Pacific Stock Assessment Review Committee (PSARC) Annual Report for 1989

S. Farlinger, N. Bourne, B. Riddell,
D. Chalmers and A. Tyler (Editors)

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PACIFIC STOCK ASSESSMENT REVIEW COMMITTEE

(PSARC)

ANNUAL REPORT FOR 1989

by

S. Farlinger, N. Bourne, B. Riddell,

D. Chalmers and A. Tyler [Editors]

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Biological Sciences Branch

Pacific Biological Station

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Chairman's Report for 1989

This is the fourth Annual Report of PSARC, summarizing the fifth year of operation of the committee providing biological advice on the status of Pacific fisheries resources. In 1989 PSARC established a complete annual meeting schedule, with the Salmon Subcommittee held its second major annual meeting. This allowed PSARC to provide biological advice in a timeframe that is consistent with the regional consultative and decision making process prior to scheduled fisheries.

In 1989, 48 Working Papers were prepared, providing the basis for the biological advice for Pacific fisheries resources. The resulting five Advisory Documents are contained in this report.

The Salmon Subcommittee Report (S89-1) resulting from the first meeting of the Salmon Subcommittee was reviewed by the Steering Committee on May 3-4, 1989. The resulting Advisory Document was submitted to the regional Fisheries Management Executive Committee (FMEC) on May 15, 1989. The Steering Committee reiterated that immediate action should be taken to acquire a minimum set of data annually to improve stock assessments for actively managed salmon stocks. Results included stock status reports, progress report on salmon mark-recovery analysis and design for adaptive management approach to cyclic dominance in Fraser sockeye.

Meetings of the PSARC Shellfish, Groundfish and Herring Subcommittees took place on August 29 - 30, August 31 - September 1, and September 6 - 7, 1989, respectively. PSARC Steering Committee reviewed the respective advisory documents (89-2, -3, -4) on September 14 for presentation to FMEC on September 25. Conservation measures were recommended for hook and line rockfish, lingcod and abalone; quotas for other groundfish and herring were approved; and conservative management recommended for those species for which information is limited. The approved biological advice was used by the fishery managers to prepare fishing plans for the region.

The Salmon Subcommittee Report on technical issues pertaining to the 1989 Pacific Salmon negotiations was reviewed by the Steering Committee December 6, 1989. The resulting Advisory Document was submitted to FMEC on December 12, 1989.

Work was initiated by the Salmon Subcommittee with models used/to be used for salmon management in the form of a workshop in mid December.

The structure of the PSARC process was reviewed by FMEC, September 14-15, 1989. It was decided that the addition of the five resource directors (Science, Fisheries Branch, Program Planning and Economics, Native Affairs and SEP) and the area managers to the Steering Committee would facilitate the preparation of recommendations and advice for review by the FMEC. As of early in 1990, indications are that this change has been effective.

The Stock Assessment Data Systems Subcommittee met November 14 - 15 to reform and submit recommendations on catch and landings data to the Steering Committee in December. Recommendations were noted and the subcommittee directed to present a report at the 1990 spring Steering Committee based on species subcommittee input on data requirements.

Thanks are due to the retiring chairs of the Salmon Subcommittee, Dr. Brian Riddell, PBS, Shellfish Subcommittee, Dr. Neil Bourne, PBS, and Herring Subcommittee, Mr. Jake Schweigert, PBS. The incoming chairmen are Mr. D. Anderson, Fisheries Branch (FB), Mr. G. Thomas, FB, and Mr. D. Chalmers, FB, respectively.

This document represents the efforts of the stock assessment community in the Pacific Region. The principal contributors are those authors listed in the PSARC Working Paper Index for 1989; numerous others of DFO staff played key roles. I want to take the opportunity to thank all those who contributed so much to make another successful year of operation of PSARC. The support of FMEC is acknowledged in making PSARC a functional process.

S. Farlinger
Chairman

Rapport du president - 1989

Vous trouverez dans ce quatrième rapport annuel du Comité d'examen de l'évaluation des stocks du Pacifique (CEESP) un résumé de la cinquième année d'activité du comité chargé de fournir des avis bioliques sur les ressources halieutiques du Pacifique. En 1989, le CEESP a de nouveau établi le calendrier annuel des réunions et le sous-comité du saumon a tenu sa deuxième grande réunion annuelle. Ceci a permis au CEESP de fournir ses avis biologiques en temps opportun dans le cadre du processus régional de consultation et de prise de décision, avant le début des pêches.

En 1989, le CEESP a préparé 48 documents de travail, donnant ainsi le fondement des avis biologiques relatifs aux ressources halieutiques du Pacifique. Les cinq documents consultatifs qui en ont résulté sont contenus dans le présent rapport.

Les 3 et 4 mai 1989, le Comité directeur a examiné le rapport (S89-1) préparé par le sous-comité du saumon à la suite de sa première réunion annuelle. Le document consultatif rédigé à la suite de cet examen a été présenté au Comité exécutif régional de gestion des pêches le 15 mai 1989. Dans son compte rendu, le Comité directeur a réitéré qu'il faut immédiatement prendre des mesures pour recueillir annuellement un minimum de données de base afin d'améliorer l'évaluation des stocks de saumon dans le cadre de la gestion active du saumon. Les résultats incluaient des comptes rendus sur l'état des stocks, un rapport sur l'avancement de l'analyse des marques de saumons récupérées et la conception d'un modèle de gestion adaptive tenant compte de la dominance cyclique du saumon rouge.

Le sous-comité des mollusques et crustacés, le sous-comité du poisson de fond et le sous-comité du hareng du CEESP se sont réunis les 29 et 30 août, les 31 août et 1 septembre et les 6 et 7 septembre 1989 respectivement. La Comité directeur du CEESP a examiné les documents consultatifs de chacun des sous-somités (89-2, -3, -4) le 14 septembre et les a présentés au Comité exécutif de gestion des pêches le 25 septembre 1989. On a recommandé de mettre en place des mesures de conservation pour la pêche à la ligne et hameçon de la rascasse, de la morue lingue et de l'ormeau; on a approuvé les quotas pour les autres poissons de fond et pour le hareng; et on a recommandé un gestion prudente des espèces pour lesquelles on dispose de peu de renseignements. Les gestionnaires des pêcheries se sont servis des avis biologiques approuvés pour préparer les plans de pêche pour la région.

Le 6 décembre 1989, le Comité directeur a examiné le rapport de sous-comité du saumon concernant les questions techniques liées aux négociations sur le saumon du Pacifique pour 1989. Le document consultatif rédigé à la suite de cet examen a été présenté au Comité exécutif de gestion des pêches le 12 décembre 1989.

Le sous-comité du saumon a tenu un atelier à la mi-décembre pour commencer les travaux sur les modèles qui sont utilisés ou qui devraient être utilisés pour la gestion du saumon.

Les 14 et 15 septembre 1989, le Comité exécutif de gestion des pêches a examiné le processus suivi par le CEESP et il a décidé que la présence des cinq directeurs de ressources (Sciences, Pêches, Planification des programmes et économie, Affaires autochtones et PMVS) et des gestionnaires de secteurs au Comité directeur faciliterait la rédaction des recommandations et des avis qui lui sont soumis. Déjà au début de 1990, ce changement semblait s'être avéré efficace.

Le sous-comité des systemes de données sur les évaluations de populations s'est réuni les 14 et 15 novembre pour délibérer et pour présenter des recommandations au sujet des données sur les prises et sur les arrivages au Comité directeur en décembre. Le Comité directeur a pris note des recommandations et il a demandé au sous-comité de lui présenter un rapport à sa réunion du printemps 1990 en tenant compte des commentaires obtenus des sous-comité des diverses espèces sur les besoins de données.

Nous tenons à remercier les présidents sortants du sous-comité du saumon M. Brian Riddell; du sous-comité des mollusques et crustacés, M. Neil Bourne; et du sous-comité du hareng, M. Jake Schweigert, tous trois de la Station biologique du Pacifique. Les nouveaux présidents de ces sous-comités sont, dans l'ordre, M. Don Anderson; M. Greg Thomas; et M. Dennis Chalmers, tous trois de la Direction des pêches.

Le présent document est le résultat du travail des groupes qui évaluent les stocks dans la région du Pacifique. Les principaux collaborateurs sont les auteurs énumérés dans l'index du document de travail du CEESP de 1989. De nombreux autres employés du MPO ont également tenu un rôle prépondérant. Je désire profiter de l'occasion pour remercier tous ceux qui ont contribué au succès des activités du CEESP encore cette année. Je tiens également à remercier le Comité exécutif de gestion des pêches de sa contribution à la réussite du travail du CEESP.

La presidente

S. Farlinger

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Section I

Report on Committee Activities

Terms of Reference
Pacific Stock Assessment Review Committee
(PSARC)

Organizational Structure

PSARC is a Departmental Committee that reviews biological advice on the status and management of Pacific fisheries resources. The Committee reviews methodologies and criteria employed in the stock assessment process, presents advice to management in the form of harvestable biomass and/or management guidelines and identifies resource assessment related research needs. In terms of a broad definition, PSARC encompasses the stock assessment community of D.F.O. in the Pacific Region responsible for providing biological advice to senior management in the Region. PSARC is controlled, organized and administered by a steering committee, which reports to the Fisheries Management Executive Committee - Pacific. The chairman reports to the Director-General, and will serve for a 2-year term.

The technical work of the organization 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.

Terms of Reference

1. PSARC is responsible for (1) reviewing and evaluating biological advice and technical advice on the status and management of Pacific fisheries resources, and (2) evaluating estimation and assessment methods and criteria used in the Region.

2. PSARC will formulate and evaluate methodologies for assessment and decision making for Pacific fisheries, and will advise the Fisheries Management Executive Committee of sound and appropriate methods for fisheries management in the Region.

3. PSARC shall provide scientific and technical advice to the Fisheries Management Executive Committee - Pacific on matters relating to fishing statistics, sampling of catches, information needs for stock assessment and coordination of resource assessment and related projects between Branches in the Pacific Region.

4. PSARC will identify resource assessment-related research priorities, and by doing, will provide input into the regional planning process.

5. PSARC will endeavour to ensure liaison with other regional committees. Such liaison will include mutual referral and joint meetings with other fora as required so as to ensure constistency of biological advice with long-term Pacific fisheries management objectives.

The Steering Committee

Composition

The Steering Committee includes 9 members as follows:

1 Chairman
1 F.R.B. Section Head from Salmon, or delegate
3 F.R.B. Section Heads from Marine Fish (Groundfish, Herring and Shellfish), or delegate
5 Subcommittee Chairmen
1 Past-Chairman
1 Director from Regional Planning and Economics Branch
1 Director from S.E.P.
1 Director from F. B.
1 Director from Science
1 Director from N.A.B.
1 Delegate from Ottawa
3 Area Managers

The immediate past Chairman and appointed members will serve on the Steering Committee for a 2 year term.
(Note: the addition of Area managers, and membershipof 5 directors rather than delegates in 1989.)

Responsibility of the Committee

The Steering Committee is established to provide a framework for reviewing Subcommittee biological advice that goes forward to senior management and to take the responsibility for advice from individuals of the stock assessment community and place it in the hands of the corporate structure.

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

PSARC has the responsibility of generating and providing biological advice to the Fisheries Management Executive Committee.

Responsibility of Members

It is the responsibility of members of the Steering Committee to attend all regular meetings if possible regardless of whether items being discussed are in their area of expertise in order to provide a broad-based evaluation of biological advice generated from PSARC. If the members cannot attend meetings they should appoint an alternate for meeting at which they are unable to be present.

The definition of a quorum will be left to the discretion of the Chairman.

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

Members are required to forward editorial modifications to proceedings to the Committee Chairman; they will not be discussed at the meeting. Corrections of a substantive nature will, however, continue to be brought to the Committee.

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

Schedule of Meetings

The Steering Committee has at least 3 regular annual meetings. Generally speaking, these meetings occur in the fall for reviewing subcommittee biological advice, and in early spring and late fall for salmon and other marine species advisory documents. Other meetings may be called as required at the discretion of the Chairman, or by request of members of the Steering Committee.

Communication with Line Management

Advisory Documents are to submitted to the Fisheries Management Executive Committee.

After Advisory Documents are approved for release by the Fisheries Management Executive Committee, they are distributed to the management working groups, area managers, the ADM - Pacific and Freshwater, ADM - Science, and other regional staff interested in receiving a copy. Notification to the Chairman of PSARC for approval of release of all Advisory Documents is coordinated through the office of the Director-General.

A listing of PSARC documentation will be forwarded to Area Managers and Section Heads with the request that they indicate what information they would like to receive on a routine basis. This includes PSARC Proceedings and Subcommittee Reports. This is intended to keep key managerial staff informed of PSARC activities. They are expected to respect the citiation guidelines of documents so received.

Items relating to program implementation and requests for assistance are to be referred through the Steering Committee to Directors for approval prior.

Subcommittees

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

   PSARC Salmon Subcommittee
   PSARC Herring Subcommittee
   PSARC Groundfish Subcommittee
   PSARC Shellfish Subcommittee
   PSARC Stock Assessment Data System Subcommittee

2. Participating branches shall nominate Chairmen for each Subcommittee in whose work it is involved. Chairmen are responsible for communicating proposed agendas to members, participants, and reviewers and coordinating their preparations for and participation at Subcommittee meetings. Chairmanship should rotate between branches every 2 years.

3. Participation at Subcommittee meetings shall include departmental stock assessment staff (Science, Fisheries Branch and SEP as appropriate), and at the discretion of the Subcommittee Chairman, D.F.O. scientists from other Regions, and non-D.F.O. scientists, for discussion of specific topics.

4. PSARC will appoint internal reviewers from the stock assessment community to participate in Subcommittee meetings in other than their own discipline. The Steering Committee will select and approve external reviewers nominated by Subcommittee Chairmen.

PSARC Salmon, Herring, Shellfish and Groundfish Subcommittees

The PSARC Subcommittees are to provide biological advice consistent with (1) sound conservation principles, and (2) optimization of production, through PSARC on the management of all salmon, herring, shellfish and groundfish stocks presently exploited, or with potential to be exploited, by:

- reviewing all pertinent information and analyses, or by conducting such analyses as may be required, to establish the status of salmon, herring, shellfish and groundfish stocks and to predict the effects of alternative management measures on potential yields;

- preparing biological advisory reports on salmon, herring, shellfish and groundfish management as may be required by PSARC;

- maintaining a written record of the Proceedings of the Subcommittee documenting the recommendations of the Subcommittee, the scientific basis of such recommendations, and resultant management actions;

- critically reviewing externally published reports of scientific research and commenting on matters relevant to the Subcommittees mandate;

- reviewing stock assessment-related research programs on salmon, herring, shellfish and groundfish, and commenting on their relevance and effectiveness in relation to management of these resources;

- providing a forum for coordination of stock assessment related research programs on salmon, herring, shellfish and groundfish;

- reviewing research requirements for salmon, herring, shellfish and groundfish resource management, and recommending initiation of such programs as may be required by PSARC;

PSARC Stock Assessment Data System Subcommittee

It is the responsibility of the Stock Assessment Data System Subcommittee to provide the scientific and technical basis for PSARC advice on catch statistics, catch sampling, and biological surveys to D.F.O. Pacific, by :

- defining the stock assessment information needs of the stock assessment community and evaluating the adequacy of information provided to meet these needs;

- reviewing Regional data management proirities, and recommending work priorities to the Information Technology and Systems Division, and review policies, procedures, and schedules to ensore they meet Regional priorities and integrate with PSARC;

- developing an integrated stock assessment data system, and reiewing stock assessment related E.D.P. work plans and assign priorities;

- maintaining a written record of the Proceedings of the Subcommittee documenting the conclusions of the Subcommittee, the scientific basis for such conclusions, and of actions taken by other Regional groups based on the Subcommittee's conclusion.

