVI chinook ISG would be classified as Probably Rebuilding.

We caution, however, that this assessment results from increasing escapements in rivers with enhancement programs. Escapements in the three natural systems (Kaouk, Artlish, Tahsish) have had reduced escapements for the past three years. Further, the index does not apply to natural rivers in Area 23 or 24.

2.4 ENHANCEMENT PROGRAMS

Enhancement has played a major role in developing chinook production along the west coast of Vancouver Island. Robertson Creek Hatchery in the Somass River (Barkley Sound, Area 23) has been Canada's most successful chinook salmon producer, and major hatcheries have also been built on the Nitinat River (Area 22) and Conuma River (Area 25). In total, eleven enhancement projects release chinook into 14 river systems, and in 1989 released over 20 million chinook juveniles (4.7 million fed-fry, 15.4 million smolts). **The only natural populations of WCVI chinook salmon, with consistent escapement records and which have not been enhanced, are the Artlish, Kaouk, and Tahsish rivers in Area 26.**

2.5 STOCK STATUS

Escapements to naturally spawning chinook populations along the west coast of Vancouver Island are likely severely depressed but the information basis for this is weak. We are unable to recommend biologically based escapement goals to maximize biological production from these stocks. This assessment was seriously compromised by our inability to corroborate the accuracy of the escapement data and due to the loss of escapement information. Escapements to enhanced populations are generally increasing but the contribution from enhancement activities has not been estimated. We are at risk of concentrating chinook production into a few large enhanced systems and not maintaining the smaller natural populations. Ocean exploitation rates on the Robertson Creek stock have declined after signing the Pacific Salmon Treaty and should continue to be reduced to facilitate rebuilding of the natural populations, particularly if expected increased requests for terminal fishery uses are realized.

A major concern identified is the inability to verify the accuracy of the escapement data and trends, and the increase in the number of streams with unknown escapements. The selection of index streams for the PSC Rebuilding Program addresses this but survey effort for these streams is not guaranteed and is heavily reliant upon work by enhancement staff, who obviously have other objectives. Further, five of the indicator streams selected are enhanced and rebuilding in these systems may mask escapement problems in the remaining 3 natural systems. This situation is not unique to the WCVI index stock group but again emphasizes the limitation to using stock aggregates as one "index stock" and whether the management actions taken to rebuild these indices will be adequate to conserve and rebuild naturally spawning chinook populations.

2.6 REVIEWERS' COMMENTS

This Working Paper was examined by two reviewers. Both reviewers commended the authors for a well written report. One reviewer believed that the authors attempted to do too much in one document and as a result did not cover any one issue in sufficient detail. The other reviewer believed the authors identified the many problems in the collection and use of escapement data and provided valuable insights into the interpretation of the available data. Both reviewers commented on the need for a review of the methods and the overall framework currently used in escapement enumerations.

The first reviewer felt the most important of the authors' recommendations is the need to re-establish a baseline of escapement information. This reviewer also recommended that some method of ground truthing be developed so that estimates from various methods could be compared to known true estimates. The second reviewer agreed with the authors' qualitative indication of reduced number of chinook producing streams, and the reduced wild escapements and the increased escapements due to enhancement. This reviewer recognized the inability to quantitatively assess the stock. Both reviewers agreed that the weighing index should not be applied to spawning escapements <u>between</u> rivers.

The second reviewer did not agree with the recommendation that the Area 26 stocks not be enhanced citing the need to assist severely depressed stocks. This reviewer also disagreed with the recommendation for a revision of the base period for measuring rebuilding.

2.7 SUB-COMMITTEE DISCUSSION

The Sub-committee acknowledged that this stock assessment was seriously compromised as a result of the quality and quantity of escapement data. A high degree of uncertainty and inconsistency exists in the understanding and corroborating the accuracy of the escapement data. Managers should appreciate the Sub-committee's advice is being provided on available data. However, this advice is based on weak information and limited to three wild populations in one inlet. It is alarming that only 7 populations with annual escapements averaging 500 spawners or more exist along the WCVI and that 6 of 7 have associated enhancement programs.

The Sub-committee had extensive discussions regarding the preserving of the Area 26 chinook stocks as unenhanced stocks. The Sub-committee supported the recommendation for preservation on the grounds that they are the sole remaining natural stocks to measure rebuilding.

There was agreement by the Sub-committee members to accept the summary as presented with the following exception:

a) The WCVI indicator stock group (ISG) should be revised but not as proposed in the Working Paper. The ISG should be based on wild stocks (Artish, Tahsish and Kaouk).

b) The classification as Probably Rebuilding results from the application of CTC evaluation criteria to the combined enhanced and wild stocks. The PSC rebuilding objectives are for wild stocks. Separating the evaluation of wild from enhanced stocks, the evaluation criteria for wild stocks would be classified as Probably Not Rebuilding. This assessment is presented in Figures 2.2 and 2.3 for enhanced and wild stocks, respectively.

The working paper discussed the need to reduce the exploitation rate to about 50% in order to rebuild the WCVI wild stocks. This value is less than the 65% exploitation rule originally used to establish the PSC rebuilding program. The 65% was an average value based on a aggregate of wild B.C. stocks. A 50% exploitation rate required for rebuilding would imply that WCVI wild stocks are less productive then the aggregate.

The Sub-committee noted that the 50% exploitation rate recommendation is based on a theoretical analysis of chinook population dynamics. The 50% exploitation rate cannot be compared with the Robertson Creek exploitation index because some marked hatchery fish stray to the natural spawning population and are not enumerated. Therefore the Robertson Creek index over-estimates the actual exploitation rate. Consequently, the Committee cannot compare the exploitation rates without an evaluation of the accuracy of the escapement data used in the Robertson Creek index.

2.8 SUB-COMMITTEE RECOMMENDATIONS

1) Harvest controls to increase escapements to WCVI chinook populations should be continued and exploitation reduced further to rebuild the naturally spawning populations.

2) The natural stocks in Area 26 (Artlish, Tahsish, and Kaouk) are the only remaining natural stocks which have been annually surveyed and which have, until recently, had reasonable numbers of chinook to enumerate. We strongly recommend these stocks be preserved as minimally disturbed natural stocks, and that standardized escapement surveys be designed and maintained in these systems, including increased monitoring and biological sampling.

3) Implement a program to survey chinook spawning populations on the WCVI to establish a baseline of escapement information. Index stocks for statistical areas 23 and 24 should be established. Annual escapement surveys should be revised so that a few high priority streams are regularly surveyed, biological samples (sex, age, size) are collected annually, and habitat impacts and survey effort are recorded.

4) The WCVI indicator stock group presently used by the Chinook Technical Committee should be revised. The dichotomy of enhanced and wild stocks does not support the assessment that these stocks are rebuilding. Rebuilding within the PSC program should be assessed based on the three natural stocks (Artlish, Tahsish and Kaouk). The rebuilding assessment, based on wild stocks only, is Probably Not Rebuilding. The base period recommended is 1979-82. It is recommended that the contribution of the enhanced populations to the total spawning stock be assessed for the 5 populations with enhancement (Gold, Burman, Tahsis, Marble, and Leiner).

5) Procedures should be established so that annual spawner enumeration forms (B.C. 16s) are completed more fully and consistently. The established reporting requirements should include; B.C. 16's, visitation logs and methods used to estimate the final escapement. Comments on the effects of serious environmental events should be included and reports of enhancement activities within the river must be detailed.

Table 2.1 Number of streams by categories for chinook escapements in Statistical Areas 22 through 27 (categories defined in the Methods)

Categories:	Area	Decade periods			
		1953-62	1963-72	1973-82	1983-90
esc. > 50 CN	22	1	1	1	1
esc. < 50 CN		1	1	0	0
esc. 0 or -1		0	0	0	0
irregular insp.		0	0	1	1
no info.		0	0	0	0
esc. > 50 CN	23	5	4	3	3
esc. < 50 CN		3	4	2	0
esc. 0 or -1		1	1	2	0
irregular insp.		3	3	5	9
no info.		0	0	0	0
esc. > 50 CN	24	9	4	2	1
esc. < 50 CN		1	7	7	3
esc. 0 or -1		1	0	1	0
irregular insp.		0	0	1	7
no info.		0	0	0	0
esc. > 50 CN	25	11	15	7	6
esc. < 50 CN		7	6	5	3
esc. 0 or -1		4	0	0	0
irregular insp.		3	4	14	17
no info.		1	1	0	0
esc. > 50 CN	26	8	6	4	3
esc. < 50 CN		8	3	1	2
esc. 0 or -1		1	0	0	0
irregular insp.		0	9	13	13
no info.		1	0	0	0
esc. > 50 CN	27	3	1	1	1
esc. < 50 CN		1	4	1	0
esc. 0 or -1		0	1	1	2
irregular insp.		3	1	4	4
no info.		0	0	0	0
esc. > 50 CN	all	37	31	18	15
esc. < 50 CN		21	25	16	8
esc. 0 or -1		7	2	4	2
irregular insp.		9	17	38	51
no info.		2	1	0	0
Total/all streams		76	76	76	76

Table 2.2 WCVI chinook escapement indicator rivers and escapement values for 1975-1990.

Year	Area 25 Leiner River	Area 25 Burman River	Area 25 Gold River	Area 25 Tahsis River	Area 26 Artlish River	Area 26 Kaouk River	Area 26 Tahsish River	Area 27 Marble River	West Coast Total
1975	200	200	400	75	25	75	25	400	1400
1976	25	400	25	200	25	25	25	400	1125
1977	70	500	2000	150	60	75	100	950	3905
1978	60	1000	3500	100	0	50	50	1500	6260
1979	200	650	800	348	40	60	200	750	3048
1980	400	345	750	249*	100	0	200	5000	7044
1981	0	300	560	150	500	100	1000	3000	5610
1982	15	387*	1000	125	100	0	1000	5000	7627
1983	50	475	1500	50	375*	300	500	1000	4250
1984	195	700	1500	12	650	400	1500	600	5557
1985	100	500	1500	50	400	300	1200	1250	5300
1986	190	400	1900	60	100	100	1000	1200	4950
1987	125	100	600	20	100	100	500	2000	3545
1988	300	400	1000	125	0	0	400	3500	5725
1989	500	700	1000	500	40	40	450	4500	7720
1990	450	1100	2000	300	50	10	200	2000	6110
Average 1977-79 & 1981	83	613	1715	187	150	71	338	1550	4706
Average 1979-82	154	421	778	218	185	40	600	3438	5832
Average 1985-90	278	533	1333	176	115	90	625	2408	5558

*interpolated values

Table 2.3 Calculated reliability weights for the WCVI chinook indicator rivers.

Year	Area 25	Area 25	Area 25	Area 25	Area 26	Area 26	Area 26	Area 27	Total
	Leiner River	Burman River	Gold River	Tahsis River	Artlish River	Kaouk River	Tahsish River	Marble River	
1975	0.83	0.95	0.36	0.83	1.01	1.29	0.45	0.20	5.91
1976	0.20	0.51	0.20	0.20	0.76	0.20	0.45	0.20	2.73
1977	0.51	1.61	1.76	0.83	0.51	1.26	0.45	0.73	7.67
1978	0.51	1.29	1.26	0.83	0.63	0.83	0.92	1.76	8.03
1979	1.26	1.40	1.48	2.70	0.83	1.29	0.83	3.01	12.80
1980	0.51	1.14	0.83	0.38	1.14	0.00	1.08	0.20	5.26
1981	0.13	1.76	0.83	0.33	0.20	0.33	0.83	2.26	6.65
1982	0.51	0.44	0.26	0.20	0.20	0.13	0.83	0.20	2.76
1983	0.98	1.11	1.45	2.08	0.00	0.20	0.20	0.20	6.21
1984	0.51	0.98	1.45	0.83	0.83	1.89	1.76	0.51	8.76
1985	0.20	0.95	0.61	1.56	0.83	0.95	1.11	1.99	8.19
1986	1.48	1.65	3.39	2.89	1.80	1.20	1.20	3.86	17.46
1987	2.95	2.83	2.91	1.35	2.70	2.08	3.23	3.26	21.29
1988	0.83	2.08	2.79	0.83	0.63	0.83	1.39	5.99	15.35
1989	2.70	3.13	2.51	1.95	3.60	2.20	3.16	7.33	26.58
1990	1.20	1.45	3.70	2.20	2.71	1.51	2.59	7.69	23.05
Total	15.31	23.27	25.78	19.94	18.36	16.17	20.45	39.40	178.69

METHODOLOGIES

3. EVALUATION FRAMEWORK FOR ASSESSING 1989 STRAIT OF GEORGIA SPORT FISHING REGULATION CHANGES (Working Paper S91-3).

3.1 INTRODUCTION

In the spring of 1989, a set of new regulations were implemented for the Strait of Georgia sport fishery with the objective of conserving depressed lower Strait of Georgia chinook stocks. In the press release announcing the new regulations, the Fisheries Minister made the following commitment: "...[the Minister] added that an important component of the 1989 program is the evaluation of chinook conservation measures and the commitment to make adjustments to ensure rebuilding goals are being met." To fulfil this commitment, the Director-General, Pacific Region, Department of Fisheries and Oceans (DFO) requested that the Biological Sciences Branch take the lead role in the evaluation of these regulations. That request was passed down to the Chinook and Coho Stock Assessment Program and an evaluation committee was struck, consisting of representatives from the Biological Sciences Branch, Fisheries Branch, and Program Planning and Economics Branch to establish a framework (or methodology) for the evaluation of the new sport regulations. This evaluation framework would then be submitted to senior management with the intent of presenting it to the sport fishing community for final endorsement. Concurrent with this process, the framework would be submitted to PSARC for a more rigorous peer review of the proposed evaluation methods.

3.2 OBJECTIVE OF REGULATION CHANGES

The object of regulation changes is to obtain at least a 20% decrease in annual harvest rate in the Strait of Georgia sport fishery (relative to 1987), beginning in 1988 and continuing to the end of the rebuilding period.

The long term goal behind this reduction is to restore chinook escapements in all lower Strait of Georgia rivers to target levels by 1998 (but not including the Fraser River). These rivers include all chinook producing rivers on the east coast of Vancouver Island 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.

3.3 DEFINITION OF HARVEST RATE

A harvest rate for a fishery is the proportion of fish removed by fishing from the population of fish which is vulnerable to that fishery. An assumption which is made throughout the evaluation is that the harvest rate is equal for all stocks taken in that fishery. Therefore, a 20% reduction in the overall harvest rate in the Strait of Georgia sport fishery will also result in a 20% reduction in the harvest rate on the target lower Strait of Georgia stocks.

Adult equivalency is a relative weight which expresses the probability of a fish spawning at a specific age or an older age in the absence of fishing. The adult equivalent value will vary with changes in assumptions regarding natural mortality. Using this factor allows for comparisons of harvest rates under circumstances of changing fishing regulations and harvest strategies, where age classes may differ in their vulnerabilities.

3.4 MANAGEMENT ACTIONS (1988-1989)

1. Raise the size limit to 62 cm (nose-fork length) in the entire Strait of Georgia (beginning in 1989).

2. Establish an annual bag limit of 8 chinook per year (1988) and raise the annual bag limit to 15 in 1989.

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

4. Add Johnstone Strait to the area covered by the above management actions and remove Juan de Fuca Strait (beginning in 1989).

3.5 DEFINITION OF AREAS

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

In 1989, the section of Juan de Fuca Strait from Sheringham Point to Cadboro Point was removed from the management regulations designed to reduce harvest rates on lower Strait of Georgia stocks. At the same time, the waters of Johnstone Strait beginning at Chatham Point and extending to the surf line drawn from Cape Sutil on Vancouver Island to Hope Island to Shelter Bay on the mainland coast were added to the area covered by the management regulations.

3.6 PROPOSED EVALUATION FRAMEWORK

The following methods were selected by the evaluation committee to make the assessment of the overall change in harvest rate in the Strait of Georgia.

3.7 EXPLOITATION RATE ANALYSIS

Exploitation rate analysis is a coastwide assessment of chinook stocks and fisheries done by the Pacific Salmon Commission (PSC) Chinook Technical Committee (CTC) using coded wire tag recoveries

(CWT). The methods used have been documented by the Chinook Technical Committee of the PSC (TCCHINOOK 88-2, Pacific Salmon Commission, 600-1155 Robson St., Vancouver B.C.). This analysis involves comparing exploitation rates estimated from CWT catches for a specific year to a defined base period and estimating the relative change in fishery specific harvest rates. The major assumption associated with this analysis is that each stock must be distributed in a similar manner for all years being analyzed, therefore assuming that all changes in exploitation rates can be attributed to changes in fishing effects (or to random error). This analysis is sensitive to errors in the estimation of the return rates of CWT by the sport fishery.

3.8 DEPLETION METHOD

This method relates the cumulative catch of the combined troll and sport fisheries plotted against the decline in CPUE (catch per effort) in either fishery. Based on a general model (Hilborn and Walters 1992), this method provides a direct estimate of the total stock available at the beginning of the assessment period, and, depending on the assumptions made, it will also estimate average recruitment and 'survival' during the period of catch accumulation. Once estimates for these parameters are obtained, harvest rate can be estimated for any year and the change in harvest rate from one year to another can be calculated. Assumptions made by this method will vary, depending on the model chosen. This method does not depend on the recovery of CWT, thus providing an alternative and independent assessment to the exploitation rate analysis.

3.9 MARINE TAGGING OF CHINOOK

It is possible to use the depletion rate in the recovery of tags to estimate the rate of fishing mortality in a fishery, provided the underlying assumptions are met. The two basic assumptions required are; a) that rates of tag loss and the recovery of tags are constant over the time that tags are recovered, and b) that the total instantaneous mortality rate is constant (even though fishing mortality will vary). The second assumption requires that fishing mortality is a relatively small component of the total mortality. Assumption b) can be relaxed somewhat by reformulating the underlying model; however, the requirement that fishing mortality be small relative to 'natural' mortality still remains.

Terry Gjernes has applied and released some 1000 external tags in both 1988 and 1990 and over 1700 tags in 1989 to troll caught chinook in Strait of Georgia. Approximately 10% of the tags placed in 1988 and 1989 have been recovered, even though there has been no systematic tag recovery program in place. However, there is no assurance that tag recovery rates have been constant between years. As the tags have been applied only since 1988, we will not be able to evaluate the change relative to 1987. However, the effect of 1988 compared to 1989 may help in the evaluation of the size limit change alone.

3.10 CATCH AT AGE RATIO ESTIMATION METHOD

The Depletion Method (Section 3.8) uses age-specific catches within a calendar year (but across brood years) to estimate harvest rate changes. The method proposed in this section also uses age-specific catches to estimate harvest rates; however, the catches are compared across calendar years, keeping brood years together. This approach should complement the depletion analysis and give a different perspective on the change in harvest rate due to Strait of Georgia sport fishing regulation changes.

It is proposed to use a combination of traditional fishery assessment techniques to complete this method. For age 4 and age 5 chinook, it is possible to estimate the catchability coefficient by using the ratios of age-specific CPUE (catch per unit effort), assuming a constant catchability coefficient between the two age classes. However, is probably not valid to make this assumption between age 3 and age 4 chinook. Therefore, the catchability coefficient is estimated iteratively for this age class using cohort analysis (a form of virtual population analysis [VPA]), beginning initially with the estimate of the catchability coefficient for age 4.

3.11 SENSITIVITY ANALYSIS

In each of the above techniques, a sensitivity analysis to each of the major underlying assumptions will be conducted. At present, it is difficult to place confidence limits on most of the estimated parameters generated by any of the methods presented in this document. This is because many of the key input data elements have unknown variance. This is particularly true for the estimated CWT recoveries and for the commercial catch estimates. As well, some of the analyses, such as cohort analysis and the catch ratio method, make estimates of the parameters which exactly predict the observed catches. These types of models do not provide a measure of how well the parameter is estimated. One possible method to establish confidence limits for these types of analyses would be to use Monte Carlo simulation techniques. However, it is proposed at this time to limit the analysis of error in these methods to the sensitivity analysis.

3.12 EVALUATION OF ENHANCEMENT CONTRIBUTION

A key component to the original assessment which led to the recommendation that a 20% reduction in harvest rate would suffice to rebuild LGS stocks was the addition of a large contribution of enhanced production to "buffer" the endangered wild stocks. Otherwise, a reduction greater than 20% would have been required.

Accordingly, the rebuilding plan approved by the Fisheries Minister provided for expanded hatchery production for chinook along with the regulation changes.

Therefore, an ongoing evaluation of hatchery contribution to the Strait of Georgia fisheries should accompany this evaluation of regulation changes. Such an evaluation is straight forward as it only requires that CWT catch estimates be expanded to represent total production. As almost all Canadian hatchery chinook production is marked (about 95%), there will not be much uncertainty associated with adjusting recoveries to represent unmarked releases. It should be noted that it is not expected that new enhancement associated with the regulation changes will already be available to these fisheries. However, it is necessary to accumulate background information so that future changes in enhancement contributions can be correctly evaluated.

As well, an assessment of the trends in enhancement contribution rates, coupled with the assessment of the Strait of Georgia harvest rate changes described in Sections 3.2 to 3.10, could help in arriving at an understanding of how the abundances of wild stocks are varying.

3.13 OVERALL EVALUATION

When comparing the outcomes of the above evaluation procedures to make an overall statement as to the effect of the regulation changes, there is a need to give relative weights to each of the four methods which reflect the reliability of each method, the data quality, and the severity of the underlying assumptions. The evaluation sub-committee has discussed this issue and has ranked the four methods as follows:

1) The Exploitation Rate Analysis and Depletion Methods are potentially the most reliable methods, as the data sources are well understood and the underlying assumptions are similar to those made when the original assessment that established the regulations was made. Also, these two methods are the most developed in terms of documentation and review by other researchers.

2) The Catch at Age Ratio Estimation Method is next in reliability. This method is based on similar data to that used for the Depletion Method; therefore, its reliability in terms of data quality is the same. However, the underlying theory for this method is less well developed and understood. As well, there are statistical properties found in ratio estimators which make them somewhat less reliable than direct parameter estimates.

3) The Marine Tagging method is potentially the least reliable method because of the difficulty in adjusting for variable tag

recovery rates between years, the severity of some of the other assumptions, and the potential that the model will not behave well in the Strait of Georgia situation.

3.14 REVIEWERS' COMMENTS

This working paper was examined by four reviewers owing to the complexity of the subject matter. All reviewers agreed that the paper was well written and that the proposed evaluation procedures were clearly described. Three of the four reviewers recommended that attention be restricted to the Exploitation Rate Analysis and the Depletion Method because these methods are likely to be much more reliable than the other methods described. Technical criticisms of the proposed methods focused on: (i) the uncertainty in parameter values, and the need for sensitivity analyses to determine the implications of errors in parameter values, especially with respect to fishing effort, awareness factors for CWT reporting, and hooking mortality; (ii) the need to evaluate how well the proposed methods can detect changes in harvest rates given the historical data records (i.e. hindcasting); and (iii) the implications of excluding age 2 fish from the analyses. One reviewer recommended that details of the final (adopted) procedure(s) be agreed upon by everyone involved <u>before</u> actual data are used to estimate the change in harvest rate that has occurred; this should eliminate conflict among user groups about which procedure should have been used.

One review stated that, regardless of the technical merit of the methods presented, the evaluation framework was inadequate to meet the objectives stated in the working paper -- because too few years of observations would be available before and after the change in fishing regulations and the inherently high inter-annual variability in the harvest rate and the procedure used to estimate the harvest rate. Another reviewer expressed similar doubts about our ability to detect statistically a 20% change in harvest rate, given the proposed duration of the study and the uncertainty in the estimates for key parameters of the models to be used. This reviewer identified "the need to explore how to present the results in clear but credible ways, being up-front about the problems and uncertainties, and convincing in how the ultimate conclusions are arrived at".

3.15 SUB-COMMITTEE DISCUSSION

The reviewers' comments led to a discussion about how much evidence is necessary to demonstrate a decline in harvest rate in a statistically "defensible" manner and whether demanding such rigor when assessing the effects of regulation changes shifts an unreasonable amount of risk onto the fish stocks. Due to the high level of background variability inherent in all fisheries data (natural biological variability plus random measurement error) there is a basic paradox facing all fisheries managers. Management actions would have to be dramatic, unless the data quality is extremely high in order to be statistically defensible. This approach, however, may be unacceptable to users. Management actions more acceptable to users may not be statistically defensible, but this would tend to put the fish stocks at greater risk.

The Sub-committee agreed that the Exploitation Rate Analysis and Depletion Methods have the best technical basis for this evaluation and the Catch-at-Age and Marine Tagging methods should be dropped. The latter because of the assumptions involved and concerns about their applicability to the Strait of Georgia sport fishery. The Sub-committee also recognized, however, that consideration of the data limitations and sensitivity analyses of the exploitation and depletion rate methods must be undertaken and reviewed before these methods can be fully supported technically. The Sub-committee also recognized the problem of correctly determining whether the harvest rate has changed in the sport fishery. Discussion of the annual variability in harvest rate and the variability in the data collected clearly supports the reviewers' concern that the Department will not, in the near term, be able to detect without uncertainty a 20% reduction in harvest rate. This change in harvest rate is relatively small in comparison with annual variability in harvest rate estimates. Given the importance of the lower Strait of Georgia chinook stock and of the sport fishery, we must acquire the best information possible but must also be aware of the statistical limitations to the advice being provided. The Sub-committee emphasizes that this issue of lack of statistical confidence in the assessments and advice provided is not limited to this evaluation. It is probably a concern in other stock assessments. It has become a point of discussion here because of the evaluation task and the volatile nature of the chinook issue in the region.

One review proposed an alternate method of evaluating the size limit change. The Sub-committee suggests that this proposal be presented to the Strait of Georgia Evaluation Committee for a full review of methods and possible later presentation to the Sub-committee.

3.16 SUB-COMMITTEE ADVICE AND RECOMMENDATIONS:

It must be acknowledged that due to the large inherent variability in biological systems, it cannot be expected to make statistically defensible conclusions in short time periods even with good data measurements and analysis. The ability to detect moderate changes in harvest rates as a result of regulation changes will be low. If it is determined that it is not possible to statistically defend the evaluation of the regulation changes, it may be necessary to re-frame the question in terms of available data which would be more statistically defensible.

a) General Advice

1) A significant concern exists that in important issues, the data used for evaluation is expected to come under close review and should be defensible statistically. Therefore, there is a requirement to improve the precision of data.

2) Measured parameters include natural variability. Therefore, there is a requirement for evaluation procedures to develop dynamic (stochastic) models to account for variability.

3) To avoid putting the resource at risk, the development of evaluation procedures should be part of the management planning process.

b) The Sub-committee recommends specifically for Working Paper S91-03

4) The Marine Tagging and Catch at Age methods be dropped and that the evaluation be conducted by the Exploitation Rate and Depletion methods.

5) The evaluation in 4) must include a sensitivity analysis to possible ranges of assumptions and variability should be incorporated into parameter estimates where possible.

c) The Sub-committee recommends the following additional data to be included:

6) Additional exploitation rate indicator stocks, such as Cowichan chinook should be added. The installation of a fence to collect CWT information could be conducted in the Autumn of 1991. This implies a long term commitment to the quantitative evaluation of this river. A permanent fence for enumeration should be considered.

7) Sample the chinook (age 2 and older) population in the Strait of Georgia to determine length frequency distributions for each age class.

8) As the current voluntary return program for CWT's by sport fishermen in the Strait of Georgia is inadequate for the purposes of this evaluation framework, a scientifically sound method for sampling of CWT's in the Strait of Georgia sport fishery should be developed.

9) Develop and improve the statistical methodology used for analysis of CWT data.

10) To maintain a core biological sampling program for chinook in the commercial troll and sport fishery. The Sub-committee understands that this component, under the Mark Recovery Program, has been cancelled for 1991.

11) The need to perform an evaluation of additional enhancement put in place to buffer the natural LGS chinook stocks. Additional enhancement is a major component, along with the regulatory measures, to rebuild these stocks.

The issues raised in the review of this working paper and the ensuing Sub-committee discussion have significant implications for the evaluation component of the South Coast Coho Initiative. In particular, careful consideration needs to be given in the Coho Initiative to; what is monitored, the degree of change to be detected, the time frame of the evaluation, and the confidence in the results.

4. FRASER SOCKEYE FORECASTING METHODOLOGIES, 1991 Late South Thompson Sockeye Salmon Forecast (Working Paper S91-5).

In 1990, the Sub-committee considered a paper which outlined a range of methods which had been used to forecast returns of up to 22 various stocks of Fraser river sockeye in the past. The Sub-committee advised that to provide a thorough documentation of methods (including procedures for estimating confidence limits and evaluation of alternate forecast models) for all 22 Fraser sockeye stocks in one paper would be too large an undertaking, and they therefore recommended that such a task be undertaken for only a single stock (Late South Thompson) in 1991.

4.1 INTRODUCTION

The paper documented the method used to forecast the 1991 return of sockeye salmon to the South Thompson River system. The method used is a systematic approach that looks at a number of linear regressions from each of three life-history stages: spawners, juveniles and siblings. A single regression from each life-history stage is chosen based on statistical reliability (highest 'r' value). Each of the three models is then evaluated for forecast reliability by comparing forecasted returns to actual returns from each year and calculating the standard errors for each model. A fourth forecast was calculated by weighting the three models from each life-history stage according to their calculated standard errors and pooling the results.

4.2 RESULTS

The regression model chosen to forecast from the sibling life-history stage is a linear regression of the log of total returns of 3_2 jacks against the log of total 4_2 adult returns the following year. This model performed the best of the sibling models examined ($r = 0.926$, $n = 38$) and had a calculated standard error of 1.96 (millions). The majority of this model's reliability is driven by previous correlation with a recent trend toward increasing standard error. This model predicts a total South Thompson River (Shuswap Lake) system return of 400,000.

The juvenile life-history stage regression model demonstrating the greatest predictive capabilities is a regression of the log of the estimated fall pre-smolt abundance in Shuswap Lake against the log of the total 4_2 adult returns. This model had the highest 'r' value of the juvenile models examined ($r = 0.930$, $n = 9$) and the lowest standard error of all models examined (SE = 1.07 million). This model predicts a total Shuswap Lake return of 10,600,000.

The only regression model examined from the spawner life-history stage was the Ricker (1975) spawner recruit model. This model predicts a total 4_2 adult return of 2,200,000 and has a calculated standard error of 3.23 million.

The pooled forecast based on the three forecasts above weighted by their calculated standard error predicts a total South Thompson sockeye salmon return of 7,800,000.

4.3 DISCUSSION

The juvenile model was chosen to forecast the 1991 South Thompson River return primarily because it had the lowest calculated standard error and has the best record in recent years of predicting total sockeye returns on the dominant/sub-dominant cycle years. The reliability of this large predicted return of 10,600,000 (± a standard error of 1.1 million) is also substantiated by supporting data such as: highest r^2 of all models examined, lowest absolute error of the models examined, the above average confidence interval of the Shuswap Lake fall pre-smolt estimate, as well as the highest estimated pre-smolt estimate for the 1991 cycle year, and the correlation demonstrated between fall pre-smolt abundance and 3_2 jack scale freshwater circulus counts from Shuswap Lake jack scale samples.

Factors that may influence the reliability of this forecast are the limited degrees of freedom due to the small number of observations, the non-linear juvenile to adult mortality demonstrated by other sockeye stocks and the lack of marine survival data. The contradictory 3_2 jack abundance data predicts a lower than expected return but this appears to be a continuation of a pattern of decreasing numbers of jacks on a number of Fraser River sockeye stocks.

One of the largest problems encountered when forecasting South Thompson River (Shuswap Lake) sockeye returns was maintaining data continuity so that all models were forecasting the same return parameter. In order to include the juvenile pre-smolt model the only forecast that all models could predict was for total Shuswap Lake returns. This resulted in the problem of apportioning the stock into early and late components which is necessary for management purposes. It was decided that all models would predict total Shuswap Lake returns and that the best method available to apportion the early and late components would be by using the proportions of the brood spawning population.

Future efforts will be directed at identifying shortcomings in the data inputs and forecasting models used, with the goal of improving forecast reliability.

4.4 REVIEWERS' COMMENTS

The two reviewers agreed that the authors developed a logical approach to the forecasting process, including a discussion of the commonly held view of the distribution of mortality in the various life stages. They noted that the sibling models should perform best from the standpoint that returns at age 3 should reflect the cumulative effects of survival variations at the sequential life stages in these stocks which mature primarily (>90%) at age 4. However, since these sibling models appear to be less reliable in recent years than models which incorporate data obtained from earlier life stages, i.e. pre-smolt estimates, the authors conclude that the pre-smolt estimates provide better forecasts.

While the authors were careful to account for biases introduced by converting means of log normal distributions to means of normal distributions, concern was expressed that the authors did not adequately investigate the discrepancy in forecasted returns (a factor of 26 times) that arose from using the sibling versus the pre-smolt data. The consistent under-estimation of returns from the sibling and spawner-recruit model was of concern and one of the reviewer's recommended that more attention should be devoted to this issue, particularly as the data series is much longer for these two models. The pre-smolt model has only 9 data points and as one reviewer noted, 5 of these are on dominant-cycle years and 4 are on sub-dominant cycle years. The use of a mix of cycles may introduce errors if there are significant biological mechanisms influencing the production, i.e. unique survival relationships for each cycle resulting in cyclic dominance. As well, using the pre-smolt data leads to difficulties in separating the forecasts for early and late run components of the 1991 forecast; a equal survival rate of smolt stage of early and late components of the stock is assumed.

Both reviewers questioned the estimates of pre-smolt abundance in the 1988 Shuswap Lake juvenile survey, one noting that this would have been an exceptional survival (11.3% compared to a 4.2% mean survival from egg to November juveniles) and the other questioning the precision (±4.3%) of the pre-smolt estimate of about 215 million in 1988.

As the pre-smolt estimate was the highest in the data series, the reviewers recommended caution in the forecast for two reasons: extrapolation outside of previous range and large numbers of smolts may lead to smaller sizes, perhaps decreasing marine survival.

Sub-committee discussion focused on the reasons for forecast bias in the past, as evidenced from the sibling "jack" and spawner-recruit models. Investigation was suggested into time series models which could incorporate a changing maturity schedule of "jacks", as well as nonparametric methods. As well, because of the importance of the pre-smolt estimates for this forecast, the Sub-committee felt that methodology to produce these estimates should be documented.

4.5 SUB-COMMITTEE ADVICE

The Sub-committee continues its concern regarding the importance of developing and documenting methods for forecasting of salmon returns. While improvement in the documentation of the methodology for the later South Thompson sockeye forecast for 1991 is noted, the Sub-committee felt further work would be necessary before it could support the methods used by the authors, specifically in the areas of the precision and high point estimate for the pre-smolts in 1988 as well as the significant bias over time in forecasts based on the sibling and spawner-recruit models.

The Sub-committee recommends:

1. re-assessment of the 1991 forecast method investigating the concerns previously mentioned;

2. review of the reliability of the estimate for the 1988 pre-smolt abundance in Shuswap Lake;

3. investigation of smolt size differences and the survival effects over time in Shuswap lake;

4. investigation of the 1958 brood year point in the spawner-recruit model in terms of the data reliability as well as the implications of removing the point from the regression.

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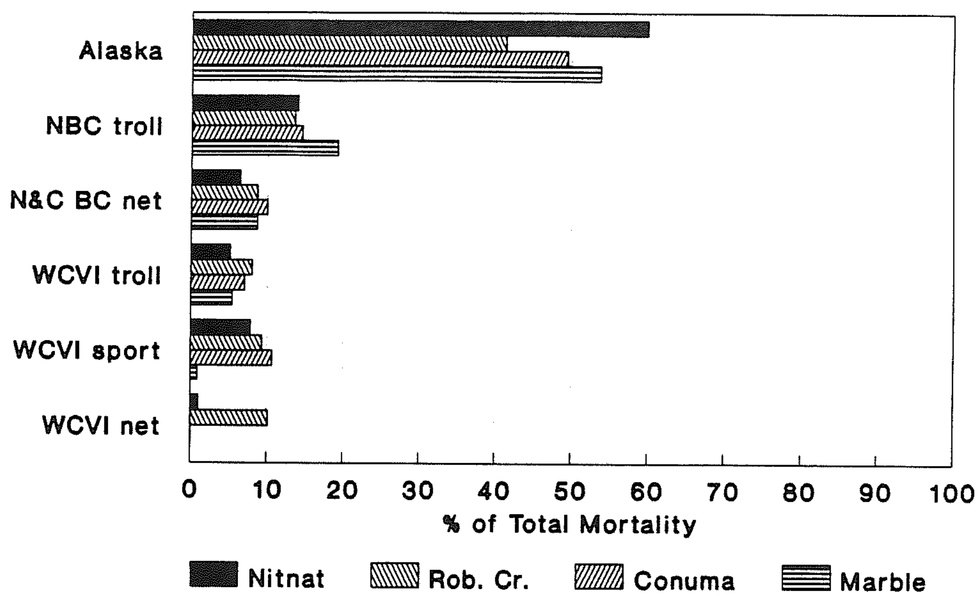
Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Fish. Res. Bd. Canada Bull. 191: 382p.