PSARC STEERING COMMITTEE

Ms. S. Farlinger, Chairman
Fisheries Branch, North Coast Division
202 - 417 2nd Ave West
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Mr. G.A. McFarlane, Section Head - Groundfish
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Mr. Doug McKone
Senior Policy/Program Advisor
Fisheries Research Branch
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LIST OF MEETINGS, 1989

1. PSARC Salmon Subcommittee Meeting - April 10-14, 1989 - Pacific Biological Station, Nanaimo, BC

2. PSARC Steering Committee Meeting - May 3-4, 1989 - Coast Bastion Inn, Nanaimo, BC

3. PSARC FMEC review of Salmon Advisory Document 89 -1, June 22, 1989 - 555 W. Hastings, Vancouver, BC

4. PSARC Shellfish Subcommittee Meeting - August 29-30, 1989 - Anchor Inn, Campbell River, BC

5. PSARC Groundfish Subcommittee Meeting - August 31-September 1, 1989 - Pacific Biological Station, Nanaimo, BC

6. PSARC Herring Subcommittee Meeting - September 6-7, 1989 - Blackcomb Lodge, Whistler, BC

7. PSARC Steering Committee Meeting - September 14-15, 1989 - Best Western Harbourside, Nanaimo, BC

8. PSARC FMEC review of herring, groundfish and shellfish advisory documents, September 25, 1989 - 555 W. Hastings, Vancouver, BC

9. PSARC Stock Assessment Data System Subcommittee - November 14-15, 1989 - 555 West Hastings Street, Vancouver, BC

10. PSARC Salmon Subcommittee meeting, November 2 - 3, 1989 - 555 W. Hastings, Vancouver, BC

11. PSARC Steering Committee Meeting - December 6, 1989 - Four Seasons Hotel, Vancouver, BC

12. PSARC FMEC review of salmon advisory document 89 - 5, December 12, 1989 - 555 W. Hastings, Vancouver, BC

13. PSARC Workshop for review and evaluation of troll fishery models - December 18 - 19, 1989 - Nanaimo, BC

PSARC WORKING PAPER INDEX FOR 1989

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H89-2	Forecasting recruitment of Pacific herring to the spawning stock from the escapement model.	J.F. Scheigert D.G. Noakes
H89-3	Summary of spawn time prediction work in Barkley Sound 1987-89.	R.W. Tanasichuk D.M. Ware
H89-4	Size-at-age trends for BC herring 1929-89.	R.W. Tanasichuk D.M. Ware
H89-5	Hydroacoustic herring survey results from Hecate Straits, December 7-18, 1988.	B. McCarter R. Kieser D.E. Hay
H89-6	Offshore herring distribution, length composition and recruitment forecast for the lower west coast Vancouver Island.	D.M. Ware R.W. Tanasichuk
H89-7	In-season Herring (Clupea harengus) Tagging Report to the Herring PSARC subcommittee.	S. Farlinger
H89-8	Report on 1989 Seabound charter to assess herring stocks in Johnstone Strait and Central Coast inlets.	V. Haist L. Hamer
2. Groundfish		
G89-2	Lingcod stock assessment for 1989 and recommended yield options for 1990.	L.J. Richards C.M. Hand
G89-3	Pacific cod stock assessment for 1989 and recommended yield options for 1990.	A.V. Tyler R.P. Foucher

Number	Title	Author
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G89-5	Sablefish stock assessment for 1989 and recommended yield options for 1990.	M.W. Saunders G.A. McFarlane
G89-6	Pacifc hake stock assessment for 1989 and recommended yield options for 1990.	M.W. Saunders
G89-7	Spiny dogfish stock assessment for 1989 and recommended yield options for 1990.	M. W. Saunders
G89-8	Walley pollock stock assessment for 1989 and recommended yield options for 1990.	M.W. Saunders
G89-9	Slope rockfish stock assessment for 1989 and recommended yield options for 1990.	B.M. Leaman
G89-10	Shelf rockfish stock assessment for 1989 and recommended yield options for 1990.	R.D. Stanley
G89-11	Inshore rockfish stock assessment for 1989 and recommended yield options for 1990.	L.J. Richards C.M. Hand
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I89-2	Comparison of catch and effort data from sales slips and logbooks for prawns.	J.D. Fulton D.J. Noakes
I89-3	Stock assessment of British Columbia crab (Cancer magister Dana) fisheries.	M. Stocker T.H. Butler

Number	Title	Author
3. Invertebrates (cont'd)		
I89-4	Preliminary analysis of geoduck growth data in British Columbia.	D.J. Noakes A. Campbell
I89-5	Invertebrate logbook systems: a review.	D.J. Noakes J.D. Fulton J.Boutillier
I89-6	Salicornia harvesting in British Columbia.	R.K. Cox
I89-7	Abalone resurvey in the Estevan Group and Aristalzabal Island, June 1989.	S. Farlinger G.A. Thomas W. Carolsfeld
	Stock Status Reports	
A.	Intertidal clams	N. Bourne R. Harbo K. Hobbs
B.	Geoducks	R. Harbo K. Hobbs G.A. Thomas
C.	Horse clams	R. Harbo K. Hobbs A. Campbell
D.	Oysters	R. Cox
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G.	Abalone	G.A. Thomas S. Farlinger
H.	Octopus	R. Harbo K. Hobbs
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Number	Title	Author
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Q.	Effect of the Nestucca oil spill on dungeness crab.	W. Harling
4. Salmon		
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S89-3	Adaptive management of Fraser sockeye.	C. Wood K. McGivney
S89-4	1988 status of the lower Strait of Georgia chinook stock.	P. Starr B. Riddell
S89-5	1988 Strait of Georgia coho salmon assessment.	K. Wilson R. Kadowaki
S89-9	South coast management model.	K. McGivney (scientific authority)
S89-10	1989 Fraser River sockeye forecasts.	W. Saito

Number	Title	Author
4. Salmon (cont'd)		
S89-11	Stock status and assessment of southern BC chum salmon in 1988 forecast for 1989.	W. Luedke S. Heizer
S89-12	Status of southern BC (non-Fraser) pink salmon and 1989 forecasts.	L. Hop Wo A. Gould
S89-13	Stock status and 1989 forecasts of Barkley Sound sockeye (with appendix)	K. Hyatt G. Steer
S89-14	Overview of methods and issues in the GSI program of southern BC chum salmon fisheries.	W. Luedke D. Anderson
S89-15	Stock status of Skeena river sockeye salmon (Oncorhynchus nerka) (with appendix).	M. Henderson R. Diewert
S89-18	Stock assessment of Skeena river chinook salmon.	B. Riddell B. Snyder
S89-19	Stock assessment of Skeena river pink.	L. Jantz
S89-20	Progress report on the statistical analysis of salmon mark-recovery data (with appendix).	J. Schnute T. Mulligan B. Kuhn L. Lapi
S89-21	Incorporating pre-season forecasts into within season abundance estimates.	D. Noakes
S89-22	Accuracy and precision in stock identification of Fraser River Sockeye.	A. Cass
S89-23	Production of chinook and coho salmon from SEP facilities (through 1987).	C. Cross L. Lapi T. Perry
S89-24	Methodology for estimating production of chum and pink salmon from SEP facilities.	D. Bailey M. Plotnikoff

Number	Title	Author
4. Salmon (cont'd)		
S89-26	From data to indecision: An evaluation of optimal stock size strategies for Adams River sockeye (Oncorhynchus nerka).	D. Welch D. Noakes
S89-27	Stock assessment of Skeena River chum salmon.	L. Jantz
S89-28	Advice for establishing coho salmon escapement goals for the Fraser River.	R. Kadowaki K. Wilson N. Schubert
S89-29	Assessment of the Harrison River chinook stock (Lower Fraser River)	R. Starr N. Schubert
	Other papers	
	Big Qualicum chinook egg allocation.	T. Perry

Section II

Advisory Documents

PACIFIC STOCK ASSESSMENT REVIEW COMMITTEE

PSARC ADVISORY DOCUMENT 89-1
MAY, 1989.

BIOLOGICAL ADVICE ON PACIFIC SALMON

CONTENTS

I. STEERING COMMITTEE REPORT

At its meeting on May 2, 1989, PSARC reviewed the Salmon Sub-committee Report as contained in this document. The report contains assessments of conservation concerns about southern B.C. chinook and coho salmon, assessments of southern B.C. sockeye, pink, and chum stocks, assessments of Skeena River salmon species in preparation for the development of the Skeena River Management Plan, and assessments of salmon production from enhancement facilities. Several chapters address strategies and evaluation for developing sockeye salmon production in the Fraser River system. Regional concerns about the use of genetic stock identification techniques in management, the statistical basis of the coded-wire tag program, and the accuracy of forecasting the abundance of salmon returns were also considered. The Steering Committee was concerned that their 1988 recommendation for the identification of a minimum set of data for assessing the major salmon stocks was not responded to in 1989.

FISHERY IMPACTS

The Salmon Sub-committee report indicates both long and short term impacts on Pacific salmon fishing. Short term impacts refer to impacts in 1989 fisheries but longer term impacts concern development of Fraser and Skeena River sockeye salmon, and conservation concerns for chinook and coho salmon in southern British Columbia. The assessments presented indicate strong returns and fishing for Fraser River sockeye and pink salmon but weaker returns for other southern B.C. stocks.

Returns of Fraser River sockeye are expected to be comparable to the large return in 1985 and largely composed of returns to the Quesnel Lake stocks (Horsefly and Mitchell). The total return of Fraser River sockeye is predicted to be 13 million, resulting in an allowable catch of 9.8 million adult sockeye (see Summary table). The predicted return of Fraser River pink salmon is for the largest return in recent history (20.6 million, see Summary table). This prediction does have a large confidence region about the estimate (90% confidence limit ± 7 million) but even at the lower limit of the estimate the allowable catch will be 8 to 9 million Fraser pinks. Harvests on other southern B.C. stocks are expected to be much more limited compared to the Fraser sockeye and pink returns, and the 1988 chum catches. Chum returns to the Inside stocks (Johnstone Strait, Strait of Georgia, and Fraser River) are expected to provide for minimal harvest rates (20%) in mixed stock fishing areas under the clockwork management process. Returns to enhancement facilities should provide more catch in terminal areas, the total catch of chum in the Inside chum stock is expected to be about 1.2 million. Harvest opportunities along the west coast of Vancouver Island are anticipated to be limited to enhanced stocks but the predicted catches from these is highly uncertain. Returns to the Conuma hatchery have not provided terminal harvests recently but the converse is true for the Nitinat hatchery. Return forecast for Nitinat are for about 250,000 chum but in 1988 the observed return was about 4 times the forecast. No harvestable surpluses are expected for southern B.C. (non-Fraser) pink salmon or Barkley Sound sockeye salmon. Small surplus returns were forecast for the southern pinks but it is anticipated that this will be caught during fisheries for the Fraser pinks.

The only forecast provided for central and northern B.C. salmon stocks was for the Skeena (Area 4) pink stock. Significant surplus returns were indicated for this stock but the forecast is highly uncertain. The Salmon Sub-committee did not consider other northern stocks since information was not presented.

Longer term fishery impacts are all likely to involve short to medium term reductions in fishing to reduce harvest rates (but catches could increase gradually). Conservation concern for the Lower Strait of Georgia chinook stock was addressed in 1988. Rebuilding this stock will require reduced harvest rates in the Strait of Georgia troll and sport, Johnstone Strait net, south central B.C. troll, and in-river native fisheries. Evidence was presented that exploitation on these stocks was reduced for the 1984 brood year and escapements increased in 2 of the 3 indicator stocks. However, conservation concerns continue for these stocks as they remain substantially below their escapement goals. Conservation concerns have now also been identified for coho salmon in the Strait of Georgia. Based on trends in spawning escapement of natural coho stocks and exploitation rates on hatchery stocks, the Sub-committee recommended a 10% reduction in total exploitation. These southern coho stocks are largely distributed within the Strait of Georgia and along the west coast of Vancouver Island. Therefore, if these coho stocks are managed to an objective of maximum biological production then management actions to conserve these stocks will further restrict fisheries within the Strait of Georgia, already impacted by the chinook conservation program.

Regrettably, PSARC can not provide final technical recommendations on development plans for Skeena or Fraser River sockeye salmon. Further technical work is required due to concerns about the estimated biological production rate used for Fraser River sockeye and the importance of lake spawning sockeye in Babine Lake in the Skeena drainage. The re-evaluation of Fraser sockeye production will not change the major conclusions that annual harvest rates on these stocks should be reduced but would influence how quickly the stocks will be expected to increase in abundance and what their optimal stock size should be. However, to increase production of Fraser sockeye will require reductions in harvest rates, and to a greater extent on stocks which are recommended for use in evaluating cyclic dominance. The issue in Skeena sockeye is how productive lake spawners and surplus returns to the channels are. To-date all assessments have considered all spawning sockeye to be equally productive. In the absence of evidence to invalidate this assumption the Sub-committee recommended maintaining the present escapement goals for Skeena sockeye. But, if the lake and surplus spawners are not productive then the sustainable exploitation rate on Babine sockeye would increase over present rates. However, these rates could probably not be sustained by the other natural sockeye stocks in the Skeena River, and would likely exacerbated the mixed-species fishing problems on chinook, coho, chum, and steelhead trout.

STEERING COMMITTEE RECOMMENDATIONS

Each chapter of the Sub-committee report contains advice for fisheries management and/or recommendations to improve stock assessments. Many of these recommendations should be acted upon by the responsible Branch and Divisions. The Steering Committee endorses these recommendations and summarizes the major recommendations in this section.

A) Advice for Fisheries Management:

1) Conservation concerns for chinook and coho stocks in Strait of Georgia. Evidence was presented that exploitation rates on chinook stocks in the lower portion of the Strait of Georgia were reduced for the most recent complete brood year (1984) but the conservation program for these stocks must be continued as the 1988 escapement was still only 25% of the escapement goal. Conservation concerns have now also been identified for coho salmon in the Strait of Georgia and the Fraser River. Exploitation rates on these stocks should not be increased and for the Strait of Georgia stocks should be decreased by about 10% points. This coho conservation need further supports the Committee's recommendation in the fall, 1988 that a coho management policy should be developed by the Department. There is an immediate need to begin work on this policy and to control harvest pressures on these stocks. (reference to Chapters 2,3 in the Sub-committee report)

2) The Steering Committee supports the Sub-committee's concerns about the Big Qualicum Hatchery chinook stock and the number of naturally spawning chinook in that river system. Given the poor survival of this stock it would seem prudent not to distribute eggs from this stock until the cause for the survival problem is understood. Further, the evaluation of natural versus hatchery survival rates in the Big Qualicum River should proceed. If natural production rates are greater than the hatchery, then a minimum number of natural spawners should be maintained in the river as added protection to the stock. The 1989 forecast of returns to Big Qualicum suggests that the egg requirement will not be met. A contingency plan for the use of available eggs should, therefore, be developed as was done for the 1988 return. (ref. Chapter 2)

3) Limited harvest opportunities were identified for southern B.C. chum salmon for 1989. Harvest opportunities will likely be associated with enhanced stocks. It is advisable therefore, to more

closely associate information on enhanced stocks in the in-season management process as recommended in the Sub-committee report. In-season estimates of the hatchery produced portion of the run should improve run-timing data and the accuracy of the test fishery. (ref. Chapter 4)

4) Harvestable surpluses for southern B.C. (non-Fraser) pinks are expected to be minimal in 1989, but this stock complex will be harvested during fisheries for the Fraser River pinks. In preparation for future harvests, progress was made on documenting management options for mainland inlet pink stocks, consultations on these options should continue and the basis for escapement goals for these stocks documented in 1989. (re. Chapter 5)

5) No harvestable surplus is expected for the 1989 return of Barkley Sound sockeye salmon. Expansion of the native and sport fisheries will impact stock assessments and could impact these stocks at low population sizes as expected in 1989. The sampling of these fisheries should be addressed as recommended by the Sub-committee. Future assessments of these stocks should focus more on biological production capabilities. (ref. Chapter 6)

6) Escapement goals for the Skeena River sockeye (900,000 spawners) and chinook salmon (double the 1979-82 average aggregate escapement = 41,200) should be maintained since assessments presented this year were inconclusive. To resolve the assessment of Skeena sockeye will require to an evaluation of the productivity of lake spawning and surplus channel sockeye in Babine Lake, and determination of the escapement objectives for non-Babine sockeye stock. If these evaluations indicate that exploitation rates on Babine sockeye can be increased then plans for alternative harvest procedures should be developed to alleviate mixed-species harvest concerns in existing fisheries. The Steering Committee supports the recommendation to evaluate the Skeena chinook escapement goal through a terminal harvest rate management policy. Consultations to develop this harvest policy should begin soon as escapements to the river already exceed the interim escapement goal. (ref. Chapter 8,9)

7) The Cyclic Dominance Working Group of the Salmon Sub-committee has identified two opportunities to evaluate the basis of cyclic dominance in Fraser River sockeye salmon. The potential benefits from rebuilding all cycles of Fraser sockeye, if possible, clearly indicates that these evaluations should be strongly pursued. However, the Working Group should be continued to complete their consideration of the role of enhancement and in developing an evaluation framework for these evaluations. Further, the Steering Committee draws particular attention to, and supports, the Sub-committee recommendations concerning documentation of the South Coast Model. This model will be the focus for Fraser River

development and must be clearly understood by the Department. The latter can probably not be assured unless the Department identifies a qualified individual to be responsible for the maintenance and use of this model. (ref. Chapter 14,15,20)

8) Results of the statistical evaluation of the coded-wire tag data should immediately be made known to the Region. Users of the data should also be aware that the embedded replicate tags are not an accurate estimate of the variance in recovery data and should be used very cautiously. Use of the embedded replicate tags as a measure of variance should probably be stopped until the issue is fully clarified. However, tags that have been purchased can be used as there is no loss of information; but costs for decoding will increase slightly. The impact of the bias identified can not be known until the cause of the error is identified; this research must be a high Regional priority for support. (ref. Chapter 17)

B) Information needs:

1) The Sub-committee must respond to the requests of the Fisheries Resource Management Executive Committee as identified in the PSARC Advisory Document 88-1. Specifically, these requests referred to identifying essential assessment needs by stock, evaluating the feasibility of a Regional stock identification laboratory, and development of research plans to compare survival trends in hatchery and natural stocks of salmon. Identification of the essential assessment information for Pacific salmon and of the major stocks continues to be needed. This activity must receive higher priority in 1989. (ref. Chapter 1)

2) There obviously continues to be a general need to review and strengthen the evaluation and collection of spawning escapement data, in particular the Steering Committee noted frequent references to:
- reviewing existing data to select the most consistent and meaningful set of data to be used in assessments or as an index measure of escapements.
- priorization of escapement surveys within a Division and/or index set of data to ensure this information is collected annually and in a repeatable method.
- restoring resources needed to conduct late fall spawn surveys (for example, lower Fraser coho and chum) until alternative enumeration programs can be established and calibrated.
- the need for more information about the composition of the fish spawning (i.e. age composition and sex ratio). (ref. Chapters 2, 3,4,5,9,10,11)

3) The recommendation concerning evaluating the relative survival of enhanced and natural chum along the west coast of Vancouver Island is advisable given the limited returns to natural stocks in recent years. If survivals are comparable it is likely that our escapement data for the natural stocks is incorrect. The

option to harvest the natural stocks under a harvest rate policy rather than a fixed escapement policy should be considered, possibly an experiment for a set number of years. (ref.Chapter 4)

4) The Babine smolt enumeration program is essential to the evaluation of the lake rearing capacity for sockeye smolts and is one of only two time series of smolt production data for sockeye salmon in British Columbia. Funding support should be maintained until the utility of this data for assessment and/or abundance forecasting can be re-evaluated. The present ad hoc support jeopardizes the continuity of this time series of information. Further, existing fry and smolt production data should be fully reviewed to determine whether there is any evidence for limitations to lake rearing capacity; particularly before any new lake assessment programs are begun. (ref. Chapter 8)

5) The Salmon Sub-committee should be tasked to complete assessments submitted to their recent meeting which were identified as requiring further work. In particular, these include: separation of the channel and natural production of sockeye salmon in Babine Lake; more thorough documentation of the methodology for Fraser River sockeye forecasts; development of the escapement goal for Fraser River coho salmon; review of the historical catch data for Skeena River pink salmon and their escapement goal; and further simulations concerning the accuracy and precision of genetic stock identification (GSI) of southern B.C. chum salmon. (ref. Chapters 3,7,8,10,16)

6) In light of the problems identified for chum GSI, the Steering Committee fully endorses the Sub-committee's recommendation to thoroughly evaluate the same problems for pink salmon GSI. The technique is being applied by staff of the Pacific Salmon Commission to determine the coastwide catch of Fraser River pink salmon and to determine Canadian interceptions of American pinks. To our knowledge these procedures have not been scientifically reviewed by Canada. (ref. Chapter 16)

7)Test Fisheries: several recommendations were presented concerning the extension of, or need to improve the accuracy of, existing test fisheries. The particular issues identified were: an early test fishery for chinook in the Skeena River, a coho test fishery in the Fraser, and improved accuracy of the Johnstone St. chum and Barkley Sound sockeye test fisheries. Since pre-season forecasts are not relied upon during the fishing season and recently more assessments are using test fishery data to evaluate stock production, the accuracy of these fisheries is increasingly important. Each responsible Division should be required to report to the Sub-committee in the fall, 1989 on their actions to address these issues. (ref. Chapters 3,4,6,9)

8) The Mark User's Committee of the Pacific Region should address the concerns about usage of the Mark Recovery database but

the Steering Committee reiterates the caveat that the onus for correct usage of the data must reside with the user rather than the database manager. (ref. Chapter 12)

9) Forecasting: the Steering Committee fully supports the concerns expressed by the Sub-committee about the lack of progress in developing and documenting rigorous, repeatable methods for salmon forecasting. This must be considered an essential aspect of the biological advice for management to be annually provided through PSARC. The Steering Committee, therefore, supports the Sub-committee's recommendations to have each Division document their present forecasting techniques, and to hold a Regional workshop to evaluate and/or develop forecasting methods. The Steering Committee also recommends that the proceedings of this workshop be published for future reference, and as a report to PSARC and the Regional Executive. The Steering Committee further suggests that a test site and stock(s) be selected where alternative forecasting methods could be compared over a time.

C) Research Needs:

The Sub-committee has identified many research needs but a few research issues must be identified as essential programs:

1) To resolve the source of error in the coded-wire tag program, research must be continued to develop mass marking techniques. The alternative hypotheses to explain the errors can not be separated without a permanent mark on all hatchery fish, and on fish marked with coded-wire tags. The results of this research could have major impacts on our understandings on harvest rates in fisheries and on the productivity of natural coho and chinook stocks. Further, the studies in mass marking should be extended to include pink and chum salmon. Mass marking of these species could replace the need for fin-clipping and the inherent uncertainties about mark mortality and missed marks during plant sampling.

2) Publication of Dr. Schnute's assessment of the embedded coded-wire tags should proceed as quickly as possible to provide broader scientific review and exposure of the probable inappropriateness of these tags for variance estimates about recovery data. (ref. Chapter 2, 12,13,17)

3) The evaluation of accuracy and precision in identifying Fraser sockeye stocks must be continued and enhanced if possible. The preliminary assessment indicated poor resolution capabilities using scale pattern data alone. Improved abilities to identify sockeye stocks will be essential for evaluating sockeye productivity, to accurately evaluate initiatives to increase Fraser sockeye production, and to test hypotheses about cyclic dominance. (ref. Chapter 14,19,20)

4) The genetic relationship of lake spawning sockeye salmon in Babine Lake and the productivity of these spawners (including the surplus returns to the channels) must be investigated before a stock assessment of Skeena River sockeye can be completed. This issue has major consequences to yields from Skeena sockeye and the impact of this harvest on other salmonids. This project could be conducted collaboratively between Resource Enhancement, Fisheries, and Science Branches. (ref. Chapter 8)

5) The Information Systems Unit of the Stock Assessment Program, B.S.B. should be tasked and supported to implement the Fin-clip database necessary for evaluation of pink and chum salmon production from enhancement facilities. Improved availability of this data should facilitate the use of enhancement data for fisheries management. (ref. Chapter 4,5,13)

6) Sampling programs to determine the sex ratio by age of chinook stocks in the Lower Strait of Georgia must be undertaken in 1989. If the portion female at age 3 has decreased, as indicated in this year's assessment, then the rate of stock rebuilding could be slower than estimated previously. A slower rebuilding rate would imply that the management actions taken to rebuild these stocks may not be sufficient to meet the escapement goal by 1998. (ref. Chapter 2)

7) In conjunction with the proposed evaluation of the appropriateness of the escapement goal for Skeena River chinook salmon, the genetic structure of the stock should be investigated. If individual stocks exist and have different productivity rates then the maximum yield from the stocks would be through harvesting each stock optimally, as opposed to the present treatment of these chinook as one stock with an averaged production rate. (ref. Chapter 9)

SUMMARY TABLE : Summary of stock assessment advice presented in Salmon Sub-committee Report.

Species	Stock	Escapement goal	1988 No. of spawners	1989 Forecast return	Absolute[b] Forecast variability	Basis for assessment data[a] Catch data	No. of spawners	Escapement goal	Forecast procedure
Sockeye	Fraser:		c		-23%	C1	M/R and Visual	S/R, and Policy	Reg. Models
	1988-cycle	1,070,000	1,418,000						
	1985-cycle	3,086,000	2,077,700	13,000,000					
	1986-cycle	5,500,000	3,723,000						
	1987-cycle	1,500,000	1,915,000						
	(c-previous cycle escapement number)								
	Barkley Sound:	410,000	460,300	387,000	49%	C1	Quant. Cnt.	Juvenile Model	Reg. Models
	Great Central	200,000	194,850						
	Sproat	150,000	235,420						
	Henderson	60,000	30,000						
Pink	Fraser River (1987 esc.)	6,000,000	3,125,000	20,600,000 ± 7,000,000	29%	C1,& CR	M/R and Visual	S/R and Policy	Juv. Prod.
	Southern B.C.								
	Even Yr. (1988)	3,111,000	1,881,000		74%	CR,	Visual	Hist.	Ave.R/S
	Odd Yr. (1987)	3,475,000	494,600	1,300,000		CR	Visual	spawners	Ave.R/S
	Skeena River	1,000,000	827,500	4,300,000	41%	C2	V&I	S/R	Ave.R/S
Chum	Southern B.C.:								
	Study Area	2,500,000	1,700,000	3,200,000	22%	CR	Visual	Spawning area	Ave.R/S
	West Coast Van.Island	925,000	511,000	?	N/A		Visual	Spawning area	Ave.R/S
Chinook	Lower Strait of Georgia	31,000	8,200	Not developed		C3,& M/R	Visual	Policy	N/A
	Big Qualicum Hatchery[d]	3,800	1,656	1900-3500		C1,& M/R	Quant. Cnt.	Enhancement goal	Reg. Models

N/A indicated not available
Footnotes on following page.

Summary table (cont'd).

[a]Footnote of descriptions for basis of assessment data:

1. Catch Data (catch is usually counted except when run reconstruction methods are used to apportion catch to stocks contributing to mixed-stock fisheries):

C1 -	all catches of stock accounted for or estimated with acceptable accuracy.
C2 -	majority of catch accounted for but significant problems known to exist (problem may be incomplete catch accounting or inadequate biological sampling).
C3 -	minority of catch by stock accounted for, catch in mixed-stock fisheries not determined.
CR -	catch estimated by run reconstruction analyses, accuracy unknown.
M/R-	tagging and recovery programs used to estimate catch of specific stock (mostly used in enhancement evaluation).

2. Numbers of spawners per year estimated via:

Visual	= Counts of spawners by visual count using various procedures.
V & I	= Visual counts supplemented by information from Indices of spawning escapements.
M/R	= Mark and Recapture procedures consistently employed.
Quant. Cnt.	= Quantitative Counts conducted annually by fence or fishway counts, or by electronic countering equipment.

3. Escapement goal established via:

Spawn Area	= extrapolation of area used per spawner to total spawning area available.
Hist. Sp.	= largest historically observed number of spawners which reproduced itself.
Juv. Models	= assessments of juvenile rearing capacity of habitat and extrapolation back to number of spawners required.
S/R	= stock-recruitment evaluation of historical data on total returns observed from the estimated broodyear escapement.
Policy	= decision to set escapements levels for measurement of changes in production.

4. Forecast of return abundance estimated via:

Ave. R/S	= broodyear escapement * average adult return per spawner observed historically * expected age composition in catch (forecast may be altered due to qualitative assessment of environmental quality).
Juv. Prod.	= estimation of downstream migrants * expected marine survival * expected age composition in catch (some models now quantitatively accounting for variation in marine survival).
Reg. Models	= development of predictive regressions, usually concerning sibling models and oceanographic parameters (i.e.) use of returns of younger age classes to predict returns of older age classes from the same broodyear.
T.S.	= time series models using trends in historical data to predict next year's returns and/or catch.

b Absolute values of plus/minus range of historical forecasts.

d Values in numbers of females, escapement goal base on 19 million eggs required and 5,000 eggs/female

II. SUB-COMMITTEE REPORT

INTRODUCTION

The Salmon Sub-committee met at the Pacific Biological Station, Nanaimo, B.C. from April 10-14, 1989. The sub-committee considered 20 working papers on stock assessments, production from enhancement facilities, special issues, and assessment methodologies. A list of participants, and a list of working papers are appended (Appendix 1,2). The objectives of this meeting were to:

1. 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, reviewer's comments, and the Sub-Committee's advice and recommendations.

1. CHAIRMAN'S REPORT FOR THE 1988 SALMON SUB-COMMITTEE (Working Paper S89-2).

In 1988, the Salmon Sub-committee submitted two committee reports summarizing 23 working papers. These papers have been prepared by staff from the Biological Science Branch, Fisheries Branch, and Resource Enhancement Branch; Program Planning and Economics has become more involved during 1988. In the spring 1988, the Sub-committee's report (PSARC report 88-1) addressed stock assessments of most major, net caught, salmon stocks on the B.C. coast; plus major conservation concerns on chinook and coho salmon, evaluation of production from enhancement facilities, and topical issues on methodology for stock assessment. In the autumn 1988, the second report (PSARC report 88-5) addressed management options and evaluation procedures for coho salmon; plus three issues pertaining to chinook salmon in the Pacific Salmon Treaty (one paper also addressed increased catch potential for coho salmon in the west coast of Vancouver Island troll fishery due to increased contributions of Canadian hatchery coho salmon). Each of these reports presented recommendations concerning data needs, fisheries management actions, and research programs. However, the Sub-committee and the PSARC Steering Committee have both identified a concern about how to monitor progress on implementation of recommendations. This report was written to summarize actions taken on recommendations in the PSARC Advisory documents 88-1, and 88-5. These Advisory documents were presented by the Steering Committee of PSARC to the Fisheries Resource Management Executive Committee (FRMEC) and summarized recommendations of the Sub- committee reports. This report also comments on the publication of assessments presented in the 1988, the accuracy of 1988 abundance forecasts, outlines the 1989 forecast for Fraser River pink salmon, and identifies topics needing continued work.

RECOMMENDATIONS IN PSARC ADVISORY DOCUMENT 88-1:
(recommendations are identified by the numbering system on pages 2-4 of Docu. 88-1)

A1) Salmon Sub-committee should identify the major salmon stocks and the minimum information required for management and assessment of these stocks; and conduct an evaluation of existing information sources with recommendations on procedures to improve data where necessary.

The FRMEC was concerned about the time commitment to meet this recommendation and tasked the Sub-committee to propose a response process and estimation of the time required to conduct this review. The first task was to establish consensus on how to define a "major" stock. The Sub-committee has not responded to this task assignment.

A2) The Region should evaluate the feasibility of establishing a Regional stock identification laboratory; an in-house laboratory was recommended to maintain expertise and to ensure annual consistency in analytical procedures.

The FRMEC agreed with the intention of the recommendation but requested that a formal proposal be prepared with a core group of in-house specialists and the establishment of a long-term contract laboratory. This proposal has not been developed but still should be undertaken; particularly in light of increasing pressures for stock allocations and equity measurements in the Pacific Salmon Commission.

B1) Spawning escapements of off-cycle Fraser River sockeye salmon should be increased but within an experimental design to identify factors affecting sockeye productivity and the biological basis for cyclic dominance in these stocks.

A Sub-committee working group, chaired by Dr. C. Wood and Kaarina McGivney, met frequently in 1988 to develop a recommended experimental design. The results of this work has been presented in Working Paper S89-3 for the April, 1989 Sub-committee review.

B2) As soon as practical, the spawning escapement of Fraser River pink salmon should be increased to the goal of six million spawners.

The 1989 return is forecasted to be one of the largest since the early 1900's, and the escapement goal has been established at six million spawners.

B3) Management and assessment plans should be developed to harvest surplus returns to enhanced and some natural populations of Study Area pink salmon; and to evaluate harvest policies for these stocks.
The South Coast Division has completed an evaluation of management options for the harvest of these stocks (the executive summary of this evaluation is appended to Working Paper S89-12). Mr. G. Scott, District Supervisor in Campbell River, has been tasked to conduct public consultations and to recommend a management plan.

C1) Fish Marking: research programs need to be designed and implemented immediately to examine assumptions and error sources in these marking programs.

Research programs in the Biological Sciences Branch and in the Resource Enhancement Branch have been implemented. These programs address the development of permanent marks on hatchery fish in order to evaluate assumptions of the coded-wire tag program; and statistical studies about the accuracy of coded-wire tag data and analyses (Working Paper S89-20).

C2) Run Forecasting: more emphasis should be placed on developing more accurate forecasting models.

Several investigators are studying how to develop more accurate forecasts but the evaluation of these studies will require several years of salmon returns. Forecasting is discussed in several working papers for the April, 1989 meeting.

C3) Hatchery survival: research should be initiated to study survival trends and determinants of fish reared in hatcheries; and parallel studies in natural stocks should be required to evaluate hatchery production rates.

It is not clear who has responsibility for undertaking these evaluations but the FRMEC deferred any further consideration to a "pending" joint executive meeting between Biological Science and Resource Enhancement Branches. No research plans have been developed.

D1) High priority should be given to maintaining documentation and standardized procedures established for acquisition and analysis of assessment and management data for Barkley Sound sockeye stocks.

Working Paper S89-13 notes that the concerns which generated this recommendation were successfully addressed in 1988.

D2) Conduct a comprehensive assessment of Skeena River sockeye stocks including wild and enhanced components.

A more in-depth assessment was undertaken in 1988 and has been submitted (Working Paper S89-15) for Sub-committee review.

D3) Initiate and continue routine biological sampling of the catch and escapement of Rivers and Smith Inlet sockeye.

North Coast Division has complied with this recommendation, and has reviewed historical scale samples. A complete inventory of age composition has been prepared (R. Goruk, pers. comm., DFO, Prince Rupert, B.C.); and a technical workshop on forecasting sockeye returns of Area 9 and 10 sockeye is to be held in late April 1989.

D4) Immediate conservation actions are required to protect the Lower Strait of Georgia chinook stock and to rebuild production. The Cowichan River stock should be established as an indicator stock for monitoring the rebuilding of this stock.

A conservation plan to reduce the annual harvest rate by 20% in five fisheries, which annually harvest about 90% of the catch of Lower Strait of Georgia chinook , was implemented in 1988. A 20% reduction in harvest rate was estimated to be adequate to rebuild this stock by 1998 based on the US/Canada chinook rebuilding model. The management plans to achieve this reduction continue to be refined this year but immediate conservation actions were taken. Escapement monitoring and hatchery evaluation programs have been initiated in the Cowichan River. These programs included a counting fence to determine chinook escapement, electrophoretic sampling, collection of biological data, and expansion of the number of smolts to be released from the Cowichan hatchery.

D5) Establish an escapement target of 33,000 coho spawners for the early run-timing Skeena coho stock. Identify needs for a Regional coho stock monitoring and assessment program; and undertake a workshop to recommend as effective and economical a program as possible.

The North Coast Division has implemented the 33,000 escapement goal. A regional workshop was successfully organized and reported on. Recommendations for a Regional coho management policy and related assessment programs were submitted toin the autumn, 1988.

D6) A high priority must be placed on collecting accurate information from hatcheries and from the total escapement of enhanced production.

Programs to evaluate the accuracy of tag recoveries in hatchery escapement sampling were undertaken but more discussion of this issue is likely needed.

D7) A technical document describing run reconstruction procedures and providing compute code of a standardized program should be prepared.

A primary scientific paper was published on this methodology but the technical paper presenting the standardized code was not prepared.

RECOMMENDATION IN PSARC ADVISORY DOCUMENT 88-5:

Sub-committee advice following from the autumn meeting was of a policy development and negotiating nature than technical recommendations. Consequently, there were not specific items for the Sub-committee to monitor. Several technical recommendations could follow from the proposed coho salmon management policy but the FRMEC has requested that an action plan be developed before a coho policy is announced. Procedures to establish this plan were to be developed by the executive committee of Fisheries Branch. Advice in the three papers on chinook salmon was used in the U.S./Canada negotiations this past fall and winter, and the following data needs will be addressed in 1989: collection of chinook catch and coded-wire tags from management sub-units to be excluded from the all-gear catch ceiling in northern B.C.; and electrophoretic data from Skeena chinook salmon to begin investigating their genetic stock structure in this river system.

STOCK ABUNDANCE FORECASTS:

Salmon returns in 1988 to the 12 stocks for which return abundances were forecasted in Advisory Document 88-1 were within the range of forecast deviations previously observed; except for the Naas River sockeye, Bella Coola chum and Big Qualicum chinook forecasts. The Big Qualicum chinook forecast was identified in 1988 as being uncertain because the data being used to predict the returns was below the range of data used to develop the regression models used in the forecast. The forecasts and observed returns were (deviations are calculated as forecasted return minus the observed return divided by the observed return):

STOCK	1988 FORECAST	ABSOLUTE DEVIATION	1988 RETURN	1988 DEVIATION
Fraser River sockeye	2,900,000	23%	3,770,000	-23%
Barkley Sound sockeye	740,000	49%	850,000	-13%
Long Lake sockeye	445,900	30%	504,850	-12%
Owikeno Lake sockeye	1,160,000	67%	872,000	+33%
Skeena River sockeye	2,280,000	52%	3,410,000	-33%
Naas River sockeye	395,000	45%	179,800	120%
Southern B.C. pink (non-Fraser River)	3,018,000	74%	2,600,000	+16%
Southern B.C. chum (Study area stocks)	4,060,000	22%	3,700,000	+10%
West Coast Van. Is. chum	2,120,000	n/a	2,230,000	-5%
Cumshewa Inlet chum	228,000	38%	184,200	+24%
Bella Coola chum	536,000	43%	1,020,000	-47%
Big Qualicum Hatchery chinook	10,000	7%	3,700	+170%

n/a indicates not previously calculated

The forecast of the Fraser River pink salmon return for 1989 was also prepared in 1988 and provided to Fisheries Branch. Based on the forecasting methodology described in Blackbourn (1985) and cited in Working Paper S88-21, the 1989 return of Fraser pink salmon is predicted to be about 21 million fish (D. Blackbourn, pers. comm., Pacific Biological Station, Nanaimo, B.C.). The predicted return of pink is based on:

i) the total abundance of emigrating fry past Mission, estimated to be 407 million in 1988 (R. Kent, pers. comm., Fisheries Branch, New Westminster, B.C.);and
ii) the marine survival predicted on the basis of average salinity at Neah Bay, Washington (June through September, 1988), and at Amphitrite Point and Race Rocks, B.C. (July through September, 1988); and average discharge from west coast Washington State rivers between June and September, 1988.