Serbic, G. 1991. The salmon escapement database and reporting system. Can. Tech. Rep. Fish. Aquat. Sci. 1791: 104p.

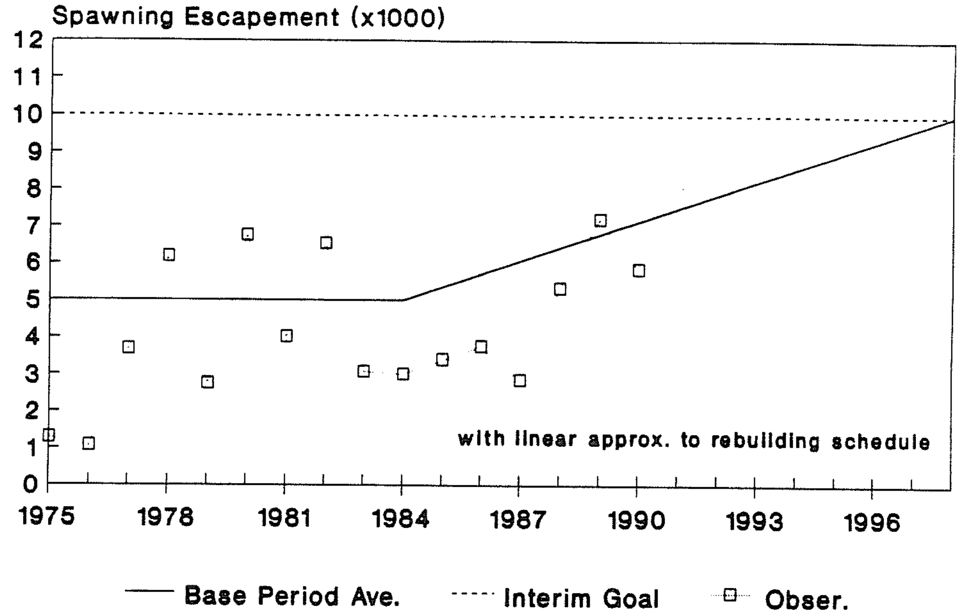
FIGURES

Figure 2.1 Distribution of fishing mortality for WCVI chinook stocks.



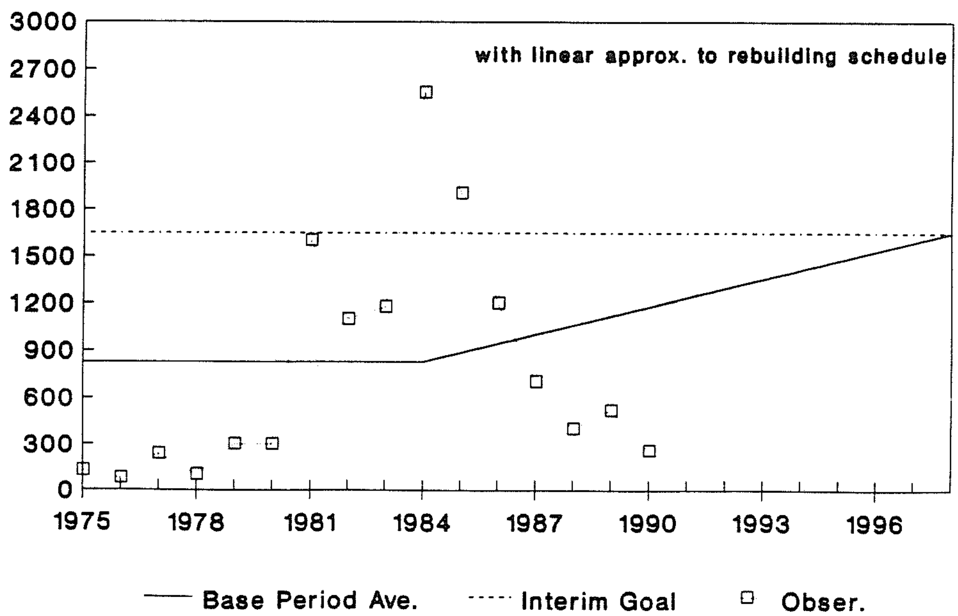
Total mortality for all years available

Figure 2.2 Rebuilding assessment of Enhanced stocks in the WCVI - ISG



(Leiner, Burman, Gold, Tahsis, Marble)

Figure 2.3 Rebuilding assessment of Wild stocks in the WCVI - ISG



(Area 26 only - Artlish, Tahsish, Kaouk)

APPENDIX 1

List of participants for the Salmon Sub-Committee Meeting, May 21-22, 1991.

MEMBERS:
D. Anderson, Chairman
B. Riddell
K. West (served as rapporteur for Working Paper S91-04)
D. Peacock
G. Berezay
D. Meerburg (served as rapporteur for Working Paper S91-05)
R. Harrison
C. Wood
R. Kadowaki
P. Starr
A. Cass (served as rapporteur for Working Paper S91-03)

AUTHORS:
W. Saito, May 21 only
G. Smith, May 21 only
P. Starr
B. Riddell
T. Shardlow
S. Argue, May 22 only

REVIEWERS: (*Indicates not present to present review)
J. Schweigert
W. Luedke
J. Woodey, May 21 only
C. Wood
J. Rice
D. Welch, May 22 only
R. Peterman*
T. Gjernes (for T. Bird and T. Davis, Co-chairmen DFO/SFAB Statistical Committee)

OBSERVERS:
B. Otway, May 22 only
P. Ryall, May 22 only
V. Palermo, May 22 only
L. Lapi, May 22 only
J. Irvine

APPENDIX 2

WORKING PAPERS PRESENTED TO THE SALMON SUB-COMMITTEE, MAY 21-22, 1991

PAPER NUMBER	TITLE	AUTHOR(S)
S91-01	Chairman's Report for the 1990 Salmon Sub-committee	A.D. Anderson
S91-03	Evaluation Framework for Assessing 1989 Strait of Georgia Sport Fishing Regulation Changes	P.J. Starr A.W. Argue
S91-04	Stock Status Information for Chinook Salmon Along the West Coast of Vancouver Island	B.E. Riddell T. Shardlow P.J. Starr
S91-05	1991 Late South Thompson Stock Sockeye Salmon Forecast	G.A. Smith W.S. Saito

Pacific Stock Assessment Review Committee **PSARC Advisory Document 91-2**

CONTENTS

I. STEERING COMMITTEE REPORT

The PSARC Steering Committee met September 19, 1991 at the Pacific Biological Station, Nanaimo to review the Invertebrate (Shellfish) Subcommittee Report. The Subcommittee Report was discussed and the following recommendations made:

1. The Steering Committee stated that management objectives need to be stated clearly for all important fishery stocks and that the rationale for these should also be provided. PSARC Subcommittees cannot be expected to provide advice that would be useful to managers when the management objectives are not clearly defined.

2. The Steering Committee identified the need to develop estimates of geoduck biomass in areas of sufficient density to support harvesting, to review the current advice on harvest rates, both in terms of new information on natural mortality and in the context of the relevance of areas of low abundance to recruitment in areas of commercial abundance, and to use the results of these analyses to identify management options and the risk associated with them.

3. The Steering Committee recommended that the appropriateness of the Leslie analysis for the available west coast invertebrate fisheries data be reviewed. If necessary, alternative techniques should be recommended.

4. The Steering Committee recommended that the Invertebrate Subcommittee prepare a Working Paper for their next Subcommittee meeting to review current management strategies and their underlying objectives.

5. The Steering Committee recognizes the difficulties that the Invertebrate Subcommittee has with its responsibility for many species, limited personnel, and, in many cases, relatively little stock information. The Steering Committee recommended the Invertebrate Subcommittee change its approach. It is suggested that fewer updates and working papers be presented annually. Detailed assessments of major stocks should occur on a staggered, perhaps triennial basis, similar to the approach initiated by the Groundfish Subcommittee this year.

II. INVERTEBRATE (SHELLFISH) SUBCOMMITTEE REPORT

INTRODUCTION

This report is a summary of advice and recommendations resulting from the PSARC Invertebrate (Shellfish) Subcommittee, held August 26-28, 1991 at the Coast Bastion Inn, Nanaimo. A list of the ten working papers submitted and 23 fishery and science updates is shown in Appendix 2. Presentations were made by staff from the Shellfish Section, Pacific Biological Station, Biological Sciences Branch, biologists from the North Coast, South Coast, and Fraser River divisions of the Fisheries Branch, and by a scientist from the Ocean Ecology Group, Biological Sciences Branch, the Institute of Ocean Sciences. D. McKone represented the Biological Sciences Directorate, Ottawa.

Invertebrate landings increased rapidly in the 1980's but have declined since 1987 primarily as a result of a reduction in intertidal clam and geoduck landings (Table 1). A decline in manila clam landings of 20% in 1989 from 1988 is followed by a continued decrease in 1990. The reduction in landings for this species reflects both annual recruitment to the stock and increased monitoring of the fishery. Dungeness crab landings increased markedly between 1989 and 1990 as a result of increased effort in area 1. The geoduck clam fishery showed the greatest landings and accrued the highest landed value in 1990. Almost 900 vessels participated in invertebrate fisheries in 1990. In the intertidal clam fishery alone, there are over sixteen hundred intertidal harvesters. Shellfish are of considerable importance in the recreational fishery and it is estimated that 37,000 people participate in this fishery.

The landed value of invertebrate fisheries was about $43.5 million (including oysters, $3.5 million) in 1990, a slight decrease over the previous year (Table 2). A decline in value of geoduck and intertidal clam in 1990 was partially compensated for by an increase in value of crab.

Recommendations from this subcommittee in 1991 provides the basis for advice to the Regional Executive Committee for development of 1992 management plans. Considerable work has been accomplished and initiated but important work has not been initiated due to lack of resources. As a result, many recommendations this year are the same as in the past and are still regarded as high priority.

The subcommittee particularly wishes to note the following:

i) In 1990, the Shellfish Subcommittee of PSARC recommended that parameters used in the calculation of geoduck quotas be verified, in particular, bed size and geoduck density (recommendation based on Working Paper I90-7). As well, the RMEC directed fishery managers to adopt a conservative approach to management of the geoduck fishery. In response to this advice the following steps were taken:

1. The geoduck quota was reduced by 15% in 1991 from 1990.
2. Some quota areas were further subdivided to prevent local overharvest.
3. Harvest logbook data were examined and commercial fishermen were consulted with a view to refining geoduck bed area estimates. These data were not completed for presentation to the PSARC subcommittee; discussion with fishermen is ongoing.
4. A field survey was carried out to collect data in support of developing a survey technique with the objective of defining harvestable bed area and densities of geoducks within these beds (Science Update 2). Another field study had been initiated in 1990, and continues in 1991, examining geoduck growth and recruitment (Science Update 1).

The field survey reported in Science Update 2 indicated that some bed areas described in harvest logs are overestimated so that calculated quotas may be exaggerated in some areas. Further evidence of concern was derived from harvest log catches compiled by bed which indicate local overharvest has likely occurred. Available evidence described above suggests that geoduck quotas should be further reduced in subsequent years.

ii) Comanagement proposals have been initiated in some areas to train native divers for invertebrate surveys. These programs require support from management biology and science branch; in return, population data useful for management will be collected.

MANAGEMENT POLICY

Substantial changes to management have been made over the past two years including licence limitation and area licensing. Management policies have been outlined below.

MAJOR FISHERIES

Dungeness Crab Fisheries: Entry is limited in 1991, 495 licences.

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

Prawn Trap Fisheries: Entry was limited in 1990, 270 licenses.

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

Intertidal Clams: Entry is open to anyone with a clam harvesting licence. Support vessels are not licensed.

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

<u>Geoducks</u>: This is a limited entry fishery with 55 vessel equal quota licences.

- Management by maximum sustained yield proposed at annual exploitation levels of .75-2% of the original biomass.
- Area quotas have been established.
- Equal quotas have been assigned to individual boats to provide a more efficient year round harvest.
- Validation program monitors landings.
- There are rotational quotas, most areas are fished once every three years.
- Quota areas are subdivided to prevent local overfishing.
- P licences have been issued in the north coast, where shore-based processing is less available.

<u>Red Sea Urchin</u>: Entry was limited in 1991, 92 licences.

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

<u>Green Sea Urchins</u>: Entry was limited in 1991, 34 licences.

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

<u>Abalone</u>: This is a limited entry fishery with 26 individual and equal quota licences. The fishery was closed in 1991. The following restrictions applied in 1990.

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

Sea Cucumber: Entry was limited in 1991, 73 licences.

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

Shrimp Trawl: This is a limited entry fishery, 249 licences.

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

MINOR OR DEVELOPING FISHERIES

Most of the minor or developing fisheries are currently regarded as underutilized. Their growth has been mainly limited because of the lack of markets, exacerbated by lack of biological information.

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

Specific fishing limitations have been set for euphausiids (quotas) and for scallops (size limits). Horse clam harvest is limited to areas of geoduck fishing.

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

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

SUMMARY OF ADVICE FOR INVERTEBRATE FISHERIES IN 1991

The first section of the following table summarizes the fisheries of major economic importance in 1990 (Table 2). These include crab and prawn trap fisheries, intertidal clams, diving fisheries for geoducks, sea urchins, abalone and sea cucumber and the offshore shrimp trawl fishery.

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

SUMMARY OF BIOLOGICAL ADVICE AND INFORMATION NEEDS FOR MANAGEMENT OF MAJOR INVERTEBRATE FISHERIES IN 1991

Major Fishery	Biological Advice and Information
TRAP	
Dungeness crab	1. Change in escape port size and number (2 ports at 110mm) for 1992. 2. Investigate biological basis for minimum size limit. 3. Continue logbooks.
Prawn	1. Leslie estimation of prawn biomass in all management areas. 2. Increase size of logbooks. 3. Study area program reduced and entering monitoring phase. 4. Continue annual seasonal coastwide closure. 5. Continue logbook and biological monitoring programs.
INTERTIDAL	
Intertidal clams	1. Open area 7 to controlled fishery in 1992. 2. Retain time and area closures and area licensing. 3. Continue and complete repeated digging study. 4. Research into clam farming techniques is required.
DIVE	
Geoduck	1. Conservative levels of harvest should be maintained at .75 to 2% of estimated prefishery stock size. 2. Maintain rotational areas. 3. Quantify geoduck bed areas and densities. 4. Further examination of Leslie method of estimating biomass. 5. Reevaluate yields based on new estimates of mortality. 6. Test options for rotational period with model. 7. Continue harvest logbook.

SUMMARY OF BIOLOGICAL ADVICE AND INFORMATION NEEDS FOR MANAGEMENT OF MAJOR INVERTEBRATE FISHERIES IN 1991 CONT'D

Major Fishery	Biological Advice and Information
Red Sea Urchin	1. Survey roe quality in north coast. 2. Continue rotational plan in north coast. Compare stock in fished and unfished areas. 3. Identify research reserves. 4. Continue harvest log system. 5. Continue and expand research to obtain biological information required to manage resource (size limit and other).
Abalone	1. Retain closure in the abalone fishery. 2. Surveys should continue in 1983/84 and expand into other areas.
Sea cucumber	1. Continue collecting basic biological data. 2. Further examination of fishery CPUE data to determine areas of decline. 3. Express quota in split weight.Continue study of conversion factors. 4. Continue harvest log program.
NET	
Shrimp trawl	1. Delay area 124 opening until Mid-May or June to maximize yield per recruit. 2. Consider quota option for offshore fishery. 3. Assess inshore fisheries. Consider active management.
Trap	
Tanner, king, and galatheid crab	1. Maintain experimental fishery for tanner crab. 2. Maintain harvest logbook program.

SUMMARY OF BIOLOGICAL ADVICE FOR MANAGEMENT OF MINOR INVERTEBRATE FISHERIES IN 1991

Minor Fishery	Biological Advice
NET	
Squid inshore	1. Continue harvest logbook program
Euphausiid	1. Review allocation of 500 t quota in the St. of Georgia. 2. Continue logbooks.
DIVE	
Scallops	1. Continue harvest logbook program 2. Monitor trawl catches.
Horse clam	1. A size limit is inappropriate for this species. 2. Catches should be monitored to detect changes in mean size in harvest. 3. Research is required to evaluate rotational fishery strategy. 4. Continue harvest logbook program.
Octopus	1. Continue harvest logbook program.
Purple sea urchin	1. A cautious approach to purple urchin management should be adopted. Any experimental permits issued should be closely monitored and areas rotated.
INTERTIDAL	
Gooseneck barnacle	1. Continue logbooks. 2. Resurvey sites for recruitment.
Mussels	1. Minor fishery. Monitor landings.

POSITION PAPERS AND RECOMMENDATIONS

This section is ordered by species and contains summaries of position papers and associated reviews as well as a list of subcommittee recommendations for the various species. Subcommittee recommendations are based on data presented in position papers. Consideration was also given to information from science updates and fishery updates.

Geoduck

I91-3. On growth and mortality of geoduck clams (Panope abrupta).

In this study, age frequency data were used to estimate mortality rates for geoduck clams. To account for any size-based sampling bias, a minimum age was established such that no clams younger than this age were included in the analysis. Although mortality estimates were quite sensitive to this minimum age, mortality estimates were consistent for cut-off ages between 20 and 40 years. Average mortality rates were in the 0.03 to 0.04 range or about twice as large as previous estimates (0.01 to 0.02).

Geoduck growth rates appear to be fairly consistent on a coast wide basis. There is some weak evidence to suggest outer coast stocks grow more slowly than individuals in the Strait of Georgia but the difference is small compared to within sample variation. With a mean estimated growth rate of 0.215, growth in any year is approximately 80 percent of the growth in the previous year (t-1) and animals would be essentially full grown by age 20.

Reviewers Comments

The reviewer had no problem with the analysis but asked for further information on alternate procedures for estimating mortality rates, as well as procedures for age validation and size related sampling bias.

Science Update 1: Preliminary report of a study on geoducks near Gabriola Island during 1990-91.

Two half ha (5,000 m^2) plots were permanently marked in a geoduck bed south of Gabriola Island during 1990. The mean age of geoducks harvested were 40.9 y (6-116 y). Growth rate was most rapid in the first 20 y and generally levelled off in shell length, but continued to increase in total weight of geoducks to at least 50 y. There was considerable variation in shell length max size and weight reached after 20 y. Average densities (adjusted for proportion "showing") were $1.89/m^2$ preharvest and $1.04/m^2$ postharvest in the Harvest Plot 1 and $2.07/m^2$ for the Control Plot 2 based on divers counting geoducks in 5 m^2 quadrats along 50 m strip-transects. Density estimates using 1 m^2 quadrats along 50 m transects were similar to those using 5 m^2 quadrats. However, 1 m^2 quadrats took three times as long as 5 m^2 quadrats to sample along a 50 m transect. Leslie analysis was used to calculate preharvest population abundance (8,687, 95% CL 5,849 - 28,823) and exploitation rate (46.8%) from catch and effort data during harvesting of Plot 1. Population abundance in Plot 1 according to 5 m^2 quadrat samples was 9,450 preharvest and 5,220 postharvest with an exploitation rate estimate of about 44.8%. Although half of each plot was seeded with juvenile geoduck seed estimation of juvenile geoduck density and survival is impossible because of the logistical difficulty in sampling small geoducks in the first few years of life. An attempt to examine recruitment by suction dredging produced very few juveniles.

Science Update 2: Results of a preliminary survey of geoduck beds in the North Coast.

In 1990 PSARC advised of problems in geoduck assessment and recommended evaluation of bed area and density estimates. A dive survey was initiated to examine some known beds, and to propose survey design.

Beds identified in harvest logs were examined in Area 4 (Melville - Dunira Island) and in Area 7 (Spider Anchorage). Transects were placed to define bed size where possible. On one site bed size was estimated to be 1/10 that shown in harvest logs; other site areas were reasonable in comparison to log data. Densities by transect ranged from less that 1 geoduck per square meter to $5.5/m^2$.

The qualification of information by survey should be initiated in major fishery locations. Surveys using transects perpendicular to shoreline through charted beds will provide estimates of the extent of beds. Show plots should be used to verify densities.

Subcommittee Recommendations for Geoduck

1. The 1990 PSARC Shellfish Advisory Document noted an inadequacy in the stock assessment for geoduck on which quotas are based. Field studies done in 1990-91 suggest that area and density estimates are suspect (Science Update 1 and 2). The subcommittee recommends that quantification of bed size and density be initiated in major geoduck locations.

Surveys using shoreline transect pattern and parameters suggested from 1991 surveys should be carried out to further define bed area. Show plots should be used to verify densities (FB lead, BSB support).

2. Modelling of trends in catch and effort (Leslie Analysis) was examined (Science Update 3). These methods should be further examined. The subcommittee recommends further analysis using data from a commercial diver and on-grounds observer to be provided in-season in 1992 (BSB lead, FB support).

3. New information was presented (I91-3) indicating mortality rates may be higher than previously estimated. Reevaluation of yields is required.

4. Systematic local harvesting of a long lived species such as geoduck has the potential to fish out stocks. Modelling is required to test rotational period options dependent on recruitment rates as measured in surveys (Science Update 1).

Intertidal Clams

I91-4. Commercial sampling of intertidal clams in Baynes Sound, B.C., June-July, 1990

Results show that commercial diggers can be very efficient at measuring and returning under-size clams. There continues to be illegal harvest of under-size clams.

The commercial catch of Manila clams had several year classes, but was dominated by two year classes, the 4+ (58%) and 3+ (25%).

The mean sizes of Manila clams (40-41.7 mm) in the commercial catch did not change over the period of the survey. The mean size of Littleneck Clams was larger (47.7 mm) and there were older year classes in the catch.

Reviewers Comments

This paper presents good data on the size frequency distribution of commercial clam catches in a heavily harvested area. It demonstrates that strict enforcement of the size limit is an effective way of managing the fishery. It also points out that diggers tend to retain smaller sized clams towards the end of fishing seasons and hence more enforcement may be required at that time.

Subcommittee Recommendations for Intertidal Clams

1. Decline in intertidal clam landings continued in 1990 due to greatly reduced landings of manila clams (47%). This reflects reduced manila clam populations available for harvest in the south coast division. Present management practices to control effort should be maintained and enforced, including minimum size limits, time and area closures, and area licensing.

2. The subcommittee recommends opening of the central coast (area 7) to controlled harvest of intertidal clams (Science Update 4, I90-3).

3. High mortalities of juvenile clams can occur because of frequent digging of beaches. Repeated digging study should be continued and completed to determine the effects of multiple digging in mortalities of juvenile clams (Science Update 5).

Mussel

I91-1. Blue Mussel (Mytilus edulis) mortality in British Columbia

Normal longevity of British Columbian blue mussels (Mytilus edulis) is about one year, with mortality suggested to be a natural senescence. In 1989, Nova Scotian mussels were brought to British Columbia so that comparative survival between Atlantic and Pacific mussels strains could be investigated. Nova Scotian mussel mortality was low in 1989, and F1 progeny remain alive in 1991. Biochemical analyses of constituent seasonal energy reserves suggested that substantial physiological differences may exist between the Nova Scotian and British Columbian strains. However, there were also differences between British Columbian strains in different years, indicating that more rigorous comparative monitoring is required to document possible strain differences. After spawning, Nova Scotian mussels began to show an increase in soma weight whereas British Columbian mussels continued to show a decrease in soma weight, with death the apparent ultimate result.

Reviewers Comments

This paper was previously reviewed in preparation for publication.

Subcommittee Recommendations for Mussels

There were no recommendations from the subcommittee.

Abalone

I. Size at maturity and fecundity of the abalone, Haliotus kamtschatkana (Jonas), in northern British Columbia.

Northern abalone, Haliotis kamtschatkana, were collected from eastern Moresby Island, Queen Charlotte Islands, during June, 1990, to determine size at maturity and fecundity. Histological examination of gonads indicated that the smallest mature abalone was 44 mm shell length (SL) and the largest immature abalone was 64 mm SL. Size at 50% maturity was estimated at 55 mm SL. Large gonad indices and histological observations suggested most mature abalone were ready to spawn. Fecundity, estimated from ovary weights and egg count subsamples, had a curvilinear power relationship with SL and weight of whole animal. A 57 mm SL abalone had 156,985 eggs and a 139 mm SL female had the largest fecundity of 11.6 million eggs. Although 20% of mature females in the sampled populations were in the legal recruit size (100-152 mm SL) these abalone could provide 50% of the total potential egg production.

Reviewers Comments

The paper provides new and much needed information on the life history of abalone and the data could be applied to previous work to provide some insights to management. The reviewer suggested that there is some possibility that maturity in abalone is size rather than age related.

I91-7. Leslie analysis of logbooks from the dive fishery for abalone, Haliotus kamtschatkana, in British Columbia, 1977 to 1990.

Fourteen years (1977-1990) of commercial logbook data from the dive fishery for abalone in British Columbia were analysed by the Leslie method. The method involves regressing a measure of fishing success against cumulative captures through a fishing season. The intercept of the regression on the cumulative catch axis gives an estimate of the total available biomass of commercial sized abalone and the slope is an estimate of catchability.

Leslie estimates of exploitation rate, commercial biomass at the start and end of each calendar year and inter-annual recruitment were attempted for nine out of twenty Statistical Areas. In many instances estimates were either not possible, as fishing success failed to decline through the year, or suffered from wide confidence limits. However, the general trends in the estimates that were generated are similar for each of the chosen areas over the period 1977-1990. Biomass levels for the late 1980's appear a fraction of levels derived for the late 1970's. Annual recruitment to the fishable stocks appears to have been less than annual landings except during the early-to-mid 1980's when commercial biomass levels increased. Paradoxically, annual mean catch per diver hour for most areas has remained stable despite the apparent declines in stock size.

Overall, the Leslie method appears a useful tool to augment existing abalone assessment techniques; however, there is a need for further studies into the potential biases of factors such as the harvesting strategies of fishermen and resource distribution.

Reviewers Comments

The reviewer stated that the analysis suffers from the fact that catch/effort data are incomplete. It was also suggested that Leslie analysis would provide a dependable assessment of abalone biomass over time if illegal removals have been consistent for the period studied. If, on the other hand, poaching increased in recent years, Leslie analysis would underestimate recent stock levels and a perceived decline of 50% would more likely be 20-25%.

Subcommittee Discussion

DFO/Native co-management opportunities exist with the Haida in the Queen Charlotte Islands, the Tsimshian in the north coast, and likely with other native groups. Data can be collected, through interviews by native technicians, on the quantity and location of catches in any past and future native fisheries. As well, anecdotal information on remaining local abundances can be compiled. This concept could be expanded to other invertebrate fisheries.

Subcommittee Recommendations for Abalone

1. The results of the Leslie analysis of harvest logbook information support the closure of the abalone fishery. Leslie analysis of abalone logbooks should be continued when a wild fishery re-opens. However, further research is required to refine the technique.

2. A resurvey to monitor abundance of abalone should be conducted in 1993/94 in the north coast. The survey should be expanded to include the south coast.

3. In abalone sampled from SE. Queen Charlotte Islands, size at maturity was estimated at 55 mm shell length and fecundity increased with shell length to a maximum of 11.6 million eggs (I). An estimate of effective fecundity will depend on local densities of abalone successfully spawning. The relationship between abundance of breeding stock and successful settlement is unknown and may depend on local densities of adults and hydrodynamics. Long term research should continue to determine the relationship between abalone reproduction, movement, and recruitment.

Shrimp

I91-8. Assessment of the area 124 shrimp (P. jordani) trawl fishery.

A shrimp biomass survey of the Tofino ground, {fisheries statistical area (FSA) 123} was conducted April 29 - May 12, 1991 using the research vessel W. E. RICKER. The Tofino shrimp ground lies offshore from the west coast of Vancouver Island between 48°15' north latitude. Since 1973, this type of survey has been conducted on these grounds 15 times in spring (April-May) and 3 times in late summer (August-September). The purpose of these cruises is to provide relative estimates of total biomass, year-class abundance, and distribution of the smooth pink shrimp, Pandalus jordani.

The prediction for 1991 was for a declining population biomass. The results of the present survey showed a total relative biomass index decline of 8-9%. The indices of 3+ and 2+ animals have declined since 1990, but the index of 1+ animals showed excellent increase. The prediction for 1992 is for a small increase in biomass over 1991 with a very weak 1991 2+ year class resulting in a low 1992 3+ year class, but a strong 1991 1+ year class resulting in a strong 1992 2+ year class. The 1992 2+ index could be similar to that seen in the 1989 2+ year class.

Reviewers Comments

The reviewer agreed with the author's assessment and suggests a substantial gain in yield may be achieved from a modest delay in fishery opening date.

Subcommittee Discussion

Fishing pressure in the Tofino area remains high with the result that the spawning stock remaining after a fishery is below the level of parent stocks (ie. recruit overfishing) (I91-8). The stock/recruitment relationship in the area, however, appears to be operative only under certain environmental conditions (1985, 87, 88, and 1990); there is no guarantee that leaving a strong spawner stock will result in good recruitment. There are two options available to managers:

a. An open pulse fishery which does not restrict the amount of shrimp taken. The fishery will be self-regulating and will result in periodic collapses of the fishery as was seen in the early 1980's.

b. A quota fishery which protects spawning stock levels. There is a risk that the industry will forego catch in the current year and that even with a large spawner stock remaining there will be negligible recruitment, as in the mid-1970's. In recent years, good spawner/recruit ratios occurred in 1985, 1987, 1988, and probably 1990. Poor recruit survival occurred in 1989. Under this scenario the risk of collapse remains, but is reduced.

Subcommittee Recommendations for Shrimp

1. Survey data from the Tofino area (I91-8) indicate a continued stock decline in 1991 and that a trawl fishery in 1992 will target mainly on a single year class (age 2+). As a result, the subcommittee strongly recommends that the opening of this fishery in 1992 be delayed from April to late May or June to take advantage of early spring shrimp growth which will increase yield. The delayed opening will also avoid capture of low quality, softshell shrimp as occurred in April 1991.

2. Declining catches in some long established inside fisheries and expansion of fisheries in the north warn of problems with stock size and overfishing may be occurring. Logbook and sales slip data should be reviewed and assessments done for inside shrimp fisheries. Some form of management restriction may be required in some areas if the fisheries are to be maintained.

Crab

I91-9. Megalopal spacial distribution and stock separation in Dungeness Crab.

The day-time depth ranges of megalopae from the outer coast and from Georgia Strait differ significantly, with megalopae at 25 and 160 m depth, respectively. At night, both populations of megalopae are mostly in the top metre of the water column. Juan de Fuca Strait, which connects Georgia Strait to the Pacific Ocean, typically has an estuarine circulation, with outflow in the top 50-100 m and inflow at deeper depths. With a daylight: dark ratio in the spring and summer (when megalopae are present) of about 3:1, the consequence is that Georgia Strait and outer coast megalopae are mostly retained within their own oceanographic systems. Small, occasional intrusions of outer coast megalopae into the Strait may occur when estuarine flow in Juan de Fuca Strait temporarily breaks down following sustained strong southwesterly winds. However, such intrusions are typically restricted to the southern side and head of Juan de Fuca Strait and do not penetrate far into Georgia Strait.

Cold (<10°C) deep water in Georgia Strait is suggested to be the explanation for both the delay in seasonal timing of larval crab settlement and a small physical size at settlement of Georgia Strait megalopae. These differences allow outer coast and Strait megalopae to be readily separated in survey samples.

Reviewers Comments

This paper has been previously reviewed in preparation for primary publication. The paper was not formally reviewed as part of the PSARC process.

I91-10. Crab morphometry by geographical location and the appropriateness of a 110 mm escape ring regulation in British Columbia.

The 1990 Dungeness crab trap escape ring diameter recommendation, to be effective in 1992, of 110 mm was based on research conducted near Tofino. Initial trials by fishermen resulted in concern being expressed that crab from other geographical areas might have different body size dimensions; this could result in a 110 mm ring size allowing the escape of too many legal size crabs from fisheries in such areas.

Evaluation of crab morphology from the south coast areas (Tofino, Sooke, Fraser estuary and Burrard Inlet, Departure Bay, and Knight Inlet) and one north coast area (Skeena R. estuary) showed no significant differences in the south coast but a significant difference between the Skeena and some south coast areas. For a given width, Skeena crab are shorter on average, allowing a 75% escapement of legal size crab in the 165-168 mm size range. The impact of this will depend annually on the proportion of recruited crab in this three mm size range, but in a worst case situation escapement of legal crab in the north would not exceed 8% of recruited crab.

Reviewers Comments

The reviewer agreed that the results and conclusions contained in the paper appeared sound. It was suggested that a perfect ring size to allow for escapement of undersize crab is not possible, given the variation in morphology within and between areas, so that a compromise is necessary.

Subcommittee Recommendations for Dungeness Crab

1. Because of the mobility of the crab fleet between areas, it is recommended that the existing 110 mm escape ring size regulation be retained. Along with prerecruit crab, legal size escapement should mostly be recaught after their next moult. Establishment of area specific escape ring sizes is not recommended.

2. Undersized crab are being landed in commercial and sport fisheries (Fishery Update). This practice could reduce the reproductive potential of crab stocks. Landings of undersized should

be limited by the 110 mm escape ring scheduled for implementation in 1992. The 110 mm escape ring should also be applied to the sport trap fishery.

3. Vertical migratory behaviour differences among Dungeness crab larvae, coupled with surface outflow and deepwater inflow in Juan de Fuca Strait, result in stock separation of outer coast and Georgia Strait Dungeness crab. Causes of fluctuations in annual abundance between these two populations are thus likely to be different. On the basis of this study, inside and outside stocks should be managed separately.

4. Given our knowledge of stock differences between Strait of Georgia and west coast Vancouver Island stocks, studies initiated in Tofino to determine the appropriateness of the minimum size limit should be expanded to other locations.

Prawn

I91-11. Prawn assessment using the shrimp by trap logbook

This PSARC paper explores the problems and potential solutions to be aware of when using the Shrimp Trap logbook information for stock assessments. There were basically four methods of data analysis used to estimate population sizes and exploitation rates.

Method one: The data were broken up into catch by month and the data was analyzed using a regression of the Standardized (for trap type) CPUE against the cumulative catch in tonnes over a shrimp year (Apr. of year X to March of year X+1). A shrimp year was used to match the biological timing of hatching and mortality of females in late March-early April.

Method two: The data from experimental areas 16 and 28 was broken up into catch in tonnes by week and the data was analyzed using a regression of the Standardized CPUE against the cumulative catch over a shrimp year.

Method three: The data from experimental areas 16 and 28 was broken up into catch of #'s of spawners week and the data was analyzed using a regression of the standardized CPUE against the cumulative catch over a shrimp year.

Method four: The data from the 1988-89 shrimp year for experimental area 28 was broken up into catch in tonnes by week and the Standardized CPUE was weighted to compensate for a 20% increase in growth of all age classes over the period of the fishery. The data was analyzed using a regression of the weighted Standardized CPUE against the cumulative catch over shrimp year.

Reviewers Comments

The reviewer had no major criticisms of the analysis. He did suggest the name of the analytical technique be provided with an explanation of the methodology. Also, this model assumes constant recruitment, natural mortality, and immigration, a restriction that was not acknowledged in the text.

Subcommittee Recommendations for Prawns

1. The prawn logbook program provides valuable information for managing this fishery. Assessment methods developed from Study Area catch and effort data (I91-11) should be used to estimate biomass and exploitation rates in all management areas.

2. Declines in landings and high exploitation rates in the north coast areas 6-8 indicate that more biological sampling and estimates of spawner indices should be done in these areas.

<u>Sea Cucumber</u>

I91-12. Market sampling of sea cucumber in 1991.

Sampling in fish plants, on vessels and by diving provided some data which suggests that conversion factors used to relate round weight of cucumbers to weights of processed sea cucumbers may require investigation and revision.

Average weights of cucumbers in the various states of processing should also be investigated and reviewed. Landings are reported in differing units (round, split, split and eviscerated) which compromises the ability to track quotas. Quotas should be expressed in the units used by industry (lb. of split product).

There is some evidence that WCVI cucumbers are larger than those from Inside VI: This should be confirmed through a sampling program as it affects numbers of sea cucumbers taken per unit of quota.