In the past, the predictions based on salinity and discharge were very similar, but in 1986 river discharge predicted a higher marine survival rate than the salinity data. The marine survival determined from the 1987 pink return proved to be closer to the prediction based on salinity data. In 1988, the two predictions again differed but salinity data gave a higher predicted marine survival than river discharge (Fig. 1a,b). Blackbourn's recommendation is to use the salinity data for the 1989 forecast, but to use an averaged marine survival rate (5.07%) based on the survival predicted by the average salinity from the three locations (5.53%, Fig. 1a) and the survival predicted by the average salinity from Amphitrite Point and Race Rocks only (4.61%). This was recommended because of concerns that the salinity level at Neah Bay has been overestimated, and consequently marine survival, due to calibration errors when converting from water density to salinity. The predicted run size with a 5.07% marine survival rate is 20.6×10^6 pinks. It should be noted though that the forecast may be high since the salinity value used in Figure 1a is outside of the range of the data used to estimate the regression, and that the potential error in the Neah Bay data would still influence the mean value (5.07%). In support of the predicted value, however, the forecast based on a multiple regression using salinity and discharge is 21.3×10^6 pinks and is obviously similar to the first prediction. Based on the regression in Figure 1a, the 90% confidence limit about the predicted value is plus or minus 7×10^6 pink salmon.

PUBLICATION RECORD:

The Salmon Sub-committee report from the 1987 meeting was published in:

Stocker, M., R. Harbo, B. Riddell, J. Schweigert, and A. Tyler (editors). 1988. Pacific Stock Assessment Review Committee (PSARC) Annual Report for 1987. Can. Manus. Rept. Fish. Aquat. Sci. No. 1988:125p.

The majority of the working papers submitted for the March, 1988 Sub-committee have been either published or revised for consideration at the April, 1989 meeting. Of the 19 papers, 5 publications were produced and 8 papers have been resubmitted, one of which as a draft primary paper. The publications are:

Starr, P. and R. Hilborn. 1988. Reconstruction of harvest rates and stock contribution in gauntlet salmon fisheries: application to British Columbia and Washington sockeye. Can. J. Fish. Aquat. Sci. 45(12): 2216-2229.

Noakes, D. J., D. W. Welch, M. Henderson, and E. Mansfield. 1989. A comparison of alternative methods for generating pre-season forecasts of sockeye salmon returns to the Adams and Chilko Rivers, British Columbia, Canada. North Amer. J. Fish. Manage.(in press).

Wood, C. C., D. T. Rutherford, and S. McKinnell. 1989. Identification of sockeye salmon stocks in mixed-stock fisheries in British Columbia and Southeast Alaska using biological markers. Can. J. Fish. Aquat. Sci. (submitted).

Kadowaki, R. K. 1988. Stock assessment of early run Skeena River coho salmon and recommendations for management. Can. Tech. Rept. Fish. Aquat. Sci. No.1638: 29p.

Cass, A. 1989. Stock assessment of Fraser River sockeye salmon. Can. Tech. Rept. Fish. Aquat. Sci. No.1674: (in press).

Publication of the four working papers submitted for the autumn 1988 Sub-committee meeting is unlikely because the three chinook papers were prepared as background to negotiations and the coho paper was a discussion paper on a management policy and assessment procedure for coho in British Columbia. The latter paper may be published at a later date but for now has been restricted to an internal planning document.

SUB-COMMITTEE ADVICE:

The Sub-committee should address 4 tasks following from Advisory Document 88-1 and recommends publication of more of the working papers. The tasks requiring attention in 1989 are, by the numbering system above, items A1, A2, C3, and D7. Two particular working papers submitted last year constituted significant assessments and should be published. The authors of these papers should be encouraged to publish them in 1989. The particular papers concern the evaluation of the Expo coho salmon experiment (Working Paper S88-12) and the assessment of Fraser River pink salmon (Working Paper S88-21).

STOCK ASSESSMENTS

2. STOCK ASSESSMENT OF CHINOOK SALMON STOCKS IN THE SOUTHERN PORTION OF THE STRAIT OF GEORGIA (Working Paper S89-4)

Chinook salmon (Oncorhynchus tshawytscha) in the lower portion of the Strait of Georgia (the LGS stock, excluding the Fraser River) utilize 17 rivers proceeding south from Toba Inlet on the mainland side of Georgia Strait and from the Big Qualicum River south on the Vancouver Island side of Georgia Strait. The majority of the production from this stock comes from three rivers managed for naturally spawning chinook (Squamish, Cowichan, and Nanaimo) and from three rivers dominated by hatchery production (Big Qualicum, Little Qualicum, and Capilano). All of the first three rivers managed for natural stocks also have smaller scale hatchery production. Chinook are not native to the Capilano River and have been transplanted from the Big Qualicum River.

Of the three large inlets (Howe Sound, Jervis Inlet and Toba Inlet) on the mainland side of Georgia Strait, only one (Howe Sound: Squamish River and its tributaries) has associated distributional catch information and a relatively complete time series of escapement data. Information pertaining to the chinook populations in the other mainland inlet rivers is very limited but they are assumed to be similar to the Squamish chinook population in terms of their ocean distribution, run timing, and life history strategy. Escapement information from these rivers (six in statistical areas 15 and 16) is highly variable and recently very few spawners have been recorded for these inlet stocks. These rivers have glacial origins and have peak flows in the summer period when chinook are believed to enter these rivers;

consequently spawner enumeration is difficult and erratic. Since very little is known about these stocks, they will not be discussed in this paper.

The major spawning stocks on Vancouver Island are fall chinook which return to the spawning grounds from mid-August through October. Entry into freshwater is frequently delayed by low water due to summer droughts in this area. Fortunately, the chinook rivers on Vancouver Island are mostly medium-sized rivers that are lake fed and have partial flow control. Spawning normally occurs from late October to mid-November. Squamish chinook have a slightly earlier return timing and are referred to as late-summer migrants, returning from July through September. There are also known spring run (entry into fresh water in May to July) chinook stocks in the Nanaimo and the Cowichan Rivers. However, these runs have currently dwindled to small relict populations.

Chinook from this stock group mature primarily as 3 and 4 year olds; 5 year olds usually comprise less than 5% of the returning adults. Most adults are produced from an ocean-type juvenile life history (0+ age at migration) but stream-type (1+ age at migration) chinook have been observed in the Nanaimo River and in the mainland inlet rivers. Average proportion age at return and average proportion females at age for the Big Qualicum chinook (Fraser et al. 1983; averaged for 1959-72 return years) are:

	% age in escapement	% females by age
Age 2:	21%	0%
Age 3:	28%	30%
Age 4:	49%	72%
Age 5:	2%	90%

More recent data from the Big Qualicum hatchery using returns of coded-wire tagged fish corroborate the above average age composition but indicate that the proportion of females in the age 3 population may have decreased considerably. The proportion of females at age 3 was 8% in 1987 and only 3.4% in 1988 (based on the expansion of tags to account for unmarked fish). The proportion of females in age 4 had also dropped: to 65% in 1987 and to 51% in 1988. The proportions for age 5 were 69% in 1987 and 100% in 1988. This shift in proportion female at age could be attributed to any of the following hypotheses: 1) a major change in the population due to the hatchery environment; 2) to the tagging process itself; 3) to errors in aging in the original assessment; or 4) to errors in sexing fish at the rack or fence.

Currently, chinook stock assessment in mixed-stock fisheries is limited to tagging (adult or juvenile) as the primary technique for determining catch by stock. Accordingly, this assessment of LGS chinook is heavily reliant upon the micro-wire tagging of juvenile chinook produced in enhancement facilities. **However, in applying these data to natural chinook stocks, we are assuming that hatchery rearing does not influence ocean distribution or exploitation patterns.**

STOCK DISTRIBUTION:

The lower Strait of Georgia chinook stocks have a limited northerly migration outside of the Strait of Georgia and the majority of the harvest of this stock group is within the Strait. Five fisheries consistently account for 89-92% of the recoveries of LGS chinook as reported in PSARC Advisory Document 88-1. These distributions are consistent between brood years but differ between ages. The distributional data also indicate that the two more southerly Vancouver Island stocks (Nanaimo and Cowichan) have a greater proportion of their harvest taken within the Strait than the Big Qualicum stock. Further, in more recent brood years, a larger proportion of the total catch for these stocks has been taken by the Strait of Georgia sport fishery.

CATCH AND ESCAPEMENT:

Total catch by stock is not available for most chinook salmon stocks. Consequently, evaluations of production from these stocks are restricted to observing trends in escapements and trends in the catch of fisheries known to exploit these stocks. Escapements to the natural spawning components in this stock group (excluding the populations in Areas 15 & 16) have declined by 81% since 1955 (based on the most recent 3 year average of escapements; Fig 2).

The 1988 escapement of the LGS stock group appears to have reversed the general trend of decline that has characterized this stock group since the early 1980's. However, there are several reasons for this observation to be treated with caution:

1. The greatest increase in escapement was in the Cowichan River. A counting fence was installed for the 1988 season and the estimated escapement index is affected by the presence of this counting facility. It was not possible to fully calibrate the fence count with previous methods of obtaining escapement indices. Therefore, the value for 1988 is not directly comparable to previous values and is likely higher than it would have been if the fence had not been present.

2. Escapement to the Chemainus and Nanaimo Rivers increased, but this may be due to the presence of increased enhancement in these rivers. This may also be the case in the Cowichan.

3. The Squamish River continued to show a decline. This observation is corroborated by the observation that the hatchery staff captured fewer broodstock than in 1987 in spite of more intensive capture efforts.

However, these pessimistic observations should be balanced by what appears to be a real decrease in exploitation rate on the 1984 brood year returning to the Big Qualicum river (see below). Therefore, at least a part of the increased escapement may be due to success in reducing total exploitation rates.

Catch in the fisheries which are the predominant harvesters of this stock group rose dramatically until 1978 but declined sharply since then (Fig. 2). The catch in 1988 was only 21% of the peak catch in 1978.

EXPLOITATION RATES:

Total brood exploitation rates (i.e. the fishing mortality divided by the fishing mortality plus the escapement by brood year) on the LGS stock group (using Big Qualicum data as an indicator stock) are estimated to exceed 80% in all but 4 brood years since 1971. Since that year, the exploitation rate has varied between 76% and 88% and may be showing a declining trend relative to the rates experienced by brood years returning in the early 1980's (Fig. 3). The most recent brood year with fairly complete data (1984, still lacking age 5 recoveries) shows a substantial drop (to 72%) in exploitation rate relative to recent years. This particular brood year was harvested primarily in 1986 to 1988, just at the beginning of some of the major initiatives for conserving chinook salmon.

Exploitation rates have been estimated with and without associated (fishery induced but not reported) fishing mortalities but the exploitation rates including all losses should be used in assessments. It is important to note that the spread between the imputed total mortality and the reported mortality is widening in the more recent brood years, particularly for the 1984 brood year (Fig. 3).

We have used a technique developed by the Chinook Technical Committee of the Pacific Salmon Commission to assess the changes in fishery harvest rates. The Georgia Strait sport fishery and the North/Central troll fishery both show declines in age 4 exploitation rate from 1987 to 1988 (Fig. 4). The Georgia Strait troll fishery shows an increase; however, the magnitude of catch in this fishery is so low that it does not affect the overall assessment of exploitation rate. Although the Johnstone St. seine fishery is low in 1988, it is also low in 1987 and this would not account for the drop seen for the 1984 brood year. Similar declines are seen in age 3 exploitation rates in all four fisheries from 1986 to 1987. The sum of these declines in both 1987 (age 3) and 1988 (age 4) are sufficient to account for the substantial drop in exploitation rate between the 1983 and 1984 brood years (the latter is subject to revision next year after the age 5 returns are in).

In applying these exploitation rates to natural stocks, we are assuming that hatchery rearing does not influence vulnerability to fisheries or age at maturity compared to the natural stocks. These exploitation rates may be conservative, however, since the natural stocks south of BQR are harvested more heavily in the sport fishery and they have terminal harvests in-river (which are not as developed in ~~the~~ BQR). A concern about incomplete recoveries in the escapement to BQR may, however, offset these effects.

ENHANCED STOCKS:

Chinook enhancement activities are significant in the LGS stock group area. Five major hatcheries and 6 smaller projects release chinook within this region. Releases of chinook, excluding fry, have increased from about 500,000 chinook in the 1971 brood year to over 20 million in the 1987 brood year (including Puntledge releases because of BQR transplants and the contribution of Puntledge chinooks to fisheries within the Strait of Georgia). Total production (Canadian fisheries plus escapement) from these releases has varied from about 2000 chinook (for the 1971 brood year) to nearly 120,000 chinook (1976 brood year). However, recent increased smolt releases are not resulting in proportionate increases in production. Changes in fishing regulations (size limits and catch ceilings) may explain some of the reduction in rate of contribution to fisheries, but the time series of releases from Big Qualicum hatchery indicates that survival to adult has been considerably lower in recent years (Fig. 5). Survivals by brood year for total Georgia Strait facility releases have also declined by similar amounts. This indicates that the decline in brood survival has been pervasive for all LGS enhancement, not just the BQR. Total production from the smaller facilities is not available since tag recoveries from escapement are not routinely collected, but there is some evidence that the survival in these small facilities may be higher than in the larger facilities. However, the overall production is dominated by the production from the larger facilities.

COMPARISON OF 1988 BQR FORECAST WITH 1988 ACTUAL RETURNS:

PSARC Working Paper S88-15 presented a forecast of the expected returns to the Big Qualicum River based on a sibling regression model. This forecast predicted a return of about 10,000 adults (age 3 and greater) and the actual return was below 3700 adults. When factored into age class, the 1988 forecast over estimated the 3 year olds by 300% (over 400% when the forecast for total survival to age is compared). There are several possible reasons for this error:

1. The 'survival' (independent variable) of age 2 fish used for the prediction of age 3 returns was only slightly greater than zero. Therefore, the prediction was dominated by the value of the intercept (about .25%) which was far too optimistic.

2. Although the age 4 'survival' prediction was higher than actually returned (in terms of total survival at age), a greater proportion of 4 year olds returned to the hatchery, presumably because of lower exploitation rates (see discussion above). While the prediction (in terms of percent survival at age) was over double the observed survival, the actual return to the river was 36% greater than the forecast. The prediction used observed 1987 exploitation rates, it follows that the exploitation rates must have declined relative to 1987. This is true for ages 3 and 5 as well.

3. The discrepancy described above between the observed proportion of females at age during the historical period (1959-72) when compared to present data caused an error in the prediction of number of females.

1989 BIG QUALICUM FORECAST:

The forecast for the 1989 return to the Big Qualicum River is for 7200 adults (age 3 and greater). This forecast is prepared using a slightly revised sibling model which, when used to reforecast 1988, resulted in improved forecasts for ages 4 and 5. The 1989 forecast is also hampered, as in 1988, by age 2 survivals which are near the extreme lower limit of observations. This is in spite of increased jack returns in 1988. Therefore, the 1989 age 3 forecast has been estimated simply by taking the average ratio of age 3 survival to age 2 survival since the 1977 brood year (when the age 2 survivals dropped below 0.5%).

The two alternate proportion females at age estimates can be used to bracket the expected number of females returning to the hatchery. The lower estimate (1900 females) comes from using the CWT expansions (3.4% age 3, 51% age 4 and 100% age 5) and the higher estimate (3500 females) uses the average proportions from the BQR from 1959 to 1972 (30% age 3, 72% age 4 and 90% age 5). The average value of these two predictions is 2700 and this is probably the best compromise. The expected number of eggs resulting from this prediction would be about 13,500,000. As for the 1988 return, the 1989 return could be larger if the harvest rates in the target fisheries continue to show declines relative to the period 1979-82.

SUB-COMMITTEE ADVICE:

1. As noted by the Sub-committee in 1988, the severe decline in escapement and loss of catch in fisheries known to harvest the lower Georgia Strait (LGS) stock indicate that these populations are below stock sizes needed to maximize production. The naturally spawning component of this stock continues to require immediate conservation actions to restore production. Exploitation rates between 65 and 70% are likely needed to rebuild this stock and sustained exploitation rates after rebuilding will likely be about 70%. Therefore, exploitation rates on these stocks should be lowered by 10 to 15 percentage points from recent levels of 78% to 85% (excluding the 1984 brood year).

2. Returns to the Big Qualicum hatchery should exceed egg requirements at this facility, but may not satisfy the total egg requirements to which this facility is committed (eggs from this facility are distributed throughout Georgia Strait). The predicted number of females returning in 1989 is between 1900 and 3500, with an associated number of available eggs between 9.5 and 17.5 million. This forecast has considerable uncertainty because of the continued low proportionate 'survival' of age 2 returns as well as conflicting estimates of the proportion of females at age. Contingency plans should be in place to allocate eggs in case the number which return are insufficient for all requirements.

3. The Sub-committee notes that fewer and fewer spawners are allowed access to the gravel upstream of the counting fence in the Big Qualicum River. We recommend that a joint committee (including representatives from all three branches) collate the available data (particularly smolt output data) and investigate whether there is significant production from these spawners. Depending on the outcome of this analysis, a recommendation for an allocation of eggs to the gravel that would then be included in the contingency plans recommended in #2 (above).

4. Given the discrepancy shown in this document between the current proportions of females at age compared with similar historical data, it is recommended that a full evaluation of the problem be implemented as soon as possible. Changes of this magnitude have a profound effect on the overall productivity of both wild and hatchery stocks.