A more reliable mechanism for collecting catch and landing data in a timely fashion should be instituted to assist in tracking quotas.

Reviewers comments

The reviewer agreed with the recommendation that quotas be expressed in split weight but suggested there was insufficient data to properly derive conversion from whole to split weight. More sampling from a broader area is necessary.

Subcommittee Recommendations for Sea Cucumber

1. Little is known about sea cucumber biology. Investigations should continue in collecting data related to growth and mortality.

2. The subcommittee noted a declining trend in annual CPUE (kg/diver hour) from logbook data for both the north and south coast areas. Coastal logbook CPUE data should be examined to determine the trend by region. Analysis should be completed before the 1992 fishing plans are finalized so that quotas and fishing plans can be altered as necessary.

3. The subcommittee supported the recommendation from working paper I91-12 to express quotas as split rather than round weight, and to further investigate conversion factors.

4. Catch has been focused in some localized areas (Fishery Update). In light of the decline in CPUE noted above it is advisable to disperse effort by closing heavily fished areas.

Red Urchin

There were no Position Papers presented for red urchin.

Subcommittee Recommendations for Red Urchin

1. In the north coast, roe yields achieved in the fishery are low relative to the south coast. A survey of roe quality from north coast areas is required to determine any seasonal change in quality with a view to maximizing yield through seasonal harvest restrictions. Currently the north coast remains open to fishing year round.

2. The north coast red urchin fishery is currently managed by minimum and maximum size limits and rotational areas. The subcommittee reviewed and recommended against a request made to managers by fishermen advisors to open the entire district to fishing (the advisors suggested an intensive fishery would thin stocks which they believed would improve roe yields). Studies are required prior to changing the management approach. A survey of fished and unfished areas is suggested for which experimental design, monitoring, and data analysis would be required.

3. Research reserves (2 or 3) in productive habitats adjacent to fished areas should be identified before they are impacted by the fishery (eg. Campbell River study site). These sites will be used to compare fished and unfished areas.

SCIENCE UPDATE AND FISHERIES UPDATE REPORTS

In addition to the ten position papers, seven science update and sixteen fishery update papers were presented along with a geoduck quota progress report. The science updates present preliminary results of studies while fishery updates provide a convenient summary of the state of invertebrate fisheries (Appendix 2).

All papers presented will appear in a later publication.

Table 1. Landings of invertebrates in tonnes in British Columbia, 1981-1990

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
INTERTIDAL CLAMS										
Razor	30	68	31	101	90	142	142	155	117	114
Butter	120	103	77	131	252	159	69	83	42	93
Manila	317	597	1049	1677	1914	1894	3608	3833	2728	1452
Nat. Ln.	179	241	325	295	192	285	373	288	428	462
Mixed	161	155	280	409	478	369	87	27	159	148
TOTAL INTERTIDAL C	807	1164	1762	2613	2926	2849	4279	4386	3474	2269
GEODUCK	2704	3135	2636	3483	5370	5006	5734	4553	4087	3980
HORSE CLAM	57	321	21	7	6	96	355	328	115	125
SHRIMP	581	415	411	408	678	768	2644	2211	2211	1816
PRAWN	358	274	331	381	514	550	620	708	894	688
CRAB	1317	1002	960	1155	1165	1321	1631	1406	1406	2166
ABALONE	85	54	56	58	42	52	49	48	49	50
OCTOPUS			37	25	34	53	130	205	205	185
SEA URCHIN										
RED			982	1764	1815	2067	2223	1951	2645	3084
GREEN								434	570	452
SEA CUCUMBER				95	346	786	1722	1930	1101	621
SCALLOP		8	11	18	53	68	66	66	77	69
PLANKTON	19	0	47	103	131	166	130	249	380	360
SQUID			71	14	111	79	86	8	70	47
MUSSELS			tr	1	tr	2	2	3	4	1
GOOSENECK BARNACLES						2	32	18	34	37
TOTAL TONNES	5928	6373	7325	10125	13191	13865	19703	18504	17322	15950

Table 2. Landings in thousands of dollars of invertebrates in British Columbia, 1981-1990

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
INTERTIDAL CLAMS										
Razor	24	55	24	123	95	127	126	137	124	130
Butter	42	36	33	55	138	75	40	40	44	46
Manila	323	611	1043	1813	2278	2762	6003	7023	5919	3748
Nat. Ln.	195	263	329	311	202	327	474	357	580	703
Mixed	175	169	293	455	575	510	132	36	196	217
TOTAL INTERTIDAL C	759	1134	1722	2757	3288	3801	6775	7593	6863	4844
GEODUCK	2434	2814	1818	2937	4777	4294	6184	9762	12967	10336
HORSE CLAM	42	235	12	5	6	63	309	300	144	138
SHRIMP	912	652	1095	1022	1180	1240	4609	2802	2985	2453
PRAWN	2019	1545	2154	2464	3379	3734	4326	5724	7694	6320
CRAB	3556	2703	3320	4558	4719	5661	6452	5555	5012	9545
ABALONE	721	457	464	530	442	734	973	1076	1170	1347
OCTOPUS			80	56	82	136	381	629	655	612
SEA URCHIN										
RED			358	712	763	1011	1276	1108	1627	1907
GREEN								569	953	895
SEA CUCUMBER				22	94	236	768	961	998	775
SCALLOP		17	45	56	139	212	244	285	321	317
PLANKTON	6	0	19	42	89	113	102	192	223	300
SQUID			95	17	184	127	123	113	94	52
MUSSELS		tr	tr	tr	0	tr	tr	tr	tr	1
GOOSENECK BARNACLES							5	478	478	407
TOTAL TONNES	10449	9557	11182	15178	19142	21362	32527	37147	42184	40249

Appendix 1. Participants

1991 PSARC-Invertebrate Subcommittee Meeting

List of participants

August 26-28, 1991

Biological Sciences Branch, Pacific Biological Station

Neil Bourne	Glen Jamieson
Jim Boutillier	Don Noakes
Alan Campbell	Robert Elner
Jake Rice	Jim Irvine (PSARC Chair)

Fisheries Branch

Barry Ackerman	Kerry Hobbs
Steve Heizer	Marilyn Joyce
Frances Dickson	Randy Webb
Sue Farlinger	Greg Thomas (Subcom. Chair.)
Rick Harbo	Bruce Adkins
Brian Lunn	Cindy Harlow

Dave Mackas (Institute of Ocean Sciences)

Doug McKone, Biological Sciences Directorate, Ottawa

Appendix 2. List of position papers, science updates and fisheries updates submitted to 1991 PSARC Shellfish (Invertebrate) Subcommittee

Number	Title	Authors

POSITION PAPERS

Note: I91-2 and I91-5 were not presented.

I91-1	Blue Mussel (Mytilus edulis) mortalities in British Columbia..................................	G. Jamieson
I91-3	On growth and mortality of geoduck clams (Panope abrupta) (or How fast do all 'ducs go to heaven ?)	D. Noakes
I91-4	Commercial sampling of intertidal clams in Baynes Sound, June - July, 1990.........................	R. Harbo
I91-7	Size at maturity and fecundity of the abalone, Haliotus kamtschatkana (Jonas), in Northern British Columbia.	A. Campbell
I91-7	Leslie Analysis of logbooks from the dive fishery for abalone, Haliotus kamtschatkana, in British Columbia, 1977-1990................................	R. Elner
I91-8	Assessment of the area 124 shrimp, P. jordani, trawl fishery...................................	J. Boutillier
I91-9	Megalopal spacial distribution and stock separation in Dungeness Crab...........................	G. Jamieson
I91-10	Crab morphometry by geographical location and the appropriateness of a 110 mm escape ring regulation in British Columbia.........................	G. Jamieson
I91-11	Prawn Assessment using the Shrimp by Trap Logbook.	J. Boutillier C. Wallace
I91-12	Market sampling of sea cucumber in 1990..	S. Heizer

Appendix 2 (cont'd)

SCIENCE UPDATES

1. Preliminary report of a study on geoducks near Gabriola Island during 1990-91.............................. A. Campbell

2. Results of a preliminary survey of geoduck beds in the north coast.. S. Farlinger

3. Analysis of CPUE data from geoduck logbooks using the Leslie method....................................... A. Campbell
   R. Elner

4. Results of the 1990 WCVI clam survey........ S. Heizer

5. Preliminary report of intertidal clam surveys in 1991.
   .... N. Bourne
   D. Heritage
   G. Cadwell

6. The effects of repeated digging on sublegal-sized manila clams, _Tapes philippinarum_................. N. Bourne
   D. Noakes
   D. Heritage

7. Review of DFO Pacific Region euphausiid studies.
   .... D.Mackas

Appendix 2 (cont'd)

FISHERIES UPDATES

Molluscs

Geoducks	R. Harbo G. Thomas S. Heizer
Horse Clams	R. Harbo
Intertidal Clams	F. Dickson
Razor Clams	S. Farlinger
Mussels	G. Thomas
Oysters	N. Bourne
Scallops	N. Bourne
Octopus	S. Heizer
Squid	S. Heizer

Crustaceans

Crab	M. Joyce
Prawn	B. Adkins
Plankton	B. Adkins
Gooseneck barnacles	B. Adkins

Echinoderms

Green sea urchins	R. Harbo
Red sea urchins	R. Harbo G. Thomas
Sea cucumbers	S. Heizer G. Thomas

Pacific Stock Assessment Review Committee **PSARC Advisory Document 91-3**

CONTENTS

I. STEERING COMMITTEE REPORT

The PSARC Steering Committee met September 20, at the Pacific Biological Station, Nanaimo to review the Subcommittee report. The Steering Committee made the following comments in addition to support of Subcommittee recommendations:

1. Management objectives need to be defined for important groundfish stocks. This may be best initiated through a workshop.

2. The Steering Committee endorsed and encouraged the initiative by the Groundfish Subcommittee into research on assemblage management for certain B.C. groundfish species.
3. The problem in which stock assessments for individual species are used for coastwide management was again identified. This can result in overfishing of the most accessible stocks, resulting in disproportionate fishing pressure on localized stocks.

4. The Steering Committee notes that the potential rockfish yields presented in Table 2 represent levels which assume an unfished population. For stocks which are currently depressed, even the low risk option may lead to further stock declines.

5. The Steering Committee recommends that the Groundfish Subcommittee evaluate potential effects of different possible levels of marine mammal predation on lingcod stocks within the Strait of Georgia, before their next Subcommittee meeting.

6. The Steering Committee took note of the Groundfish Subcommittee's recommendation that details of investigations leading to changes in assessment methodology and results be included in assessment results. The Steering Committee considers that this

should be a general principle for all Subcommittees and that comparison of results from the new and old methodology should be presented.

II. GROUNDFISH SUBCOMMITTEE REPORT

BIOLOGICAL ADVICE ON MANAGEMENT OF BRITISH COLUMBIA GROUNDFISH FOR 1992

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

In 1991, the Subcommittee initiated a multi-year schedule for groundfish stock assessments and yield recommendations. This schedule specifies that major updates for most stocks will occur on a staggered, triennial basis, with statistical updates in intervening years. Intervening year assessments will also provide information on any significant changes in stocks, particularly those that may dictate more frequent assessment revisions. Recommended yield options will normally remain unchanged between major assessments. This initiative arose out of recognition of the time scale of the underlying population dynamics of most groundfish species. These species are long-lived and have extended recruitment phases, such that annual recruitment is a small proportion of the exploitable biomass. This means that the stock biomass supporting the fishery will normally change very little among years. Some shorter-lived groundfish species (e.g. Pacific cod) may require more frequent assessment updates. It is anticipated that this schedule will permit greater depth of investigation during major assessment years, and also provide more opportunity for economic planning by the groundfish industry.

Groundfish Section biologists begin their assessments in the spring of the year using a multi-year data base of fishery statistics and biological sampling. A variety of assessment models are used including several catch-at-age, age-independent surplus production, yield-per-recruit, and other linear models. Assessment working papers are completed in August and reviewed by the PSARC Groundfish Subcommittee, which includes management staff from the Offshore Division of Fisheries Branch. Stock assessments are assigned to reviewers by the Subcommittee chairperson, and written review comments are provided to the authors prior to the Subcommittee meeting. Reviews for major assessment revisions normally incorporate one external (government or non-government) and one internal investigator. Assessments and recommended yield options are then reviewed by the Subcommittee as a whole, before submission to the PSARC Steering Committee.

LIST OF 1991 ASSESSMENTS AND AUTHORS

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

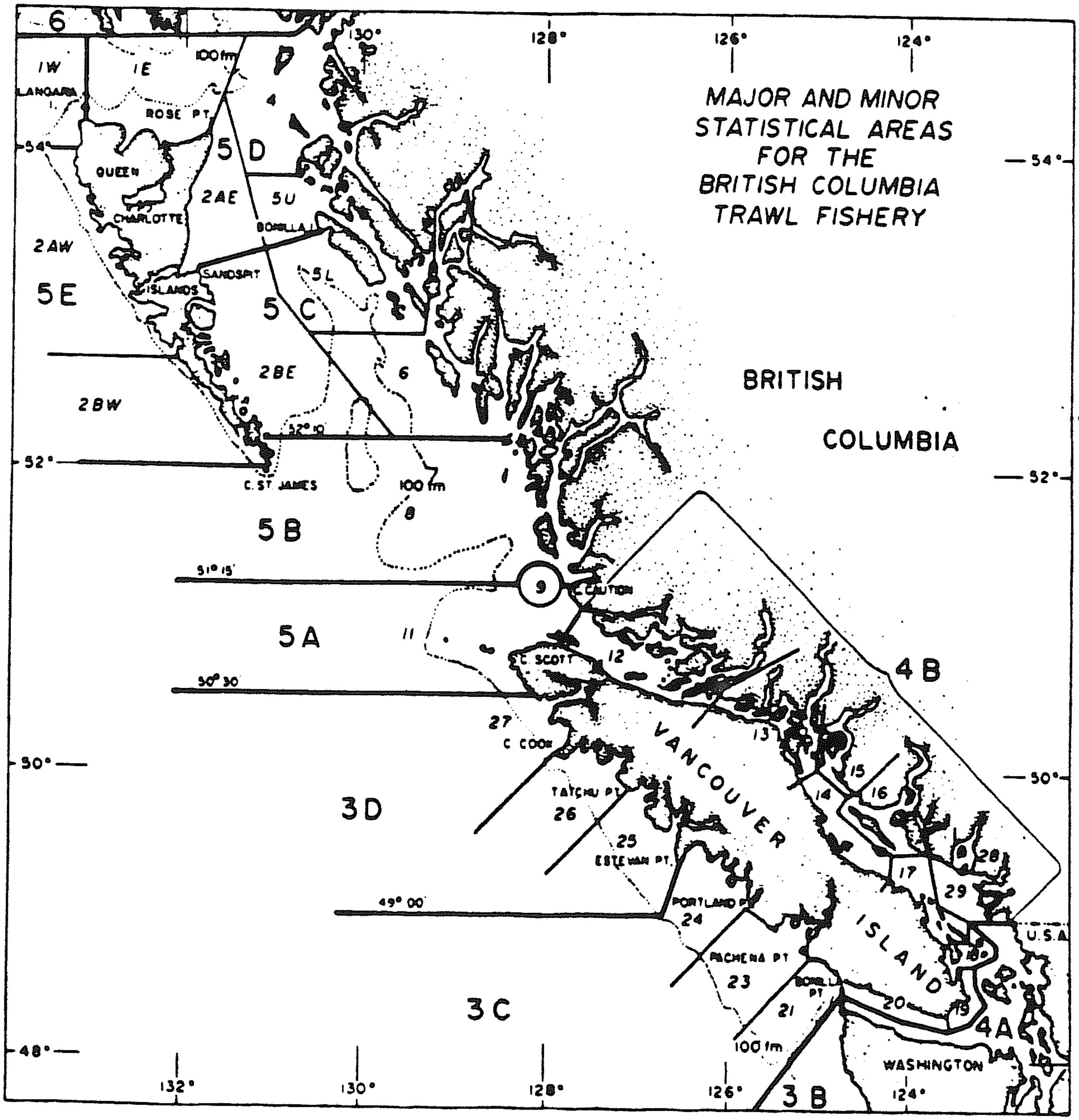

MAJOR AND MINOR
STATISTICAL AREAS
FOR THE
BRITISH COLUMBIA
TRAWL FISHERY
BRITISH
COLUMBIA
VANCOUVER
ISLAND
WASHINGTON
U.S.A.
QUEEN
CHARLOTTE
ISLANDS
ROSE PT.
SANDSPIT
C. ST. JAMES
C. SCOTT
C. COOK
ESTEVAN PT.
PORTLAND PT.
PACHENA PT.
5E
5D
5C
5B
5A
4B
4A
3D
3C
3B
2AE
2AW
2BE
2BW
1W
1E
100 fm
130°
128°
126°
124°
132°
54°
52°
50°
48°
52° 10'
51° 15'
50° 30'
49° 00'

Fig. 1.

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

Species or species group	Current stock condition
Strait of Georgia lingcod	Low
Offshore lingcod	Average
Pacific cod	Low to average*
Petrale sole	Low
Rock sole, English sole, Dover sole, and arrowtooth flounder	Average to high*
Sablefish	Average
Pacific hake	Average to high*
Spiny dogfish	Average to high*
Walleye pollock	Low to average*
Slope rockfish	Low to average*
Shelf rockfish	Low to average*
Inshore rockfish	Low to average*
Hagfish	Unknown
Pacific halibut	Low

* depending on specific stock.

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/rebuilding yield; (iii) equilibrium yield; (iv) high risk yield; (v) unrestricted yield. The conceptual basis for these categories was presented by Leaman and Stanley (1985) and is summarized here. If there is insufficient information upon which to base a scientific assessment of stock condition, investigators may not propose yield options. Yield options are intended to achieve appropriate levels of fishing mortality. It is these levels of fishing mortality that are the management objectives. Managers should be aware that maintenance of target fishing mortality requires changes in the level of fishing effort, which will not necessarily follow the same trend as that of stock biomass. Lower levels of fishing effort are required to produce the same level of fishing mortality, if CPUE increases with stock biomass increases.

(i) Zero yield

This option could be entertained in situations of known and severe stock depletion, or where particular areas may represent necessary refugia for stocks. Additional ecological considerations might include, for example, situations where a subject stock acts as a predator on a less desirable species, and the object is to maximize that predation.

(ii) Low risk or rebuilding yield

Under this option the probability of overfishing is minimized while the probability of rehabilitation for depleted stocks is increased. With the exception of option (i), this option will incur the lowest risk of deleterious fishing effects on stock biomass or dynamics. However, management should be aware that some yield from the stock may be lost to the fishery under this option.

(iii) Sustainable or equilibrium yield

This option provides some opportunity to maintain stocks at existing levels. In many ways this is the least certain of the options available since it entrains many assumptions about the behaviour of stocks in response to fishing and biological processes. The term 'sustainable' should be understood in its broad sense, i.e., that the stock will undergo natural increases and decreases around the expected level as a result of oscillations in recruitment, rather than be maintained at a fixed level. The amplitude and frequency of these oscillations will vary considerably among and within stocks at different levels of biomass.

(iv) High risk or non-sustainable yield

Employment of this option implies either experimental or non-biological management, since stock declines are highly probable with this option in effect over a significant proportion of the average life of a population cohort. Instances where this option might be exercised include: economic or social conditions requiring short-term yields which are higher than could be sustained over longer periods; experiments where knowledge of the effects of well defined and disparate exploitations rates is required; or, attendant management policies that require pulsed fishing mortality on a number of different stocks.

Concomitant to the use of this option is the requirement that management will have to shift to a more conservative option prior to major and irreversible changes in the target stock. Therefore, the use of this option either guarantees a pulsed exploitation pattern, or accepts short-term yield over long-term productivity. The hazard associated with this option will vary with the biological characters of the target stock. In particular, the residence time of a cohort in the exploited stock will be a key determinant in the detection and response times for the effects of the option. Where residence is long, yields may be maintained over several years in spite of strongly deleterious, yet undetected, effects on stock productivity.

(v) Unrestricted yield

A very limited number of situations would call for consideration of this option. Depletion of stocks and elimination of fisheries when harvests are uncontrolled are well documented throughout the world. However, this option might be considered for experimental purposes, or for control of competing non-commercial and commercial species. It should only be employed after thorough review of potential consequences.

Risk assessment

Assessment biologists are actively investigating the quantification of the risks to future productivity, associated with various yield options. This process also involves an analysis of the sensitivity of recommended yields to uncertainty in both the input data and the models which describe population dynamics. At present, these analyses have been performed for only a very few stocks. However, both this and other work indicate that the risk to stock productivity is not uniform across yield options. Rather, there is a sharply increasing risk as yield increases, and the potential changes in stock dynamics are much greater with high risk yield options than with low risk options. This non-linear risk trajectory should be considered in the choice of yield options.

Other management measures

The fishery for groundfish is characterized by multiple gear types and multi-species catches. Managers, biologists, and fishermen have noted that three principal difficulties are created by these characteristics. First, biological interactions among species may affect the simultaneous maximization of potential yield for all co-existing species. Second, where there are multiple quotas on a group of co-existing species, the species quota that is taken first could close down fishing on the entire group. Third, multiple gear types may compete for the same quotas. At present biological interactions are not built explicitly into most stock assessments. In a few cases, species-mixture or group quotas are given, and an area not closed until the group quota is reached. Species ratios are checked for imbalance. If a gross imbalance is found, the group quota may be adjusted. However, management has employed trip limits and quarterly quotas to spread the yield of lower production species throughout the year. It should be noted that these measures are management, rather than biological constructs.

MAJOR FISHERY CONCERNS

With the adoption of coastwide trip limits for most rockfishes the groundfish fleet does not apply fishing effort on individual stocks in an ordered manner. Instead, vessels have fished at the closest point offering acceptable catch rates, regardless of stock productivity. Some stocks are therefore experiencing excessively high exploitation rates. The long term effects of this are clear and serious. A coastwide management tool cannot achieve individual stock goals, where area stock productivities are grossly different. Management must address the philosophical divergence of individual stock assessment and coastwide management. Several investigations into assemblage management for B.C. groundfish are in progress. However, it should be noted that long-term total yields from such assemblages will generally be lower than those which could be achieved through individual stock management. The latter is due to the differences in productivity and historical exploitation of constituent species in the assemblages.

For inshore areas, rockfish species (quillback, copper, yelloweye rockfish) are being taken in some locations of the Queen Charlotte Strait, Johnstone Strait, and Strait of Georgia at rates greater than can be supported by natural production. Strait of Georgia lingcod have been over-exploited in the past and continue to be. There is evidence that the initial depletion of lingcod was due to the commercial fishery. That fishery is now closed and the sports fishery, which accounts for all fishery removals, is also under restriction. The Subcommittee expressed concern that natural predation by marine mammals may produce mortality sufficiently large to interfere with attempts to rehabilitate this stock.

The Pacific cod fishery in Hecate Strait will require yield restrictions for 1992, to ensure a minimum spawning biomass is maintained. The 1991 fishery produced very high fishing effort on post-spawning aggregations of Pacific cod in this area. Such an effort distribution has not been observed previously, and resulted in a catch that was twice the predicted level. Stock size at the end of 1991 was estimated to be below a minimum spawning biomass and a quota on this fishery is proposed, for the first time. It is anticipated that adherence to this quota will produce the necessary remedial results on the stock.

Several assessments noted that changing fishery regulations (trip limits) and frameworks (IQ systems) tend to erode the value of traditional indices of relative abundance, such as CPUE. This trend means that assessment biologists and managers must attempt to design management strategies which both achieve stock objectives and preserve the value of fishery-based indices of abundance, wherever possible. Biologists may also have to develop new and fishery-independent indices of stock abundance. This is likely to raise additional funding issues within the Department, and initiatives to offset the cost of such indices through joint funding with industry should be explored.

ADDITIONAL SUBCOMMITTEE DISCUSSIONS

The subcommittee addressed several other issues bearing on the quality of assessment information. These items will be investigated in greater detail in the coming year. Briefly, they concern: how well creel surveys, normally designed for salmonids, reflect groundfish catches; whether bycatch of a species in non-target fisheries can be used as a tuning index for directed fishery population models; the feasibility of a multispecies juvenile survey for elucidating incoming recruitment strength for groundfish; and, further assessment of the density of nearshore rockfish by habitat type.

SUMMARIES OF ASSESSMENTS AND REVIEWERS' COMMENTS

Lingcod

Lingcod stocks were assessed by examination of historical trends in catch and CPUE, and by mortality rate estimation from age data and a size-structured model. The Strait of Georgia lingcod stock has declined in abundance since the 1950s and is now at an extremely low level. A complete closure to all gear types is recommended. Off the west coast of Vancouver Island and in Queen Charlotte Sound, stocks are at moderate to high levels, with yields ranging from 2900-5800 t for 1992. The 1985 year-class appears to be above average in strength and is helping to maintain the offshore stocks at current abundance levels.

There were two reviews of the lingcod assessment. Both reviewers considered that the decline of lingcod abundance in the Strait of Georgia was well documented and supported by the assessment. One reviewer requested that more detail be included on some statistical aspects of CPUE calculation in the analysis for the Strait of Georgia. Neither reviewer disagreed with recommended yield options for other stock units. However, both reviewers expressed concern about CPUE estimation for the west coast of Vancouver Island. These concerns involve the effort standardization procedure and the estimation of catchability, but were not perceived to bias the assessment of stock condition and will be addressed by the author. One reviewer also noted that the issue of stock identity of the Vancouver Island stock was not well established in relation to the Canada-U.S. boundary area. A complete analysis of joint tagging information was suggested. Finally, the reviewers noted that there appears to be sufficient material available to conduct an age-structured analysis, particularly if ageing data from the two countries can be combined. The authors noted that some of the Canadian age data became available only recently.

The Subcommittee noted that the mortality caused by marine mammals in the Strait of Georgia was not well determined. If the estimate is reasonable, this mortality might have a large impact on rebuilding of this stock, since it is likely to increase with the mammal population and may use all of the available surplus production from the stock. The Subcommittee also discussed the value of a winter closure for areas outside of the Strait of Georgia. It was agreed that a winter closure, to reduce total fishing mortality, was not warranted by stock conditions at this time. It was also noted that implementation of such closures requires a clear statement of intent with regard to recruitment or growth overfishing. Lastly, the Subcommittee agreed that cooperation of investigators in the two countries would help resolve the potential issue of transboundary movement.

Pacific cod

The major Pacific cod stocks for which assessments have been conducted are located off the lower west coast of Vancouver Island (La Perouse Bank region), and in Hecate Strait. Catch statistics were also compiled for the Strait of Georgia and Queen Charlotte Sound stocks. At the beginning of 1991 both the Hecate Strait and the La Perouse stocks were at average levels of abundance, based on their CPUE indices. Length-frequency analysis indicated that recruitment has been average to above average for these two stocks during the past two years. The 1989 year-class, now recruiting to the fishery, was estimated as above average in Hecate Strait, but only average in the La Perouse stock. For Hecate Strait, potential yields were estimated with a simple age-structured simulation model. A very intense fishery developed in Hecate Strait during April and May of 1991, resulting in over 6000 t of landings from the stock by June 30, 1991. These landings were well in excess of the estimated potential yield of 3400 t. Though a closure was placed on the stock during the spawning season in 1991, no annual quota or other catch limitations were implemented since effort levels for the last three years had been moderate. Because of the new intensity of the Pacific cod fishery in Hecate Strait and the resultant 1991 overfishing, a yield of 1200-2600 t has been recommended for the stock, combined with a closure from January 1 to April 15. Management measures are considered unnecessary for the La Perouse stock due to continued moderate effort levels there.

The single reviewer of this assessment noted some technical issues related to CPUE standardization and mortality rate estimation. The estimate of natural mortality has high statistical variance and the reviewer suggested that different estimation procedures would lead to a lower estimate. It was also noted that the biological reference points for determination of yield levels were not articulated, although reference to minimum spawning stock size for the Hecate Strait stock was made. The reviewer agreed that further restrictions on the Area 5C-5D fishery are warranted, but believed that the yields could be as much as 400-800 t greater than proposed levels.

The Subcommittee reviewed the implications of a change in mortality rate with the authors. It is believed that, while the estimate may be somewhat high, the effect on the yield estimation would not be great. It was agreed that restrictions on the 1992 fishery are required. Pending review of fourth quarter fishery data for resolution of incoming recruitment, the Subcommittee endorsed the yield recommendations of the authors.

Flatfish

Flatfish stocks were assessed in 1991 on an interim basis. No new analysis was completed, but standardized landing statistics were updated and adjusted for the effect of changes in vessel horsepower over time. Stocks were assessed based on trends in standardized landing statistics. Petrale sole stocks were determined to be at low levels, rock sole stocks at average to high levels, and English sole and Dover sole stocks at above average levels. Abundance of the rock sole stocks in Areas 5A-D continued to remain at above average levels due to strong recruitment. Sustainable yield estimates for rock sole stocks in all areas remain unchanged from 1990 assessments. An increase in landings of English sole in Hecate Strait in 1990 was coincidental with an increase in the abundance index (CPUE). CPUE for Areas 3C-3D Dover sole and Area 5C-5E Dover sole remained stable in 1990.

The reviewer of this assessment endorsed the recommendations but noted that trip limits will be effective control measures only if effort patterns remain relatively constant. Increased effort levels may require in-season controls. The lack of information on the current level of recruitment, which is used as a reference point, for Areas 5A and 5D rock sole was noted. The author will insert this information. The reviewer also requested an accounting for achievement of trip limits in future assessments, so that potential problems with discarding can be monitored. It was also noted that quotas for flatfish in Hecate Strait are not generally enforced, out of deference to the Pacific cod fishery. Since this is de facto assemblage management, there should be increased emphasis on completing the scientific studies supporting assemblage management.

The Subcommittee endorsed the recommendations of the assessment and agreed that assemblage management studies should be completed.

Sablefish

Overall, the condition of the sablefish stock in the Charlotte-Vancouver area is good. Nominal CPUE values remain high and several indices of recruitment indicate that recruitment from several year-classes in the 1980's is estimated to be above average. Examination of the variation in population parameters by area and depth indicates that the proportion of fish that are both older and have smaller size-at-age increases with depth. Yields ranging from 2900 to 5000 t, based on previous age-structured analysis were presented as low to high risk yield options for 1992.

The two reviewers of the assessment noted a general lack of detail on the sequential population model and the reference points for the yield recommendations. Both reviewers believed the biological information in the first section of the assessment could be reduced and restructured. One reviewer expressed strong reservations about the reliability of the results of the sequential analysis, based on limitations in the quality and quantity of the data upon which it is based. He also believed that fishery-based indices of relative abundance are generally unreliable and endorsed development of alternative indices. The authors agreed with many of the comments received and the first portion of the document will be revised. However, they noted that an appreciation of these elements is an important part of understanding the present difficulties in the interpretation of fishery-based information. The shortcomings of the sequential analysis were acknowledged and the authors noted that this analysis is scheduled for major revision. They also indicated that incoming recruitment appears above average.

The Subcommittee noted the concerns of the reviewers and agreed that caution is warranted until incoming recruitment is more fully assessed and the sequential model is revised. It therefore suggests that managers do not adopt a high risk yield option for 1992.

Pacific hake

The inshore hake fishery remains stable with landings of 7092 t and 7077 t in 1990 and 1989, respectively. No new analyses were conducted and yield options remain unchanged from the previous assessment. Previously, a forward simulation model was used to project spawner biomass and yield at varying levels of recruitment. The model, using results from a virtual population analysis, indicated that low to high risk yields range from 8000 t to 14000 t, respectively. Assessment information for the offshore stock is developed in concert with U.S. agencies and is not yet available.

The reviewer of this assessment raised only minor technical issues and endorsed the recommendations. The reviewer did note that the catch may attain the quota for the first time in 1991. The assessment may therefore require increased attention in the future.

The subcommittee endorsed the yield recommendations for Area 4B. Management staff noted increasing interest in this stock for at-sea processing by joint venture, and supported the reviewer's comment on increased attention to this stock assessment in future.

Dogfish

The stock assessment for spiny dogfish in both offshore and Strait of Georgia waters remains unchanged from last year. A summary of fishery statistics for the 1979-1990 period details recent catch and effort patterns. Directed effort for spiny dogfish remains market driven. Current harvest rates are below the level of low risk for a sustainable fishery for both areas. Yield options for 1992 are unchanged from those of recent years at 9000-25,000 t for the offshore stock, and 4000-6000 t for the Strait of Georgia-Puget Sound stock.

The reviewer requested more detail on statements concerning the marginal economics of the fishery and the data limitations of the age-structured model. The author responded that ongoing biological studies are expected to provide resolution of conflicting information concerning age-specific fecundity for the next assessment. Additional information requested by the reviewer will be provided in the revised document.

The Subcommittee endorsed existing yield recommendations.

Walleye pollock

The 1990 pollock catch in the Canadian domestic fishery increased from 504 t in 1989, to 986 t in 1990. The 1990 incidental catch in the joint-venture and foreign hake fisheries decreased to 584 t, from 907 t in 1989. 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, are 1500 and 3700 t, respectively. Yield options are not proposed for stocks of the west coast of Vancouver Island and in Dixon Entrance/Hecate Strait.

The reviewer of this assessment noted a number of minor technical issues to be resolved by the author. She also noted that not all of the yield estimates mentioned in the abstract were discussed in the text. The author will provide the appropriate text. Lastly, the lack of a single table presenting landings from all fisheries on the Vancouver Island stock was noted.

The Subcommittee endorsed the yield recommendations. It also noted that the mortality rate for this species is under review and may affect subsequent assessments. The general effect will be a decrease in estimated yields, however it was noted that there are presently no extensive fisheries for this species in B.C. waters.

Slope rockfish

No new analyses were conducted for slope rockfishes (Sebastes alutus, S. reedi, S. aleutianus, and S. proriger) in 1991. Based on previous assessments, stocks of Pacific ocean perch (S. alutus) are generally depressed and have shown no recovery from lowered abundances caused by high fishing mortalities during the mid-1960s. Coastwide yield estimates range from 3350-5470 t. Yellowmouth (S. reedi), rougheye (S. aleutianus) and redstripe (S. proriger) rockfishes are in moderate to poor condition with coastwide yield estimates of 1160-2450 t, 250-400 t, and 1450-3270 t, respectively. The lack of adherence to stock-specific yield options, resulting from the use of coastwide trip limits, was noted in the assessment.

The reviewer of this document endorsed the yield options presented and complimented the author for the inclusion of a table, indicating the reference points for yield options of each stock. However, some technical deficiencies were identified. He noted that CPUE trends were difficult to interpret without consideration of effort data, and requested that such data be included in all tables. He expressed concern that a time series of standardized CPUE was dismissed, but details on the problems with the series and its relationship to other indices were not included. A clarification of the effects of trip limits on CPUE indices was also requested. The author responded that an analogue to effort data could be calculated from elements of the tables, but acknowledged that effort was not directly available and would be added. She also presented verbal details on investigations of effort standardization and indicated that general revisions would be incorporated in the next assessment.

The Subcommittee endorsed the yield recommendations of the assessment. It also endorsed the continuation of the experimental program in Area 5E(N). The lack of adherence to stock-specific yields and consequent overexploitation of some stocks is a cause of concern. The same concern was noted in previous years. The Subcommittee also agreed that, as a general principle, details of any investigations leading to changes in assessment methodology and results be included in the assessment reports.

Shelf rockfish

Interim assessments are presented for seven shelf rockfish stocks. Quota recommendations are unchanged from the previous year. The recommendations for the three silvergray rockfish stocks of Areas 3C-3D (Vancouver Island), Areas 5A-5B (Queen Charlotte Sound), and Areas 5C-5D (Hecate Strait) are 400-600 t, 200-700 t, and 400-600 t respectively. For the two canary rockfish stocks of Areas 3C-3D and Areas 5A-5B, the recommended yield ranges are 400-600 t and 350-500 t. The recommended yield range for the joint U.S. and Canadian yellowtail rockfish stock in Areas 3B-3C is 1000-2000 t.

For Area 3D and Areas 5A-5B, the recommended yellowtail rockfish yield ranges are 500-1000 t and 1400-3000 t.

Standardized indices of CPUE have declined in all major canary and silvergray rockfish fisheries. We advise managers that the full assessment of shelf rockfish that is scheduled for 1992 will probably result in lower recommended yield ranges for these five stocks. In the interim, we suggest that managers consider choosing lower quotas from within the recommended yield ranges for silvergray and canary rockfish stocks.

The reviewer endorsed the yield options presented in the document but noted some inconsistencies in data between text, tables, and figures. The author will correct these items in re-draft.