5. Given the poor survival trends in the Big Qualicum River, it is recommended that eggs from this stock not be distributed to any **new** locations, pending an assessment of the causes of

the current poor survival. This recommendation is purely cautionary in case some disease endemic to the BQR environment is the cause of the poor survival. At present, there is no evidence of such a disease problem.

6. Continued research is required to reduce the uncertainty concerning the productivity of chinook salmon stocks in the lower Strait of Georgia. The sub-committee recommends the following to evaluate stock rebuilding and the appropriateness of current escapement goals:

   a) evaluation of the accuracy of coded-wire tag programs in these indicator stocks.
   b) monitoring of exploitation rates on the Cowichan River chinook.
   c) examination of biological characteristics and life history types of chinook in the mainland inlet rivers, particularly in the Squamish River.
   d) initiate an experimental program of tagging smolts from parents which have spawned naturally in the Big Qualicum River. This is to test if the poor survivals of the BQR hatchery are duplicated in the river.

3. UPDATE OF STOCK ASSESSMENT ADVICE FOR STRAIT OF GEORGIA COHO SALMON STOCKS WITH PARTICULAR REFERENCE TO THE FRASER RIVER (Working Paper S89-5):

STRAIT OF GEORGIA UPDATE:

The escapement trend reported in last year's Advisory Document 88-1 remains the same, with total escapement appearing stable and the streams without major hatcheries showing a decline (Fig. 6a) The estimated escapement is especially poor in 1987. Returns to three naturally spawning stocks on the east coast of Vancouver Island with intensive enumeration programs were also very low in 1987 relative to other years (escapements to these systems improved in 1988).

Catches in 1988 also continued the trends described last year. Net catch remained low, while sport and troll catches were high relative to the early 1980's. In fact, both the sport and troll fisheries reached decade highs in 1988.

Hatchery contributions to Strait of Georgia fisheries continued to increase. In 1987, the proportion of Canadian hatchery fish in the catch reached 40 percent for the first time in the sport and troll fisheries. Although total catch is at a decade high in these fisheries, there is a concern that as contributions from both Canadian and U.S. (currently unassessed) hatcheries increase, fishery responses to apparent abundance may cause overfishing of wild stocks. In 1988, a relatively high proportion of the catch of Strait of Georgia hatchery stocks was taken in the Strait of Georgia sport fishery (Fig. 7). In contrast to this, an unusually low proportion was taken in the southwest Vancouver Island troll fishery.

Three year average (1985-87 vs 1982-84) exploitation rates have increased for all stocks, with most of the increase attributable to the sport fishery. Recent exploitation rates for all Strait of Georgia hatchery stocks are approximately 10 percentage points higher than the 65 to 70 percent range recommended for maximum sustained yield (Fig. 6b).

FRASER RIVER:

Estimated total escapement to the Fraser River does not show a clear trend, in part because of large estimated escapements in the last four years (1984 to 1987) (Fig. 8a). Index stream escapements (consistently enumerated streams excluding hatchery streams and outplant sites) above Hope have declined steadily since the 1950's, while index escapement below Hope have increased sharply in the 1970's and declined in the 1980's. It should be noted that increased total escapements in 1984 through 1986 are coincident with increased hatchery returns and are not reflected in the index stocks.

The Fraser River coho index from the sockeye and chum test fisheries is positively correlated with terminal run size minus the Area 29 catch (r=0.71). The correlation improves if hatchery rack escapements are excluded from the estimate of terminal run (r=0.79) indicating that hatchery fish may be less vulnerable to the test fisheries than wild fish, perhaps due to differences in run timing, migration routes or size. The average coho index for 1980 through 1987 increased by 30 percent over the average combined index in the 1970's, due entirely to increased catch in the sockeye test fishery. If the index is adjusted to subtract out the increased hatchery catch there is no increase in the average index in the 1970' and 1980's.

Coho catches in the Area 29 commercial net fishery have declined sharply since 1951. The average catch in the 1980's is only 18 percent of the average catch in the 1950's (14 percent if hatchery catch is excluded). From the 1950's to the 1980's the estimated Indian food fish catch of coho has increased by over 400 percent. The increase in the Indian food fish catch of coho is greater in even years when there are no pink salmon returning to the Fraser River. The freshwater sport fishery catch appears to be stable for those years when estimates are available (1969 to 1980, 1984 to 1987), except for a sharp increase in 1986 and 1987 when large numbers of hatchery fish became available. In total, the Fraser River terminal coho catch is currently (1980's average) less than one half of the 1950's average.

Total return to the Fraser River has declined slightly over the 36 years of record. However, if hatchery contributions are removed, wild terminal run has declined on average by over 20 percent since the 1960's. Hatchery contribution to the terminal run has increased from zero in 1980 to over 40 percent in 1987.

As with the Strait of Georgia hatchery stocks, Fraser River hatchery stocks exhibit great inter-annual variability in catch distribution, although they too vary in a similar manner within a particular year (Fig. 9). There are small but persistent differences between the three lower Frasr stocks but the Eagle River stock is markedly different. Lower Fraser River hatchery coho are taken primarily in the Strait of Georgia sport fishery, the Strait of Georgia troll fishery and the southwest Vancouver Island troll fishery. Although it is in close proximity to the Chilliwack River, Chehalis River coho are consistently caught at higher rates in the southwest and northwest Vancouver Island troll fisheries and at lower rates in Strait of Georgia fisheries. Eagle River hatchery coho are caught at higher rates in the southwest and northwest Vancouver Island troll fisheries than even the Chehalis River stock. Although 1988 was a year of relatively high inside distribution for the Eagle stock, over 42 percent of the catch still occurred in the two west coast of Vancouver Island troll fishing areas, while approximately 45 percent was taken in the Strait of Georgia sport and troll fisheries.

Recent estimated exploitation rates from CWT recovery data for Fraser River hatchery coho stocks indicate that fishery impacts on stocks other than Inch Creek, do not appear to be substantially above levels recommended to maintain maximum sustained yield (Fig 8b). However, since U.S. catches and in-river Indian food fish catches have not yet been included in the analysis, caution should be exercised when interpreting these results.

SUB-COMMITTEE ADVICE:

Strait of Georgia

1. The Sub-committee believes that wild coho stocks in the Strait of Georgia are under a high risk of overfishing at the current exploitation rates. Exploitation rates, as estimated for Strait of Georgia hatchery stocks, need to be reduced by approximately 10 percentage points if fishery impacts are to be brought within limits required to maximize yield of wild coho stocks.

Fraser River

1. The Sub-committee recognizes the need to define biological objectives for Fraser River coho. To this end, we recommend that a working paper be submitted for the fall, 1989 Salmon

Sub-committee meeting which evaluates the current escapement goal and recommends an alternative management objective if the current escapement goal is found to be inappropriate. This paper will contain a detailed evaluation of escapement, catch and exploitation rate data used and the assumptions and sources of bias in the analysis.

2. Current exploitation rates on wild Fraser River coho stocks may be above the rate required to produce MSY and should not be increased, pending the review in 1) above.

3. The feasibility of establishing a coho test fishery should be investigated and if feasible, should be implemented to provide an estimate of run size independent of the fishery officer estimate.

4. The fishery officer estimates of coho spawning escapement must be maintained, at least until a satisfactory alternative assessment methodology is developed. Without this broad coverage large inter-annual fluctuations in spawning escapement will be very difficult to detect. This problem is particularly critical in the lower Fraser River where the number of streams surveyed has declined markedly since 1986: specifically in 1987, 7 of the 10 largest lower Fraser coho stocks comprising 56.0 percent of the lower Fraser River escapement (1982 to 86 average) were not surveyed. Four of the seven, spawning in the Pitt, Birkenhead, Lower Lilloet and Harrison rivers would have been included in the index streams, if they had been surveyed. Although 1988 escapement data has not yet been reviewed, this situation has apparently not improved.

4. SOUTHERN BRITISH COLUMBIA CHUM SALMON AND FORECAST FOR 1989 (Working Paper S89-11):

This report will describe the assessments made in the 1988 fishing season, the forecasts for 1989, and emphasizes changes from last years report in PSARC Advisory Document 88-1. Progress on recommendations made by PSARC last year is also reviewed.

SUMMARY OF 1988 ASSESSMENTS:

Assessment of Inside chum stocks (Statistical Areas 11-19, 29) during the 1988 season was influenced by an unusually compressed run timing. Assessments made early in the season indicated a small chum run, while assessments during the peak run period indicated a very large run. Due to a number of considerations discussed in working paper S89-11, estimates made around the peak period were given more weight than earlier estimates, resulting in a final in-season run size estimate of 4.2 million. The post-season estimate of run size (catch plus spawning escapement) was 3.2 million (revised from PSARC S89-11). This is one of the largest errors in in-season assessment in recent years. The weighting of the in-season estimates of run size is being reviewed to reduce the possibility of such error in the future. Chum escapement in Inside waters was about 1.7 million, which is less than the 2.0 million overall target. Spawning escapements were quite strong to non-enhanced systems throughout the Study Area (Johnstone Strait to Fraser River), except in the Fraser River where a total escapement of 425,000 (based on a test fishery index and includes broodstock for facilities) was achieved. The minimum escapement target for naturally spawning chum in the Fraser River is 700,000.

Chum stocks along the west coast of Vancouver Island (Areas 21-27) were generally weak and escapement targets were not met, except for Area 22 (Nitinat). The total chum return to Area 22 was 1.9 million. The large return and early timing required extraordinary fishing effort to prevent over-escapement.

FORECAST OF CHUM RETURNS IN 1989:

The preliminary forecast (using preliminary 1988 escapements and catches) of the 1989 return of Study Area chum stock is 3.2 million, including 2.2 million wild production and 1.0 million enhanced production. The forecasting method is the same as described in PSARC Advisory Document 88-1 (pg 38). Error rates about these forecasts have averaged 22% with a range from -36% to +24%.

As in 1988, surpluses to west coast Vancouver Island stocks are only expected for those systems with enhancement facilities. The forecasts provided by REB are 264,000 surplus chum at Nitinat and 272,000 surplus chum at Conuma. The Conuma Hatchery has not produced the surpluses forecasted for several years in a row. As a consequence, a review of hatchery production and forecasting has been undertaken to try to identify the reasons for poor production. Last year's forecasted return of Nitinat enhanced stock was 357,000 chum; the preliminary estimate of the 1988 return is about four times this estimate. It should be mentioned that natural chum escapements to the west coast of Vancouver Island remain depressed and no harvestable surpluses are expected.

PROGRESS ON ADVICE FROM PSARC IN 1988:

Following the March 1988 Sub-committee meeting, the South Coast Division of Fisheries's Branch was advised to examine the chum escapement data and eliminate biased data from stock assessments. This work is incomplete but the Division is attempting to determine the utility of the historic escapement database for stock assessment. Their hypothesis is that, in each statistical area, there exists a subset of chum spawning streams with relatively reliable and consistent enumeration effort. This subset of streams will be determined by ranking each stream based on interviews with past and present fisheries officers, guardians, and biologists. The ranking will reflect a rating determined by water clarity, ease of access to the stream, percent coverage of enumeration effort, reliability of enumeration methods, proportion of reported escapement actually seen, general confidence in the estimate, the average number of visits per year, and the consistency of effort between years.

The Sub-committee also advised that the accuracy and consistency of escapement estimation, and abundance forecasts should be improved. The above analysis of the escapement database will contribute to the solution of this problem by identifying a subset of streams in each area which should be consistently enumerated. This would produce the most efficient use of the limited resources of the fisheries officers who enumerate escapement. However, consistent enumeration effort also requires consistent funding for enumeration. Increased accuracy in the escapement data used in forecasts may also contribute to improved accuracy in forecasts. The Division is also examining whether environmental variables can improve chum forecasts but this work is incomplete. Enumeration of chum escapements has decreased since 1986 and should be restored to 1986 levels, especially in the Fraser River.

Finally, the Sub-committee requested that future assessments more thoroughly examine production from enhanced stocks in the Study Area chums. Complete brood year information on Study Area chum salmon is available from approximately 1960 through 1983. During this period the enhanced contribution to the total chum stock has been less than 10 percent annually. In recent years the enhanced contribution has increased to between 30 and 40 percent. Discrimination of the production from these two sources is underway, however, more assessment and incorporation of enhancement data into the management system is still required.

SUB-COMMITTEE ADVICE:

Both reviewer and sub-committee discussions centered on three issues concerning these stocks:

i) increased accuracy needed in the Johnstone Strait test fishery indices of total return abundance;
ii) a need for closer integration of chum assessment information from the Resource Enhancement Branch with in-season management and post-season assessments by Fisheries Branch; and
iii) the appropriateness of fixed escapement goals as management objectives for some Study Area stocks and all naturally spawning stocks along the west coast of Vancouver Island.

In-season management is the strength of the over-all management of inside chum stocks. In-season abundance indicators are combined with pre-determined rules for fishing in an effort to ensure achievement of minimum spawning escapement goals. Harvest rates at all abundance levels seem to be conservative which is a prudent approach given the uncertainty about the productivity of this stock. However, the onus for applying the appropriate harvest rate is clearly on having an accurate estimate of return abundance in-season. Increased use of data on the return abundance and timing of enhanced chum may improve the accuracy of these test fishery indices. Further, it was indicated in our discussions that the peaked return of chum in 1988 may have been a consequence of the deliberate selection in enhancement facilities for return timing in these stocks. This possibility has not yet been evaluated but should be reviewed by management and enhancement staff.

The appropriateness of escapement goals was questioned because the escapements to most naturally spawning chum stocks are not meeting their escapement goals. Although the total return to the Inside chum stocks is increasing (Fig. 1 in S89-11) and the authors reported that spawning escapements were "relatively strong" in these stocks, the 1988 escapement goals were not met in eight of the fourteen Inside stocks. Further, natural chum stocks along the west coast of Vancouver Island appear to be severely depressed. In particular, stocks in areas 23, 24, 26, and 27 have had limited fisheries, if any, in recent years and escapements continue to be below escapement goals. Recent catches in these areas have only averaged 17,000 chum (1983-88) compared to an average of 281,000 in the 1950's. In 1988 the natural escapement to these areas, in the absence of fishing, was only 30% of the aggregate goal.

Committee members indicated that efforts to rebuild chum stocks along the west coast of the Queen Charlotte Islands and Vancouver Island had not increased chum production. Yet in the Nitinat River, the enhancement facility has successfully increased adult production. How the Department should respond to these stocks depends, to some degree, on what is limiting the production of naturally spawning chum salmon in these areas. To evaluate this, the Sub-committee suggested establishing an assessment program in the Nitinat River to monitor the relative survival of hatchery and wild stocks. However, during this assessment program, the Sub-committee would also suggest that Fisheries Branch review the applicability of escapement goals and the management objectives for these stocks. For example, if the poor recent escapements are an artifact of limited escapement surveys possibly a more practical management objective would be a fixed terminal harvest rate or fishing effort instead of a highly uncertain escapement goal. These alternatives may also have the advantage of providing better information on annual variations in chum returns.

Following from these discussions, the Sub-committee recommends:

i) incorporation of assessment opportunities on enhanced chum stocks in in-season management procedures and post-season assessments, particularly in a review of the 1988 test fishery index of Inside chum abundance and how to improve the accuracy of this index;

ii) the development of a program design and proposal for the comparative study of natural and enhanced chum salmon in the Nitinat River; and consideration of the alternative management option to harvest west coast Vancouver Island chum on a fixed harvest rate basis for an experimental period;

iii) increased effort be directed to the 1988 Sub-committee recommendations concerning evaluation of historical escapement data, forecasting methodology, and estimation of enhanced and wild production. It is particularly important to identify streams where escapement data is considered to be most useful and to ensure continuation of escapement enumerations in these streams, especially within the Fraser River.

5. SOUTHERN B.C.(NON-FRASER) PINK SALMON AND FORECAST FOR 1989 (Working Paper S89-12):

This paper is intended to update the status of Study Area pink salmon, review the 1988 salmon season and provide a forecast for the 1989 pink salmon return. The Study Area pink stocks include pink salmon returning to streams in Johnstone Strait and the Strait of Georgia areas, with the exception of the Fraser River. Over the past 30 years, Study Area pink stocks have produced from 392,000 to 5.5 million pink salmon. The majority of their catch occurs in large mixed-stock fisheries (west coast troll and Johnstone Strait net fisheries) and in terminal approach areas (Mainland Inlets of Area 12).

Spawning escapements have generally declined, especially in the northern areas. Recently there have been major enhancement developments under construction to help reverse this trend (spawning channels : Glendale River - 1988, Kakweiken River proposed 1989). In addition to spawning channel enhancement, hatchery facilities have recently contributed to returns (Quinsam hatchery). The details of abundance, migration, catch and enhancement are provided in the previous PSARC Working Paper (S88-8).

1988 STOCK STATUS:

The 1988 Study Area pink return was forecasted to be 3.0 million, 0.5 million above the overall target escapement of 2.5 million. However, because management is by individual stocks certain stocks were not expected to achieve escapement goals. Conversely, a surplus of 1.0 million pinks was expected in the Mainland Inlets (Bond to Knight and Kingcome inlets) and Mid Vancouver Island areas.

The pre-season forecasted surplus (630,000) to the Mainland Inlets was assessed during the season with a test fishing vessel and numerous DFO patrol and charter aircraft. Only after sufficient escapement was either on the spawning grounds or behind protected boundaries did the fishery commence. This terminal fishery occurred simultaneously with the Johnstone Strait mix-stock fishery. The catch for this 2 day fishery was 300,000 pinks. No additional surplus was identified, hence no further fishing was permitted. The required target escapement was 1.18 million. Preliminary escapements to this area were estimated at 1.41 million.

The forecasted surplus to the mid Vancouver Island stock was anticipated to be intercepted in the major mixed-stock fisheries. Present estimates of the catch in these fisheries are 68,000 in the west coast troll and 262,000 in the Johnstone Strait net fisheries. It should be noted that not all this harvest originates from the Mid Vancouver Island stock, although the contribution is substantial due to its geographic location. The required target escapement for the Mid Vancouver Island stock is 345,000, but the preliminary 1988 escapement was estimated at 176,000 pink salmon.

The total Study Area pink stock was 2.6 million and consisted of 686,000 catch and 1.9 million escapement. Only Kingcome and Bond to Knight Inlets reached their required escapement targets (Table 1). The 1988 pre-season forecast of 3.0 million represents and error of 16% between forecasted and actual returns for 1988.