The Subcommittee commented on the change in yield options for some canary and silvergray rockfish stocks and some inconsistency in their interpretation. It was agreed that, since one of the objectives of the new assessment schedule was to provide some stability, yield options should remain in place during interim assessments unless extraordinary events occur. In the case of these shelf rockfish assessments, it was agreed that changes in the indices of abundance should be noted but that managers had sufficient scope within existing yield options to respond to concerns expressed in the assessment. It was therefore recommended that managers exercise caution in setting quota levels for these canary and silvergrey rockfish stocks.

Inshore rockfish

Inshore rockfish stocks were assessed by historical trends in catch, CPUE, fishing fleet size and pattern of movement, and changes in size and age structure of commercial fishery samples. The line rockfish fishery has continued to expand in all areas of the coast. In general, the stock condition is poor in the Strait of Georgia, and unknown in other areas. Productivity estimates by statistical area were determined by multiplying catch density estimates (t/km^2) by the size of the rockfish habitat within each statistical area (km^2). Rockfish habitat within each statistical area was defined using depth ranges, and the size of the rockfish habitat areas were determined using a geographic information system.

To determine appropriate catch densities, hence productivity levels, two extreme catch densities were identified on an area-by-area basis for the Strait of Georgia. The low estimates of catch density were determined using 1980 catch figures. The 1980 catches were chosen to reflect pre-fishery expansion densities. High estimates of catch density were determined by selecting the peak-fishery catch figures for any year between 1980-90, where the area subsequently showed clear evidence of stock decline. Catch densities used to determine risk levels were chosen as one third and one half of the estimated peak fishery density, respectively. Additionally, grouped area estimates of productivity are presented. These estimates are assessed at 75 percent of the summed area estimates, in recognition of the difficulty of simultaneously managing all areas with adequate precision. In all areas, estimates of the potential catch were based on the size of the rockfish habitat area and all rockfish removals from an area were included in the habitat analyses. These included sport and incidental catch, as well as directed commercial fishery catch.

The two reviewers complimented the authors for the compilation of new data on the Strait of Georgia stocks. However, one reviewer requested re-organization of this material to provide a more coherent framework for presentation of material on given stocks. The reviewer also stressed that the presentation should focus on areas where we have detailed knowledge, and indicate the relevance of findings in other jurisdictions. Both reviewers appreciated the initiative looking at yield options from the perspective of habitat productivity. They noted that this presentation should be clarified, particularly because yield options include all removals from stocks (including sport catches and incidental capture in other fisheries). Because yield options for all areas are based on productivity estimates from the Strait of Georgia and apply to all species caught with hook gear, both reviewers expressed concern that conservative management options should be selected for these outside areas, until their productivity can be assessed directly.

The Subcommittee endorsed reviewers' comments on re-organization of tabular material into a more appropriate framework, and an improved presentation of the source of the density and sustainability estimates for the habitat-based yield options. There was extensive discussion of whether the estimates provided were indeed sustainable, but no resolution of this issue was possible. Instead, the Subcommittee recommended that low risk options be employed by managers. Management should note that options include all rockfish species in an area captured with hook gear, and removals by all gear sectors (directed commercial, bycatch, and sport).

Hagfish

The experimental hagfish fishery in B.C. is new and information on the life history and population parameters of the species is limited. Catch statistics were summarized for the fishing period (October 1988 June 1991) and changes in CPUE discussed. It is recommended that the fishery remain classified as experimental until more information on hagfish biology is known.

The reviewer noted that extensive biological sampling has been conducted as a mandatory component of the management of this fishery, yet none of these data were presented. The obligation to present these data was noted and their inclusion requested. The authors agreed to include these data in re-draft. The reviewer also requested that the future direction of the assessment be identified. In particular, the authors should consider some alternative estimates of productivity, such as those based on habitat.

The Subcommittee agreed with the reviewer's request for presentation of results of biological sampling, especially those data for the index site. Although noting the paucity of knowledge for the species, the Subcommittee endorsed the request for an identification of the future direction for the assessment. In the interim, expansion of this experimental fishery was not encouraged.

Pacific halibut

A section on the assessment of the Pacific halibut stock in British Columbia has not traditionally been included in the report of the PSARC Groundfish Subcommittee. However, the increasing interaction of trawl and hook fisheries, where halibut and groundfish are captured jointly, has accentuated the need for optimization of both directed landings and bycatch of these species. Therefore, we present a synopsis of the halibut stock assessment conducted by the International Pacific Halibut Commission in January 1991, pertaining to the 1991 fishing year. The halibut resource continued the decline recorded in recent years, although the rate of decline increased in 1990. The recruitment to the stock in 1990 was the lowest on record and the stock is projected to continue to decline in biomass until at least the mid-1990s. Yield to the setline fishery is decreased by high levels of incidental mortality of halibut in non-directed trawl fisheries, primarily in the Gulf of Alaska. Approximately 28% of the available yield was expropriated for bycatch mortality compensation in 1991. The recommended yield from the total stock in 1991 was 25,111 t (55.36 million lb, net weight), and that for British Columbia waters was 3352 t (7.39 million lb).

The reviewer noted that this document was simply a summary of the IPHC assessment but requested clarification of several items. Specifically, more details on the bycatch compensation procedures, the reference points for bycatch reduction, and the recent trends in CPUE were requested. She also identified errors in presentation concerning cohort identification. The author will correct and clarify the items identified by the reviewer.

The Subcommittee noted that this document reports on an assessment conducted in another forum. However, it identified the lack of relevance of CPUE in the directed fishery for halibut, and suggested that bycatch in other groundfish fisheries may provide a tuning index for the halibut stock model. The author will present this concept to the appropriate IPHC staff.

TABLE 1.
RECOMMENDED YIELD OPTION SUMMARY

The recommended yield options for 1992 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	SPECIES	YIELD OPTIONS
4B	Lingcod	Zero yield.
Minor area 12	"	Winter closure Size limit of 65 cm.
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/E	Lingcod	No options proposed.
4B	Pacific cod	No options proposed.
3C/3D	Pacific cod	No options proposed.
5A/5B	Pacific cod	No options proposed.
5C/5D	Pacific cod	Low risk yield 600 t Sustainable yield 1200 t High risk yield 2600 t
5E	Pacific cod	No options proposed.

AREA	SPECIES	YIELD OPTIONS
Coastwide	Petrale sole	Low risk yield 10,000 lb trip limit, Jan.-March High risk yield 44,000 lb trip limit, Jan.-March
4B	Flatfish	No options proposed.
3C/D	Dover sole	Low risk yield 500 t Sustainable yield 1300 t High risk yield 2000 t
5A	Rock sole	Low risk yield 250 t (with 30,000 lb trip limit) High risk yield 500 t
5B	Rock sole	Low risk yield 250 t (with 30,000 lb trip limit) High risk yield 600 t
5C	Rock sole	Low risk yield 100 t High risk yield 400 t (with 30,000 lb trip limit)
5D	Rock sole	Low risk yield 800 t (with 30,000 lb trip limit) High risk yield 1000 t
5C/D	English sole	Low risk yield 700 t High risk yield 1000 t
5C/D/E	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

AREA	SPECIES	YIELD OPTIONS
4B, except MSA 19, 20	Pacific hake	Low risk yield 8000 t Sustainable yield 11,000 t High risk yield 14,000 t
3C	Pacific hake	Yield options to be announced at a later date when all current biological information is collated in the joint Canada-U.S. assessment algorithm
Coastwide (including U.S. waters)	Dogfish	Yield option 1: No 1st and 2nd quarter fishery low risk 15,000 t high risk 25,000 t Yield option 2: 1st and 2nd quarter fisheries only low risk 9000 t high risk 15,000 t Yield option 3: Pulse fishing. The impact of specific pulse fisheries proposed by management can be assessed when proposed.
4B, not including MSA 12, 19, and 20	Dogfish	Low risk yield 4000 t Strait of Georgia-Puget Sound (2,000 t Strait of Georgia only) High risk yield 6000 t Strait of Georgia-Puget Sound (3,000 t Strait of Georgia only).
4B	Walleye pollock	Low risk yield 1500 t High risk yield 3700 t

AREA	SPECIES	YIELD OPTIONS
3C-5E	Walleye pollock	No options proposed.
3C options (including Area 125)	Pacific ocean perch	Low risk yield 100 t High risk yield 200 t
3C	Redstripe rockfish	Low risk yield 200 t High risk yield 1000 t
3D	Pacific ocean perch	Low risk yield 200 t High risk yield 600 t
3D/5A	Yellowmouth	Low risk yield 250 t High risk yield 750 t
3D/5A	Redstripe	Low risk yield 350 t High risk yield 900 t
5A/5B	Pacific ocean perch	Low risk yield 700 t High risk yield 1000 t
5C/5D	Pacific ocean perch	Low risk yield 1900 t High risk yield 3000 t
5C/5D	Yellowmouth	Low risk yield 160 t High risk yield 500 t
5C/5D	Redstripe	Low risk yield 350 t High risk yield 570 t
5E(S)	Pacific ocean perch	Low risk yield 300 t High risk yield 500 t
5E(S)	Yellowmouth	Low risk yield 400 t High risk yield 700 t

AREA	SPECIES	YIELD OPTIONS
5E(S)	Rougheye	Low risk yield 200 t High risk yield 300 t
5E(S)	Redstripe	Low risk yield 50 t High risk yield 100 t
5E(S)	Grouped slope rockfish (Pacific ocean perch, yellow mouth and rougheye)	January-June Low risk yield 300 t High risk yield 500t September-December Low risk yield 600 t High risk yield 1000 t
5E(N)	Pacific ocean perch	Experimental fishing area
5E(N)	Yellowmouth	Experimental fishing area
5E(N)	Rougheye	Experimental fishing area
5E(N)	Redstripe	Experimental fishing area
5E(N)	Slope rockfish (Pacific ocean perch and rougheye)	Experimental fishing area
3B-3C* *Combined U.S. & CDN. quota	Yellowtail rockfish	Low risk yield 1000 t High risk yield 2000 t
3D	Yellowtail rockfish	Low risk yield 500 t High risk yield 1000 t

AREA	SPECIES	YIELD OPTIONS
5A/5B	Yellowtail rockfish	Low risk yield 1400 t High risk yield 3000 t
3C/3D	Silvergray rockfish	Low risk yield 400 t High risk yield 600 t
5A/5B	Silvergray rockfish	Low risk yield 200 t High risk yield 700 t
5C/5D	Silvergray rockfish	Low risk yield 400 t High risk yield 600 t
5E(S)	Silvergray rockfish	No options proposed
3C/3D	Canary rockfish	Low risk yield 400 t High risk yield 600 t
5A/5B	Canary rockfish	Low risk yield 350 t High risk yield 500 t
3C-5E	Hagfish	Experimental fishery
3C-5E	Pacific halibut	Sustainable yield 3352 t

Table 2. Estimated productivity of inshore rockfish stocks, by statistical area and grouped area, for "red snapper" and "rockfish" species categories. These levels reflect productivity at virgin conditions and will not apply if significant fisheries have occurred. Grouped area productivity estimates are assessed at 75% of the sum of the individual area productivity estimates.

Statistical area	"red snapper" low risk	"red snapper" high risk	"rockfish" low risk	"rockfish" high risk
Queen Charlotte Islands				
1, 101	32	48	92	138
2, 102	63	94	260	390
130	4	6	2	4
142	7	11	11	16
Grouped area	80	119	274	411
North Coast				
3, 103	6	10	13	20
4, 104	22	33	132	198
5, 105	39	58	191	286
Grouped area	50	76	252	378
Central Coast				
6, 106	62	92	102	153
7, 107	55	83	69	103
8, 108	33	50	143	214
9, 109	10	16	7	11
10, 110	16	25	35	53
Grouped area	132	200	267	400

Table 2. (cont'd).

Statistical area	"red snapper" low risk	"red snapper" high risk	"rockfish" low risk	"rockfish" high risk
Strait of Georgia				
12	19	28	65	97
13	9	13	33	49
14	8	12	22	33
15	6	8	16	25
16	5	8	13	19
17	3	4	24	35
18	4	6	20	31
19	6	9	25	37
20	9	13	9	14
28	3	4	7	11
29	7	10	12	18
Grouped area	59	86	185	277
West Coast				
11, 110	41	61	134	200
21, 121	12	17	28	42
23, 123	34	51	95	142
24, 124	32	48	135	202
25, 125	23	35	66	99
26, 126	12	19	74	110
27, 127	22	33	63	94
Grouped area	132	198	445	668

REVIEWER ASSIGNMENTS FOR GROUNDFISH STOCK ASSESSMENTS

Title	Authors	Reviewers
Lingcod	Richards, Yamanaka	Jagielo, Stanley
Pacific cod	Tyler, Hand	Richards
Flatfish	Fargo	Saunders
Sablefish	Saunders, McFarlane	Schweigert, Tyler
Dogfish	Thomson	Fargo
Walleye pollock	Saunders	Neville
Pacific hake	Saunders	Thomson
Slope rockfish	Richards	Leaman
Shelf rockfish	Stanley	Hand
Inshore rockfish	Yamanaka, Richards	Farlinger, McFarlane
Hagfish	Neville, Beamish	Yamanaka
Halibut	Leaman	Thomson

PARTICIPANTS AT THE GROUNDFISH SUBCOMMITTEE MEETING
August 29-30, 1991

NAME	AFFILIATION
B. Leaman, Chairman	BSB, Groundfish Section, Nanaimo
B. Ackerman	FB, Offshore Division, Vancouver
D. Adams	"
G. Buechler	"
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S. Farlinger	FB, North Coast Division, Prince Rupert
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R. Harbo	FB, South Coast Division, Nanaimo
J. Irvine	PSARC Chairman, Nanaimo
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L. Richards	"
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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, 1980-1990.

Species	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1980-89	1990[b]
English sole	1,244	1,500	559	532	812	692	452	755	879	1,041	847	1,266
Rock sole	1,843	1,059	745	668	525	430	454	887	1,960	2,066	1,064	2,264
Petrale sole	222	290	367	439	417	336	416	445	790	952	467	1,063
Dover sole	1,273	1,245	914	871	1,148	963	1,167	633	1,281	2,149	1,164	2,403
Rex sole	145	190	74	49	219	205	87	83	145	140	134	134
Starry flounder	118	198	168	66	170	66	54	65	110	123	114	143
Turbot	1,448	946	525	323	369	764	895	1,193	375	609	745	2,641
Other flatfish	57	183	220	199	141	161	215	232	147	50	161	53
Pacific cod	8,703	6,708	4,810	4,505	3,465	2,342	3,650	13,917	11,015	9,149	6,826	6,465
Lingcod	2,151	2,467	4,162	3,755	3,688	5,668	3,827	3,591	3,462	3,980	3,675	5,184
Sablefish	3,793	3,888	3,976	4,414	3,855	4,275	4,668	4,719	5,770	5,493	4,485	4,718
Pollock	2,201	1,251	924	1,070	800	1,895	577	1,270	1,111	443	1,154	941
Hake	606	5,691	2,826	3,122	4,600	6,055	6,802	13,275	6,054	8,682	5,771	10,544
Ocean perch	5,290	5,103	5,983	5,655	6,698	6,069	5,914	6,335	6,929	6,004	5,998	5,842
Other rockfish	4,476	4,857	5,093	7,024	8,512	11,709	19,040	18,177	20,399	18,437	11,772	22,835
Misc. species	303	266	141	156	175	192	245	344	353	172	235	124
Dogfish	4,547	1,151	3,875	3,274	2,510	2,815	3,289	3,801	5,483	2,780	3,353	3,371
Hagfish	-	-	-	-	-	-	-	-	66	829	90	175
Animal food	191	42	65	94	161	309	255	188	130	127	156	17
Reduction	528	302	450	321	244	214	175	210	581	353	338	209
Total	39,139	37,337	35,877	36,537	38,509	45,160	52,182	70,120	67,040	63,579	48,548	70,392

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

[b]Preliminary data.

Table 4. Joint-venture and foreign catches[a] (t) of groundfish from international Area 3C -- southwest coast of Vancouver Island in 1990.

Nation and species	Joint-venture Quota (t)	Joint-venture Catch (t)	Supplemental Quota (t)	Supplemental Catch (t)	Total
Poland					
Pacific hake	32,500	32,527	4,000	3,976	36,503
Walleye pollock	incidental	402	incidental	1	403
Pacific ocean perch	incidental	tr.	incidental	5	5
Other rockfish	incidental	163	incidental	123	286
Other species	incidental	1	incidental	-	1
USSR					
Pacific hake	20,000	19,918	-	-	19,918
Walleye pollock	incidental	92	-	-	92
Pacific ocean perch	incidental	-	-	-	0
Other rockfish	incidental	84	-	-	84
Other species	incidental	-	-	-	0
Japan					
Pacific hake	17,000	16,848	-	-	16,848
Walleye pollock	incidental	43	-	-	43
Pacific ocean perch	incidental	-	-	-	0
Other rockfish	incidental	52	-	-	52
Other species	incidental	-	-	-	0
Total					
Pacific hake	69,500	69,293	4,000	3,976	73,269
Walleye pollock	incidental	537	incidental	1	538
Pacific ocean perch	incidental	tr.	incidental	5	5
Other rockfish	incidental	299	incidental	123	422
Other species	incidental	1	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 91-4

CONTENTS

I. STEERING COMMITTEE REPORT.

The PSARC Steering Committee reviewed the Herring Subcommittee Report on September 20, 1991 at the Pacific Biological Station, Nanaimo. The following recommendations were made:

1) The Steering Committee recommends that management objectives for important herring stocks be evaluated.

2) The Steering Committee expressed a concern that the roe fishery catch exceeds the quota in almost every year and area. Therefore, the Steering Committee is concerned that localized areas may be being over-harvested. It is recommended that the Herring Subcommittee evaluate the biological implications of exceeding quotas at their next Subcommittee meeting.

3) The steering committee notes that the assumption of average recruitment adopted for the West coast Vancouver Island stocks is inconsistent with procedures used in past years. Previously when stock forecasts were approaching CUTOFF levels, the sub-committee adopted a more conservative approach and assumed poor recruitment. Given the high degree of uncertainty associated with the forecast for average recruitment from the August 1991 survey off the lower west coast of Vancouver Island, an assumption of average recruitment for 1992 may be over-optimistic. Additionally, it is noted that the current inability of DFO to manage herring fisheries to quota levels further increases the probability that spawning abundance on the west coast of Vancouver Island could be below CUTOFF levels

in 1992. The steering committee recommends that the Herring Working Group consider the detailed information of stock status for the west coast Vancouver Island stocks, as presented in the PSARC herring subcommittee report, when developing fishing plans for this area.

4) The coastwide spawning biomass declined 29% in 1991. Prince Rupert is the only area in which recruitment was good in 1991. It is recommended that the Herring Working Group be apprised that major closures could result from another year of coastwide below average recruitment.

II. HERRING SUBCOMMITTEE REPORT

The Subcommittee met at the Inn at Westminster Quay in New Westminster during September 4-5, 1991 to derive a consensus on the status of herring stocks in 1991 and to forecast abundance and potential catch levels for 1992. The list of working papers (Appendix 1), participants (Appendix 2), criteria used to evaluate stocks in each region (Appendix 3), Subcommittee recommendations (Appendix 4), summaries of reviewed working papers and reviews (Appendix 5), and summaries of unreviewed working papers (Appendix 6) are attached.

The Subcommittee appreciates the regional commitment to maintain a high priority for herring spawn surveys, obtained from the Regional Executive at the Sept. 20, 1990 review of PSARC. The Subcommittee maintains that spawn survey data are integral to the current herring management system; without consistent spawn data alternate management systems will be required. In general, spawn survey assessments in 1991 were adequate. Where exceptions occurred they are noted in this document.

Three fisheries issues were identified by the Subcommittee:

1. For the west coast of the Queen Charlotte Islands the Subcommittee felt that the assessment data was inadequate to provide scientifically sound forecasts of abundance and to recommend fishing quotas for 1992. Additionally, the committee felt that there was no scientific basis for determining CUTOFF, or minimum spawning stock biomass, levels for this region. However, recognizing that the Herring Working Group may choose to implement fishing plans which include fisheries in this region, the Subcommittee continues its recommendation that no more than 50% of the biomass estimated in-season should be caught in any location.

2. For the Prince Rupert District the Subcommittee noted that stock forecasts suggest that 66% of the stock will be comprised of 3 and 4 year old fish. Given the current low

catchability of these age classes by gillnet gear the committee suggests that fishing plans recognize that there could be problems in allocating a large proportion of the quota to gillnets in this area.

3. For the Northern West Coast Vancouver Island stock assessment region every effort should be made to catch the assigned quota within the assessment region rather than from the Southern West Coast Vancouver Island assessment region. There is concern that if all the fish are caught in the south these stocks could approach the CUTOFF level and therefore impact on future fisheries in this region.

The primary objectives for the meeting were to:

1. Review the stock assessment source documents and other pertinent stock assessment information and reach a consensus on stock status in 1990/1991 and forecasts of abundance in 1991/92; and recommend catch levels for consideration by the PSARC steering committee.

2. Review the five papers prepared on stock structure in the Strait of Georgia and reach consensus on the appropriate geographic units for future stock assessments.

3. Identify areas where further assessment work is most needed for management purposes and develop recommendations 8regarding these areas (Appendix 4).

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

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

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

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

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

5. CUTOFF.

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

7. Additional information.

8. Quota recommendation.

Based on the evaluation of these criteria for each of the seven stock assessment regions, conclusions were drawn on the current biological status of the stock and recommendations made as to the potential catch levels for each. A similar evaluation was conducted for minor stocks on the west coast of the Queen Charlotte Islands. No attempt was made to evaluate stock status for other minor stocks outside the seven assessment regions.

Biological and Management Objectives

British Columbia herring are currently managed by a fixed harvest rate policy in conjunction with a CUTOFF level. Cutoff levels have been set at 25 percent of the estimated unfished average biomass, as estimated by simulation analyses. To attempt to harvest herring conservatively, 20 percent of the forecast biomass for each of the seven recognized stocks is harvested annually unless the run falls below the CUTOFF level. In that event, the decision may be made to close the fishery to rebuild the stock. The intent of the 20 percent harvest rate is to minimize fluctuations in both catch and spawning biomass. This management policy has been in place since 1983 prior to which the fishery was managed through a fixed escapement policy.

Catch trends

Herring in British Columbia waters have supported some form of commercial fishery since 1877. Reliable records of place, date, and quantity caught are available since 1950. A fishery for a dry salted market from 1904-1934 (with catches up to 85,000 tonnes 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 tonnes annually) in the early 1960s, in conjunction with a series of poor recruitments, led to the collapse of the reduction fishery and subsequent closure in 1968. Cessation of the intensive reduction fishery resulted in a gradual recovery of stocks. The roe herring fishery began in 1971. Herring are now caught on or near the spawning grounds by both gillnets and purse seines. Evaluation of the impact of fishing on the spawning beds is incomplete. Roe herring landings have averaged 37,100 tonnes for the last five years. Allocations to other herring fisheries have averaged 5,466 tonnes.

The roe fishery first came under quota regulations in 1983. Prior to this, guidelines of anticipated roe catches were given. Roe catches since 1983 (for 1991 data are hail estimates; catches and quotas are in thousands of tonnes):

		1983	1984	1985	1986	1987	1988	1989	1990	1991
Queen Charlotte	Catch	8.1	5.0	6.3	3.6	2.0	0.3[a]	1.5	9.0[b]	7.0[b]
Is.	Quota	*	4.6	5.0	3.8	1.4	0.0	0.9	5.5	4.7
Prince Rupert	Catch	0.0	3.5	6.5	8.3	6.1	7.9	8.5	4.7	3.3
District	Quota	*	4.0	5.0	6.4	5.4	7.5	7.3	3.5	2.6
Central Coast	Catch	5.6	7.2	5.2	3.3	3.6	4.5	9.4	8.4	8.9
	Quota	*	6.6	4.1	2.3	3.4	3.7	7.8	7.4	6.2
Strait of Georgia	Catch	16.4	10.2	6.2	0.2[a]	9.1	7.5	8.4	8.1	9.9
	Quota	11.7	11.6	4.7	0.0	8.1	6.4	7.4	7.1	9.1
West coast	Catch	8.7	6.7	0.2[a]	0.2[a]	15.9	9.7	13.3	9.8	8.1
Vancouver Is.	Quota	4.5	4.5	0.0	0.0	9.4	8.1	10.3	7.2	6.7
Total	Catch	38.8	32.6	24.4	15.6	36.7	29.9	41.7	40.0	37.2
Coast	Quota	28.0	31.3	18.8	12.5	27.7	25.8	33.7	30.7	29.3

* North of Cape Caution the quota for 1983 was 11.8
[a] Charter boat removals
[b] Includes removals from Area 2W

Stock status and forecasts for assessment regions

The assessment regions used for the 1991 stock assessments are the same as those used in 1990. For 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. In the south coast both the Strait of Georgia and the west coast of Vancouver Island are separated into two stock assessment regions. The boundary between the northern and southern Strait of Georgia assessment regions is at Dodds Narrows. The southern west coast Vancouver Island assessment region comprises Areas 23 and 24 while the northern region comprises Area 25.

Herring abundance in the major assessment regions in B.C. decreased substantially in 1991. The estimated weighted spawning biomass for the seven assessment regions is 152,800 tonnes, a 29% decrease from 1990 spawn levels. The only assessment region where stocks did not decline in 1991 is the Prince Rupert District. Stock trends are shown in Figures 1 and 2, and other assessment criteria are listed in Appendix Table 3.

For the Queen Charlotte Islands region the two analytical assessment models indicate similar trends in spawning stock biomass. Both models suggest a decrease in abundance from 1989 to 1991. This is consistent with other trend information (Appendix 3) with the exception of the winter hydroacoustic survey. However, the time series of stock estimates from this survey was not presented and therefore this piece of information could not be evaluated with respect to relevancy. The above-average 1985 year class remains dominant in the Queen Charlotte Islands assessment region, with age 6 fish comprising 37% of the stock in 1991. Both the 1987 and 1988 year classes appear to be well below average. The estimates of 1991 spawning stock biomass are 19,800 and 14,600 tonnes from age-structured and escapement model analyses, respectively.

Stock trend information for the Prince Rupert District is not consistent between the various indices considered by the Subcommittee. Age-structured model estimates of abundance are consistently higher than those from the escapement model, and for the past three years in particular the two models indicate divergent stock trends. Both age-structured analysis and total spawn length indicate a substantial increase in abundance from 1990 to 1991. The escapement model estimate suggests a slight increase, and the winter hydroacoustic survey estimate of abundance is the lowest obtained for this area (although, as stated for QCI information was not presented to allow evaluation of the time trends). Because of the inconsistency in stock estimates for this region the Subcommittee decided to use only stock forecasts from the escapement model. The estimated 1991 spawning stock biomass is 20,800 tonnes from the escapement model. The 1988 year class is dominant in this region with 3 year old fish comprising 48% of the stock. This year class is above average levels, and may be one of the strongest year classes ever.

Estimates of spawning stock biomass for the Central Coast assessment region are very similar for the two analytical models and suggest a slight decline in abundance in 1991. In- season soundings suggest a slight increase in abundance in 1991, however, most of this increase is attributable to a high stock estimate for Kwakshua Channel. The strong 1985 year class remains dominant in this area with age 6 fish comprising 56% of the stock. The 1991 spawning stock biomass estimates are 37,900 and 30,500 tonnes from age-structured and escapement model analyses, respectively.

All stock indicators confirm a decline in herring abundance in 1991 in the two Strait of Georgia assessment regions. The 1988 year class, which recruited to the fishery in 1991 is poor. However, the strong 1987 year class maintains abundance in this area at relatively high levels. The age-structured model estimates of escapement are 58,900 tonnes for the northern stock and 15,600 tonnes for the southern stock. The estimates from the escapement model are 39,100 tonnes and 4,200 tonnes for the northern and southern stocks, respectively.
Virtually all stock indicators suggest a decrease in herring abundance for the Southern West Coast Vancouver Island assessment

region. The only exception to this is the perception of the two charter skippers (and industry in general). The spawning biomass estimates for this area are 21,500 tonnes from the escapement model and 9,900 tonnes from the age-structured model. The 1985 year class remains dominant, with age 6 fish comprising 38% of the sampled fish while age 4 fish comprised 23% of the stock. The 1988 year class appears to be poor.

As in past assessments, the age-structured model estimates significantly greater spawning abundance than the escapement model for the Northern West Coast Vancouver Island assessment region. This could result from inconsistent reduction fishery catch information for this area. Tag recovery data, from tagging conducted between 1937 and 1967, showed that only half of the tags recovered in winter fisheries in Area 25 were from fish which had been tagged during the spawning period in Area 25. The remaining recoveries were primarily fish tagged in other areas on the west coast of Vancouver Island. This could result in an overestimate of the productivity of this stock. The 1991 spawning biomass estimates are 2,500 tonnes and 20,000 tonnes from the escapement and age-structured models, respectively. Because of concern that age-structured model estimates may be biased the Subcommittee adopted a 80:20 weighting in favour of the escapement model for this region. The 1986, 1987 and 1988 year-classes appear to be poor in this area.

To provide an overall stock forecast subjective probabilities are assigned to the forecasts from the two analytical assessment models. In general, forecasts from the two models are weighted equally. Where there are inconsistencies in the various stock and spawn indicators the weighting may be increased for the model which is more consistent with other stock estimates. The potential recruitment to each stock is calculated as the mean of the third best, the middle third, and the third poorest recruitments as estimated by the two analytical models for the 1951-1991 time series. Generally, the expectation used for the forecast year is average, unless there is additional information to forecast recruitment. Recruitments are added to expected age 4 and older fish, and when the forecast run exceeds the CUTOFF level a 20% harvest rate is recommended.

The recruitment assumption, the corresponding 1992 forecasts, and the recommended catches are shown below (also see Appendix 3):

Stock Assessment Region	CUTOFF	Recruitment Assumption	Forecast	Recommended Catch
Queen Charlotte Islands	11,700	avg.	18,100	3,620
Prince Rupert District	12,100	avg.	30,500	6,100
Central Coast	10,600	avg.	37,650	7,530
Strait of Georgia	22,100[a]			
Northern Region		avg.	48,500	9,700
Southern Region		avg.	10,650	2,130
West Coast Vancouver Is. Southern Region	15,100	avg.	21,100	4,220
Northern Region	5,200	avg.	8,040	1,608
Total Coast			174,540	34,908

[a] CUTOFF estimated for combined northern and southern assessment regions

Impact of modifications to analytical models on stock forecasts

For this year's stock assessments modifications were made to both analytical models to account for identified biases in stock forecasts. These modifications are discussed in Appendix 5. It is important to point out that the impact of these changes are that stock forecasts are higher than they would have been using the same analytical methods as last year. Thus, while the estimated spawning stock biomass decreased substantially in 1991 (29% from 1990), the recommended quotas do not reflect these stock declines (5% decrease - 36,890 t. in 1990 versus 34,908 t. this year). The stock specific forecasts of age 4 and older biomass from both the current assessments and those obtained using last years methods are shown in the following table:

Stock Assessment Region	Escapement Model Forecast (1000 t.)		Age-Structured Model Forecast (1000 t.)	
	current version	old version	current version	old version
Queen Charlotte Islands	13.6	10.0	16.0	15.4
Prince Rupert District	25.7	16.0	81.5	75.9
Central Coast	29.1	22.0	33.7	30.0
Strait of Georgia Northern Region	29.8	29.0	39.2	46.0
Southern Region	2.5	2.8	9.0	10.7
W. Coast Vancouver Is. Southern Region	20.3	15.0	8.7	10.0
Northern Region	2.3	1.8	11.9	13.1

Stock Status for Minor Herring Stocks

Because there have been roe herring fisheries on the west coast of the Queen Charlotte Islands in each of the past two years, the Subcommittee considered all the available information regarding stock status in this area. The estimated 1991 spawning stock biomass (3,700 tonnes) is substantially lower than the estimates for the previous three years. This could be strictly the result of poor spawn survey coverage in these areas. It was felt that half of the fish in Rennell Sound had not spawned at the time of the survey, that many eggs had hatched by the time Otard Bay was surveyed, and that some spawn may have been missed in Port Louis. The in-season sounding estimate for this area was 10,000 tons, similar to last years estimate. The 1985 year-class (age 6) was dominant in this area, comprising 60% of the Port Louis stock, 69% of the Rennell Sound stock, and 68% of the Inskip stock. While a decrease in stock size would be expected based on the age structure of this stock, it would not be of the same magnitude as shown by the spawn data. The in-season soundings may provide the best estimate for 1991. However, because the available information is inconsistent the Subcommittee felt that it was not possible to make quota recommendations for this area.

This year, there was no information presented on stock status for the other minor herring stocks on the B.C. coast. Information was presented to show that both spawn and catch data for these areas may often be incomplete. For example, Figure 3 shows the number of herring sections for which spawn was reported over the 1935 to 1991 period. There has been a significant decrease in the areas for which spawn was reported since the mid 1970's. It is not possible at this time to determine to what degree this decrease is attributable to incomplete survey coverage or to a real decrease in the number of sites where herring spawn. Catch data for the non-roe herring fisheries are also not consistently reported. For the 1989/90 season, for example, 3,551 tons were allocated to non-roe herring fisheries, excluding Spawn-on-kelp (SOK); the sales slip data documented landings for only 287 tons. Because presentation of stock estimates for the minor herring stocks could lead to erroneous conclusions regarding stock trends and the impact of fisheries on the stocks, the Subcommittee recommends that future assessments should not include biomass estimates for these areas. If stock assessments are requested for specific areas, these should include a thorough evaluation of the data quality.

Herring stock structure in the Strait of Georgia

The Subcommittee addressed the topic of herring stock structure in the Strait of Georgia, as recommended at the 1990 PSARC herring meeting. This review was recommended because the geographic units used for assessment (northern and southern Strait) were different than those used for fisheries management (combined Strait). Five papers related to this topic were presented and two reviews summarized the basis for stock delineation in the Strait of Georgia (Appendix 5).

Reviews of the papers emphasized the need to differentiate between the biological basis for assessment units and management aspects. Correct definition of populations is important to fulfil the assumptions of an analytical assessment. Management units need not coincide. The subcommittee discussed whether there was sufficient information to justify a change in assessment units.

Analyses of the historical spawning records indicate several sites with a history of continuous spawning since systematic surveys began. However, morphological and genetic studies of fish from different areas have not shown definitive differences among areas. Analyses of larval distributions shows two major concentrations: the north (Areas 13,15) and the Vancouver Island shore (Areas 14-17) but there is a continuum between these concentrations. Historical (pre-1970) tagging results show differences in migratory patterns between fish in Areas 13,15 and Areas 17S,18, however, fish tagged in Areas 14,17N, and 16 migrated through both the northern and the southern Strait. Analyses of size at age trends shows detectable differences between fish from area 15 and those from other areas.

The focus of the analyses was on a genetic basis for stock structure rather than one which separated units with different productivity dynamics. The data presented were inconclusive, but there was general agreement that a more appropriate stock definition would separate Vancouver Island spawners (Areas 14 to 18) from mainland spawners (Areas 13-16). However, it was recognized that data could not be resolved to this scale (ie. reduction catches in Area 13, Area 14 fish migrating through Area 16) so assessments using this structure would be inappropriate. The Subcommittee recommended that future assessments be conducted for a single Strait of Georgia region. Recognizing that some components of this region may have different productivity dynamics, spawning trends in subcomponents should be evaluated.

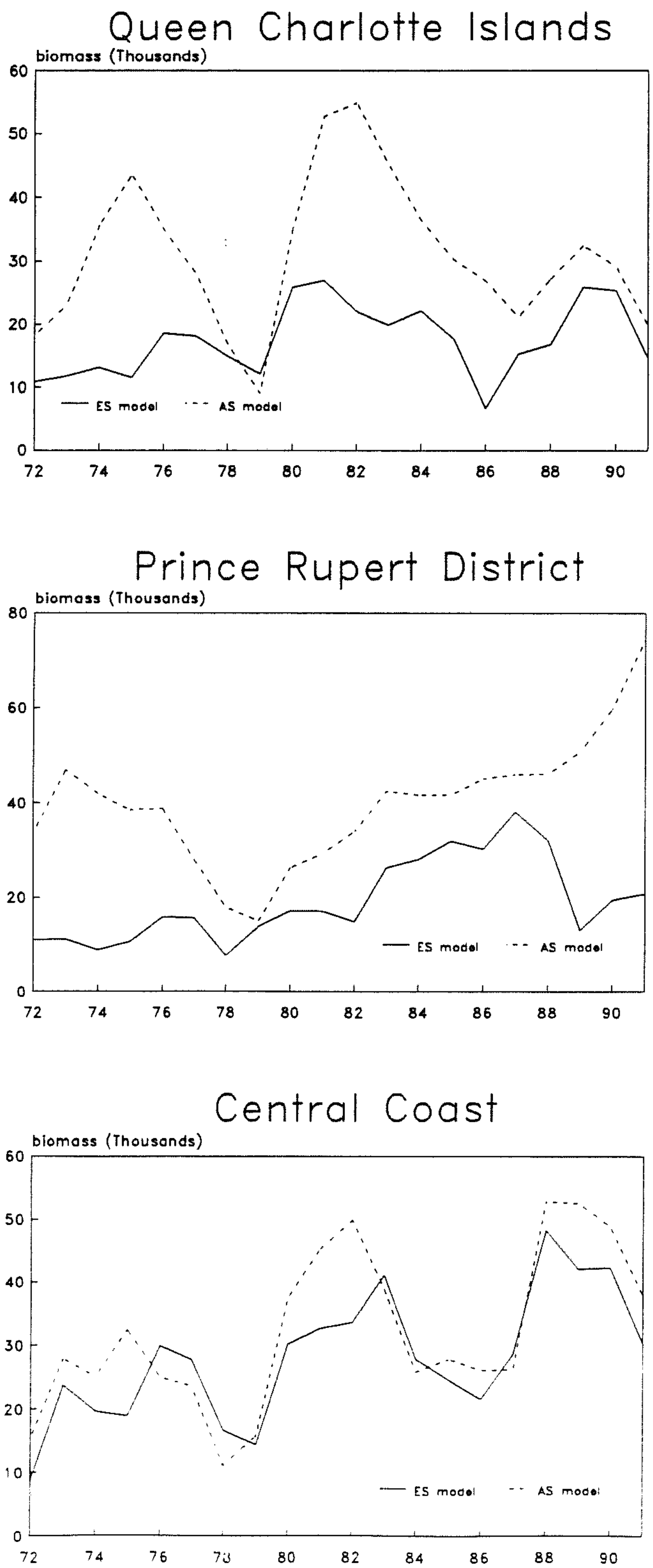

Fig. 1 Estimates of spawning stock biomass (tonnes) from age-structured and model analyses for northern B.C. herring stock assessment regions, 1972-1991.

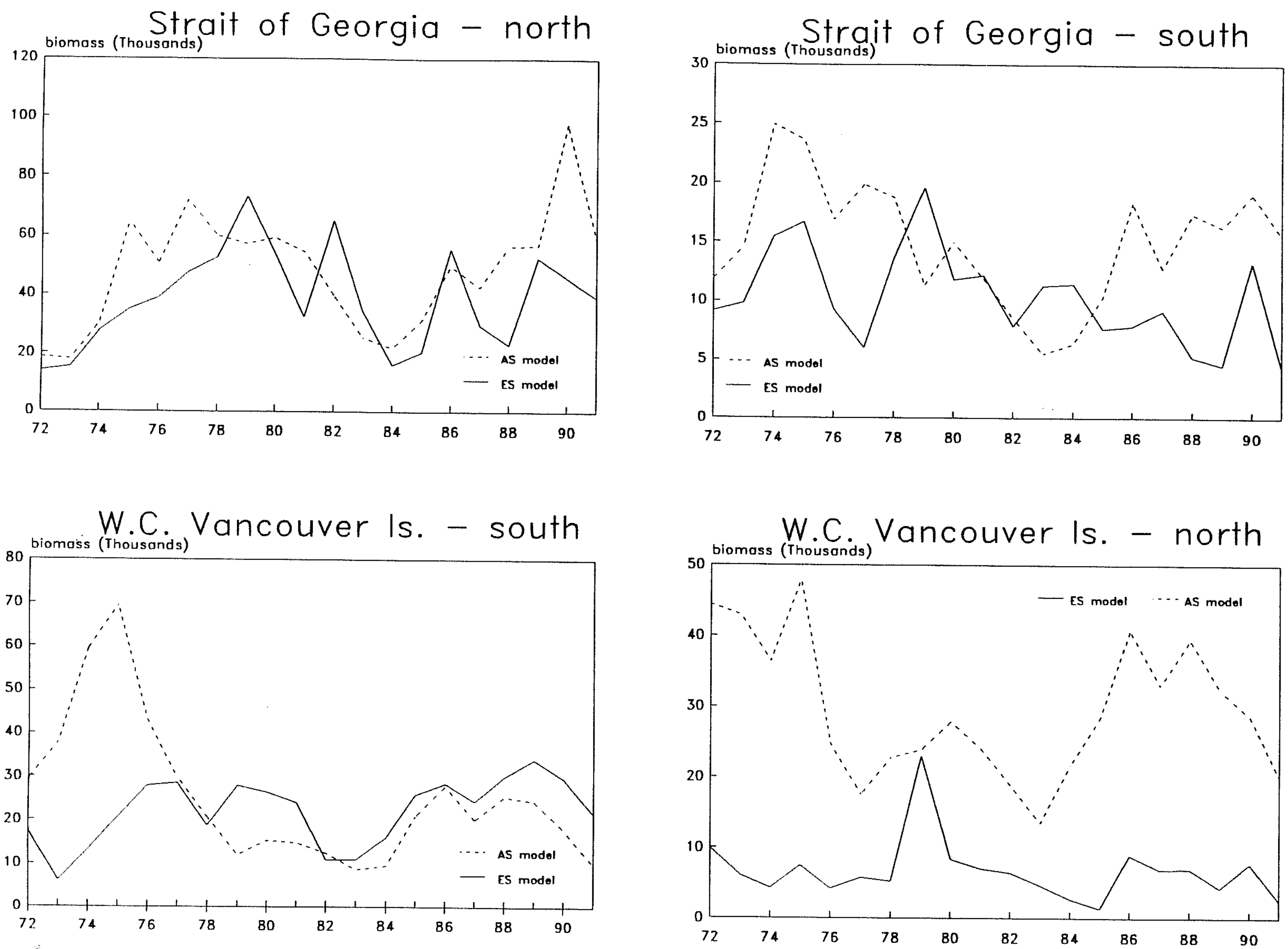

Fig. 2 Estimates of spawning stock biomass (tonnes) from age-structured and escapement model analyses for southern B.C. herring stock assessment regions, 1972-1991.

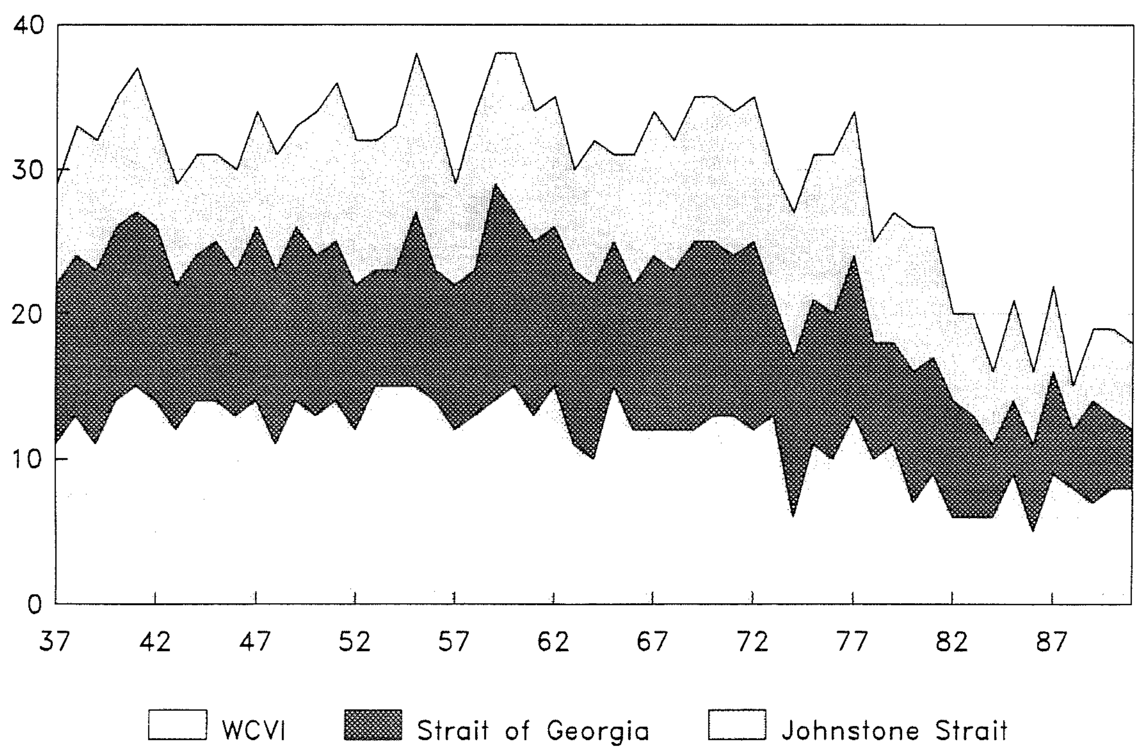

Fig. 3 Number of herring sections with spawn reported (1937-1991) for districts in southern B.C.

Appendix 1. 1991 PSARC Herring Subcommittee working papers.

Number	Title	Authors
H91-1	Stock Assessment for British Columbia herring in 1991 and forecasts of the potential catch in 1992	V. Haist J. Schweigert
H91-2	Genetic and non-genetic aspects of Pacific herring stock identification in the Strait of Georgia	J.F. Schweigert
H91-3	Movement of herring in Georgia Strait as indicated from tagging studies	C.W. Haegele
H91-4	Distribution of herring larvae in the Strait of Georgia in April of 1989 and 1990 and implications for homing and stock structure	D.E. Hay P.B. McCarter
H91-5	The distribution and timing of spawning as a basis for recognition of herring stocks in B.C.	D.E. Hay
H91-6	Growth and size-at-age in B.C. herring	R.W. Tanasichuk D.M. Ware
H91-8	Delineating Strait of Georgia herring stocks using growth and reproductive characteristics	R.W. Tanasichuk
Research Updates - not reviewed		
H91-7	Offshore herring distribution and recruitment forecast for the lower west coast of Vancouver Island, August 1991	D.M. Ware R.W. Tanasichuk
H91-9	Hydroacoustic herring survey results from Hecate Strait December 3-15, 1990. W. E. Ricker Cruise 90HER2	P.B. McCarter P. Withler D.E. Hay R. Kieser
H91-10	1991 in-season tagging results and recommendations	S. Farlinger B. Armstrong V. Haist

Appendix 2. List of Participants

Name	Association
Vivian Haist (Chairperson)	Pacific Biological Station, Nanaimo
Doug McKone	Biological Sciences Directorate, HQ, Ottawa
Doug Hay	Pacific Biological Station, Nanaimo
Ron Tanasichuk	Pacific Biological Station, Nanaimo
Carl Haegele	Pacific Biological Station, Nanaimo
Stuart Kerr	Dept. of Fisheries and Oceans, Vancouver
Susan Farlinger (Co-chairperson)	Dept. of Fisheries and Oceans, Prince Rupert
Lorena Hamer	Pacific Biological Station, Nanaimo
Dennis Chalmers	Dept. of Fisheries and Oceans, Nanaimo
Jake Schweigert	Pacific Biological Station, Nanaimo
Bob Armstrong	Dept. of Fisheries and Oceans, Nanaimo
John Greenlee	Dept. of Fisheries and Oceans, Port Alberni
Lloyd Webb	Dept. of Fisheries and Oceans, Vancouver
Dan Ware	Pacific Biological Station, Nanaimo
Bruce McCarter	Pacific Biological Station, Nanaimo
Chuck Fort	Pacific Biological Station, Nanaimo
Ed Safarick	Fisheries Council, Vancouver
Jake Rice	Pacific Biological Station, Nanaimo
John Radosevic	U.F.A.W.U., Vancouver
Jim Irvine	Pacific Biological Station, Nanaimo
Chris Ashton	Fishing Vessel Owners Association
Joe Chambers	Dept. of Fisheries and Oceans, Port Hardy
Robb Wilson	Dept. of Fisheries and Oceans, Prince Rupert
Dean Miller	Dept. of Fisheries and Oceans, Queen Charlotte Islands
Greg Savard	Dept. of Fisheries and Oceans, Central Coast
Rick Stanley	Pacific Biological Station, Nanaimo
Bruce Leaman	Pacific Biological Station, Nanaimo
Bob O'Boyle	Dept. of Fisheries and Oceans, B.I.O., Halifax
Ian Perry	Pacific Biological Station, Nanaimo
Rob Stephenson	Dept. of Fisheries and Oceans, St. Andrews Biological Station

Appendix 3. Criteria used in the assessment of stock status for the Queen Charlotte Islands stock assessment region in 1991.

Criteria	Status
1. Data quality	
a) all catch reported	SOK usage may have been higher than 100 tons/pond for a few operators. IFF usage not completely assessed
b) all spawn surveyed	appears complete
c) consistent age composition	slightly higher prop. of 6 yr olds in Louscoone
2. Spawn and stock trends	
a) age-structured model	decreasing since 1989
b) escapement model	decreasing since 1989
c) spawn indices	slight decrease since 1989
d) in-season echo-soundings	9,500 t, decreasing, but poor correlation with other est.
e) winter echo-soundings	32,000 t, highest est. ever (ie 1986-88), no trend evaluation given
f) consistent trend info	consistently indicates decrease with exception of winter survey
3) Perception of stock status	
a) charter skippers comments	didn't look that bad - has certainly looked better at times in the past (estimated at 25-30,000 tons)
b) district staff	feel that stocks are not in good shape, downward trend
4) Recruitment trends	
a) age-structured model	1988 yr-class is poor; 1987 yr-class below average
b) escapement model	1988 yr-class poor; 1987 yr-class below average
5) CUTOFF	11,700 t.
6) Forecast weighted run size	
a) weighting	50:50
b) assuming-poor recruitment	15,750 t
- average recruitment	18,100 t
- good recruitment	24,200 t
7) Additional information	
8) Quota recommendation	Average recruitment assumption adopted; potential catch of 3,620 t.

Appendix 3. Criteria used in the assessment of stock status for the Prince Rupert District stock assessment region in 1991.

Criteria	Status
1. Data quality	
a) all catch reported	SOK usage may be underestimated, DFO received reports of considerable mortality (approx. 600 t) in one ponding operation
b) all spawn surveyed	appears to be complete
c) consistent age composition	slightly higher proportion at age 3 in Kitkatla than Big Bay
2. Spawn and stock trends	
a) age-structured model	substantial increase since 1988
b) escapement model	substantial decrease 1987-88; slight increase since
c) spawn indices	significant increase from 1990 to 1991
d) in-season echo-soundings	trends not consistent with other estimates
e) winter echo-soundings	15,000 t lower than previous surveys in the area (1988)
f) consistent trend info	no
3) Perception of stock status	
a) charter skippers comments	Kitkatla looked very poor - needs a rest
b) district staff	spawning looked better in Pt. Simpson/Big Bay; Kitkatla should not be fished in 1992
4) Recruitment trends	
a) age-structured model	1988 yr-class best ever; 1987 and 1988 yr-classes average
b) escapement model	1988 yr-class above avg.; 1986 and 1987 yr-classes below average
5) CUTOFF	12,100 t.
6) Forecast weighted run size	
a) weighting	0:100 (AS:ES)
b) assuming-poor recruitment	27,400 t
- average recruitment	30,500 t.
- good recruitment	39,100 t.
7) Additional information	
8) Quota recommendation	Average recruitment assumed; potential 6,100 t catch.

Appendix 3. Criteria used in the assessment of stock status for the Central Coast stock assessment region in 1991.

Criteria	Status
1. Data quality	
a) all catch reported	information for major fisheries felt to be complete
b) all spawn surveyed	mostly surveyed; some dive survey close to hatching
c) consistent age composition	age 3 - 50% in Kwaksua (1 sample); 20% other areas
2. Spawn and stock trends	
a) age-structured model	decline from 1990
b) escapement model	decline from 1990
c) spawn indices	little change in spawn length, 1988-91
d) in-season echo-soundings	up slightly from 1990, 1/3 in Kwakshua Channel
e) winter echo-soundings	N/A
f) consistent trend info	best agreement on the coast
3) Perception of stock status	
a) charter skippers comments	most fish ever sounded in Central Coast; lots in Kwakshua Channel
b) district staff	in-season perception was that stocks were down somewhat from 1990 for areas outside of Kwakshua
4) Recruitment trends	
a) age-structured model	1988 yr-class avg.; 1987 and 1986 yr-classes poor
b) escapement model	1988 yr-class below avg.; 1986 and 1987 yr-classes poor
5) CUTOFF	10,600 t.
6) Forecast weighted run size	
a) weighting	50:50
b) assuming-poor recruitment	34,150 t
- average recruitment	37,650 t
- good recruitment	48,400 t
7) Additional information	
8) Quota recommendation	Average recruitment assumed; potential catch of 7,530t.

Appendix 3. Criteria used in the assessment of stock status for the Northern Strait of Georgia stock assessment region in 1991.

Criteria	Status
1. Data quality	
a) all catch reported	OK, except for non-roe fisheries where sales slip data are incomplete
b) all spawn surveyed	good survey coverage
c) consistent age composition	mostly consistent, higher prop of 2 yr olds off Nanoose
2. Spawn and stock trends	
a) age-structured model	decline from 1990
b) escapement model	decline since 1989
c) spawn indices	slight decline in length since 1989
d) in-season echo-soundings	consistent with model estimates
e) winter echo-soundings	not consistent since 1989
f) consistent trend info	good agreement the last few years
3) Perception of stock status	
a) charter skippers comments	similar tonnage to last yr - different behaviour (all spawned together)
b) district staff	stock appears in good shape
4) Recruitment trends	
a) age-structured model	1987 yr-class good, 1988 yr-class poor
b) escapement model	1986 yr-class good, 1988 yr-class poor
5) CUTOFF	22,100 t. (entire Strait of Georgia)
6) Forecast weighted run size	
a) weighting	50:50
b) assuming-poor recruitment	41,800 t
- average recruitment	48,500 t
- good recruitment	62,250 t
7) Additional information	
8) Quota recommendation	Average recruitment assumed; potential catch of 9,700t.

Appendix 3. Criteria used in the assessment of stock status for the Southern Strait of Georgia stock assessment region in 1991.

Criteria	Status
1. Data quality	
a) all catch reported	incomplete sales slip data for food and bait fishery
b) all spawn surveyed	felt to be complete
c) consistent age composition	high variability between samples
2. Spawn and stock trends	
a) age-structured model	slight decline from 1990
b) escapement model	substantial decline from 1990
c) spawn indices	spawn length half of 1990 estimate
d) in-season echo-soundings	decrease from 1990
e) winter echo-soundings	inconsistent since 1989
f) consistent trend info	consistent for the last few years
3) Perception of stock status	
a) charter skippers comments	
b) district staff	
4) Recruitment trends	
a) age-structured model	1987 yr-class avg.; 1988 yr-class poor
b) escapement model	1987 yr-class above avg.; 1988 yr-class poor
5) CUTOFF	22,100 t. (entire Strait of Georgia)
6) Forecast weighted run size	
a) weighting	50:50
b) assuming-poor recruitment	8,400 t
- average recruitment	10,650 t
- good recruitment	14,450 t
7) Additional information	
8) Quota recommendation	Average recruitment assumed; potential catch of 2,130t.

Appendix 3. Criteria used in the assessment of stock status for the Southern West Coast Vancouver Island stock assessment region in 1991.

Criteria	Status
1. Data quality	
a) all catch reported	yes with the exception of a minor IFF catch
b) all spawn surveyed	most of Hesquiat Harbour spawn missed, other areas surveyed consistently
c) consistent age composition	slight increase in 2's and 3's - 2nd week of March
2. Spawn and stock trends	
a) age-structured model	decline since 1989
b) escapement model	decline since 1989
c) spawn indices	length declining since 1988
d) in-season echo-soundings	not applicable
e) winter echo-soundings	not available
f) consistent trend info	good agreement since diving surveys began
3) Perception of stock status	
a) charter skippers comments	1) similar to 1990, about 28-30,000t and 2) best ever seen in Barkley (as much as 1977!) but lots of this fish outside of Barkley Sound
b) district staff	stock decreasing in Barkley; very little spawn in Clayoquot; concerned about the fishing levels in Barkley over the past few years; concern that the quota may be overoptimistic
4) Recruitment trends	
a) age-structured model	1986, 1987 & 1988 yr-classes poor
b) escapement model	1986 & 1987 yr-classes below avg; 1988 yr-classes poor
5) CUTOFF	15,100 t.
6) Forecast weighted run size	
a) weighting	50:50
b) assuming-poor recruitment	17,750 t
- average recruitment	21,100 t
- good recruitment	29,400 t
7) Additional information	estimate of 44% age 3 herring on La Perouse Bank during summer 1991 suggests average recruitment for 1992
8) Quota recommendation	Average recruitment assumed; potential catch of 4,220t.

Appendix 3. Criteria used in the assessment of stock status for the Northern West Coast Vancouver Island stock assessment region in 1991.

Criteria	Status
1. Data quality	
a) all catch reported	yes
b) all spawn surveyed	yes, good coverage in all areas
c) consistent age composition	yes
2. Spawn and stock trends	
a) age-structured model	declining since 1988
b) escapement model	decline from 1990 level
c) spawn indices	length declining since 1989
d) in-season echo-soundings	not applicable
e) winter echo-soundings	not available
f) consistent trend info	good agreement the last few years
3) Perception of stock status	
a) charter skippers comments	6,500 - 7,000 tons prior to opening
b) district staff	concern about stock boundaries; stocks in-season appeared better than last year but lower than past years
4) Recruitment trends	
a) age-structured model	1986, 1987 & 1988 yr-classes poor
b) escapement model	1986-1988 yr-classes poor
5) CUTOFF	5,200 t.
6) Forecast weighted run size	
a) weighting	80:20
b) assuming-poor recruitment	5,720 t
- average recruitment	8,040 t
- good recruitment	14,760 t
7) Additional information	
8) Quota recommendation	Average recruitment assumed; potential catch of 1,608t.

Appendix 3. Criteria used in the assessment of stock status for the west coast of the Queen Charlotte Islands in 1991.

Criteria	Status
1. Data quality	
a) all catch reported	yes
b) all spawn surveyed	concern about serious undersurvey of Rennell Sound and inconsistent survey of other areas
c) consistent age composition	slightly higher prop of 3 yr olds in Port Louis
2. Spawn and stock trends	
a) age-structured model	not applicable
b) escapement model	decreased substantially from 1990
c) spawn indices	decreased substantially from 1990
d) in-season echo-soundings	similar to 1990
e) winter echo-soundings	not applicable
f) consistent trend info	not applicable
3) Perception of stock status	
a) charter skippers comments	est. 10 K
b) district staff	concerned that spawn survey incomplete
4) Recruitment trends	
a) age-structured model	not applicable
b) escapement model	from age composition - strong 1985 year class, all other year classes weak
5) CUTOFF	District staff presented recommendations but due to lack of biological data to support current stock levels no consensus could be reached on how to deal with them
6) Forecast weighted run size	
a) weighting	escapement model estimated 1991 spawning biomass at approximately 3,700t; with poor spawn coverage this is probably an underestimate
b) assuming-poor recruitment	unknown
- average recruitment	unknown
- good recruitment	unknown
7) Additional information	
8) Quota recommendation	PSARC unable to reach consensus on stock status due to inconsistent data.

Appendix 4. Recommendations for stock assessment and related activities

1) For the Strait of Georgia the Subcommittee recommended that future stock assessments be conducted for a stock assessment region which combines the current southern and northern regions. However, recognizing that some components of this unit may have different productivity dynamics details on spawn trends for subcomponents should also be provided.

2) Three issues related to data quality and reporting are directed to the Herring Working Group for resolution:

   - A herring spawn reporting form, intended to document the completeness of spawn survey coverage, has been drafted and requires review by district staff.

   - There has been an increase in the number of errors detected for surface spawn surveys. An orientation process (i.e. training session or document summarizing methodology) is required to ensure consistent data quality.

   - Sales slip data for minor herring fisheries (eg. bait, winter food and bait, charity, etc.) is incomplete. A system is required to ensure landings are reported.

3) Information on the validity of using growth or size-at-age trends as an index of stock trends is incomplete. Size-at-age trends are not to be included in the criteria of stock trends until the methodologies are thoroughly documented to allow a complete evaluation of the validity of the assumptions.

4) The Subcommittee recommends that the coastwide in-season tagging program be discontinued. This program has been useful in documenting in-season herring movement within a district. However, there is reason to be concerned that many of the recoveries which infer movement between districts may be erroneous and these can lead to incorrect conclusions regarding stock structure. Tagging should only be conducted in the future if it is directed to answering specific, well formulated questions which have the potential to be resolved.

5) The PSARC working paper which summarizes analytical stock assessments should not include stock estimates for the minor B.C. herring stocks. Where an assessment of a minor stock is requested the assessment must include a thorough evaluation of data quality and the impact of uncertainty in the abundance estimates on the assessment.

6) For 1992 a stock assessment for Area 27 should be conducted. This should include a thorough evaluation of the quality and consistency of the data and an evaluation of the accuracy of stock forecasts and risks associated with potential catch levels.

7) For the 1992 herring PSARC meeting stock assessments should be conducted for both the current assessment regions on the west coast of Vancouver Island and for a combined region.

Appendix 5. Summary of reviewed working papers and reviews

H91-1. Stock assessment for British Columbia herring in 1991 and forecasts of the potential catch in 1992.
by V. Haist and J.F. Schweigert

This document describes the two analytical models used to assess B.C herring stocks; presents estimates of current and past stock abundance; and presents forecasts of stock levels for 1992. Significant changes were made to both models for the current assessment. The age-structured parameterization was modified to incorporate weight-specific rather than age-specific selectivity. It was hoped that this change would produce more realistic abundance estimates for the Prince Rupert stock but the assessment for this area remains a problem. The escapement model was modified to include an age-specific apparent mortality rate for forecasting abundance of repeat spawners. The effect of this change is to increase forecast biomass for all but the Georgia Strait stocks by about 30-40 percent. Results of egg counts for 1991 from the Prince Rupert District were equal to model predictions and indicate a significant increase relative to 1990. Stock forecasts by the two assessment models are consistent and indicate slight declines in all other areas relative to 1990. No assessment was attempted this year for minor stocks with the exception of Area 2W.

Summary of reviewer's comments (J.C. Rice):

Overall, the reviewer was comfortable with the quantitative methods used in the assessment, and their application and interpretation. There are attributes of the data base which caused some unease, such as the inconsistent levels of dive surveys across years, but the users are clearly aware of the potential problems presented by such data. Herring staff were commended for the amount and quality of data they have accumulated.

This assessment dealt with uncertainty more thoroughly that in most PSARC assessments. Nonetheless, in some areas more work is needed, particularly when several variables are combined to produce a single parameter. In any such cases, tabling the relative uncertainty of each component guides further research and present advice, by identifying the attributes or processes which contribute the most potential inaccuracies in the assessment.

This was the only PSARC assessment to provide diagnostics on model fits. Even then, only the minima for the objective function was given along with appendices of residuals. More information is essential to assess how well-defined the "best" parameter estimates were. The PSARC reviews should focus much more strongly on such diagnostics, to ensure that the best possible scientific advice is being provided.

The introduction needs to be expanded in a couple of areas. Concerns regarding the concentration of harvesting in small areas, and the conservative nature of the final estimates, because minor stocks are not included must be emphasized. The age-specific survival is a new modification of the escapement model. This parameter seems to lump partial recruitment with natural mortality. Combining the parameters seems appropriate, especially as the data don't allow their estimation independently. If the combined parameter continues to be used, lack-of-fit indicators should be reviewed for each process independently. In the age-structured model the variable natural mortality rates are new. More details on the methods for estimating the variable m's should be provided. Also the pr vector is fixed as flat-topped. Sometimes this is biologically correct, but the step precludes considering a lot of things in the assessment. There are some aspects of herring biology, and of the information in appendices 3.x which suggest the shape of pr's are more variable.

The weight-specific selectivities are also new, and need a careful look. Generally, length or weight based models are very sensitive to growth rate parameters. Statistically the evidence favours using the weight-specific selectivities, but generally the differences are tiny. The sampling data should be reviewed to ensure sample weights are representative. Using weight-specific selectivities, produces a higher proportion of middle ages recruited to the gear (Table 3.2). By how much would last year's estimates of cohort sizes have been reduced with weight based selectivities? Would this have made them more accurate, given this year's estimates of the same cohorts?

H91-6. Growth and size-at-age in B.C. herring.
by R. Tanasichuk and D.M. Ware.

This document described intra- and inter-annual variation in growth and size-at-age of south coast herring stocks. Seasonal growth consisted of a slow, followed by a rapid growth phase between April and October, including a period of weight loss between October and March. Inter-annual variations in size-at-age of recruit fish are the result of inverse relationships between year-class strength and sea temperature which are exerted during the first year of life. Adult biomass and plankton abundance impact growth rates of adults from the northern Strait of Georgia and the lower west coast of Vancouver Island (LWCVI). No effect of biomass and oceanic conditions on adult growth rates of herring from the southern Strait of Georgia was found suggesting that they may summer off the Washington coast. A growth model which describes within- and between-year changes in growth for adult LWCVI herring is presented. Historical size-at-age trends suggest density-dependent growth for all major herring stocks.

Appendix 5. Summary of reviewed working papers and reviews.

Summary of reviewer's comments (B. M. Leaman):

The hypothesis being examined in this paper, that biomass changes are mapped directly into size-at-age observations, may well be true. However, the paper does not contain enough information to assist the reader in determining if that is so. The paper was felt to be deficient in two important areas, description of methodology and identification of data sources. The latter is extremely important because the factors affecting size-at-age (SAA) are legion. If the source of the data is not known in detail, it is not possible for the reader to eliminate sources of growth variation other than those identified. For example, when told only that some observations come from the LWCVI, it is unclear whether potential sub-stock, locality, or seasonal effects have always been accounted for. Similarly, for regressions involving 'independent' variables which are also subject to measurement error, have the correct Model II (major axis or reduced major axis) regressions been performed? While the document is a stock assessment working paper and does not necessarily have the same requirements as formal publications, much more detail in these areas is required to carry the arguments.

The observations most often examined are the maximum or the mean of the maximum sizes at age (or length). The authors do not establish why the maxima are the observations of interest, rather than some measure of central tendency, such as the median. It is necessary to establish that these maxima behave in the same fashion as measures of central tendency, or that the maxima are uniquely pertinent to testing the hypotheses. In addition, since cohort averages are measured there is limited insight into individual growth.

The model has almost no mathematical description in the paper. Since the model is claimed to have good success at predicting SAA it is important to provide a complete description of it. The reader should not have to go searching through several other publications to construct the model equations.

In the end, it was felt that the paper does not provide the proof the authors require. They have not successfully dismissed other causative factors for growth changes or, alternatively, isolated biomass as a dominant factor. The reviewer does not dispute the merit of the hypotheses, merely this examination of them.

Stock structure within the Strait of Georgia - The following five working papers summarize current knowledge regarding stock structure of herring in the Strait of Georgia. Two reviews of these papers follows.

Appendix 5. Summary of reviewed working papers and reviews.

H91-2. Genetic and non-genetic aspects of Pacific herring stock identification in the Strait of Georgia by J.F. Schweigert

Evidence was presented for the genetic and non-genetic stock structuring within Georgia Strait. To date, electrophoresis, mitochondrial DNA, and nuclear DNA have not provided evidence for separate stocks of herring within this assessment region. However, this does not provide evidence that they do not exist. Indications from morphometric and merisitc data as well as size at age and age composition data are that differences do exist. These data indicate differences between stocks of herring found in Johnstone Strait and the northeast side of Georgia Strait as far south as Jervis Inlet and those which occur along the west side from Cape Lazo south through the Gulf Islands. It is suggested that the Powell River stocks be removed from the northern assessment region and treated as a minor stock while the remainder of the currently separate assessment regions be combined into a single stock for management.

H91-3. Movement of herring in Georgia Strait as indicated from tagging studies by C. W. Haegele

Belly tagged fish, released at spawning between 1937 and 1956, were recovered after their first or subsequent summer migrations after release. Most of the fish that had previously spawned south of Dodds Narrows (statistical area 17S and 18) returned from the south to spawn, while most fish that had previously spawned in statistical area 13 or 15 returned from the north to spawn. Fish that had previously spawned in statistical area 14 or 17N returned to spawn both from the north and south, with a larger proportion of statistical area 14 spawners returning from the north and a larger proportion of statistical area 17N spawners returning from the south. Fish tagged in statistical area 16 appeared to behave similar to fish tagged in statistical area 14.

Anchor tagged fish, released in the late fall between 1981 and 1983, were recovered at spawning, 3-4 months after release. Fish that entered from the south to spawn in statistical area 14 or 15 had mostly left statistical area 17S by December while fish that spawned in statistical area 17N or 17S remained in statistical area 17S at least until December. Fish that entered through the north to spawn in statistical area 14 had mostly left statistical area 13 by November, while fish that entered through the north to spawn in statistical area 15 were present in statistical area 13 in November.

Appendix 5. Summary of reviewed working papers and reviews.

H91-4. Distribution of herring larvae in the Strait of Georgia in April of 1989 and 1990 and implications for homing and stock structure by D.E. Hay and P.B. McCarter

Larval herring distribution in the Strait of Georgia was assessed by 403 oblique plankton hauls taken between April 10-20, 1989 and 424 hauls taken between April 9-19, 1990, approximately 2-3 weeks after hatching. Larval herring densities were estimated by comparing larval numbers by volume filtered. Larvae were found throughout most of the Strait of Georgia, but most were caught on the west side from Ladysmith to Hornby Island and the east side from Lasqueti Island to Cortes Island. Distributions were similar between years with maximum densities of 94 larvae/m^3 (1989) and 451 larvae/m^3 (1990) recorded near Qualicum Bay. Plankton densities, larval lengths and other fish larval distributions were also examined to see if rates and directions of larval dispersal could be determined. The nearly continuous distribution of herring larvae in Georgia Strait is strong evidence of mixing between different spawning sites. This mixing of larvae virtually precludes the potential for genetically distinct herring stocks in Georgia Strait. Therefore we conclude that there is no more than one genetically distinct herring stock in the Strait of Georgia.

H91-5. The distribution and timing of spawning as a basis for recognition of herring stocks in B.C. by D.E. Hay

This study proposes that British Columbia herring stocks can be recognized by the geographic distribution and timing of their spawning. For this study a 'stock' was defined as a population that (1) spawned in a geographically distinct area and (2) had continuous or virtually continuous spawning each year for 50 years between 1937 and 1986. When analyzed this way there is a maximum of 40 different areas with continuous spawning on the B.C. coast, including 7 in Georgia Strait. Results from other studies (tagging, morphological and electrophoretic analyses, larval surveys) are used to 'pool' adjacent spawning with close geographical proximity. This reduces the maximum number of possible stocks in B.C. to 30 with 3 in Georgia Strait. There is potential for further reduction. Excluding southern Johnstone Strait and Sechelt Inlet, the cumulative biological evidence indicates that there is only one biological 'stock' in Georgia Strait.

H91-8. Delineating Strait of Georgia herring stocks using growth and reproductive characteristics by R. W. Tanasichuk

The growth (weight-at-length, size-at-age 4) and reproductive (size-specific ripe ovary weight) characteristics and age compositions of ripe females collected in Areas 14, 15, and 17S in 1981-1985, 1987, and 1989 were compared. Size-at-age was the

Appendix 5. Summary of reviewed working papers and reviews.

only character which differed among areas with Area 15 being consistently smaller. Size-at-age suggests that Area 15 fish are a separate stock but any follow-up work must ensure as was attempted here, that fish are taken near their spawning grounds.

Summary of reviewer comments (R. I. Perry):

It is useful at the outset to define a stock as a local population which is a self-sustaining component of a species (Sinclair 1988). "Self-sustaining" implies it is continuous over (many) years and that, while not necessarily prohibiting spawning contributions by fish migrating from other local populations, continuation of the population does not depend on these "outside" fish.

The present management structure for herring in the Strait of Georgia basically reflects the recognized stocks: a Northern population, consisting of Sections <173 and a Southern population, consisting of Sections ≥173. No data were presented in the documents showing the basis for the present stock structure, although Haegele presents results of belly tagging from 1937-1956 which show that southern stocks primarily migrated into the Strait from the south and that northern stocks migrated primarily from the north.