TABLE 1. EVEN AND ODD YEAR CYCLE SPAWNING ESCAPEMENTS FOR STUDY AREA PINK SALMON.

1) Odd year cycle for Study Area Pink Salmon (in thousands)

Sub-Areas	Target Esc.	1987	1985	1983	1981	1971-79 Average
Upper Van. Is.	690	4.3	36.5	15.9	0.4	7
Johnstone Strait	184	70.3	21.5	26.8	16.3	52
Mid Van. Is.	270	202.7	52.7	36.3	36.4	20
Kingcome Inlet	285	45.0	115.5	160.0	190.0	186
Bond to Knight	866	72.6	688.1	1152.5	661.4	434
Loughborough/Bute	392	21.3	29.3	195.5	112.1	132
Toba Inlet	135	0.3	1.6	0.8	11.6	22
Jervis Inlet	130	30.0	3.2	7.1	29.6	25
Howe Sound	422	11.6	1.3	1.5	14.0	43
Burrard Inlet	100	36.6	0.0	25.1	41.5	30
TOTAL	3475	494.6	949.6	1621.4	1113.4	951

2) Even year cycle for Study Area Pink Salmon (in thousands)

Sub-Areas	Target Esc.	1988	1986	1984	1982	1972-80 Average
Upper Van. Is.	690	79.2	172.1	54.0	41.2	159
Johnstone Strait	299	123.4	62.9	6.5	6.9	126
Mid Van. Is.	300	176.3	235.7	13.5	3.7	29
Kingcome Inlet	287	369.4	175.8	13.2	72.2	215
Bond to Knight	888	1040.4	695.3	286.0	339.7	503
Loughborough/Bute	647	92.5	39.0	14.3	110.0	160
TOTAL	3111	1881.2	1380.7	387.5	573.7	1192

1989 STUDY AREA PINK FORECAST:

The forecast for 1989 Study Area pink is 1.3 million and consists of 982,000 naturally produced pink and 309,000 enhanced pink (Table 6 of S89-12). The forecast of natural returns is based on the ratio of returns from escapements and environmental factors (oceanic). Enhanced production is derived from Salmon Enhancement Program reports. The required target escapement for 1989 is 3.5 million. The previous odd year target (1987) was 1.7 million. Substantial increases have occurred in the northern areas where targets have been set equal to even year escapement targets.

Although a surplus of 400,000 is anticipated (mainly to the Mid Vancouver Island area) this surplus is expected to be incidentally harvested in the Johnstone Strait interception fishery. No directed fishery for southern B.C., non-Fraser, pink salmon is expected.

SUB-COMMITTEE ADVICE:

Discussion by reviewers and the Sub-committee concerned forecasting methods, the basis for escapement targets, and the need for a review of escapement data as outlined in the previous chapter on southern B.C. chum salmon. The forecast presented was based on an average recruit per spawner (R/S) and the brood year escapement per stock. A subjective environmental index has been used in the past to account for freshest conditions etc. but was not used in the 1989 forecast since the R/S was reduced to 2.0 from 2.5 in previous forecasts. This change in R/S was attributed to using the R/S observed in recent years (1.57 in Table 4 of this working paper) and a return prediction prepared by D. Blackbourn (pers.comm., Pacific Biological Station, Nanaimo, B.C.) which suggested an R/S of 2.4. The R/S ratio of 2.0 is the average of these two ratios. The committee could not evaluate the technical merit of this approach since the Blackbourn analysis was not presented and two additional points were discussed:

- The use of an average R/S ratio assumes that recruitment and spawning stock are linearly related with a constant slope of 2.0; however, the recruitment data presented in the paper does not support this assumption. A non-linear function, such as the Ricker curve, does fit the data significantly and should form the basis for the forecast.

- The use of a constant R/S ratio and subjective environmental indices does not permit the estimation of confidence limits about the prediction. The committee continues to recommend that ranges of forecasted returns be used to express forecasts given the uncertainties in our assessment data.

Both reviewers recommended that since some southern, non-Fraser pink stocks are rebuilding and fishing plans are being considered; it would be appropriate to review and document the basis for the escapement goals for these stocks, particularly for Knight Inlet.

For the 1990 assessment of this stock complex, the Sub-committee recommends:

i) a thorough assessment of alternative forecasting methods and a recommendation on which one to use;
ii) documenting the basis for the escapement goals used for these stocks; and

iii) an examination of the escapement records for the stocks to select a set of index systems which are determined to likely have a more reliable record of escapement data than simply pooling escapements from all streams.

6. STOCK STATUS of BARKLEY SOUND SOCKEYE SALMON WITH RECOMMENDATIONS FOR RESEARCH AND STOCK ASSESSMENT ACTIVITIES (Working Paper S89-13)

Three Barkley Sound sockeye stocks (Great Central, Sproat and Henderson) are managed within a mixed-stock, mixed-gear fishery operating in Area 23. Intensive management is aimed at (i) achieving stock-specific escapement goals to ensure that future production of sockeye is either maintained or increased, (ii) meeting the food fish needs of aboriginal peoples resident at Uchucklesit Inlet and especially along the lower reaches of the Somass River and (iii) achieving a 60% to 40% split of the remaining sockeye to be taken by purse seine and gillnet fleets respectively.

TOTAL STOCK TRENDS:

For the 70 year period of record prior to 1972, total returns of sockeye to Barkley Sound averaged 83,952 fish per annum and ranged from 6,526 to 200,151. Beginning in 1973, Barkley Sound sockeye exhibited dramatic increases in total returns which appear to be largely attributable to research, management, and enhancement initiatives involving lake fertilization and escapement optimization. The magnitude of the increase in adult returns was clearly unprecedented within the eighty plus year period of record for the Barkley Sound stocks and has been sustained over the past 12 years. Since 1983, there have been five consecutive years of below average returns of Barkley Sound sockeye due primarily to decreases in marine survivals. Although average returns over the past 5 years (736,000 sockeye) have been significantly lower than during the preceding 10 years (915,000 sockeye), these recent year returns are still almost 9 times higher than average annual returns during the 70 year period prior to 1972.

ESCAPEMENT AND CATCH TRENDS:

Trends in escapement and catch for the most recent decade are summarized below. Escapement and catch trends for Barkley Sound sockeye over the entire period of record (1903-1986) were presented in Advisory Document 86-5 (Stocker 1987).

Catch Trends:

Barkley Sound has supported an average annual catch of 615,000 fish during the past 10 years. During this same period, the commercial catch (excluding 1986) has varied between 185,000 and

1.1 million fish while the exploitation rate has ranged between 6% and 79%. In recent years the Great Central Lake stock has been the single largest contributor to the fishery (52% of catch), followed by Sproat Lake sockeye (43% of catch), and Henderson Lake sockeye (5% of catch). Returns of sockeye to Barkley Sound in 1988 achieved 92% of the most recent 10 year average and supported a catch of 389,397 fish. This was a significant improvement over both 1986 and 1987 which only had catches of 30,000 and 200,000 sockeye, respectively.

Escapement Trends:

Henderson Lake:

Escapements have averaged 32,161 sockeye since 1979 (range 5,000-56,065). Escapements declined in both 1985 and 1986 due to low stock returns to Barkley Sound. Escapements of approximately 30,000 sockeye in 1987 and 1988 represent a considerable improvement over the 5000 fish that reached the spawning grounds in 1986. Management initiatives to date have been unsuccessful in permitting routine achievement of the nominal escapement objective for Henderson sockeye i.e. the objective has been met or exceeded in only 2 of the past 10 years and the stock has been underescaped on average by 46% over the past five years.

Great Central Lake:

Escapements to Great Central Lake exhibited significant declines in each of 1984, 1985 and 1986. These low escapements are likely to influence sockeye production and fishery yields in Barkley Sound during the 1989-1991 return years. It is encouraging to note that the 1987 and 1988 escapements were either near or above the nominal objective of 200,000.

Sproat Lake:

Escapements to Sproat Lake averaged 111,300 sockeye between 1973 and 1986 and achieved an all time high of 250,000 fish in 1983. Escapements to Sproat Lake have roughly equalled or exceeded the nominal target of 150,000 spawners in four of the past five years and the mean absolute deviation from the objective averaged 26%. Sproat Lake escapements during 1988 amounted to 235,000 sockeye or 157% of objective.

DEFINITION OF ESCAPEMENT TARGETS:

Escapement targets prior to the late 1970's appear to have been set arbitrarily on the basis of historical precedent and largely without reference to any objective assessment of the productive capacity of the stocks. Since 1980 escapement targets have been based on estimates of smolt production capacity of nursery lakes and are set at 200,000 sockeye for Great Central, 150,000 for Sproat and 50,000 for Henderson. Recent evidence suggests that escapement targets for Great Central and Sproat sockeye may still be increased by 50,000 to 100,000 fish above existing targets without obvious loss of productive capacity."Surplus" escapement to Sproat Lake during 1988 will provide an opportunity to test this hypothesis further by the time of the 1990 smolt migration.

FORECASTING:

1987 And 1988 Pre-season Forecasts:

Application in 1987 of the discovery that Barkley Sound sockeye returns vary periodically due to shifts from high to low marine survival states permitted the successful prediction that only 600 to 700 thousand sockeye would return in 1987. Confidence in the 1987 pre-season forecast was greatly weakened by a three week delay in sockeye return timing such the Departmental spokesmen alternately concluded that the pre-season forecast seriously overestimated returns and then that it seriously underestimated returns. In retrospect, the pre-season forecast performed well (i.e. 600-700 thousand sockeye were predicted to return and 635,600 returned).

Three independent techniques were employed to generate return forecasts for 1988. These were a survival stanza method (SStM), a sea survival and salinity method (SSM) and a sibling age class method (SACM). A number of considerations led us to express a preference for the SSM forecast of 740,000 sockeye in 1988. Returns observed during 1988 were reasonably close to prediction i.e. 850,000 sockeye returned relative to the SSM forecast of 740,000. Further, the SSM forecast was far closer to the observed return during 1988 than were either the SStM or SACM forecasts.

In-season Stock Forecasting:

Since 1984, the process of assembling and analyzing the information necessary to make in-season management decisions has been aided through the development of a "return timing model" hereafter referred to as the RTM. Catch and escapement data are used in the model to forecast weekly and total abundance of returns for each of the Barkley Sound sockeye stocks. The RTM was successfully applied during the 1985 and 1986 fishing seasons to advise curtailment of exploitation in the face of lower than expected returns. However, late returns by sockeye in both 1987 and 1988 confounded application of the RTM and indicate that it will have limited utility in years when sockeye timing exhibits unpredictable departures of greater than 1 week from the long term mean. Comparisons of returns observed with either pre-season forecasts (1987, 1988) or in-season forecasts based on the RTM (1985-1988) suggests that the pre-season forecasts may be more reliable than the RTM even at decision points just prior to the last opening of the season. The reason for this appears to be that we can currently predict marine survival variations more accurately than we can predict or measure return timing variations to the terminal fishing area. None of the abundance indicators currently used in-season provide sufficiently reliable abundance or timing indices to consistently identify the quantity of surplus sockeye available for catch on a weekly basis in Area 23.

Forecast for 1989:

The same forecast techniques applied in 1988 (SStM, SSM and SACM) have been employed to generate return forecasts for 1989. The forecasts are for 501,000 (SStM), 387,000 (SSM) and 402,000 (SACM) sockeye. Due to the recent development of these techniques to forecast Barkley Sound sockeye, there is only limited experience gained during 1987 and 1988 to assess their utility. But given the success of the SSM forecast in 1988 we recommend the **SSM** forecast of **387,000** sockeye in 1989. This forecast of abundance suggests that there is not likely to be a harvestable surplus of sockeye salmon to Barkley Sound in 1989.

SUMMARY COMMENTS:

1. A body of subjective evidence suggests that Native and sport fisheries have recently increased their harvest of Barkley Sound sockeye to more than 50,000 fish per year. We are concerned that the sport fishery in particular has taken on the potential of developing into a major fishery of unknown impact on sockeye. In the absence of biosample data and reliable estimates of catch it will be impossible to predict the future impact of these fisheries on sex, age or stock composition of Barkley Sound sockeye. Impacts may be especially significant in years of low sockeye returns such as that predicted for 1989 (i.e. total returns predicted are roughly equal to escapement requirements).

2. Barkley Sound sockeye have exhibited increased variability in return timing patterns over the past 5 years by comparison with the preceding 5 years. None of the estimators currently in use provides sufficiently reliable information for a return timing model to consistently identify the quantity of surplus sockeye available for catch on a weekly basis in Area 23. Further development of techniques to provide estimates of the timing of movements of sockeye through Area 23 on a weekly basis are critical to improvement of the basis for management decisions about fishery openings. Two brief studies were conducted in 1988 to assess the potential for application of acoustics survey techniques to solve this problem. They yielded mixed results. One study, conducted by personnel from IOS, indicated that prospects are poor for development of fixed-location, acoustics installations to monitor sockeye returns. However, a second independent study, conducted jointly by BSB and FB personnel, demonstrated that use of simple acoustic gear (JRC sounders), transecting and echocounting before and after commercial fishery openings has considerable potential for improving Barkley Sound sockeye run timing estimates.

3. Objective escapement targets have been defined for each of the three Barkley Sound sockeye stocks; however, optimal escapements have not. It is important to recognize that the current escapement objectives set for Sproat and Great Central Lake sockeye may represent minimum rather than maximum objectives since both stocks have demonstrated linear increases in smolt output at escapements as high as 100,000 adults over the current levels set for each stock. However, considerable uncertainty remains in setting "optimal" escapement objectives for Barkley Sound sockeye.

Escapement management and enhancement techniques such as lake fertilization may be used to either maximize the numbers or the size of sockeye smolts produced. It is not clear at this time which precise combination of sockeye smolt numbers and size will maximize the benefits in terms of biomass of returning adults to Barkley Sound or to any other stock of sockeye along the British Columbia coast. Management for increases in escapements to the three Barkley Sound stocks contributed to increased stock production during the late 1970's and early 1980's. However, declining marine survivals during the last several years has raised questions about what the most appropriate management objectives are for: smolt sizes, smolt numbers, and implicitly adult escapements.

SUB-COMMITTEE ADVICE:

Both reviewers commented that this paper was a good assessment of the Barkley Sound sockeye stocks. One reviewer expressed concerns about the definition of the escapement targets and the biological basis for selecting one forecast model versus the others. The second reviewer, however, concentrated more on management related issues, and particularly noted concern about the accuracy of the run timing model, incorporating escapements to Great Central Lake which occur after the escapement counters are removed, and the possibility of increasing the productivity of Henderson Lake sockeye (i.e. to protect this stock in mixed-stock fisheries directed on the other two larger stocks). How the Region could proceed with the latter suggestion was not pursued in committee discussions.

Following the reviewers' comments and summary comments in the paper, the committee discussed and recommends that:

i) concerns about the impact of Native and sport catches on stock assessment data be approached by collating historical catches in these fisheries, reviewing existing assessment procedures used to estimate the catch in these fisheries and standardizing procedures where necessary, and collection of biosamples from sport caught sockeye to determine stock of origin, sex, and age. (These tasks should be referred to the South Coast Division of Fisheries Branch and the Lake Enrichment Assessment Unit of the Biological Sciences Branch.);

ii) the development of acoustic techniques to improve in-season estimates of abundance and run timing of adult sockeye in Area 23 be continued, but that the various programs in this area should be more closely integrated to avoid needless duplications. Further, the Lake Enrichment Assessment program should examine the use of the run timing model by assuming that run duration is constant between years but that the starting date of the run is variable.

iii) research be continued on factors determining marine survival and, in particular, on effects of juvenile sockeye size and time at migration. These studies will be required to determine the optimal escapement levels for these stocks.

The committee also noted that the forecast of sockeye returns to Barkley Sound stocks in 1989 does not indicate any allowable surplus to harvest if the escapement goals are to be met.

7. 1989 FORECAST FOR FRASER RIVER SOCKEYE SALMON (Working Paper S89-10):

Since 1953, Fraser River sockeye returns on the 1989 cycle have averaged 6.5 million fish annually (Fig. 10). Prior to 1981, the returns were relatively stable at 5-6 million sockeye. However, the Horsefly River run, which is dominant on this cycle, has increased sharply in recent years and may rival the production of the dominant year Adams River run. In fact, given the recent performance of the Horsefly River, the 1989 cycle year is clearly showing the potential to equal or possibly exceed the 1990 Adams cycle return. Although the average return for Horsefly stock is 2.4 million sockeye per cycle year, this statistic does not give an accurate reflection of the recent dynamics of this population (Fig. 10). Since 1977, Horsefly River and Mitchell River (included in Horsefly data) have demonstrated a remarkable population growth rate culminating with the 1985 return of 9.6 million adults.

Other major stocks producing on this cycle are Early and Late Stuart sockeye. The Early Stuart run has averaged 814,000 on the cycle since 1953 but some concern exists regarding the steady decline in return sizes since 1977. The Late Stuart run co-migrates with the Horsefly stock. Over the years, production from this stock has been relatively stable, the cycle year average being 1.3 million annually. The Chilko, Stellako and Birkenhead rivers have also been relatively consistent producers of sockeye with cycle year average production of 0.4, 0.2 and 0.3 million respectively.

FORECAST APPROACH:

The 1985 brood escapement of 2.1 million spawners and the 1.1 million effective females (the estimated number of female spawners allowing for pre-spawn mortality and egg retention) was the largest since reliable records have been kept (1938). The average rate of 4_2 returns per effective female since 1949 has been 12.6. Since 1965, when rates of return generally improved on each cycle, the average has been 15.6 returns per effective female. If these averages were to continue, the basic expectations would be in the range of 13.6 to 16.9 million 4_2's in 1989. However, there is a considerable amount of stock specific information available with which to develop forecasts for individual stocks that presumably would result in a more reliable prediction of the Fraser River sockeye return.

In stocks with historical records of "jack" returns (age 3_2 male sockeye) and when production relationships with jacks are considered reliable, forecasts have been based on that data. Generally, the numerical estimates of jack production are believed to be indicative of marine survival conditions(i.e. the more jacks observed, the more 4_2's that could be expected in the following year return). Jack lengths and marine growth measurements from scale readings also reflect ocean conditions that affect the maturation schedule of the male cohorts. Freshwater scale circulus counts on the other hand, provide an assessment of lake densities. When circulus counts are less than average, it is believed to be indicative of higher than average fry density conditions. Appendices 1 and 2 in Working Paper S89-10 respectively summarize the environmental variables considered in these forecasts and the basic data sets for each stock.