In the present review of the stock structure question, most of the potential adult characteristics that could be used to identify separate stocks produced negative or inconclusive results. These included biochemical, genetic and length-weight and gonad weight-body weight analyses. Differences were noted between fish spawning in the northern, southern, and Jervis Inlet parts of the Strait, and it was concluded that two stocks could be recognized: one in Areas 12, 13, 15, 16 (the Northern stock) and the other in Areas 14, 17, 18, 19.

Historical data (pre 1970) using belly tags placed on fish on spawning grounds identified two return routes, that fish spawning in the northern strait migrated in mostly from the north, that southern-spawning fish migrated from the south, and mid-strait fish migrated from both directions. Recent data (post 1980) from anchor tags placed on fish in overwinter areas shows a temporal separation of fish from different areas, with fish that spawn further away leaving the overwinter grounds first. In particular, note that fish spawning in Area 15 (Powell River) remained in the Johnstone Strait region later than fish spawning in Area 14 (mid-east coast Vancouver Island).

The locations and timing of spawning indicated that eight distinct grounds could be identified, which could be grouped into three spawning areas: Area 14, 15, 17 (Denman Island to Yellow Point, including Powell River); Area 16 (Sechelt/Jervis Inlets); and Areas 18, 19 (Gulf Islands). However, considering the mean timing and geographic separation of spawning grounds, it was suggested that four spawning areas could be recognized by separating Area 15 (Powell River) from Areas 14 and 17. Mean timing of spawning then proceeds south to north with spawning occurring early in the Gulf Islands, then the mid-east coast (Areas 14, 17), followed by Area 15, 16 and 13.

This separation of Area 15 from Areas 14 and 17 is also consistent with the larval distribution data. It was noted that two major larval distribution areas occurred in 1989, one in Area 15 and the other on the east coast of Vancouver Island from Sections 142 to 181. Further analyses on larval ages and possible transport trajectories and modelled growth rate analyses would be very interesting and pertinent. The observation of one larval distribution centre along the middle east coast of Vancouver Island suggests that the spawning groups in Areas 14 and 18 could be combined. This produces a stock structure pattern which is consistent between spawning and larval distributions, tagging data, and size-structure analyses, with Areas 14, 17, 18 representing the southern stock and Areas 15, 16, 13 representing the northern stock. An important question is the extent to which the observed stock differences may be genetic or environmentally determined. They could be environmental if it is shown that spawning groups tend to remain together over their life history. There is an indication of this, for example in the later spawning, coherent larval distribution, and later return of fish from Areas 15. It may be worthwhile to do another tagging study of fish on the spawning grounds.

If populations are defined on the basis of reproductive isolation, then the spawn data leads to the conclusion of at least eight separate stocks in the Strait of Georgia. This leads to a range of potential spatial scales of management; from the small scale of each local spawning ground to the large scale of considering the whole strait as a single population. However, it is impractical to manage the individual spawning grounds, considering their small spatial scale and the intermittent spawning history of most of these grounds. There are several interesting research questions here, including why and when grounds are colonized or disappear (related to overall population densities?) and whether sustained grounds have any common but unique characteristics. There is also the question of homing to such specific locations, and when during the life cycle imprinting might occur. However, at the other extreme of whole-strait management, there is a risk of imposing a whole-strait quota on a smaller sub-population which may not be able to sustain such pressure.

The conclusion of this review of herring stock structure in the Strait of Georgia is that the present system of a northern and a southern stock is reasonable and consistent with existing data. However, it is suggested that Area 14 should be included in the southern stock instead of the northern stock as at present. The stock definitions would therefore be: Northern stock: Areas 13, 15, 16, 14-1; Southern stock: Areas 14-2, 14-3, 17, 18. As a suggestion, the catch and spawning bed data for these "new" areas could be examined using the usual assessment methodology to see if better agreement is obtained between forecast probability frequency distributions of age-structured and escapement models.

Summary of reviewer comments (R. Stephenson):

It is important to put this review of stock structure in context, and to be clear about the objectives. The question of stock structure is important to the assessment, in that we are assuming populations. It seems that this session was prompted by the question of how focused fishing effort could be within the Strait of Georgia. There is a problem of terminology. One must be clear about the definitions of population structure, assessment units and management units. Population structure is a biological concept. Assessment units should match (as far as possible) biological populations. Management units are usually a compromise of biological, management, political and historical considerations. The term stock has been used loosely and should be clearly defined when discussed.

It is unlikely that all of questions of biological stock structure will be resolved. Rather, the best decision regarding the structure of the assessment units in light of the evidence available at present should be made. The best logical, documented decision which will stand up for some time should be sought. In general, the papers demonstrate that there is a considerable amount of historical information.

The historical data on spawn records is unique and valuable. The logic, of using historical consistency criteria and lumping adjacent areas to define spawning groups seems useful. A concern is the relative consistency of Fishery Officer search effort over the time period, i.e. could small spawning units with short spawning duration have gone unnoticed? (the possibility of incomplete survey of remote areas is mentioned.) However, the impact would be to reduce the number of areas and treat the number as maximum.

The similarity of spawning time is striking, and is not readily interpreted. In the Atlantic, substantial differences in spawning time between adjacent areas (e.g., spring/fall) have been used as rationale for population status (e.g., 4T). The Goldstream Flat/Blind Bay spawns are suggested as examples of ephemeral stocks and are very convincing (subject to details of F.O. survey effort). <u>But</u> are they truly ephemeral as is suggested; or are they ticking over at a low level which is hard to detect - the "boom" to become noticeable? (The reason is that some Nova Scotia spawning groups "pop up" in odd Bays from time to time -- but they tend to be spring spawners in an area where the likely large groups of origin are all Fall spawners!) Is there historical age/size info associated with any of these events which may help shed light? One would expect expansion-type colonization to reflect characters of neighbouring groups.

The need to account for colonization -- and the post-glacial establishment of herring populations is important. The possibility of prespawning movement up to 100 km does not seem unreasonable. If Atlantic herring examples are relevant, we have movement of that order. The 40-km Saltspring Island/Boundary Bay example does not seem unbelievable.

Larval herring surveys play a very influential role in Atlantic herring. Larval surveys can provide a lot of good information including verification of spawn areas, time and a variety of aspects of early life ecology. However, what is of use from these studies to date with respect to the stock structure question?

The general disappointment that genetic studies have been with respect to stock discrimination in herring is summarized. With respect to mt-DNA, a more extensive study of Atlantic herring including over 400 fish (Kornfield and Stephenson, unpubl.) confirms the lack of discriminating power even with larger sample size. Some modelling work indicates that sample sizes would have to be very much larger (orders of magnitude) to successfully determine stock differences amidst the overwhelming number of low frequency composites which herring exhibit. However, the lack of demonstrable genetic differences does not prove similarity. There are a number of possible alternate explanations; including lack of characterization of the correct part of the genome and lack of differentiation in herring populations which are relatively large and of post-glacial origin. The pursuit of more advanced techniques (including nuclear DNA characterization) is to be encouraged, but we should not have over-expectations. The size and age differences are interesting. These differences may be transient but are, perhaps, of use at present.

Tag evidence for movement has been among the most useful for herring. It was noted that the tagging are dated. On the East coast there is concern that there may have been changes since comparable tagging studies were done? Presumably these tag results were used in setting up current stock structure ideas. The more recent anchor-tag experiments may be of less relevance, in that they were not on spawning fish on spawning grounds mixing is to be expected outside of the spawning time.

Most growth characteristics were not useful in discrimination of stocks - but as in the genetics should not be viewed as indicating affinity. The size-at-age differences are intriguing. Examples elsewhere (North Sea, Georges Bank, Gulf of St. Lawrence) are also suggestive but often are not a persistent stock characteristic. However, even if it is ephemeral, it may be useful. Limitations of the technique are listed including fish movement and timing of sampling.

Appendix 6. Summary of unreviewed working papers.

H91-7. Offshore herring distribution and recruitment forecast for the lower west coast of Vancouver Island, August 1991 by D. M. Ware and R. Tanasichuk

During the August 1991 La Perouse trawl survey, herring were distributed in their typical summer pattern. The largest concentrations tended to be on La Perouse and Swiftsure Banks. However, we also encountered some large concentrations of herring along the outer shelf near the Canada-USA border. Size composition samples were taken from all the major aggregations. Based on the modal distribution on lengths, and previous information on the relationship between length and age, we forecast that 44% of the Barkley and Clayoquot Sounds herring spawning stock will consist of 3-yr old recruit spawners in the spring of 1992. A frequency this high implies that the 1989 yr-class is of slightly better than average strength. The 5-yr track record of this simple forecasting procedure demonstrates that it has been fairly accurate, and therefore worth continuing.

H91-9. Hydroacoustic herring survey results from Hecate Strait December 3-15, 1990. W. E. Ricker Cruise 90HER2 by P.B. McCarter, P. Withler, D. E. Hay, and R. Kieser

Two major Pacific herring overwintering areas in Hecate Strait are Juan Perez Sound, in the Southern Queen Charlotte Islands and the vicinity of Browning Entrance on the mainland side of Hecate Strait. Echo integration biomass estimates of midwater herring totalled 15,235 tonnes in the Browning Entrance area and 32,575 tonnes in Juan Perez Sound. The effects of bottom echo interference during the day and limited echo integration range near the surface at night were mitigated during this survey by sounding during a 6-8 hour period at dusk and dawn. Six repeated soundings in Juan Perez Sound gave a measure of the variability of the hydroacoustic biomass estimates over 3 successive evenings. The biomass estimates determined during this survey are similar to those determined by other stock assessment methods.

H91-10. 1991 in-season tagging results and recommendations by S. Farlinger, B. Armstrong, and V. Haist

Results of the 1991 in-season anchor tagging are presented. Of 56,869 tags applied, at total of 783 (1.37%) were recovered together with 171 from previous years. Another 30 tags were recovered but were unusable. Results of an analysis which assesses the probability of detecting erroneous tag recoveries is presented and indicates that a significant proportion of the observed recoveries could potentially contain errors. It is concluded that the initial objectives of the tagging program, to examine in-season movement of herring within stock assessment regions, have been completed and it appears that little is to be gained by continuing the program at this time.

Pacific Stock Assessment Review Committee

PSARC Advisory Document 91-5

CONTENTS

I. STEERING COMMITTEE REPORT

The PSARC Steering Committee met September 20, 1991 at the Pacific Biological Station, Nanaimo to review the Data and Systems Subcommittee (DSSC) Report. The Subcommittee Report was discussed and the following recommendations made:

1. The Steering Committee recommends that the proposed shellfish logbook study be undertaken under the supervision of the PSARC Invertebrate (Shellfish) Subcommittee. However, someone familiar with logbooks who is not on the Invertebrate Subcommittee should participate in the study. The Steering Committee recommends that the Invertebrate Subcommittee Chairperson recommend who this individual might be.

2. The Steering Committee recognizes there are not sufficient numbers of people within the Pacific Region who are adequately skilled in survey design and methodology to undertake workshops on survey methodology. Similarly, there is a paucity of staff available with strong modelling skills. To remedy this situation, the Steering Committee recommends that the RMEC investigate the possibility of:
   a) securing appropriate contract services; and
   b) initiating processes to hire appropriate staff within the region.

II. DATA AND SYSTEMS SUBCOMMITTEE REPORT

INTRODUCTION

Two meetings of the Data and Systems Subcommittee (DSSC) were held in 1991. The June 18 meeting was used to review requests from the June meeting of the Steering Committee. The September 6 meeting reviewed progress on these and other tasks. Lists of participants and discussion papers are appended. This report provides a synopsis of the discussion papers, review comments, and the Subcommittee's recommendations.

1. CHAIRMAN'S REPORT FOR THE 1991 DATA AND SYSTEMS SUBCOMMITTEE

INTRODUCTION

This report is a summary of the activities of the Data and Systems Subcommittee of PSARC for 1991. The role of DSSC was reviewed during the Subcommittee and Steering Committee meetings in June. The Steering Committee suggested that DSSC activities would evolve in response to the tasks presented. Assignments for DSSC would be identified by the Steering Committee who would also be responsible for resolving workplan conflicts or assigning non-DSSC staff to the tasks.

SUBCOMMITTEE ACTIVITIES 1991

The Steering Committee tasked DSSC with two assignments at the June 1991 meeting. They requested that DSSC draft study outlines to: 1) examine the value and costs of shellfish logbooks and, 2) to examine the status of biological data for stock assessment. They asked that the latter study be outlined after DSSC reviewed the progress of the "Fisheries Management Information Systems Study Team" (FMISST) on this issue.

Subsequent to the meeting of the Steering Committee, the Regional Management Executive Committee (RMEC) requested that DSSC examine the potential for a Regional Modelling Group.

Following the August meeting of the PSARC Shellfish Subcommittee, DSSC was asked to examine the potential of holding workshops on survey methodology for intertidal and subtidal invertebrate fisheries.

SUMMARY OF DISCUSSION PAPERS

SHELLFISH LOGBOOK STUDY (Discussion Paper 91-1)

The study paper outlines the terms of reference for a study of the region's use of shellfish logbooks. The proposed format would examine the logbooks from a stock assessment viewpoint with regard to:

- are the systems collecting the necessary data;
- completeness and length of time series;
- accessibility;
- technical structure and compatibility with other shellfish and regional databases;
- accuracy;
- cost to industry and DFO;
- alternative information sources.

If possible, the team should examine whether the data being collected are actually being used and, if so, are the data providing the stock assessment information that was expected.

The study will require about 1-2 weeks effort on the part of 3-4 core staff members. The managers of the logbook systems would also have to provide 1-2 days. The study team should include both shellfish management and research staff as well as non-shellfish staff to provide an impartial perspective on the value of the databases. The report should be submitted to both Shellfish and DSSC PSARC Subcommittees for review in the fall 1992 meetings.
The Subcommittee recommends that the study be conducted.

REVIEW OF REGIONAL BIOLOGICAL DATABASES (Discussion Paper 91-2)

Following discussions with FMISST participants at the June meeting of DSSC, the Subcommittee concluded that an examination of biological databases by DSSC at this time would duplicate part of the Terms of Reference of FMISST. The Subcommittee decided that it would best serve regional needs if it provided a review forum for FMISST progress. FMISST staff were asked by DSSC to prepare a progress report on biological databases for the September meeting. On the basis of results at that time, DSSC would frame a recommendation for review by the Steering Committee.

At the September meeting, a summary of FMISST activities was presented but FMISST staff requested that the review be postponed for 1-2 months until the groundfish and herring modules were completed. DSSC agreed to schedule a meeting for October 29 at PBS and asked FMISST staff to present a progress report on the completed modules and progress to date on the salmon and shellfish modules. The FMISST review would be the main focus of the October meeting and would result in a summary document outlining DSSC's response to whether FMISST was meeting its objectives with respect to stock assessment databases.

SHELLFISH SURVEY METHODOLOGY WORKSHOP (Discussion Paper 91-3)

The Shellfish PSARC Subcommittee requested the DSSC consider the need to sponsor regional workshops on sampling methodology for subtidal and intertidal invertebrates. The Shellfish Subcommittee proposed a 1-2 day workshop which would cover: 1) basic survey design issues and 2) one or two survey examples.

The DSSC suggests that the shellfish request, like the need for a Regional Modelling Group addressed below, reflects the regional shortage of staff with quantitative analytical skills. In fact, while there may be a handful of DFO staff with strong mathematical and statistical backgrounds, there is probably no one with specialized skills in sampling/survey design. Secondly, while DSSC strongly endorses the shellfish group's attempt to provide a sound quantitative basis for their surveys, the process of designing appropriate sampling surveys, even for one fishery, cannot be adequately addressed in a 1-2 day workshop. A more reasonable expectation of a workshop is that it would provide precise definitions of the questions that were being asked of each survey. A workshop might also be useful for drafting the terms of reference for a contract to develop a survey design. Survey design is non-trivial, especially if DFO expects the design to withstand court challenges.

On a general note, requests of this nature indicate the growing regional recognition that the increasingly complex analytical issues which now face many staff are beyond their current abilities. Recognizing the shortage of staff with specialized quantitative skills, the DSSC suggests that regional training and staffing initiatives be designed to address this issue. Workshops may be one vehicle for such training. The region should recognize that a series of workshops for each species may be required to address these concerns but that significant resources would be imperative to undertake such a task. DSSC recommends that shellfish staff resolve more precisely their expectations from the surveys before considering the workshops.

REGIONAL MODELLING GROUP (Discussion Paper 91-4)

At the July 2 RMEC meeting, DSSC was asked to respond to four queries related to formation of a Regional Modelling Group:

1) Do sufficient DFO staff have the expertise to form such a group?
2) What are the requirements of such a group in terms of program and staff?
3) If staff were not available within DFO, could we hire outside staff?

4) Could the formation of a regional modelling group be done through the DSSC?

The discussion paper presented at the DSSC September meeting attempts to provide guidance for the RMEC on how to proceed with such a group, as well as addressing what DSSC's contribution might be to the process. The document summarizes the views of the subcommittee as well as the comments of approximately 10 additional respondents from BSB and FB.

Operational Definitions

This discussion assumes that the Subcommittee was to address the need for help in **developing** models. The Subcommittee recommends, however, that the region also requires a more effective means for **reviewing** the models used in stock assessment and management. Models are usually too complex to review within the time frames provided by the PSARC process. Furthermore, many of the models used in the region are too poorly documented to review adequately in any time frame. The model review function is also critical in international negotiations and the review of non-Canadian fishery dynamics models.

The question of a Regional Modelling Group appears to have originated with Fisheries Branch and refers to that class of models that simulate a specific fishery, usually salmon, and can be directly manipulated by managers. They typically take one of three forms:

1) Inseason management (e.g. Fraser River Sockeye);
2) Longterm management (e.g. South Coast Model used by Fraser River Task Force);
3) Reconstruction models (e.g. Fraser River Stock Reconstruction Model).

Questions referred to DSSC

1) Is there the expertise in the Region?

There is a shortage of statistical, programming, and modelling skills within the Region. These people will have to be seconded from their current activities. There will be difficulties in seconding fishery managers away from their fisheries for extended periods.

2) What would be the staffing requirements?

The minimum core group would include 3-4 people with statistical and programming skills as well as the management biologist familiar with the system being modelled. Staff requirements would vary depending on scope and timeliness required. Model building might commence with a workshop to ensure that all users' needs will be addressed. Over the longer term, and in the context of a dedicated model production group, an additional biologist position could be committed to develop continuity of the management perspective within the team and thereby reduce the commitment of the specific fishery managers.

3) If DFO staff were not available, could model development be contracted?

Yes, but respondents felt that the models should be developed within DFO for the following reasons:

a) Continuing support

Models will need to be updated and upgraded at frequent intervals. There will also be significant work involved in introducing the models to the user community and then supporting the model for the lifetime of the model.

b) Consistency and economy

Continuity in model development and operation would reduce total support costs. For example, some model components may be transferable among salmon models although there is some risk of error propagation.

c) Quality control

Many respondents commented on the lack of critical review for some fishery models currently in use. The review of models in PSARC context will be greatly simplified by a stable support structure, commitment to documentation, and the presence of modellers during the review process.

d) Defensibility

Model performance and the decisions based upon the model may have to be defended in court.

4) Can DSSC put together a modelling group?

DSSC does not have a mandate to create a regional modelling group. DSSC does not have the comprehensive expertise to develop a variety of models, although individuals on the committee could certainly participate on specific modelling projects. As emphasized above, a modelling group within the region will only produce real benefits only if it has a stable personnel commitment whose major responsibility is to develop and document realistic fishery models.

Issues to consider in the creation of a Regional Modelling Group

1) Structure

If the objective of these modelling exercises is to provide fishery managers with useful management tools, success will require a close working relationship between the technical specialists on the team and the fishery manager. The scope and objectives of the project should be defined by the manager after extensive consultation with scientific staff. The nature and priority of the project will determine the commitment of each team member. It is important that these working relationships and expectations be established before the project begins. This type of collaboration will be essential for the group to successfully develop a useful product.

2) Duties

Principal duties of the unit would be to:

- assist senior managers in setting modelling priorities;
- provide model documentation and user's guides;
- support models previously produced by the unit;
- provide workshops in how to use and understand the models;
- conduct workshops in preparation for future models (ie. what information is still required if a model were to be built);
- monitor use of these and other models (probably in PSARC and International context);
- assist other DFO staff in development of models.

3) Data requirements

The most obvious requirement of a Regional Modelling Group is the appropriate data sources. **DSSC emphasizes that the regional data problems currently being examined by the FMISST group are of far greater importance and urgency than the issue of a Regional Modelling Group.** Without a better data system in the region, the value and credibility of models will be limited.

4) Productivity

It is difficult to estimate the time required to build a model. It will depend on the type of model, the availability of the data/information, and the commitment of staff resources. Development of some models may occur in stages over 2-3 years as data sources are improved and background studies are completed.

Nevertheless, most respondents felt that if the data were available, then a modelling team might be able to develop and support **one** major new model per year. Costs could decrease significantly if groups of models were of a generic type (ie. in-season salmon management). However, as more models are developed, the group will be increasingly committed to support and extension work.

5) Complexity

Some models within the region have been criticized for lacking a sound mathematical basis. They are criticized for being simple, deterministic, step-wise models with little or no parameterization of probability. There is concern about the objectivity of these models and suspicion as to whether they simply reconstruct management intuition.

On the other hand, some models that are soundly based statistically, have been criticized for being interesting academic exercises but relatively useless for managing a fishery. Models clearly require both a sound statistical foundation and a practical orientation. Model development will be an evolving process that may pass through simple deterministic phases before becoming more sophisticated. It is noted that the fact that a model has a practical orientation does not guarantee that the directions or solutions indicated by model output will be possible.

Complex models are harder to explain, understand, operate, and defend in use. The results, to some extent, will have to be interpreted by the primary users in terms of patterns of residuals, likelihood values, etc.. While these users may not understand all the mathematical structure, they will have to be educated about how to interpret the output and be able translate the results to other DFO staff and industry.

6) Commitment

There must be a commitment to pursue the model results to implementation, as long as the model results, and model functioning survive critical peer review.

SAMPLING DESIGN FOR ESTIMATING HALIBUT BYCATCH (Discussion Paper 91-5)

A presentation was made on the analysis of halibut bycatch data. Previous data were examined to project the necessary sample size that would be required to produce acceptable precision in estimating halibut bycatch. The DSSC endorsed the example of providing a quantitative treatment of data prior to conducting fishery studies. The committee commented that most studies were developed on an <u>ad hoc</u> basis and suggested that DSSC's role in the future could be to recommend such studies to the Steering Committee prior to commitment of resources.

Appendix 1. List of discussion papers

Discussion Papers

1.	Study Plan of Shellfish Logbooks	D. Noakes S. Somjee R. Stanley
2.	Progress report of FMISST study with respect to stock assessment databases	M. Birch
3.	Survey methodology for intertidal and subtidal invertebrates	S. Farlinger
4.	Regional Modelling Group	R. Stanley
5.	Sampling analysis for halibut bycatch observer program.	R. Stanley J. Fargo C. Hand

Appendix 2. List of Participants at the DSSC Subcommittee meetings

June 18, 1991

R. Stanley, Chairman
M. Birch
J. Bjerring
C. Cross
L. Hamer
L. Hop Wo
D. Noakes
D. Radford
S. Somjee

September 6, 1991

R. Stanley, Chairman
M. Birch
T. Calvin (for Sadiq Somjee)
C. Cross
L. Hamer
L. Hop Wo
D. Noakes
P. Starr
J. Irvine (Chairman, PSARC)
S. McKinnell (Chairman, PSARC Salmon Subcommittee)

PACIFIC STOCK ASSESSMENT REVIEW COMMITTEE

PSARC ADVISORY DOCUMENT 91-6
DECEMBER 1991

BIOLOGICAL ADVICE ON PACIFIC SALMON

CONTENT

I. STEERING COMMITTEE REPORT

At its meeting on December 9, 1991, the PSARC Steering Committee reviewed the Salmon Subcommittee Report as contained in this document. The Salmon Subcommittee considered five working papers (S91-06a+b, S91-07, S91-09, S91-10, and S91-11) which are summarized in this document.

The Steering Committee has the following advice concerning the recommendations provided by the Salmon Subcommittee at the beginning of their report:

Skeena River Steelhead

The Steering Committee was pleased to see the participation by Provincial staff at the Salmon Subcommittee meeting and the report on Skeena River steelhead prepared by them. The Steering Committee agreed with both recommendations provided by the Salmon Subcommittee.

The Steering Committee would like to see further involvement by Provincial Staff within the PSARC process. In particular, they encourage the completion and presentation of a Working Paper examining the habitat modelling approach used to develop escapement targets for the Skeena River system.

Upper Johnstone Strait Coho

The Steering Committee supports the establishment of a working group which would examine alternative assessment methods and present their results to the Salmon Subcommittee. Although the Steering Committee felt that the Keogh River was probably a reasonable choice for an exploitation rate and productivity indicator, the Committee would like additional information before it endorses this recommendation. The Steering Committee requests a more clear definition of the expected output from the proposed work. It recommends that CWT data from the region that was not included in this working paper be examined to determine the representativeness of the Keogh system. The Steering Committee recommends that the working group consider these points in their review.

Fraser River Coho : Floor Escapement

The Steering Committee recognizes the difficulties the authors of this Working Paper had because of their inability to establish the spawner recruit relationship. Nevertheless, to preserve Fraser River coho stocks, the Steering Committee agrees that Subcommittee recommendations 1 and 2 appear suitable as interim measures pending further analyses. The Steering Committee is uncertain how much effort would be necessary to calibrate the Fraser River test fishery against known escapements and is therefore unable to recommend this be done. The Steering Committee again supports the establishment of a coho working group which would evaluate alternative methods of estimating coho escapements to the Fraser River drainage. The utility of coho escapement goals based on estimates of habitat carrying capacity should be considered by the working group.

Sport Fishery Regulation Changes : Chinook

The Steering Committee accepts the advice provided by the Salmon Subcommittee. The Steering Committee requests that new programs necessary to improve our understanding of the size at age of Georgia Strait chinook (Subcommittee recommendation 2) should be identified in the Working Paper scheduled for the upcoming Salmon Subcommittee meeting. The Committee understands that the research identified in Subcommittee recommendation 3 is underway and agrees that this should be a high priority. The concept of bringing the Department and user groups together and attempting to resolve data and analytical methods (Subcommittee recommendation 4) is endorsed. The Steering Committee also agrees with recommendation 5 that a comprehensive review of the rebuilding program be provided at the next Salmon Subcommittee meeting.

Nass River Sockeye

The Steering Committee agrees that harvest rates and escapement targets for Nass River sockeye should not be changed at this point. The Steering Committee notes that the means are available to trace the pattern of contributions of Meziadin sockeye to intercepting fisheries (Subcommittee recommendation 2). The data could then be extended, based on analysis of the Meziadin/non-Meziadin mix within the Nass, to estimate contributions of non-Meziadin stocks to intercepting fisheries. These studies would be expensive, with costs depending upon the extent that the analyses are required to cover sequentially earlier fisheries. The justification for the different possible levels of study will depend upon management goals established. The Steering Committee understands that the work proposed as Subcommittee recommendations 3 and 5 is included in the Nass Interim Measures Package and requests that a PSARC Working Paper be prepared when the work is completed. The Steering Committee understands that the work identified in Subcommittee recommendation 4 has been proposed by North Coast Fisheries Branch and agrees that it should be done.

II. Salmon Subcommittee Report

INTRODUCTION

The Salmon Subcommittee met at the Pacific Biological Station, Nanaimo, B.C., from November 19 to November 21, 1991. The Subcommittee reviewed six working papers on assessments of Pacific salmon and steelhead. The objectives of the meeting were to:

- review the assessments, methods, and advice provided in each working paper.
- develop consensus on stock status and recommendations.
- identify additional research or information required.

List of Working Papers

S91-06a A method of estimating the commercial catch and escapement of steelhead trout (Oncorhynchus mykiss) at the mouth of the Skeena River. C.R. Spence, A.R. Facchin, A.F. Tautz, and R.S. Hooton

S91-06b Run timing and target escapements for summer-run steelhead trout (Oncorhynchus mykiss) stocks in the Skeena River system. C.R. Spence and R.S. Hooton.

S91-07 Stock status information for coho salmon (Oncorhynchus kisutch) in upper Johnstone Strait. (An assessment of distribution in Canadian fisheries and time trends in the natural spawning population.) T.F. Shardlow

S91-08 Smith Inlet Sockeye - Not received in time for review.

S91-09 Advice for establishing a floor escapement goal for Fraser River coho salmon (follow-up to PSARC Working Paper S89-28). R. Kadowaki and N. Schubert.

S91-10 Evaluation of the 1988 and 1989 Strait of Georgia sport fishing regulation changes for the years 1989-1990. P. Starr.

S91-11 Assessment of the status of Nass River sockeye salmon (Oncorhynchus nerka). M.A. Henderson, A. Cass, C.C. Wood, D. Rutherford, R. Diewert, L. Jantz.

PARTICIPATION - SALMON SUBCOMMITTEE MEETING - FALL/1991

COMMITTEE MEMBERSHIP

A. Cass
S. McKinnell, Chair
P. Starr (November 20 p.m. only)
D. Meerburg, FRB, Ottawa
R. Harrison, FR,NBC&Y Div.
K. West, REB
Habitat Management, VACANT

R. Kadowaki
B. Riddell
C. Wood
D. Anderson, SC Div.
D. Peacock, NC Div.
G. Berezay, PP&E

SENIOR AUTHORS

T. Shardlow (November 20)
M. Henderson (November 19)
C. Spence (November 19 p.m.)
P. Starr (November 20, afternoon)
R. Kadowaki

REVIEWERS (* indicates not at meeting to present review)

A. Cass
D. Anderson
K. Hyatt, November 19
B. Holtby
K. Wilson, November 20
T. Gjernes, November 20 p.m.
D. Peacock
R. Kronlund*
J. Hume*
R. Hilborn, U. of W.*
J. Rice, November 20 p.m.

OBSERVERS AND JUNIOR AUTHORS

K. Pitre
T. Shortt, AFSAC Chair
P. Ryall, November 19
J. Irvine, PSARC Chair
L. Jantz (November 19)
D. Rutherford (November 19)
C. MacKinnon, November 19
L. Lapi
T. Perry, Not November 19 a.m.
D. Blackbourn
A. Facchin, R. Hooton, A. Tautz (November 19, p.m.)
N. Schubert (November 19)

SUMMARY OF SUBCOMMITTEE RECOMMENDATIONS

The following summary provides a brief list of the Subcommittee recommendations and advice related to the working papers reviewed during the November 19-21, 1991 meeting of the P.S.A.R.C. Salmon Subcommittee. For the detailed background and discussion, refer to the summary of specific documents listed below.

Skeena River Steelhead

1. The authors concluded that the harvest rates of summer-run steelhead in the Skeena River are above optimum. The Subcommittee accepted the methodology presented in Working Paper S91-06a, but not the conclusions of the analysis because two key assumptions were questionable. Cooperative MELP-DFO studies should be initiated to (i) calibrate the Skeena steelhead test fishery index against known steelhead escapements for the purpose of estimating steelhead escapements; and (ii) examine the relative catchability of sockeye and steelhead in Area 4 fisheries and in the Skeena test fishery for the purpose of estimating steelhead catch.

2. The authors proposed target escapements for individual steelhead stocks within the Skeena River system. The target escapements were not supported by the Subcommittee as the methodology used to develop the targets was not presented to the Subcommittee for review. The Subcommittee recommends that MELP submit a Working Paper for the Spring 1992 meeting.

Topics should include methods of establishing habitat-based escapement goals and harvest rates for individual steelhead stocks in the Skeena River, exploitation rates in sockeye/pink fisheries, and recommended procedures for managing fisheries on mixed steelhead populations with different productivities.

Upper Johnstone Strait Coho

1. The majority of the Subcommittee agreed that there was sufficient uncertainty in the coho escapement data that the status of coho stocks in upper Johnstone Strait is uncertain. To provide some information, two representative stocks, one on NE Vancouver Island (Keogh River) and one on the mainland (to be determined), should be designated as exploitation rate and productivity indicators. A CWT tagging and escapement enumeration program could provide this information.

2. The Subcommittee does not support the author's recommendation to spend additional resources to improve the Johnstone St. natural escapement enumeration methods until a review of alternative stock assessment methodologies is completed. The Subcommittee recommends that a working group be established to address the cost, feasibility, and effort associated with alternative assessment methodologies. The working group should report the results of their investigations to the Subcommittee in the fall of 1992.

Fraser River Coho : Floor Escapement

1. Exploitation rates of Fraser River coho have previously been estimated to be around 78% (S89-28). To protect less productive coho stocks in the Fraser, the Subcommittee recommends that the total exploitation rate should fall within the 65% to 70% target range previously recommended for Strait of Georgia coho.

2. Within an overall target exploitation rate, an escapement floor for Fraser River coho should initially be set at 250,000 naturally spawning coho (measured at the test fishery) such that harvest could be permitted above the floor in some yet undetermined manner. Details of a possible terminal harvest should be developed by fishery managers in consultation with stock assessment staff.

3. The Fraser River test fishery should be calibrated against known escapements to provide reliable inseason abundance estimates. An evaluation of alternative methods to provide more accurate estimates of escapement of Fraser River coho is advised, preferably as part of the assignment contained in Recommendation 2 for upper Johnstone Strait coho.

4. Separate coho escapement goals should be established for major tributary streams, perhaps based on estimates of habitat carrying capacity.

Sport Fishery Regulation Changes : Chinook

1. Based on the analyses presented, the Subcommittee concluded that the harvest rate in the Strait of Georgia sport fishery probably did not decline by 20% relative to 1987 in 1989, but probably did decline by that amount in 1990.

2. It is important to obtain a better representation of the size at age of the populations of chinook available to the Strait of Georgia sport fishery and to estimate the effort directed at chinook by the sport fishery. Existing programs can be upgraded (e.g. T. Gjernes's troll sampling program) or new programs may have to be developed.

3. Research is required to understand and describe mathematically the sources of error and bias in coded wire tag data in order to provide confidence intervals around parameter estimates. The Subcommittee considers the development of this theory a high priority.

4. Given the uncertainties in this analysis, the Subcommittee recommends that the Department and user groups agree on what type of data and analyses are required to warrant management action when there is reason to believe that salmon stocks are at risk or are not being exploited optimally.

5. Given the original objective of rebuilding LGS chinook stocks by 1998, the Subcommittee strongly recommends that a comprehensive review of all aspects of the program be conducted immediately so that corrective actions could be taken in a timely manner, if required. This evaluation will be presented as a PSARC working paper and is scheduled for the spring/1992 PSARC Salmon Subcommittee meeting.

Nass River Sockeye

1. Harvest rates and escapement targets for Meziadin and non-Meziadin stocks should not be changed from current levels. Limitations in data quality and quantity result in considerable uncertainty in the estimates of optimal escapements and stock productivities. These appear to be unusual when compared with estimates for other sockeye stocks.

2. Many of the uncertainties associated with future run sizes of Nass sockeye stocks (catch and escapement) could be alleviated by establishing a stock identification (genetic, age

composition, parasites, scale pattern) program in northern fisheries and test fisheries. The scale and cost of this program would depend upon spatial and temporal resolution required to meet the management objectives established for these stocks.

3. Production capacity and limitations in freshwater and marine environments should be examined directly to compensate for the uncertainty that will likely continue to plague run reconstructions from unreliable historical data. In particular for 1992, the Subcommittee recommends examination of fry growth and abundance, and productive capacity of Meziadin Lake following the very high spawning escapement observed in 1991.

4. A critical evaluation of the representativeness of catches in Nass and Skeena test fisheries should be undertaken as a high priority. These test fisheries are critical to management and provision of accurate stock assessment data (run timing and age composition by stock, escapement and stock identification samples by stock). However, several concerns exist about saturation of the gillnets and calibration, size and stock selectivities, and the appropriateness of their duration of operation. Both test fisheries must be evaluated because of the simultaneous use of these data in any run reconstruction to partition catches of Nass and Skeena sockeye.

5. A review of basic assessment data is needed for Nass sockeye; specifically the availability of scale samples since 1969 to partition Meziadin and non-Meziadin stocks in the test fishery, verification of changes in the age composition reported, and examination of the adequacy of biological sampling programs in areas 3 and 4 to collect size and age composition data by time, area, and gear type.

DOCUMENT SUMMARIES, REVIEWS AND DISCUSSION

Two companion working papers were prepared by staff of the Province of B.C. and submitted to P.S.A.R.C. for review. Separate summaries of the two documents are reported below, however, the Subcommittee discussion and advice considers both documents together.

<u>S91-06a</u> <u>A method of estimating the commercial catch and escapement of steelhead trout (Oncorhynchus mykiss) at the mouth of the Skeena River. C.R. Spence, A.R. Facchin, A.F. Tautz, and R.S. Hooton</u>

DOCUMENT SUMMARY [Prepared by the authors, B.C. Ministry of Environment, Lands and Parks]

INTRODUCTION

Returns of Skeena River summer-run steelhead are severely affected by gillnet and seine fisheries targeting salmon stocks passing through southeast Alaska and northern British Columbia waters. The majority of domestic catches of Skeena-bound steelhead occur near the mouth of the Skeena River, within DFO Statistical Area 4. Long term catch and escapement data are required to accurately assess the status of Skeena River summer-run steelhead but cannot be obtained by direct means. In this report, we use sockeye escapement and catch data to assist in generating estimates of steelhead catch, escapement and stock size in Area 4.

BACKGROUND

Our methods employ 1984 and 1985 hail catch data for steelhead, and assume steelhead and sockeye catchability are similar within any given week in the Area 4 fishery. Information in support of this approach is outlined below. Sales slip data significantly underestimate the number of steelhead caught by commercial fishermen because many of these fish are kept for personal use or sold as coho. Steelhead have been included in DFO's hail program since 1984 in an attempt to improve the catch database. Hails for steelhead are believed to have been accurate when first developed in 1984 and 1985 but have become less reliable over time as industry sensitivity to the steelhead bycatch problem has increased.

The Area 4 fishery is dominated by gillnets, which account for more than 90% of the boat day effort. Hang ratios are in the order of 2.5-3.0:1, resulting in extensive tangling of the catch. Another important catchability consideration is that, in a typical opening, fleet sizes are large and the fishery is opened for 3 to 4 consecutive days. Any fish initially avoiding a net will very likely encounter several more nets before the opening is over, thereby increasing the chance of capture.

Tagging studies have shown that steelhead and sockeye require about the same length of time to travel through Area 4. Additionally, there have been no indications of other behaviourial differences that may result in different exposures to the fishery.

METHODS

Test fishery indices for steelhead were calibrated using weekly sockeye harvest rates in conjunction with weekly steelhead hails from 1984 and 1985. Assuming sockeye and steelhead are harvested at the same rate in any given week, the weekly total steelhead catch was divided by the corresponding weekly sockeye exploitation rate to give the steelhead stock size for that week. The catch was then subtracted from the stock size to give the weekly escapement. The resulting 14 weekly escapement estimates from 1984 and 1985 were then regressed against the corresponding cumulative weekly index values to develop the following calibration relationship:

$$Log_{10} \text{ Escapement} = 2.4784 + 0.9013 * Log_{10} \text{ Test Index} \quad (r^2=0.46)$$

This regression was applied to lagged cumulative weekly steelhead test fishery indices to produce weekly escapement estimates. Assuming equal catchability for sockeye and steelhead, estimated weekly steelhead escapements were divided by the corresponding weekly sockeye harvest rates to give a steelhead stock size for each week. The commercial catch was estimated by subtracting the escapement from the stock size. In all harvest rate calculations, test fishery indices were adjusted in time (lagged) to account for the distance and migration time between the locations of the commercial fleet and test fishery. Analyses were undertaken for the 8 statistical weeks beginning on average on July 1 and ending on average August 25 (weeks 27-34). Available data allowed steelhead stock size, catch and escapement data to be generated for 35 years, from 1956 to 1990.

RESULTS

Estimates of the annual steelhead stock size in Area 4 averaged approximately 37,000 and varied by a factor of 8 over the 35 year period of analysis. Peaks in stock size, catch and numbers passing the test fishery occurred in the mid 1960's and again in the mid-1980's. Increasing annual variation has also occurred through the 1980's. Although growth in both catch and stock size was evident in the mid-1980's, marine survivals of steelhead in 1984 - 1986 were exceptionally high and led to large returns coast-wide. Estimates from 1987-90 suggest a return to stock sizes more typical of longer term averages.

As expected, model-based catches were consistently higher than those indicated by sales slips. The average modelled annual harvest was 2.4 times greater than the sales slip records (range 1.1 - 6.7). Considerably more year to year variation was evident in the modelled catches than in the sales slip data; annual sales slip and modelled catches differed by factors ranging from 1.1 (1985) to 6.7 (1970).

The annual exploitation rate for steelhead in Area 4 has averaged 45%. Weekly average harvest rates have ranged from a low of 26% in week 27 to a high of 59% in week 30. The highest weekly harvest rates have taken place during the peak of the sockeye migration. Current aggregate stock Skeena steelhead harvest rates are higher than the ceiling used in management of steelhead in the Boldt case area (Washington State), where the exploitation rate for steelhead under conditions of maximum sustainable harvest has been determined to be 40%. Given comparatively low productivity in the

Skeena system, this suggests current harvest rates are above optimum.

The Skeena summer-run steelhead population is composed of many distinct stocks and studies have indicated that run timings and hence commercial fishery harvest rates vary between these stocks. Variations in the productive capacity of these stocks would be expected, based on factors such as fecundity and habitat capability. However, because commercial and test fishery catches could not be segregated into individual stocks in this study, stock-specific impacts were not assessed. Specific stocks are dealt with in a companion document (S91-06b).

Development of a system to expand test fishery indices to estimates of escapement is an important outcome of this analysis. This information will be essential in measuring the success of management efforts. Catch and stock size data generated by the study are of less utility since these results are restricted to Area 4. Recent coded wire tag recoveries have revealed significant harvests of Skeena steelhead in Areas 3 and 5, as well as in southeast Alaska. Although the cumulative extent of harvests in these other fisheries is assumed to be less than the Area 4 catch, overall exploitation rates and stock sizes would be significantly larger than this analysis suggests.

S91-06b Run timing and target escapements for summer-run steelhead trout (Oncorhynchus mykiss) stocks in the Skeena River system. C.R. Spence and R.S. Hooton.

INTRODUCTION

Skeena River summer-run steelhead trout (Oncorhynchus mykiss) attract anglers from throughout the world and support a substantial guide and tourism industry. In the Skeena River, summer steelhead begin to enter the system in July and the run is virtually complete by the end of September. Gillnet and seine fisheries in southeast Alaska and northern British Columbia waters operate during the early weeks of the Skeena steelhead run and harvest fish that would otherwise be available to contribute to the most valuable component of the sport fishery. In-river Native fisheries target additional summer-run steelhead, and harvests of 50% or more of early returning stocks may occur in specific Native fisheries. Sport fishery harvests have declined to insignificant levels through voluntary catch and release, as well as strict regulation.

Evidence of declining steelhead abundance in certain Skeena tributaries has led to concern over harvest levels. Of greatest concern are steelhead stocks with run timings overlapping those of enhanced sockeye from spawning channels on the Babine system. Harvests sustainable for enhanced sockeye would unquestionably result in the loss of similarly timed wild steelhead stocks.

Recently, coded wire tag recoveries and anchor tagging programs have begun to generate sufficient data to allow analysis of stock specific run timings. Progress in this area has been coupled with habitat capability and escapement target modelling for each tributary (in prep.). In this report, stock specific run timing and habitat capability data are employed to estimate summer steelhead escapement requirements for the Skeena River system.

METHODS

Habitat capability modelling provided the basis for developing tributary specific escapement targets. Targets were grouped to provide totals for the Babine, Bulkley, Kispiox, Morice, Sustut and Zymoetz River stocks. Remaining stocks, in particular the mainstem Skeena River, were grouped as a single, general target.

Run timing data were gathered primarily from anchor tag recoveries. Commercial catches of steelhead from pilot scale CWT steelhead fry releases in the Bulkley (including Suskwa), Morice and Zymoetz rivers added further to the database during 1988-1990. The Skeena River test fishery at Tyee was selected as a common point for assessment of river entry dates for steelhead.

Tag recoveries from all years and tag sources were pooled for each major steelhead stock. The resulting distribution was normalized and summarized to estimate the proportion of each stock passing Tyee during each week of the commercial fishing season. Stocks for which run timing data were unavailable were assigned weekly proportions based on the average weekly values of other stocks.

Stock specific weekly escapement requirements were determined by multiplying the estimated weekly proportion of each stock passing Tyee by the total escapement requirement for that stock (using the habitat capability modelling). Escapement requirements for each stock were then summed to provide weekly target escapements for the entire Skeena. Based in part on historic harvests, an additional 10,000 steelhead were added to the estimated spawner requirement to account for requirements of the inland Native and sport fisheries.

RESULTS

Run Timing

A total of 178 recoveries of Skeena River summer-run steelhead were used to describe stock specific run timings. Normalized estimates of run timing indicated that the start, peak and completion of the Morice run was notably earlier than other stocks. The mean date of arrival of Morice steelhead (July 31) was more than 2 weeks earlier than the mean time of entry noted for Bulkley and Kispiox stocks (August 15). Peaks for the Babine, Sustut and

Zymoetz stocks fell centrally between the timings of the Morice and Bulkley/Kispiox stocks.

Several years of data from the commercial, test and lower Skeena bar fisheries were pooled to provide run timing descriptions over the entire migration of steelhead into the Skeena River, and to produce useful sample sizes. Tags were generally placed on adults that had survived at least one commercial fishing season, or on the progeny of such adults in the case of CWT studies. A variety of biases may have been introduced into the run timing curves as a result. A method of adjusting the data to account for these problems could not be found. The use of raw numbers of tag recoveries irrespective of their source was therefore assumed to adequately represent the spectrum of stock specific run timings.

The historic timing of Skeena steelhead stocks may not be accurately depicted by the patterns in this analysis. The commercial fishery has consistently affected mainly the early components of the run and may have introduced changes not detectable this late in the evolution of the fishery. Other anadromous salmonids have responded to harvests with shifts in run timing and hatchery-based steelhead experiments have shown that run timing is heritable. If the time of entry of Skeena steelhead is similarly heritable, intensive and disproportionate harvest of early returning fish could already have shifted the run toward later arrival.

Escapement Requirements

Estimated escapement targets from the habitat capability modelling totalled 26,515 steelhead. Accommodation of inland Native and recreational users is anticipated to require a further 10,000 steelhead. Run timing data revealed that 76% of these totals, nearly 27,000 fish, would be required to enter the Skeena River during statistical weeks 27 to 34 inclusive, the period bracketing the Area 3, 4 and 5 commercial fishing season in recent years. The remaining 24% or approximately 9,500 fish would be expected in weeks following the commercial season.

The Babine River system can support the largest population of spawners of any Skeena tributary and accounted for nearly 19% of the total requirement. Target escapements in the first 3 weeks of the run were heavily influenced by the Morice stock; 25% of the requirement during that period was for Morice origin fish, whereas the Morice accounted for only 12% of the annual drainage-wide Skeena target.

Conversion of Skeena River test fishery indices to estimates of actual fish passage permitted comparison between actual and target populations. This comparison was only possible during the first 8 weeks of the season because the test fishery has not operated consistently beyond late August. On average, weekly targets described in the present study were not met over the 36 years for which steelhead test indices were available. Escapement and inland user targets for weeks 35 and later may well have been met on average due to an absence of significant commercial fishing pressure during those weeks in most years. However, late season test fishery data were unavailable to support this.

Realization of weekly targets for steelhead entering the Skeena River is considered critical to both conservation and maintenance of the genetic integrity of individual stocks. Provision of adequate numbers of steelhead to sustain all stocks and viable sport fishing opportunities, especially over the traditional late August through October angling season, will require modification of commercial and Native fishery harvest patterns.

REVIEWERS' COMMENTS (S91-06a,S91-06b)

Both reviewers concurred that the methodology used in Working Paper S91-06a was sound, but both questioned two basic assumptions in the analysis: (1) that steelhead and sockeye are harvested at the same rate in Area 4; and (2) that the observed relationship for 1984-85 between the weekly steelhead test fishery index and estimated escapements is representative, and can be applied appropriately to other years from 1956-1990. Steelhead and sockeye would be harvested at the same rate if their migratory routes were similar, and they were equally vulnerable to fishing gear (mainly gillnets). The second reviewer accepted the authors' evidence for similar migratory speed and routing as reasonable, but argued that harvest rates on sockeye and steelhead would likely differ because (a) most steelhead migrate near the surface (within the top meter) whereas many sockeye migrate at greater depths, beyond those fished by gillnets; and (b) pink salmon are the target species in Area 4 for almost half of the fishing season, and gillnetters often change gear and fishing patterns to target on pink salmon. The second reviewer also noted that the authors assumed that the catchability of steelhead equalled that of sockeye in Area 4 fisheries but was four times that of sockeye in the test fishery; very different results would have been obtained if the authors had assumed that the catchability of steelhead equalled that of sockeye in the test fishery.

The first reviewer pointed out that steelhead escapements were computed from a test fishery index calibrated from only two years (1984 and 1985), and that the confidence intervals on escapement estimates from this calibration were very wide. Moreover, this reviewer questioned whether it was reasonable to expect the relationship to apply to other years from 1956-1990, especially considering that one year (1985) was a year of record sockeye returns. The second reviewer had similar concerns and observed that the test fishery index for Skeena sockeye is not directly proportional to sockeye escapement due to gear saturation during large runs. For this reason, it has been necessary to calibrate the conversion factors used to predict sockeye escapement against combined pink and sockeye run sizes, and this calibration is now based on data from 26 years. It seems highly probable that the steelhead test fishery index would also vary with sockeye and pink run size and that a similar approach to calibrate conversion factors will be required.

Working Paper S91-06b was reviewed by only one reviewer who agreed with the intent of the analysis, but commented that the data sources for the run timing analyses were subject to bias because the tagging studies had not been designed to answer questions about run timing. Despite these objections, the reviewer allowed that the results seemed reasonable. The reviewer pointed out that the authors had implicitly assumed that individual steelhead stocks were at the same abundance relative to carrying capacity and that they had equal productivity. This assumption is probably incorrect, and should be treated explicitly before recommending harvest rate goals in mixed-stock fisheries. The reviewer recommended that unpublished information on habitat capacities for steelhead be presented for review, and noted that the issue of allocation was outside the bounds of the present review.

Finally, both reviewers concluded that the analyses presented in the working papers did not support the authors' recommendations for reduced harvest rates, and stated that further documentation and analysis would be necessary to support these recommendations.

SUBCOMMITTEE RECOMMENDATIONS

1. The authors concluded that the harvest rates of summer-run steelhead in the Skeena River are above optimum. The Subcommittee accepted the methodology presented in Working Paper S91-06a, but not the conclusions of the analysis because two key assumptions were questionable. Cooperative MELP-DFO studies should be initiated to (i) calibrate the Skeena steelhead test fishery index against known steelhead escapements for the purpose of estimating steelhead escapements; and (ii) examine the relative catchability of sockeye and steelhead in Area 4 fisheries and in the Skeena test fishery for the purpose of estimating steelhead catch.

2. The authors proposed target escapements for individual steelhead stocks within the Skeena River system. The target escapements were not supported by the Subcommittee as the methodology used to develop the targets was not presented to the Subcommittee for review. The Subcommittee recommends that MELP submit a Working Paper for the Spring 1992 meeting. Topics should include methods of establishing habitat-based escapement goals and harvest rates for individual steelhead stocks in the Skeena River, exploitation rates in sockeye/pink

fisheries, and recommended procedures for managing fisheries on mixed steelhead populations with different productivities.

S91-07 Stock status information for coho salmon (Oncorhynchus kisutch) in upper Johnstone Strait. (An assessment of distribution in Canadian fisheries and time trends in the natural spawning population.) T.F. Shardlow

DOCUMENT SUMMARY

This report reviewed the available stock assessment information for Johnstone Strait (Stat. Areas 11 and 12). The coho escapement record for upper Johnstone Strait was examined to assess the patterns in escapement over the last four decades and to evaluate the reliability of the data. The escapement data set from all 72 coho streams in the area indicate a significant decline over the past four decades. Survey effort in terms of the percent of the total number of coho rivers surveyed did not change appreciably over the period (1953-1972) during which the majority of the decline occurred.

The pattern of diversity (a measure of how the escapements are distributed between stocks) declined until the early eighties and has since increased to about half the original level. With respect to the subset of 13 streams identified as having 'more reliable' escapement data, the reliability indices were very low prior to 1980, partly since details of the enumeration were unknown. During the period when information to assess the reliability is available (1980 onwards), escapements have been relatively stable. Catch distribution as identified from CWT's indicates the bulk of the harvest is taken in primarily in troll fisheries.

In spite of the uncertainties associated with coho escapement data, a decline is suggested in view of: 1) escapements to rivers where surveys are considered "reliable" rivers show similar declines, 2) concerns over the changes in the diversity index, and 3) the basic belief that more spawners would mean more production.

REVIEWER'S COMMENTS

Review # 1.

The reviewer believes the data set is of such poor quality that it is of no value and did not understand why DFO still uses coho escapement data of this quality. The coho escapement records in the BC 16 are generally incidental observations as the visits were intended to count chum and pink salmon. As an example of the poor quality of the coho escapement information, the coho smolt output from the Keogh River is counted through a weir. The recorded coho escapements to the system do not correlate well with the smolts produced, and in some cases recorded escapements were too low to account for the smolt output. If the declining trend in coho escapements is real, what could have caused the decline? There is no rationale for a decline resulting from high exploitation rates and the habitat changes that have occurred also cannot account for the declining pattern. The reviewer suggested the approach of estimating productivity based on the habitat capacity to support juvenile production. He found a reasonably close relationship between current escapements and crude habitat based estimates of what should be there. The Johnstone Strait coho escapement estimates from the fifties and sixties are well above the habitat based estimate.

The reviewer found the reliability index to be of little use. He questioned the assumption that more visits equates to a more accurate assessment. The following rating was proposed as a fairer reflection of data quality: absolute count (weir or fishway): 100, systematic well designed sampling programs or mark recovery: 50, systematic anecdotal: 5, anecdotal with no design: 1, and if there is no recorded methodologies: 0.

The validity of the spatial diversity analysis was questioned. The apparent change in spatial diversity could have resulted from decreasing escapements in a few large systems, and the quality of the escapements to these systems is the most questionable.

The development of exploitation rate indicators was supported, but should include associated biological assessments of habitat capacity and utilization.

A review of the SEDS database for Johnstone Strait coho was not supported since the underlying nature of the coho escapements is too poor.

Review #2.

The survey effort for coho may differ from the all-species survey effort which was the measure used in the study. The spatial diversity evaluation shows a decline in the number of stocks that contribute a given percentage of the escapement, however, changes in the enumeration effort could be contributing to this observed trend. The reliability index is biased towards the more recent information mainly because the reliability of the earlier estimates is unknown. The catch distributions from the CWT analysis should be described separately to evaluate any differences between mainland and Vancouver Island stocks.

The reviewer supported the recommendation to establish exploitation rate indicators. He agreed that enumeration effort should be concentrated where it will do the most good but questioned whether index streams should be associated with the mainland inlets. The number of index streams will depend on the variability of coho escapements between streams and within years. The recommendation of the need to set up management goals was not supported based on the evidence presented. The SEDS 9database review may not be required depending on the interpretation of the 'errors'.

SUBCOMMITTEE DISCUSSION

The Subcommittee unanimously supported the need for exploitation rate indicators and the associated biological information for key coho streams. The Subcommittee held mixed views regarding whether to, or how to improve escapement estimations. There was considerable enthusiasm regarding new approaches focusing on the habitat productive capacity for juveniles, and how these techniques related to other stock assessment avenues. After considerable discussion, the majority view was that the uncertainty in the accuracy of the escapement enumerations precluded any conclusions regarding stock status. The Subcommittee concluded that no review of the SEDS database was worthwhile, but that the current practise of resolving any discrepancies should be continued.

SUBCOMMITTEE RECOMMENDATIONS

The Subcommittee recommends that:

1. The majority of the Subcommittee agreed that there was sufficient uncertainty in the coho escapement data that the status of coho stocks in upper Johnstone Strait is uncertain. To provide some information, two representative stocks, one on NE Vancouver Island (Keogh River) and one on the mainland (to be determined), should be designated as exploitation rate and productivity indicators. A CWT tagging and escapement enumeration program could provide this information.

2. The Subcommittee does not support the author's recommendation to spend additional resources to improve the Johnstone St. natural escapement enumeration methods until a review of alternative stock assessment methodologies is completed. The Subcommittee recommends that a working group be established to address the cost, feasibility, and effort associated with alternative assessment methodologies. The working group should report the results of their investigations to the Subcommittee in the fall of 1992.

S91-09 Advice for establishing a floor escapement goal for Fraser River coho salmon (follow-up to PSARC Working Paper S89-28). R. Kadowaki and N. Schubert.

DOCUMENT SUMMARY

In 1989, the Pacific Stock Assessment Review Committee (PSARC) recommended the development of an adaptive management approach for Fraser River coho salmon (Farlinger et al 1990). The development of the adaptive approach was approved by the Pacific Region Resource Management Executive Committee and was assigned to PSARC in late 1989. This paper addresses the development of an escapement floor by:

a) updating the five Ricker stock-recruit analyses presented in Working Paper S89-28, and analyzing three additional data sets using an alternate escapement index;
b) reanalysing the above data sets using Beverton-Holt and rectilinear recruitment models;
c) evaluating model sensitivity to input data bias and error; and
d) discussing the applicability of an adaptive approach to managing Fraser River coho and providing advice on harvest management.

Stock Recruit Analysis

Two formal stock-recruit models, the Ricker and Beverton-Holt models, and a rectilinear model based on a simple linear regression were used to analyze eight Fraser River coho data sets constructed from wild stock escapement data and Chilliwack hatchery exploitation rates. The analytical results should be interpreted with caution, because errors and biases can produce misleading results. The effect of some of these errors and biases are discussed in the working paper but they all result in an overestimate of stock productivity.

Adaptive Management

The following adaptive management framework was used to develop the floor escapement:

a) Clearly define objectives and constraints.
b) Provide the best understanding of stock dynamics possible with the existing data, but explicitly define assumptions and potential errors and biases.
c) Evaluate the uncertainty surrounding our best understanding of stock dynamics and assess the risks and potential rewards of adaptive probing policies.
d) Provide management advice that balances immediate harvests against profitable learning opportunities.

Objectives and Constraints

The first objective in developing an escapement goal is to protect the stock from overharvesting that could result in future recruitment failure or a permanent reduction in genetic variability. Protection of the stock must also be a primary concern in setting this floor escapement goal. The second objective in setting an escapement goal is to maximize long term surplus production for harvest. Practical constraints in implementing an adaptive management program for Fraser coho using a floor escapement goal include our current ability to accurately monitor the results of any adaptive measures taken. The willingness of fishing groups to participate in a high risk adaptive management program is also questionable.

Stock Dynamics

The Ricker model produced MSY spawner levels ranging from 268 to 413 thousand fish depending on the method used to estimate escapement. However, MSY exploitation rates varied over a narrow range of 0.71 to 0.73. Although intuitively attractive for coho, the Beverton-Holt model can be misleading because it assumes very high productivity at moderately low spawner levels. Considering the poor reliability of Fraser coho escapement estimates, variable stock productivities within the aggregate, and the biases which result in stock productivity overestimates, we believe that the Beverton-Holt model should not be used in setting management objectives for this stock. Further analysis of the Ricker and Beverton-Holt recruitment curves indicates that recruitment is within 10% of the maximum recruitment over a wide range of spawners. For the Ricker model, this range varied between roughly 300 and 550 thousand spawners.

Potential Risks and Benefits

The potential benefits in harvest at the low spawner end of the recruitment curve are not large relative to the risks to the stock aggregate of Fraser River coho. Risks include the possible loss of less productive stocks within the aggregate leading to a reduction in genetic variability. This loss of stocks and genetic variability would make the remaining aggregate of stocks less resilient to adverse environmental conditions, disease and habitat degradation.

The stock dynamics described above indicate that we are unlikely to learn very much by probing above an escapement floor unless the probing is done at very high spawner levels. For example, permitting escapements within a range of two hundred thousand spawners above a conservative escapement floor is unlikely to elicit a recruitment response that would allow alternative models to be separated. Furthermore, if the underlying recruitment relationship is in fact a broad, flat-topped curve as indicated by the analysis of the existing data, then increases in production are going to be very difficult to detect, even if we knew which model was correct.

REVIEWERS' COMMENTS

The two reviews of this document differed in scope and focus of their reviews. One review (reviewer no. 1) focused on the appropriateness of the analytical techniques used to estimate the spawner-recruit relationship. The other review (reviewer no. 2) concentrated more on the implications for fisheries management of Fraser River coho.

From a re-analysis of data presented in the review, Reviewer no. 1 concluded that the data do not contain sufficient information to resolve the spawner-recruit relationship. As a consequence there is insufficient statistical power to detect the effects of manipulating escapement levels above a floor value. This reviewer suggests work be initiated to improve accuracy and precision of escapement estimates rather than recommend further management action.

Reviewer no. 2 questioned the value of probing the system by varying escapements since the ability to detect changes in production is limited by deficiencies in the spawner-recruit data. Nevertheless, the reviewer agreed with the recommendations put forward in the analysis. The reviewer further recommends that a management plan for terminal harvest of surplus production be developed in consultation with the authors.

SUBCOMMITTEE DISCUSSION

The Subcommittee discussed the relevance of manipulating the escapement to evaluate the effects on subsequent production. Probing at low escapements was considered too risky and might result in a decline, particularly in less productive populations. Alternatively, a large number of years of high escapements would be required to test for density-dependent effects at high escapements. The Sub-committee concluded that active probing of the system to assess production potential was not warranted because of poor data quality.

The Subcommittee agreed that it was necessary to set an escapement goal for management purposes. An escapement floor of 250,000 naturally spawning coho (estimated at the test fishery) was selected as a result of a conservative interpretation of the Ricker spawner-recruit relationship. It is also supported by a crude assessment of available coho rearing habitat in the Fraser River watershed. Although estimated escapements have often fallen below 250,000, reducing the exploitation rate on lower Fraser coho to 65-70% should ensure that the escapement floor would be achieved for all but the poorest survivals (Fig. 1). Production surpluses above the escapement floor would by shared among terminal resource user groups with a gradation in the shared allocation (escapement versus catch) depending on the surplus.

The Subcommittee recognized an obvious need to increase accuracy and precision in estimates of spawning escapements of Fraser River coho. Deficiencies in data quality prevent an adequate assessment of the productivity of Fraser River coho. Alternative methods for estimating escapement goals such as habitat capacity estimates need to be evaluated.

SUBCOMMITTEE RECOMMENDATIONS

The Subcommittee recommends that:

1. Exploitation rates of Fraser River coho have previously been estimated to be around 78% (S89-28). To protect less productive coho stocks in the Fraser, the Subcommittee recommends that the total exploitation rate should fall within the 65% to 70% target range previously recommended for Strait of Georgia coho.

2. Within an overall target exploitation rate, an escapement floor for Fraser River coho should initially be set at 250,000 naturally spawning coho (measured at the test fishery) such that harvest could be permitted above the floor in some yet undetermined manner. Details of a possible terminal harvest should be developed by fishery managers in consultation with stock assessment staff.

3. The Fraser River test fishery should be calibrated against known escapements to provide reliable inseason abundance estimates. An evaluation of alternative methods to provide more accurate estimates of escapement of Fraser River coho is advised, preferably as part of the assignment contained in Recommendation 2 for upper Johnstone Strait coho.

4. Separate coho escapement goals should be established for major tributary streams, perhaps based on estimates of habitat carrying capacity.

S91-10 Evaluation of the 1988 and 1989 Strait of Georgia sport fishing regulation changes for the years 1989-1990. P. Starr.

DOCUMENT SUMMARY

In the spring of 1989, a set of new regulations was implemented for the Strait of Georgia sport fishery with the objective of conserving depressed lower Strait of Georgia chinook stocks. In the press release announcing the new regulations, the Minister of Fisheries and Oceans made the following commitment: "...[the Minister] added that an important component of the 1989 program is the evaluation of chinook conservation measures and the commitment to make adjustments to ensure rebuilding goals are being met." As part of this commitment to the evaluation of the new sport regulations, a framework for evaluation was submitted to PSARC for peer review in May, 1991 (PSARC Working Paper S91-3). This paper is the evaluation based on the outcome of that review.

Objective of Regulation Changes

The objective of the regulation changes in the Strait of Georgia sport fishery was to obtain at least a 20% decrease in the annual harvest rate on chinook salmon, relative to 1987, beginning in 1988 and continuing to the end of the rebuilding period.

The long term goal behind this reduction is to restore chinook escapements in all lower Strait of Georgia rivers to target levels by 1998 (but not including the Fraser River). These rivers include all chinook producing rivers on the east coast of Vancouver Island as far north as the Big Qualicum River and those flowing into the large inlets on the mainland side of the Strait of Georgia, between Howe Sound and Toba Inlet.

Management Actions (1988-1989)

The management actions which were put into place during 1988 and 1989 to achieve the 20% decline in harvest rate were as follows:

1. Raised the size limit to 62 cm from 45 cm (nose-fork length) in the entire Strait of Georgia (1989 only).
2. Established an annual bag limit of 8 chinook per year (1988) and raised the annual bag limit to 15 in 1989.
3. Closed a number of specific terminal areas for varying periods of time to all sport fishing (1988 and 1989).
4. Added Johnstone Strait to the area covered by the above management actions and removed Juan de Fuca Strait (1989 only).

Definition of Areas

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

In 1989, the section of Juan de Fuca Strait from Sheringham Point to Cadboro Point was removed from the management regulations designed to reduce harvest rates on lower Strait of Georgia stocks. At the same time, the waters of Johnstone Strait beginning at Chatham Point and extending to the surf line drawn from Cape Sutil on Vancouver Island to Hope Island to Shelter Bay on the mainland coast were added to the area covered by the management regulations.

Evaluation Methods

The following two methods were selected to make the assessment of the overall change in harvest rate in the Strait of Georgia resulting from the 1988 and 1989 regulation changes. The selection process began with an initial choosing of methods made by an internal DFO evaluation committee. These methods were then developed and presented to PSARC in Working Paper S91-3. The following two methods were then selected from those presented to PSARC for the final evaluation.

Exploitation Rate Analysis

Exploitation rate analysis is a coastwide assessment of chinook stocks and fisheries done by the Pacific Salmon Commission (PSC) Chinook Technical Committee (CTC) using coded wire tag recoveries (CWT). The methods used have been documented in PSC (1988) and were described in Working Paper S91-3 (Section 2.1 and Appendix 2). This analysis involves comparing exploitation rates estimated from CWT catches for a specific year to a defined base period and estimating the relative change in fishery specific harvest rates. The major assumption associated with this analysis is that each stock must be distributed in a similar manner for all years being analyzed, therefore, it assumes that all changes in exploitation rates can be attributed to changes in fishing effects (or to random error).

Depletion Method

This method relates the cumulative catch of the combined troll and sport fisheries plotted against the decline in CPUE (catch per unit effort) in either fishery. Based on a general model developed by Walters (Hilborn and Walters 1992, and described in Working Paper 91-3: Section 2.2 and Appendix 3), this method makes a direct estimate of the total stock available at the beginning of the assessment period, and, depending on the model fitted, it will also estimate average recruitment and 'survival' during the period of catch accumulation. Once estimates for these parameters are obtained, harvest rate can be estimated for any year and the change in harvest rate from one year to another can be calculated. Assumptions made by this method will vary, depending on the model chosen. This method does not depend on the recovery of CWT's, thus providing an alternative and independent assessment to the exploitation rate analysis.

RESULTS

1) The CWT exploitation rate analysis indicated that the 1989 sport harvest rate increased by about 30% relative to 1987 and declined by 25% relative to 1987 in 1990, for ages three to five chinook (Fig. 2). Therefore, this assessment concluded that the Strait of Georgia sport fishery failed to achieve the expected -20% decline in harvest rate in 1989 and achieved it in 1990.

2) The depletion method assessed the change in harvest rate for 1989 and 1990 using two models which had different underlying assumptions, four different possible sets of estimated mean lengths at age, two levels of compliance to the new size limits, four different shaker mortality rates, and two methods of weighting the catch for adult equivalency. The 1989 results ranged from a -50% decline in harvest rate to a +18% increase and the 1990 results from a -22% decline to +37% increase. However, when the models and assumptions were examined in detail and extreme or inconsistent results were ruled out, the range of possible results decreased to -4% to +11% (median= +3%) in 1989 and to -14% to +8% (median= -1%) in 1990. Therefore, this assessment concluded that the Strait of Georgia sport fishery failed to achieve the expected -20% decline in harvest rate in both 1989 and in 1990.

Effect of Assumptions and Potential Error on the Analysis

1) Although the CWT exploitation rate analysis used five different stocks, a single stock (Big Qualicum, which is very typical of Strait of Georgia chinook stocks and which has better than average escapement data) dominated the analysis. This dependence increased the probability of an incorrect assessment simply due to chance variation in this stock. Also, this analysis was not conducted using the same wide range of assumptions regarding length at age, level of compliance to the size limit and shaker mortality rates as was the depletion method. The degree of sensitivity to these assumptions should be as great for this analysis as it was for the depletion analysis and therefore the potential range of possible outcomes from the exploitation rate analysis could be as great as that shown in (2) [above]. Because of this, the

analysis may have been biased upward by only using a 30% shaker mortality rate for released sub-legal fish.

2) The depletion method showed that the estimated parameters and the resulting change in harvest rate were quite sensitive to the assumptions made regarding the average mean length of the population by age and month and to the rate of mortality associated with the release of sub-legal fish. These are assumptions for which we do not currently have fully adequate supporting data, making this analysis equivocal in its outcome. The choice of underlying model and the level of compliance to the size limit regulation also contributed to the uncertainty in the analysis. However, this analysis concluded that even low levels of shaker mortality reduced or even eliminated many of the benefits resulting from the change in size limit, especially when the data set characterizing the underlying size of the population tended to have relatively low mean lengths at age.

3) Both assessments failed to place appropriate confidence limits on the estimated parameters and to quantitatively assess sources of potential bias. This was mainly due to two problems: a) to a lack of research to understand and mathematically describe the sources of error and bias; and, b) to a general deficiency in the Pacific Region of DFO to collect the type of data needed to perform analyses such as those described in this paper. However, it is unlikely that the Department will ever have sufficient funds to obtain data that will remove or even explain all the inherent underlying uncertainty and error in a manner which will satisfy all affected parties. Therefore, it is vital that the Department and the user groups come to some agreement as to what type of data and analyses will be sufficient to act on when there is reason to believe that salmon stocks are at risk or are not being exploited optimally.

REVIEWERS' COMMENTS

Two of the three reviewers concluded that the analysis was the best that could be done with the data available. Both of these reviewers supported the conclusions of the exploitation rate and depletion analyses with respect to the decline in harvest rate. However, one reviewer characterized support for the conclusions as "weak", while the other reviewer described the possibility of different conclusions as "unlikely" but not "impossible". One reviewer suggested using a Monte-Carlo method to evaluate the reliability of the two analyses, however, the second reviewer did not believe that the quality of the data supported this kind of treatment. One reviewer also suggested that a posterior probability distribution be applied to the harvest rate estimates as a way of providing managers with a sense of the likelihood of alternative outcomes. The second reviewer placed considerable emphasis on the need to collect better data, particularly length at age data and species-directed effort data. The author generally agreed with these two reviews.

The third reviewer, representing the SFAB/DFO Statistical Committee did not have adequate time to fully review the document. However, his initial comments on the exploitation rate method pointed out the difficulty in reliably detecting a 20% harvest rate reduction due to a regulation change given the high background variability in harvest rate observed prior to the regulation being implemented. He also pointed out that the 1989 depletion analysis was questionable because of the small size and high abundance of 3 year old chinook available early in that year. This reviewer believed that the size data for 1989 were incorrectly applied and alluded to the results from a different model that were different than those presented in this working paper. He also correctly pointed out that the old minimum size limit of 45 cm was incorrectly described as 48 cm in the report. Because of the preliminary nature of the review, the author was not able to fully respond or understand the concerns expressed by this reviewer in the time available. (note: Further comments by a member of the SFAB/DFO Statistical Committee (Memo: B. Ottway to T. Bird) were received by the Subcommittee Chair at the meeting but were not distributed or discussed.)

SUBCOMMITTEE DISCUSSION

The Subcommittee discussed the data quality issues raised by the author and the reviewers and the uncertainty they imparted to the conclusions of the analysis. The Subcommittee agreed with the author that it is unlikely that the Department will ever have sufficient funds to obtain data that will remove or even explain all the inherent underlying uncertainty and error in a manner which will satisfy all affected parties. Therefore, it is vital that the Department and the user groups come to some agreement as to what type of data and analyses will be sufficient to justify action when there is reason to believe that salmon stocks are at risk or are not being exploited optimally.