In the absence of more reliable methods, the default forecast method is a Ricker spawner-recruit relationships. These relationships were developed using all years or cycle-specific years. In some instances, aggregations of cycle years or Ricker-type relationships utilizing juvenile information were considered. Expectations were modified by data and information relating to the dynamics of the populations at the most chronologically advanced life history stage such as the year preceding the return of the age class being forecast. Projections were made on the basis of forecast parameters associated with jacks, smolts, fry or effective females in descending order of preference. Biological and environmental data supporting the forecasts were used to improve the reliability of the expectations.

Expert judgement was exercised in evaluating the reliability of the numerical estimates of fry, smolts or jacks and correlation relationships employing the estimates. Expert judgement was also used in assessing the relative merits of biological and environmental parameters and the number of years a particular relationship appeared to be operative.

SUMMARY OF FORECASTS:

The 1989 Fraser sockeye return is expected to be dominated by mid-summer run sockeye stocks of which Quesnel Lake stocks (Horsefly and Mitchell), forecasted at 9.1 million, are expected to form the largest component. In addition, the dominant year returns of Early Stuart at 1.1 million and Late Stuart at 1.3 million adults are expected to contribute significantly to all fisheries. For all stocks combined, the forecast is 12.8 million adults and 0.2 million jacks for a total return over all ages of 13.0 million sockeye (Table 2).

FORECAST SUCCESS:

Since 1962, forecasts of return abundance across all Fraser sockeye stocks have on average been about 17% less than the actual returns. For the 1989 cycle year, the trend has been somewhat better with an average of 13% below actual return levels. It is notable that on only four occasions were the forecasts greater than the actual returns and that there does not appear to be a trend towards improvement in forecast precision (Fig. 11). This is also demonstrated by the relative success rate (absolute deviation) for all years which has averaged 22% per year. This success rate has been relative consistent across all cycle years. It is the opinion of the author that forecast precision could be improved upon with a better understanding of freshwater survival rates (more fry and smolt information).

SUB-COMMITTEE ADVICE:

While this paper was a significant step towards documenting the forecasting procedures used for our most valuable group of salmon stocks, both reviewers and the Sub-committee were critical that the paper did not present sufficient analyses to enable evaluation of the scientific basis of the forecast. Specifically, a reviewer needs to be presented with:

- the basic input data (as provided in this paper),
- analyses supporting the selection of specific regression models used and what evaluation criteria were used,
- explanations as to how one forecast value is selected from several competing forecast models, and
- an evaluation of how well previous forecasts have predicted the subsequent returns (this data was provided for the total Fraser sockeye return but should be evaluated by stock).

The committee was also concerned that confidence limits about the predicted return were not presented and that previous forecasts systematically under estimate the observed returns. The latter may

TABLE 2. A SUMMARY OF FRASER RIVER SOCKEYE RETURN PROJECTIONS FOR 1989 BY STOCK AND THE FORECAST METHOD USED.

STOCK	4(2) FORECAST	5(2)&5(3) FORECAST	TOTAL	METHODOLOGY (a)
EARLY STUART	1,100,000	10,000	1,110,000	Adult S/R+Env.reg.
BOWRON	29,000	1,000	30,000	Adult S/R+5vs.4comp
FENNELL	7,000	3,000	10,000	Adult S/R+5vs.4comp
UPPER PITT	25,000	45,000	70,000	Juv. S/R+5vs.4comp
GATES	38,000	2,000	40,000	Jack+5vs.4comp
LATE NADINA	40,000	10,000	50,000	Juv.est+5vs.4comp
HORSEFLY	7,300,000	0	7,300,000	Jack growth
MITCHELL	1,800,000	0	1,800,000	(0.2*Horsefly ret.)
LATE STUART	1,300,000	0	1,300,000	Adult S/R + Inter.
SCOTCH	20,000	0	20,000	Adult S/R
SEYMOUR	33,000	2,000	35,000	Adult S/R+5vs.4comp
CHILKO RIVER	280,000	40,000	320,000	Juv. S/R+Env.reg.+ 5vs.4comp
STELLAKO	160,000	75,000	235,000	Adult S/R+5vs.4comp
BIRKENHEAD	120,000	55,000	175,000	Adult S/R+5vs.4comp
ADAMS	1,000	0	1,000	Adult S/R
LOWER SHUSWAP	5,000	0	5,000	Adult S/R
WEAVER	110,000	90,000	200,000	Inter. (b)
PORTAGE	16,000	0	16,000	Adult S/R
HARRISON	20,000	10,000	30,000	Adult S/R+5vs.4comp
CULTUS	2,000	0	2,000	Adult S/R
MISCELLANEOUS	24,000	27,000	51,000	
TOTAL ADULTS	12,430,000	370,000	12,800,000	

(a) Notation for methodology used:

5 vs. 4 comparison = estimates of age 5 return based on historical percentage of age 5 returns and the observed return of age 4 fish in 1988.

Juv. est. = estimated numbers of juveniles * an assumed survival rate

Env. reg.= use of various environmental parameters in a linear regression model.

S/R = Ricker stock recruitment function; maybe based on numbers of Adults in the spawning population or an estimate of the number of Juveniles produced from a spawning year.

Jack = sibling regression model of 4 yr. old return vs. jack return

Jack growth = regression models of adult return per jack return versus measures of jack growth and marine survival indicators.

Inter. = non-quantitative interpretation of data based on expert opinion.

(b) The Weaver Creek forecast is a "best guess" due to conflicting information; fry S/R relations suggest a substantially greater return than jack indicators from 1988 returns.

result from using stock and cycle specific stock-recruitment functions during a rebuilding phase in Fraser sockeye and/or not applying a bias correction factor when estimating the number of returns expected based on a stock-recruitment model with log-normal error structure.

At this time, the Sub-committee can not endorse the methods used in preparing the 1989 forecast since the analytical procedures were not adequately described. Therefore, the Sub-committee recommends that:

i) a thorough documentation of methods used in forecasting Fraser sockeye returns be prepared in 1989, and
ii) included in this documentation should be an evaluation of the cause of the negative bias in previous forecasts, development of procedures for estimating confidence limits about the forecast, and evaluation of alternative forecasting models.

In the future, subjective interpretations of the data should be minimized and more objective criteria used for selecting one forecast from several alternative ones. The committee recognizes the value of expert interpretation at times, but is concerned that such interpretations rely on individuals (who won't always be present) and preclude the statistical determination of confidence limits.

8. STATUS OF SKEENA RIVER SOCKEYE SALMON (ONCORHYNCHUS NERKA) (Working Paper S89-15):

The Skeena River supports the second largest sockeye stock complex on the B.C. coast. The commercial harvest in statistical area 4 has averaged 928,904 fish annually from 1978 to 1987 while escapement to the river has averaged 1,090,461 over the same period. The history of the commercial fishery has been well documented since its inception in 1877. A brief overview of this information is provided in Table 1 of the Working Paper. Despite the importance of this stock to the fishing industry, in recent years there has not been a thorough evaluation of the optimum spawning escapement objectives. This study evaluates the current escapement objective through stock-recruitment analysis.

The first spawning escapement target for Skeena River sockeye salmon (850,000) was set by the Skeena Sockeye Management Committee in the early 1950's. This number was based on the spawning escapements that produced the large catches in the early 1900's. Shepherd and Withler (1958) proposed an escapement target of 900,000 to 1,000,000 based on the relationship between recruitment and spawning stock size for brood years 1908 to 1952. Shepherd et al. (1964) repeated the analysis adding brood years 1953 to 1958 and found that there was no change in the optimum escapement.

Ricker (1968) examined the stock-recruitment relationship for several groups of brood years and found that for the period from 1950 to 1961 the optimum escapement was 600,000. Finally, Ricker and Smith (1975) evaluated the relationship for the periods 1908 to 1928, 1929 to 1950 and 1953 to 1967 and found that the optimum escapement decreased over the three periods. Their optimum spawning escapement estimate for the most recent period (1953 to 1967) was also 600,000.

There are several reasons why it is the appropriate time to re-evaluate the optimum spawning escapement to the Skeena system for sockeye salmon. The most recently estimated optimum escapement is 600,000, but the current target escapement for managing the stock is 900,000 of which 750,000 is designated as Babine Lake stock. Since the last year of an evaluation (1967) Pinkut Creek and Fulton River spawning channels have been constructed and now account for up to 60% of the Skeena sockeye production (West and Mason 1987). Finally, since the last evaluation many advances have been made in the analytical framework of stock-recruitment analysis.

STOCK-RECRUITMENT ANALYSIS:

The stock-recruitment analysis described in this report covers the brood years from 1965 to 1982 and includes only age 4_2 and 5_2 fish. These age classes make up the principal type of sockeye returning to the Skeena and almost the only types from the Babine lake sub-system.

Total annual catch of Skeena River sockeye in northern B.C. and southern S.E. Alaska was estimated for the period 1968 through 1988 based on stock identification studies in these areas during the 1980's. The extensive appendix to this paper documents the three methods used and the stock identification procedure used by fishery and year. To our knowledge, this analysis is the first reconstruction of the total catch of Skeena sockeye which incorporates Alaskan and Canadian fisheries. Variations in annual catch were identical in each method and the two methods incorporating all intercepting fisheries were very similar in total catch estimates (Fig. 12). Total catch estimates by these two methods were obviously greater than the terminal catch estimate but the latter was only included to indicate the minimum catch level and inter-annual variability in returns. In this stock-recruitment analysis the modified interception method in Fig. 12 was used.

The total return of age 4_2 and 5_2 sockeye salmon from 1965 to 1982 ranged from 547,101 in 1974 to 5,728,026 in 1977 and averaged 2,108,548 fish. Average spawning escapement was 897,967 while exploitation rates ranged from 0.47 to 0.71 and averaged 0.57 over the same period (Fig. 13). Large over-escapement in some years presumably reflects excess channel production. This results in a large population of spawners in Babine Lake, particularly concentrated off the mouth of Fulton and Pinkut Rivers. The productivity of these spawners is uncertain. Therefore, two different data sets of spawning numbers were fit to a Ricker model. The unadjusted data set simply used the total spawning escapement in a year. Alternatively, the adjusted data set assumed that all spawners in Babine Lake and those spawners in Fulton River in excess of the escapement target had a productivity of zero. An estimated net escapement was calculated by subtracting these spawners from the total escapement.

The fit of both data sets was similar. However, they produced very different estimates of optimum spawning escapement (unadjusted - 883,854 ; adjusted - 403,258) and exploitation rates for maximum sustained harvest. There was no significant autocorrelation of residuals at any lag for either data set.

DISCUSSION:

An accurate estimate of the spawning escapement required to produce the maximum adult returns is an important component in the management of the Skeena River sockeye. The analysis described in this document gives two very different answers to this question depending on the productivity assigned to the lake spawners and to those spawners in excess of the target for Fulton River. We have no direct measure of the productivity of these populations but the Ricker 'a' parameter estimated for the unadjusted data set is very similar to values estimated for other naturally spawning sockeye stocks. This assessment assumes that all spawners contribute equally to the next generation. However, the presence of the large spawning channels would have been expected to increase the overall productivity of the Babine stock compared to other natural stocks. Possibly then, the lake and/or surplus Fulton spawners do have a lower productivity and results in the net productiviy of the unadjusted data set to be similar to natural stocks.

The estimate of optimum escapement using the unadjusted data set is similar to that proposed in the earlier evaluations of the Skeena River sockeye stock-recruitment relationship (Shepherd and Withler 1958, Shepherd et al. 1964). However, the optimum escapement obtained using the adjusted data set is even less than reported in the most recent study by Ricker and Smith (1975).

Three areas of study are required to resolve the optimum escapement and production potential for Skeena River sockeye salmon. First, we must determine the productivity of the spawners in Babine Lake and the excess spawners in Fulton River. This information could be acquired directly by measuring egg deposition and subsequent egg to fry survival for Babine Lake and Fulton River spawners over a range of spawner densities. Alternatively, the actual spawning escapement would have to be varied over a wide range (possibly between 400,000 and 1 million) over a series of years so that the resultant production could be examined.

Secondly, the rearing capacity of Babine Lake should be re-evaluated. Examination of the returns from 1965 to the present reveals that large returns of a brood year are usually followed by one or more brood years of low returns particularly since the 1973 brood year. It has been shown (Kyle and Koenings 1988) that large concentrations of sockeye juveniles can alter the composition and concentration of zooplankton in a lake and thus reduce the survival of juveniles in successive years. Consequently, the potential limitation of production in Babine Lake should be examined. Finally, the optimum spawning escapement for the non-Babine sockeye salmon stocks in the Skeena system should be examined. These stocks have declined from historical levels of about 30% of the total Skeena sockeye run to 5-10%. This is despite management efforts to protect them from the fishery. Due to the difficulty in obtaining reliable escapement estimates as well as in apportioning catch to these smaller stocks it is not possible to evaluate optimum escapement based on a stock-recruitment analysis. It is probably necessary to approach the question from the perspective of available spawning area and lake rearing capacity.

SUB-COMMITTEE ADVICE:

This paper is a significant contribution to assessment of the Skeena River sockeye stock and both reviewers complimented the authors for the obviously extensive analysis. Both reviewers provided extensive comments but they focused on the appropriateness of the stock-recruitment calculations and the recommendations. One reviewer was concerned about the statistical and biological basis of the modified inteception method, but given the similarity of the modified versus the standard methods in Figure 12, these concerns apparently have little impact on the estimated catch. This reviewer was also critical of the subjective nature of the assumptions in the adjusted data set and the use of data between 1965 and 1970; this period is acknowledged as a transition period as production from the channels "came on line". The reviewer did not support the recommendation to manipulate escapements but recommended more oceanographic and fisheries research to examine the causes of recruitment variation. It was suggested that there is so much variability in the stock-recruitment data that many years of escapement manipulations would likely be required before more confidence in our results could be expected. Further, this reviewer did not feel that the paper provided supportative evidence to suggest the recommendation for re-newed studies of lake rearing capacity.

The other reviewer was also concerned about the basis of the stock-recruitment model and the consequences of any advice provided on the basis of the adjusted data set. Alternative recruitment models should be examined to investigate whether model selection influences the advice provided. Further, the paper should acknowledge that if the adjusted data set were correct then recommended harvests of sockeye will exacerbate the present mixed-species catch problems in Skeena area fisheries. This reviewer also did not support the recommendations to manipulate escapement levels and to renew studies in Babine Lake. This reviewer recommended that studies to evaluate whether lake spawners were separate populations from stream spawners, and the spawning success of lake spawners should precede any major manipulations of the total escapement.

The differences in the management advice which follows from the two data sets evaluated clearly indicates the need for further evaluation before such advice is provided by this Sub-committee. In the interim, the committee recommends that existing escapement objectives be maintained. To refine this assessment, however, we recommend:

i) continued evaluations of existing data to partition the total Babine returns into production from the spawning channels (an associated rivers) and other natural populations;
ii) immediate implementation of programs to identify whether lake spawners are an independant population, evaluate their spawning success, and evaluate the fate surplus spawners in Fulton River;
iii) examination of alternative recruitment models (Ricker, Beverton-Holt, or life history models) to examine their influence on advice provided; and
iv) evaluation of the optimum spawning escapements for non-Babine sockeye stocks (as recommended by the authors).

Further, the Sub-committee did not support the recommendation to renew lake productivity studies but did discuss the need to examine existing data on fry and smolt production to determine whether there is evidence of lake production limitations. This evaluation should be completed before new studies in Babine Lake are supported. The Sub-committee was, however, particularly concerned about the ad-hoc nature of support for the major information source for this evaluation, i.e. the Babine smolt enumeration. This program annually provides the only data available to evaluate concerns about lake rearing capacity and merits stable, long-term support. Previous criticisms of the program have referred to the weak relationship between smolt production and subsequent adult returns, but this information is not likely the principle value of the program. **The Sub-committee recommends that the Region re-establish stable funding to this program in order to maintain a time series of juvenile production data for enhancement evaluation and stock assessements.**

9. STATUS OF SKEENA RIVER CHINOOK SALMON (Working Paper S89-18):

Chinook salmon (Oncorhynchus tshawytscha) from the Skeena River (Canadian statistical Area 4) have historically supported a large terminal gillnet fishery, and, since about 1930, both coastal net and off-shore troll fisheries. Records of the number of cans of chinook processed since 1904 indicate that the gillnet catch peaked between the late 1910's and early 1920's but declined rapidly after 1925. The annual average can-pack peaked at 21,150 cases between 1918-22 but between the late 1920's and late 1940's averaged only 6030 cases of chinook caught in the Skeena area. Estimates of the number of chinook caught during the peak depends on the conversion factors used to equate the can-pack to numbers of chinook. But the peak terminal catch was probably in the range of 100,000 to 150,000 chinook including a category of small fish referred to as "Jacks and Pink Salmon".

The can-pack statistics during the pre-1925 period accounts for the majority of the Skeena chinook catch. However, after then, the majority of the catch was likely taken in expanding troll fisheries in northern B.C. and S.E. Alaska. However, the number of Skeena chinook caught in these troll fisheries was unknown.

It is interesting to note though that even with large troll catches, commercial gillnet fisheries, and Native freshwater fisheries; the initial assessements of Skeena salmon production reported that "spring salmon are at least maintaining themselves", and that "there is no real indication of a downward trend in the number of spawners" (pg. 5, Pritchard 1948). What could not be evaluated was whether the Skeena chinook stock was being sustained at less than maximum biological production. This paper collates more recent information required to determine the productivity of Skeena River chinook and to assess the present status of this stock. Unfortunately, the available data are still too limited to adequately evaluate the stock's biological production, but the available data are reviewed and recommendations for future assessments presented.

BIOLOGICAL CHARACTERISTICS:

Information on the biological characteristics of the various spawning populations is very limited. Spawning has been observed in 67 different streams in the system but both previously published papers with information on age and size at age are based on test fishery catches. Anecdotal information suggests that chinook begin entering the Skeena River in early spring, with the Cedar River chinook being amongst the earliest, but the majority of the stocks enter the river in June and July. Spawning occurs from early August through September in most. Some information is now being collected which may allow clearer definition of the stock structure within the Skeena drainage but, at present, the chinook must be treated as one large stock aggregate.