Concerning an alternative analysis suggested by the third reviewer, (representing the SFAB), the Subcommittee reaffirmed its previous invitation to accept alternative methodologies and analyses (in the form of Working Papers submitted to the Subcommittee). This paper has tentatively been scheduled for review at the Spring 1992 meeting.

SUBCOMMITTEE RECOMMENDATIONS

After hearing from the author and the three reviewers, the Subcommittee offers the following advice pertaining to this issue:

1. Based on the analyses presented, the Subcommittee concluded that the harvest rate in the Strait of Georgia sport fishery probably did not decline by 20% relative to 1987 in 1989, but probably did decline by that amount in 1990.

2. It is important to obtain a better representation of the size at age of the populations of chinook available to the Strait of Georgia sport fishery and to estimate the effort directed at chinook by the sport fishery. Existing programs can be upgraded (e.g. T. Gjernes's troll sampling program) or new programs may have to be developed.

3. Research is required to understand and describe mathematically the sources of error and bias in coded wire tag data in order to provide confidence intervals around parameter estimates. The Subcommittee considers the development of this theory a high priority.

4. Given the uncertainties in this analysis, the Subcommittee recommends that the Department and user groups agree on what type of data and analyses are required to warrant management action when there is reason to believe that salmon stocks are at risk or are not being exploited optimally.

5. Given the original objective of rebuilding LGS chinook stocks by 1998, the Subcommittee strongly recommends that a comprehensive review of all aspects of the program be conducted immediately so that corrective actions could be taken in a timely manner, if required. This evaluation will be presented as a PSARC working paper and is scheduled for the spring/1992 PSARC Salmon Subcommittee meeting.

S91-11 Assessment of the status of Nass River sockeye salmon (Oncorhynchus nerka). M.A. Henderson, A. Cass, C.C. Wood, D. Rutherford, R. Diewert, L. Jantz.

DOCUMENT SUMMARY

The Nass River, located in northern British Columbia, supports a large and important sockeye salmon (Oncorhynchus nerka) stock complex. Adult Nass River sockeye salmon are harvested in commercial fisheries throughout northern British Columbia and southern southeast Alaska, and in marine and freshwater sport and

Native food fisheries in the vicinity of the Nass river. Although important on both a local and regional scale, few attempts have been made to synthesize available information, and assess the overall status of the Nass River sockeye salmon stock complex. The objectives of the current assessment were to:

1. reconstruct the total return (i.e. catch plus spawning escapement) of Nass River sockeye salmon stock complex for the period from 1969 to 1990;

2. estimate the productivity and optimum spawning escapement for Nass River sockeye salmon based on stock-recruitment analysis;

3. describe the size and age structure of the Nass River sockeye salmon stock complex for the period from 1969 to 1990 and,

4. determine the degree of interannual variation in return run timing of adult sockeye salmon to the Nass River within the context of how this variation effects the manageability of the sockeye salmon and other species of Pacific salmon returning to the river.

Production of sockeye salmon from the Nass River derives from numerous individual stocks. For the purpose of the analyses reported below, these stocks were grouped into either the Meziadin or the non-Meziadin sockeye stock complex. The harvest of Nass River sockeye salmon was allocated to either the inside (statistical areas 3X, 3Y, 3Z, and 4, 5, and district 101) or outside (statistical area 1, and district 104) fishery.

Annual estimates of total return, and catch of Nass River sockeye salmon were determined using a reconstruction algorithm. This approach involves "backing out" the estimates of spawning escapement through the fisheries harvesting Nass sockeye. Catch in each of the fisheries is allocated to the different stock complexes based on their spawning escapement, run timing, and migration pattern through the various fisheries. The reconstruction analysis does not permit explicit statements to be made regarding the uncertainty associated with the estimates of catch and total return by stock complex. However, it is possible to make a qualitative assessment of the uncertainty.

The level of confidence in estimates of spawning escapement for Meziadin sockeye salmon is high. These estimates are made at a counting facility and can be considered to be free of error. However, the estimates for the non-Meziadin stock complex are associated with a low level of confidence. These estimates are made primarily by foot and aerial surveys.

Estimates of run timing of the Meziadin and non-Meziadin stock complexes were determined from tagging and electrophoretic stock identification data, and from results of the Nass River test fishery. There was a moderate level of confidence associated with the timing data for both stock complexes.

Information on the migration route of adult Meziadin and non-Meziadin sockeye in coastal waters was based primarily on the results of tagging studies in 1982 and 1983. The level of confidence in this information is high for both stock complexes.

Overall, there is a moderate to high level of confidence in the estimates of total run size and catch for the Meziadin sockeye salmon stock complex. However, primarily as the result of uncertainties in spawning escapement estimates, there is a low level of confidence in the results for the non-Meziadin stock complex.

Meziadin Sockeye

The total return of Meziadin sockeye over the period from 1969 to 1990 was greater than 500,000 in 1973, 1982, and 1985, and greater than 400,000 in 1977 (Fig. 3). Total returns in the remaining years were less than 310,000 and less than 200,000 in three of the last five years. Spawning escapement ranged from approximately 50,000 to 290,000 and averaged 153,000. The total catch of Meziadin sockeye ranged from 50,000 to almost 400,000 and averaged 140,000. The total annual harvest rate for Meziadin sockeye varied from 27% to 73% and averaged 46% over the period from 1969 to 1990.

Estimates the Ricker a and b values for the Meziadin sockeye stock (Fig. 4), based on stock-recruitment analyses, were 1.66 and 6.3E-06 respectively. The estimate of optimal spawning escapement, 107,000, was somewhat less than the average escapement over the period from 1969 to 1990 (153,000). Estimates of maximum catch and the optimal harvest rate were higher than the average over the period from 1969 to 1990.

Non-Meziadin Sockeye

The total return of non-Meziadin sockeye did not exhibit any trend over the period from 1969 to 1990 and averaged 109,000 (Fig. 5). Spawning escapement was variable, without trend, and averaged approximately 40,000. In contrast, the total annual catch of non-Meziadin sockeye has been variable, ranging from 6,000 to 175,000 and has averaged 64,000. The total annual harvest rate has varied from 22% to 80% and averaged 54% over the period from 1969 to 1990.

Estimates of the Ricker a and b values for the non-Meziadin stock (Fig. 6), based on stock-recruitment analyses, were 1.39 and 9.3E-05 respectively. The optimal spawning escapement, 65,000, was greater than the average escapement over the period from 1969 to 1990 (46,000). Also, estimates for both maximum catch and optimal harvest rate were greater than the average for the period from 1969 to 1990.

Size and Age Structure

Three age classes, 4_2, 5_2, and 5_3, account for more than 85% of the total return of sockeye to the Nass River. The contribution of 4_2 sockeye to the total return was stable over the period from 1969 to 1990 and averaged 26%. The 5_2 and 5_3 components were stable over the period from 1969 to 1980 and averaged 13% and 56% of the total return respectively. However, over the last 10 years, the 5_2 component has increased to 22% while the 5_3 component has decreased to 39%. The average size of individuals in all dominant age classes in the returns has declined discontinuously over the period from 1977 to 1990 (size at age data were not available prior to 1977).

Variation in Timing of Adult Returns

The timing of the return of sockeye salmon to the Nass River test fishery exhibited a long term, cyclical behaviour. The date when 50% of the fish passed the test fishery was as much as 10-14 days above the long term mean in the mid to late 1960s but decreased to 16 days below the mean by 1977 before increasing again through 1989. There was no apparent consistency in timing anomalies between Nass and Skeena river sockeye from the mid 1960s through the late 1970s. However, since that time, there has been a strong correlation in the timing anomalies between the two stock complexes.

REVIEWERS' COMMENTS

Both reviewers noted the numerous assumptions required to estimate the catch by stock using run reconstruction and the frequent extrapolation of a few years of data to the full period analyzed. Particular concerns emphasized were: a need for further evaluation of model sensitivity to errors in input data, a request for a clearer tabulation of the reconstruction model assumptions and likely impacts, and, one reviewer, disagreed with presenting one stock-recruitment analysis to represent a group of populations using different habitats (i.e. Non-Meziadin stock). Both reviewers did, however, agree generally with the authors' recommendations with the provision that <u>freshwater</u> and marine limits to production should be studied. Studies in freshwater are more tractable and a comparative basis with numerous other B.C. lakes now exists for evaluation of juvenile production capacity and the present status of the Nass sockeye populations.

SUBCOMMITTEE DISCUSSION

Subcommittee discussion also focused on limitations to the run reconstructions but did acknowledge that run reconstruction is the only method available to evaluate historical data. Future assessments should evaluate the effects of unequal precision in the Meziadin vs. non-Meziadin stock escapement data (violates an assumption of run reconstruction), accuracy of run timing data in Nass and Skeena sockeye stocks, and how representative the test fishery catches (catch rates and age composition) are of the total populations. Further, the Subcommittee cautions that the stock-recruitment analysis for the non-Meziadin stock is likely biased resulting in an inflated productivity estimate, thus causing the optimal escapement to be underestimated (as evidence from Fig. 7) due to under-estimation of spawning escapements. Also, underestimation of catch attributed to the non-Meziadin stock would contribute to over-estimation of catch attributed to the Meziadin stock. This effect would exacerbate two apparent inconsistencies in this analysis that the Subcommittee feel must be examined further before stock status of Nass sockeye can be determined i.e. substantial differences in recent harvest rates on the two Nass stocks and the apparently low productivity of Meziadin sockeye.

SUBCOMMITTEE RECOMMENDATIONS

The Subcommittee recommends that:

1. Harvest rates and escapement targets for Meziadin and non-Meziadin stocks should not be changed from current levels. Limitations in data quality and quantity result in considerable uncertainty in the estimates of optimal escapements and stock productivities. These appear to be unusual when compared with estimates for other sockeye stocks.

2. Many of the uncertainties associated with future run sizes of Nass sockeye stocks (catch and escapement) could be alleviated by establishing a stock identification (genetic, age composition, parasites, scale pattern) program in northern fisheries and test fisheries. The scale and cost of this program would depend upon spatial and temporal resolution required to meet the management objectives established for these stocks.

3. Production capacity and limitations in freshwater and marine environments should be examined directly to compensate for the uncertainty that will likely continue to plague run reconstructions from unreliable historical data. In particular for 1992, the Subcommittee recommends examination of fry growth and abundance, and productive capacity of Meziadin Lake following the very high spawning escapement observed in 1991.

4. A critical evaluation of the representativeness of catches in Nass and Skeena test fisheries should be undertaken as a high priority. These test fisheries are critical to management and provision of accurate stock assessment data (run timing and age composition by stock, escapement and stock identification samples by stock). However, several concerns exist about saturation of the gillnets and calibration, size and stock selectivities, and the appropriateness of their duration of operation. Both test fisheries must be evaluated because of the simultaneous use of these data in any run reconstruction to partition catches of Nass and Skeena sockeye.

5. A review of basic assessment data is needed for Nass sockeye; specifically the availability of scale samples since 1969 to partition Meziadin and non-Meziadin stocks in the test fishery, verification of changes in the age composition reported, and examination of the adequacy of biological sampling programs in areas 3 and 4 to collect size and age composition data by time, area, and gear type.

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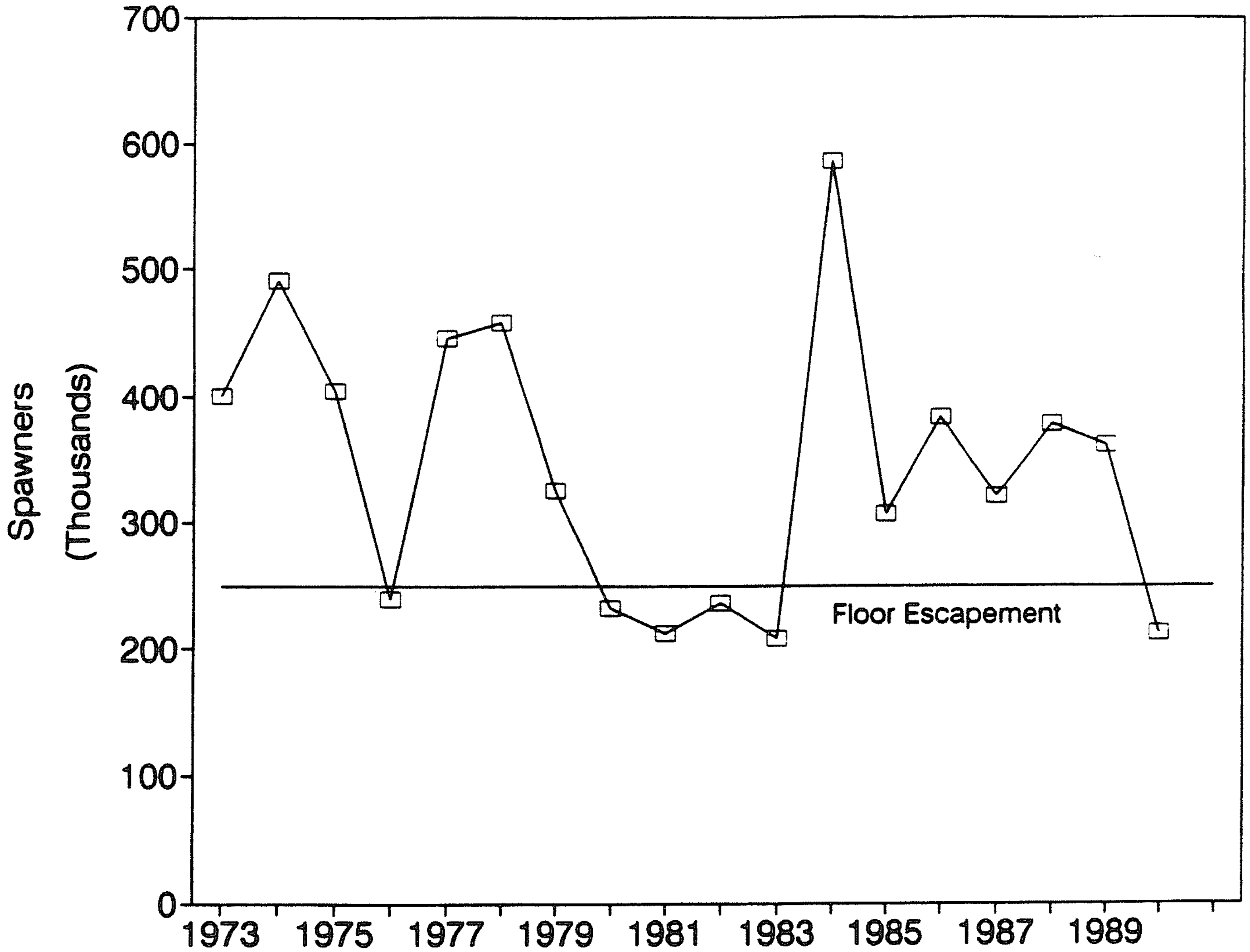

Figure 1. Estimated spawning escapement of Fraser River coho salmon at a 65 percent exploitation rate.

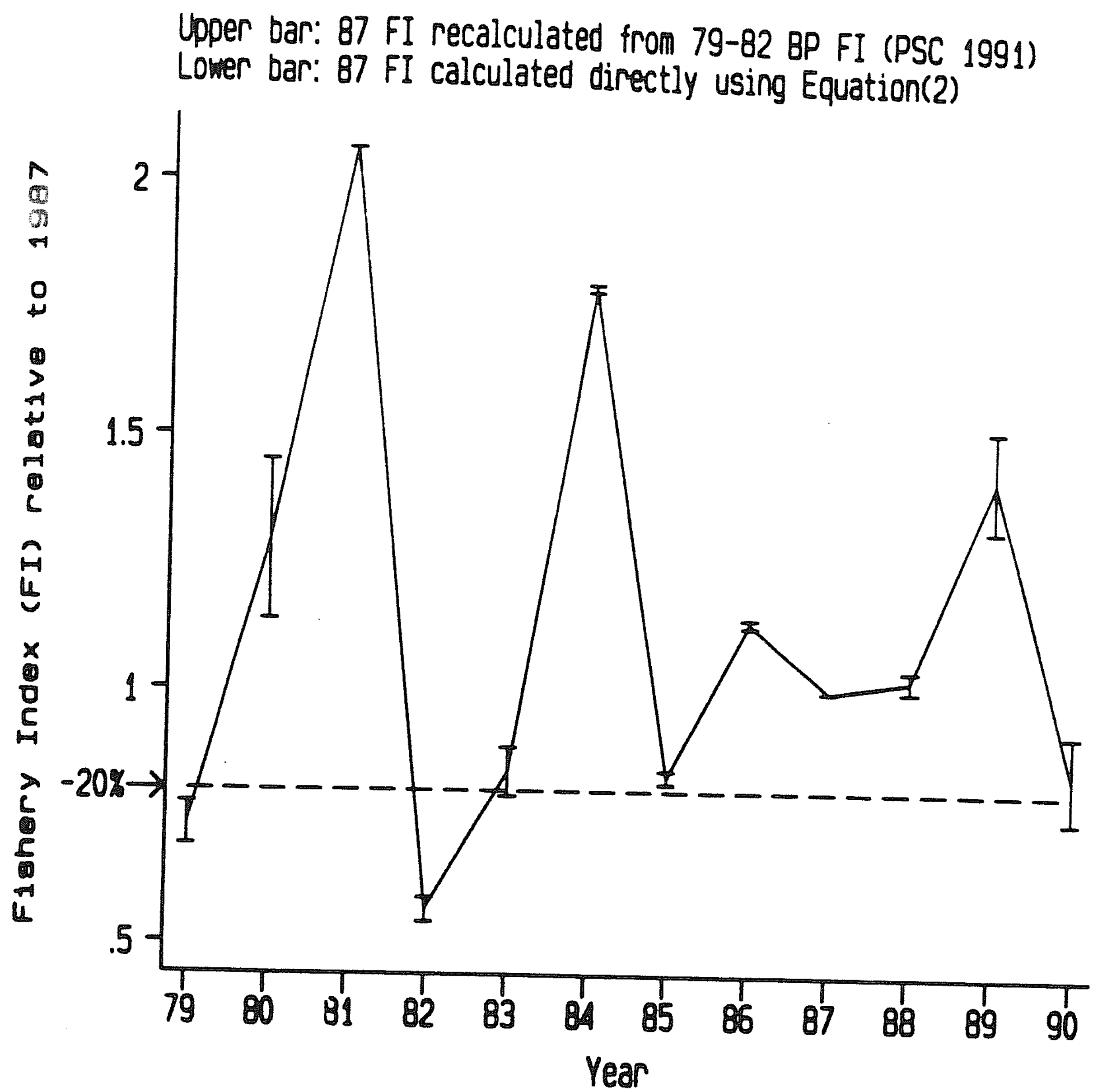

Figure 2. Fishery indicies for the Strait of Georgia sport fishery (ages three to five combined) calculated using the Exploitation Rate Analysis method for the period 1979 to 1990. Two indices are presented, both relative to the 1987 exploitation rate (1987 Fishery Index=1). The first (upper bar) was recalculated from the fishery indices estimated for the 1979-82 base period. The second (lower bar) was calculated directly for the 1987 base period. The connecting line is the mean of the two estimates.

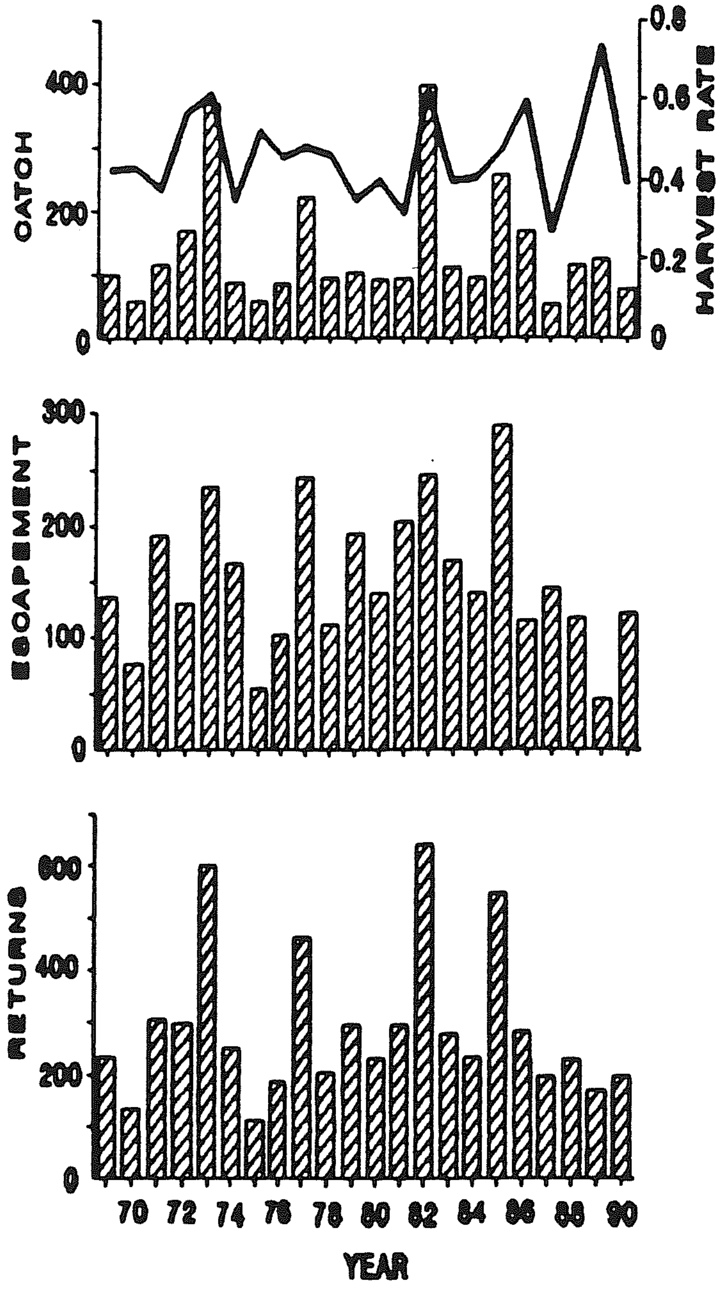

Fig. 3 . Catch, harvest rate, spawning escapement and returns (thousands) for Meziadin sockeye (1969-90).

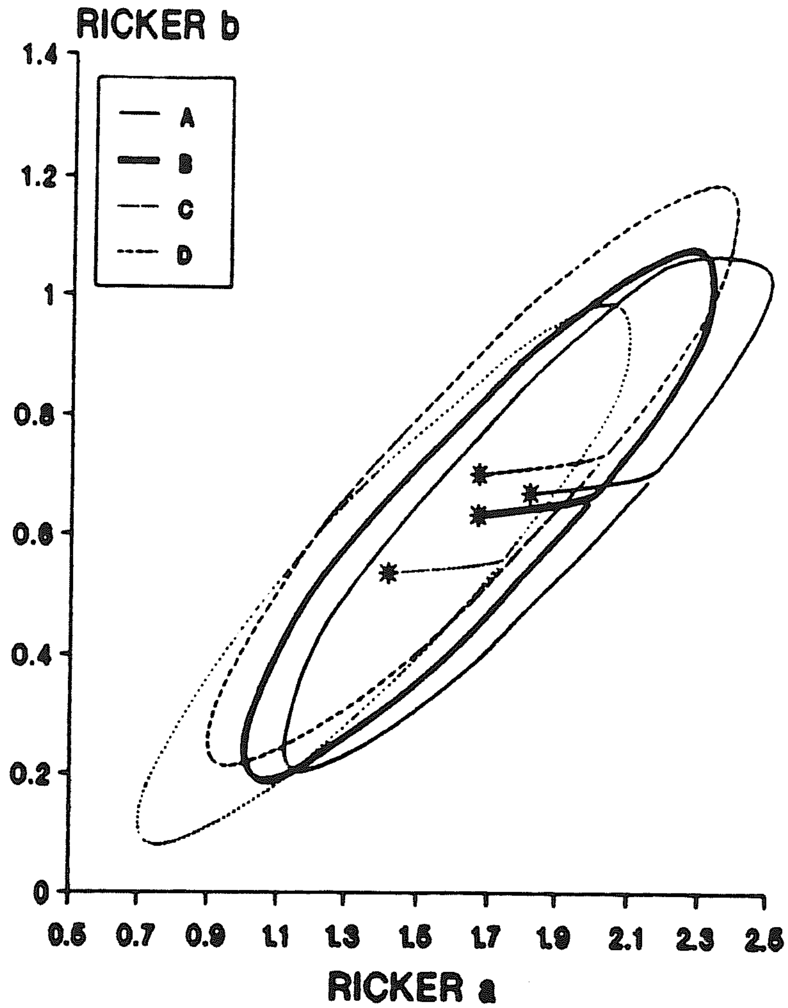

Fig. 4 . Joint Ricker a-b 95% confidence interval for four run timing scenarios encompassing the range of variation in parameter estimates used in run reconstructions of Meziadin Lake sockeye. All four scenarios shift the run timing of non-Meziadin sockeye relative to the annual timing of Meziadin sockeye: a) uses a zero lag from the inside fishery to the test fishery and the 50% date of passage at the test fishery and Meziadin fence to lag fish from the fence to the test fishery, b) uses a 1 wk lag to move fish from the inside fishery to the test fishery, c) uses a 2 wk lag to move fish from the inside fishery to the test fishery, and d) estimates the run timing of Meziadin sockeye directly from the test fishery index and uses a 1 wk lag to move fish from the inside fishery to the test fishery and 50% date of passage at the test fishery and Meziadin fence to lag sockeye from the fence to the test fishery.

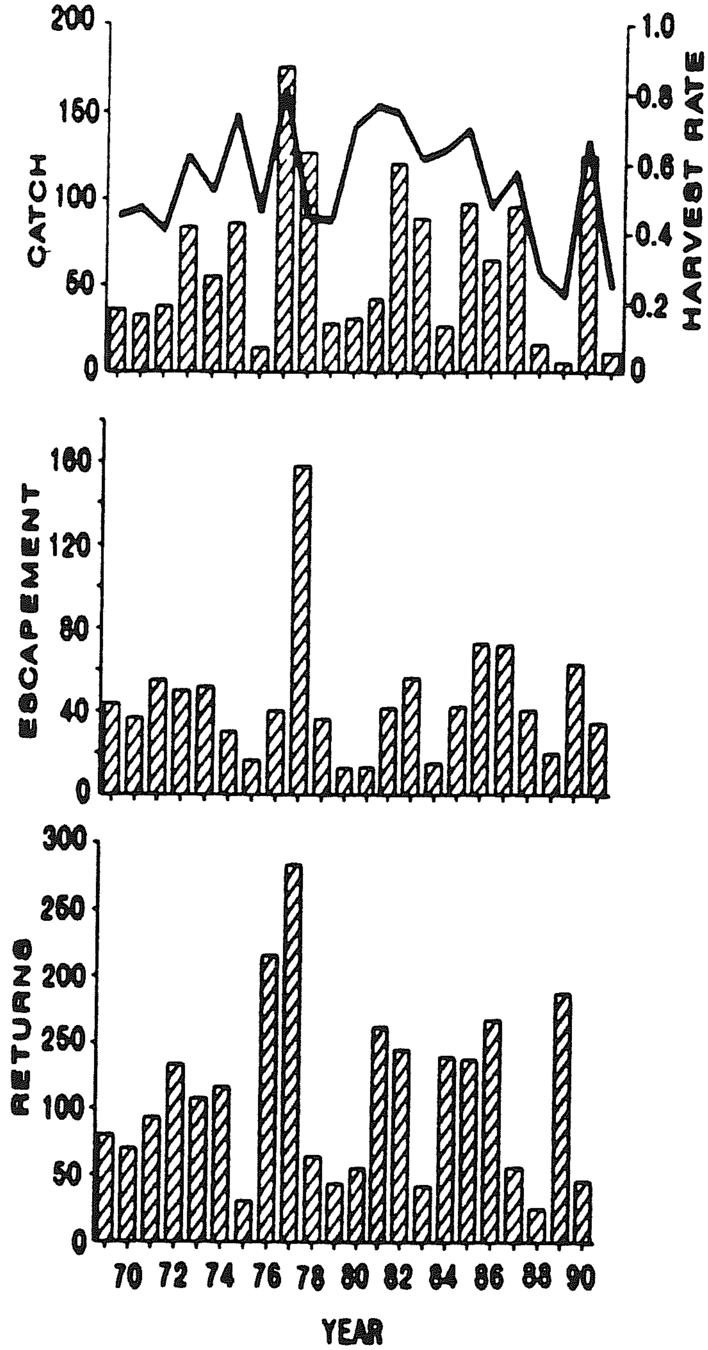

Fig. 5. Catch, harvest rate, spawning escapement and returns (thousands) for non-Meziadin sockeye (1969-90).

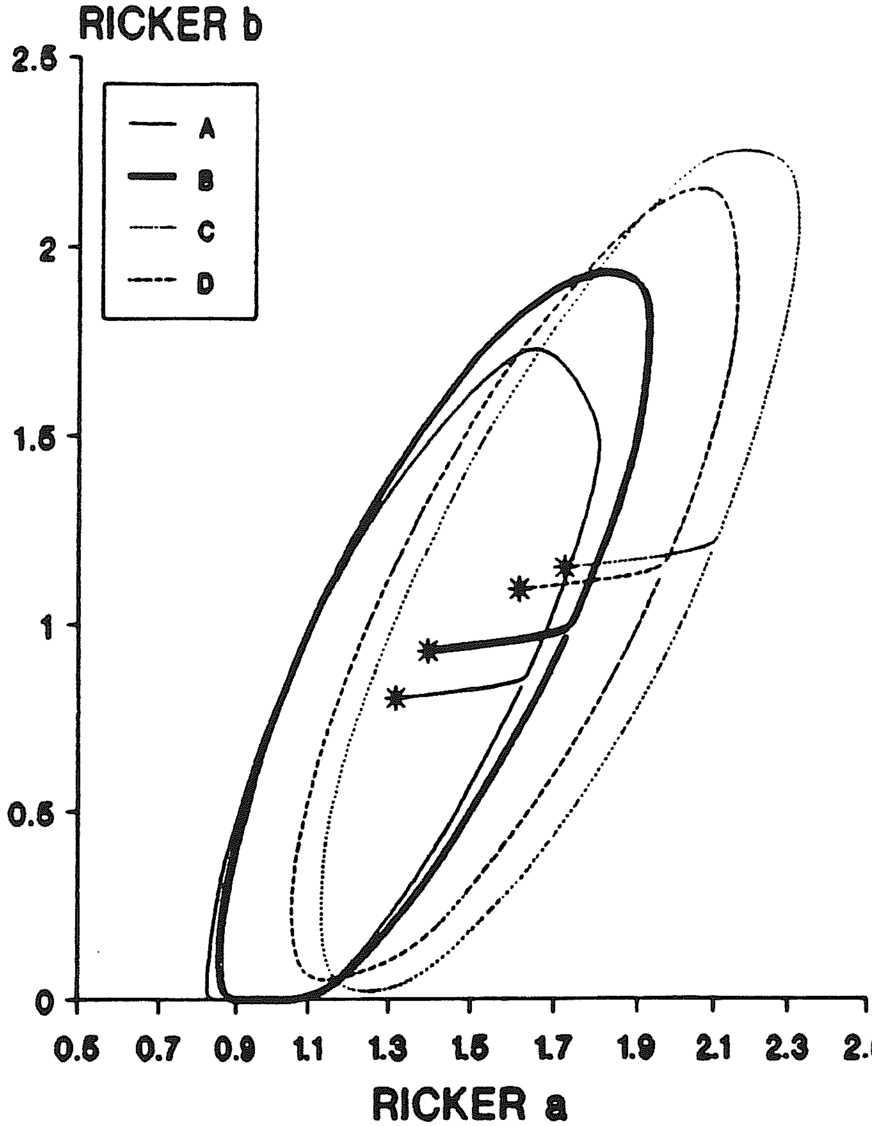

Fig. 6. Joint Ricker a-b 95% confidence interval for four run timing scenarios encompassing the range of variation in parameter estimates used in run reconstructions of non-Meziadin sockeye. All four scenarios shift the run timing of non-Meziadin sockeye relative to the annual timing of Meziadin sockeye: a) uses a zero lag from the inside fishery to the test fishery and the 50% date of passage at the test fishery and Meziadin fence to lag fish from the fence to the test fishery, b) uses a 1 wk lag to move fish from the inside fishery to the test fishery, c) uses a 2 wk lag to move fish from the inside fishery to the test fishery, and d) estimates the run timing of Meziadin sockeye directly from the test fishery index and uses a 1 wk lag to move fish from the inside fishery to the test fishery and 50% date of passage at the test fishery and Meziadin fence to lag sockeye from the fence to the test fishery.

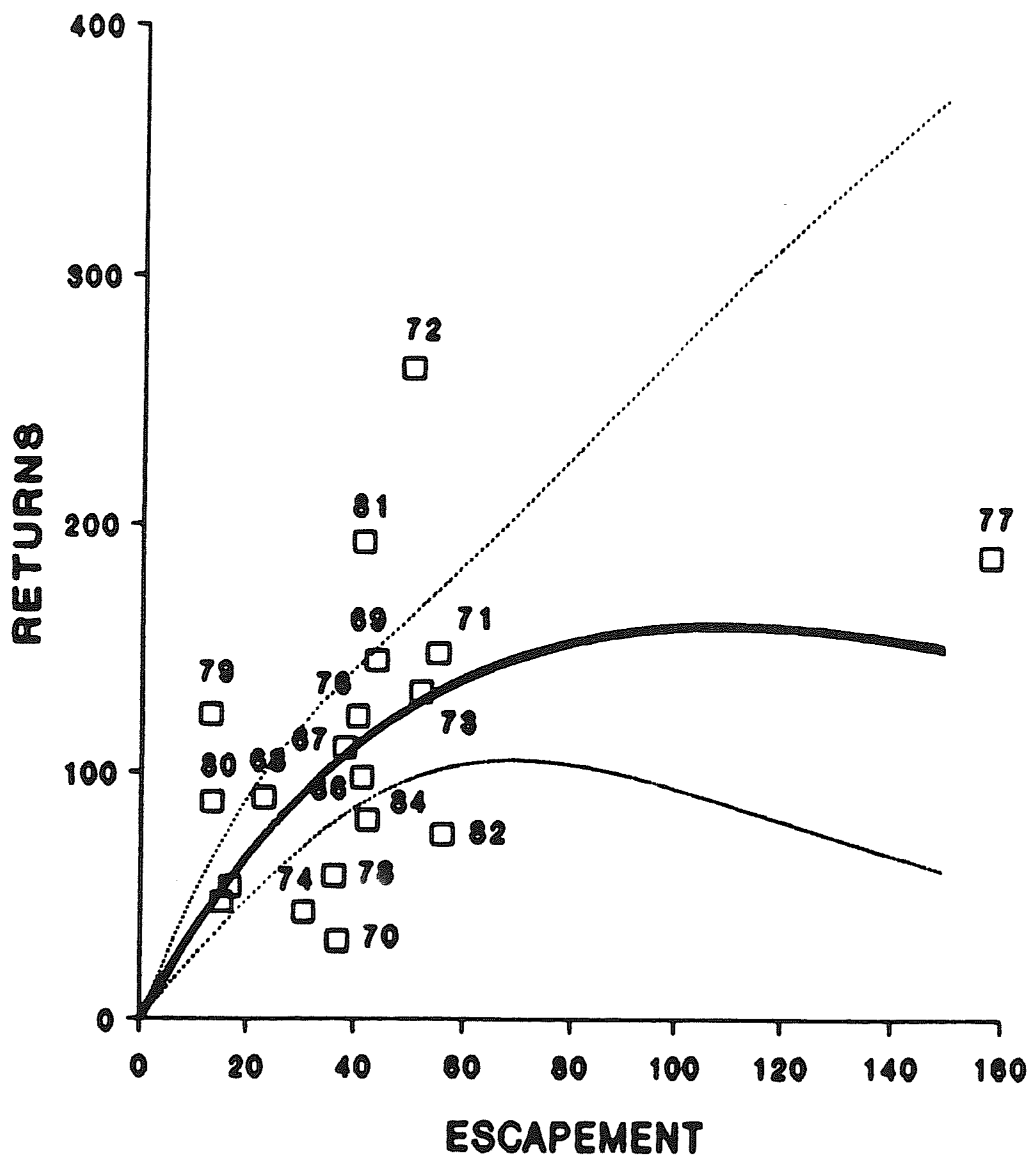

Fig. 7. Ricker stock-recruitment relationship and 95% confidence interval for non-Meziadin sockeye (brood years 1967-84).