Based on the age structure of the chinook sampled since 1980, Skeena chinook are mostly stream-type chinook primarily maturing between 4 and 6 years of age (total age) (Table 5 in S89-18). Godfrey (1968) reported that the chinook were mostly ocean-type, so there may be evidence that the composition of the stock has changed. However, there is not an adequate time series of age data to evaluate whether there was an actual change or simply a change in how these life histories were identified on the scales. The actual age-composition of the spawning stock may be older than the test fishing samples because of a likely gillnet selectivity for smaller fish.

Length at age data is also reported (in Table 6 of Working Paper S89-18) but the most striking characteristic of the age-length data for Skeena chinook is the later maturity and more limited variation in size at return of female chinook. The co-efficient of variation (CV) for average size at return for male chinook is 3 times the CV of females (23% vs. 8.4%).

The only information on the fecundity of Skeena chinook is reported in Godfrey (1968). More information should be available from enhancement programs but these data have not been collated.

CATCH DISTRIBUTION:

Skeena River chinook populations which have been coded-wire tagged have primarily been recovered in the Alaskan troll and northern B.C. troll fisheries, and the northern B.C. net fishery. But recoveries of these stocks are also known from as far west as the Aluetian Islands. Very few tags have been recovered from central B.C. fisheries or freshwater fisheries; the latter, however, reflects a lack of sampling in freshwater sport (except recently in the Kitsumkalum area) and Skeena native fisheries. The only populations with adequate recovery numbers to determine a catch distribution are Babine River (brood years 1977-79) and Kitsumkalum (brood year 1980-81). Tagging is continuing in the Kitsumkalum but recoveries for later brood years are incomplete.

The catch distributions of these two populations are surprisingly similar (Fig. 2 in S89-18). Roughly one-third of the recoveries for both were reported from these three catch regions. The recoveries are primarily age 4 and 5 fish, with age 6 fish more common in the Kitsumkalum population than in Babine.

Unfortunately, without recoveries of tags in the freshwater escapement, we are not able to estimate the exploitation rate on Skeena chinook. It is possible that the low number of recoveries in commercial fisheries indicates low exploitation rate but we are not able to differentiate this hypothesis from one of poor survival of the tagged fish. Information needed to estimate exploitation rates is now being collected for the Kitsumkalum population but estimated tag recoveries in the spawning escapement for 1987 and 1988 are needed before any estimates are possible.

CATCH AND SPAWNING ESCAPEMENT:

Total catch of Skeena chinook is unknown because of the catch in mixed-stock troll fisheries. In terminal areas, the reported catch between 1950 and 1983 has varied from 9,316 to 40,783 (averaging 21,000). Terminal catches during this period were actually quite stable except for the increases between 1966-68 (Fig 14a). Since 1984, restrictions in troll fisheries have apparently resulted in more chinook passing to inside waters and larger terminal catches (averaging 35,400). It is noteworthy that since 1976 it is equally likely that the catch by native and sport fisheries will exceed the catch by the Area 4 gillnet fishery as not.

Based on cumulative catch of chinook through the gillnet fishing season, summer run-timing chinook enter the Skeena River from late June till the end of July. The timing of spring runs can not be examined based on catch records because we have not been able to locate any weekly catch information for April and May fisheries in earlier years. Cumulative catch data from Skeena test fishing between June 15 and August 15 corroborates this entry pattern through the gillnet fishery. The increase in test fishery catch is actually quite linear between day 1 and day 40, about the end of July. At lower abundances (assumed to be equated with lower total catch) the catch rate seems to be steeper in July than in late June. It is also evident from the annual cumulative catch in the test fishery that the curve has been earlier in the past 5 years than ever previously recorded. As the stock rebuilds we may observe that the more natural return timing for summer chinook is actually in early July.

The recorded spawning escapement has followed a similar trend to the terminal catch. Total escapements varied between 20,000 to 60,000 in the 1950's, declined to 13,000 to 30,000 between 1961 and 1983, and increased rapidly since 1984 (Fig. 14a). Total escapements are based on field officer visual counts and do not include each spawning population each year, particularly during early years when the existence of some spawning areas were still being discovered. To adjust for inconsistent sampling, Figure 14a uses an index sub-set of streams and extrapolated escapements when data are missing for these streams (Appendix 1 in S89-18). However, even if a stream is annually visited, the accuracy of the count is still unknown. The only actual count of chinook escapement in the Skeena stock is from the fence on the Babine River (Fig. 14b). These data support the general trend in annual returns indicated by the catch and spawning escapement, except that the decline in escapements is more continuous between 1961 and 1981 and that the increases in recent years are not evident. In general, therefore, the visual counts of chinook spawning escapement do seem to follow the only known escapements in the Skeena system.

Under the chinook rebuilding program, the escapement goal for Skeena River chinook is 41,233 spawners, based on doubling the average aggregate spawning escapement for 1979-82. It is worth noting that this average escapement is amongst the lowest possible for a four year average in the Skeena chinook. Consequently, it seems reasonible to expect that future escapement goals will increase above the present interim target in the rebuilding program.

REGRESSION ANALYSES:

Regression analyses further support the conclusion that the visual record of escapements to the 67 chinook spawning areas does generally reflect the between year variation in return abundance of chinook. If the visual estimates of spawning numbers contain information on the annual variation in return abundance of chinook then the escapement estimates should be related to independant measures of chinook abundance. In the Skeena there are three independant measures: the cumulative test fishing index, catch per unit effort in the gillnet fishery, and the Babine fence count. Linear and multiple regression analyses were conducted to examine whether such associations existed. Various regression reported in S89-18 accounted for up to 56% of the variability in the escapement record, and until 1984 the total escapement reported for the Skeena was highly correlated with chinook counts at the Babine fence (r=0.88; Fig. 15a,b). Since 1984, however, this latter relationship has broken down. Overall, therefore, it was encouraging that the visual escapement data does seem to provide an index of the annual variation in return abundance of Skeena River chinook.

BIOLOGICAL PRODUCTION POTENTIAL:

There is not sufficient information to provide an empirically based assessment of the potential production from this stock, its optimum escapement goal, or its present status. The total catch of the stock is unknown and there has not been an annual sampling of age composition in the returns. Without these data, it is not possible to reconstruct brood year returns and estimate productivity curves. Mathematical modelling of the stock is probably the only means to provide advice for management. Hankin and Healey (1986) used a modelling approach to estimate the exploitation rates for maximum sustained yield of chinook stocks with differing maturity schedules, and sex-specific ages at maturity. They indicate that Skeena-type chinook can probably only sustain about a 40% total exploitation rate at maximum biological yield, and this value will be optimistic if most Skeena chinook are stream-type. This provides some need for concern since the terminal harvest rate on Skeena chinook averages 45%, but the accuracy of this value is uncertain due to the likely underestimation of total escapement. These results suggest that exploitation in mixed-stock fisheries may have to continue to be minimized if maximum biological yield from this stock is a management objective.

These analyses do not provide any advice on the desired spawning escapement target. Unfortunately, there is simply no way to empirically estimate an escapement target for the Skeena chinook. Estimates might be based on available spawning area or historical escapement records but there is no technical justification for selecting one of those approaches over the present policy approach of doubling the escapement and evaluating the resultant production. However, as we noted earlier, doubling the 1979-82 average in the Skeena chinook stock probably underestimates the appropriate goal.

RECOMMENDATIONS:

Achievement of maximum biological yield from the Skeena chinook stock is unlikely to be a realistic management objective in the near to medium term. It is recommended that the requirements of the various users be identified and a stock management plan developed to meet these needs while more quantitative information is collected. Specifically, an information system should involve:

1. The existing interim escapement goal of 41,200 chinook should be maintained and an evaluation program implemented, specifically including the establishment of a harvest sharing policy for terminal runs in excess of the interim escapement goal. This policy would include rules, agreed to by the user groups and the Department, on how to utilize large returns to increase fishing opportunities and also evaluate production from larger spawning escapements. A fixed harvest rate on returns above a minimum escapement level (the interim goal) is suggested as a policy to evaluate.

2. Annual biological sampling of the escapement in specified populations to provide data on variation in brood year survival, age composition of the separate populations, age at maturity by sex, and biological traits useful for stock identification. Hankin and Healey's (1986) analysis clearly indicates the necessity of collecting age composition and maturity data in chinook populations. Without this information we will not be able to assess the biological productivity of Skeena chinook.

3. Priorization of the streams to be monitored for escapement so that the streams which have been consistently surveyed continue to be annually monitored, and in a standardized and reproducible method. Included in this priorization must be a process for collecting the data recommended in point (2).

4. A program should be developed to investigate the stock structure of Skeena River chinook salmon. This program will be essential to developing an appropriate escapement goal for the Skeena system. The program should initially evaluate how to discriminate between spawning populations and collect basic age composition data. At least the populations within major run- timing segments should be identified.

5. The Skeena River test fishery should be conducted earlier to collect data on run timing, abundance, and biological samples. How early the fishery might start is uncertain and will likely require some experimental fishing. This will be particularly important if terminal fisheries on increased returns of chinook are anticipated. During evaluation of when to start fishing, the number of weeks to be monitored could be increased by reducing the number of days fished per week.

SUB-COMMITTEE ADVICE:

This paper is correctly described as a review of available data since data to evaluate the productivity of Skeena chinook is apparently not available. Reviewer's comments concerned the accuracy of the estimate of harvest rate in terminal areas (as noted in the text by the authors), and the statements that data from the Kitsumkalum programs will provide the necessary information to estimate the exploitation rate on this Skeena chinook stock. The reviewer was skeptical that the accuracy and precision of the data collected in that program will be sufficient to be useful in stock assessment. If exploitation data is essential to future assessments then the authors should review this data source or examine alternative locations where this data could be more accurately collected.

Committee discussion centered on two points requiring further examination. Recent counts at the Babine fence should not immediately be assumed to indicate non-rebuilding of this upper river stock. Concerns were expressed that chinook had recently appeared to be held back behind the fence, possibly by low water and or increased numbers of pinks in the river, and subsequently move above the fence site after the fence is removed. Further, more chinook also seem to be spawning in the Babine River below the fence. Accurate estimates of these spawners would be difficult and the historical record of spawners would not, of course, be as accurate as the fence counts. Resolution of this concern may be important to our future assessments of chinook rebuilding in the Skeena River. The second point concerned examining whether the terminal harvest rate could be estimated by expanding the test fishery catch of chinook to an estimate of the total escapement of chinook. The expansion would be based on the calibrated expansion for sockeye salmon and the relative catchability of chinook and sockeye in the test fishery. Further discussion about this possibility will be undertaken.

The Sub-committee agreed with all recommendations presented in the working paper. However, while the committee fully supports recommendations 2 and 3, the potential need for increased resources for ageing analyses should be brought to the attention of the senior managers. Further, if the test fishery was conducted earlier in the spring it may have to be conducted in the estuary due to ice flows in the river.

10. STATUS OF SKEENA AREA 4 PINK SALMON (Working Paper S89-19):

Pink salmon are annually the first or second most abundant salmon species returning to Statistical Area 4 (Skeena) with sockeye being the other most abundant species. Average returns from 1959 to 1988 have been similar in even and odd years; the odd returns averaging 2,820,000 and even returns 2,730,000. Skeena pink production has contributed large numbers of fish to the commercial net and troll fisheries in northern B.C. and southern S.E. Alaska, plus native subsistence and sport fisheries in Canadian statistical Area 4.

There are 113 documented spawning populations of pink salmon in the Area 4 pink stock group. Major spawning populations are the Babine, Kispiox, Kitwanga and Lakelse Rivers and the mainstem Skeena River. The single largest producer is the Lakelse River with average escapements since 1950 of 462,000 and 496,000 for the odd and even cycles, respectively.

Area 4 pink returns are separated into three groups for management purposes based on run timing information. The early timing stock group consists of the Babine River, Kispiox River, all smaller stocks located upstream of Terrace. Peak timing of this stock group in the area 4 commercial fishery is in the last week of July and first week of August. The mid timing group consists of the Lakelse River, Kitsumkalum River, mainstem Skeena River, and all smaller tributaries from Terrace downstream to the Khyex River. The timing of this group is slightly later peaking in the fishery during the first two weeks of August. Later timing coastal stocks consist of pink populations returning to Moore Cove Creek, La Hou Creek, Ecstall River and the Khyex River. These stocks peak in abundance during the last two weeks of August and occasionally into the first week of September if water levels in the streams are low delaying entry.

Area 4 pink returns are primarily monitored using the Skeena test fishery at Tyee, catch per unit effort information from commercial fisheries in Areas 3, 4 and 5 and visual observations of escapement. Management of the Area 4 net fishery normally switches from sockeye to pink salmon in early August and continues into early September, however, during the sockeye fishery large numbers of Skeena pink salmon may also be harvested. The fishery is managed to achieve a weekly escapement target which is monitored daily at the Skeena test fishery at Tyee. On a weekly basis throughout the season total stock estimates and final stock projections are calculated from the test fishery escapement estimates and hailed catch data. These are then used to design a fishing pattern for the ensuing weeks.

At present there is no direct enhancement of area 4 pink salmon however the construction of a fishway at Moricetown falls has improved access to spawning grounds in the Bulkley/Morice system and may be the reason for increasing escapement to this region.

CATCH TRENDS:

Historical catch information indicates a peak catch of 4,087,000 pink salmon in area 4 in 1922 and an average of 2,687,000 from 1917 to 1930 when the majority of the fishery occurred in the Skeena River itself. Since 1930 catches declined significantly despite an increase in fleet mobility with an average Area 4 catch of 865,000 from 1930 to 1988. Also during this period fishing expanded to non-terminal areas of northern B.C. and southern S.E. Alaska, where it has been shown by tagging studies that substantial numbers of Skeena pink salmon are harvested.

Since the catch by spawning population can not be estimated, Skeena pink salmon must be treated as a single stock for the purposes of estimating Skeena pink catch. Using the interception estimates from the most recent adult tagging studies, catches of Skeena pinks in northern B.C. and S.E. Alaska were estimated by assuming the recent interception rates, averaged for the three years of study, were appropriate for the period 1959 to 1988. By this assumption average catches of Skeena pinks were 1,392,000 for odd year returns and 1,708,000 for even year returns during this period. Odd cycle catches have increased from an average of 870,000 in the 1960's to 2,477,000 in the 1980's. Even year catches averaged 1,973,000 in the 1960's and 1,950,000 in the 1980's.

Native subsistence catch of Skeena pink salmon has increased substantially in recent years. From 1951 to 1980 the average pink catch was 7,000 while from 1981 to 1988 the average catch has risen to 45,000. Sport fish catches have also increased in recent years from fewer than 1,000 per year prior to 1978 to an average of 4,000 from 1983 to 1988.

SPAWNING ESCAPEMENT:

Area 4 pink escapement since 1950 has averaged 1,224,000 for odd year returns and 937,000 for even year returns. In general most of the major producers have similar escapement levels in both odd and even years with the exception of the Kispiox and Kitsumkalum rivers which have much stronger odd year returns.

Since the 1950's, many of the major stock groups have increased in escapement levels with the largest increases occurring in the odd year returns and in the even year returns to the Babine and Lower Skeena populations (Fig. 16). During the 1980's the average escapement for both odd and even cycles were the highest decade averages since the 1950's, 2,255,000 and 1,137,000 respectively. The highest odd year escapement of 3,180,464 spawners was recorded in 1987 while the largest even year escapement of 2,324,454 was recorded in 1986. The 1988 escapement of 827,490 showed a significant reduction from the record even year brood escapement in 1986. This is the first indication of a decline in production since 1978.

TOTAL STOCK:

The average annual return Area 4 pink salmon between 1959 and 1988 has been almost identical in even and odd years, and was estimated to be about 2.75 million pinks based on the catch analysis outlined above.

During the 1960's the even year returns were substantially larger than odd year returns, followed by equal returns during the 1970's and significantly larger odd year returns in the 1980's (Fig. 17). Average exploitation rates, however, have been greater in the even year returns than in the odd (57% vs.46%). Total returns in the 1980's have been above average for both odd and even year returns perhaps due to increases in recent escapement levels but more likely due to improved ocean survival rates.

FORECASTING:

Pre-season forecasting of Area 4 pink returns applies an average return rate (most recent 10 year average) for each cycle to the appropriate brood year escapements. Based on this methodology, the forecasts for 1989 and 1990 are 4,325,600 and 2,005,600 respectively. The 1989 return is expected to have significant production from all stock groups while the 1990 return is expected to have harvestable surpluses in only the Lakelse, Bulkley/Morice and Coastal stock groups. Historical forecasts since 1959 have been far from accurate with average errors of 41 and 56 percent for odd and even year returns, respectively.

ASSESSMENT OF POTENTIAL PRODUCTION:

Presently Area 4 pink salmon returns are managed to achieve a target escapement of one million fish past the Skeena test fishery. This target was determined through a stock recruitment analysis using data up to 1975 (Shepherd, B. unpublished ms.). Since 1975, total returns have increased substantially in both cycles with production coming from escapements well in excess of the one million target. In addition, the recruit per spawner rates during the 1980's have increased significantly, particularly in the odd year cycle. In 1986 a review of the escapement targets was undertaken by DFO biologists and fishery officers. Based on historical escapement estimates, available spawning and rearing habitat, competition with other species for spawning and rearing habitat, and resulting returns; a larger target escapement past the Skeena test fishery was suggested (1.7 million pinks for both cycles and 1.9 million when the stocks below the test fishery and along the coastal area were included). In summary, the present management target of one million spawners past the Skeena test fishery should be reviewed through a stock recruitment analysis. Based on historical catch information and more recent returns a target escapement of 1.5 million pink salmon may be more appropriate.

SUB-COMMITTEE ADVICE:

The reviewers both indicated that this paper was a very useful collation of the information on Skeena pink salmon, but also agreed that a stock-recruitment analysis should have been conducted to examine the escapement goal and status of these stocks. One reviewer calculated the Ricker stock-recruitment relationship for each cycle year, based on the data presented. These analysis indicated that the optimum escapement level for odd year returns is substantially greater than the present target escapement but that for even year returns was less than the present target. These analysis were not incorporated into the committee advice, however, due to concerns about the appropriateness of the historical catch estimates. Reviewer's comments also concerned incorporating catches of Skeena pinks in all southern S.E. Alaskan fisheries in the reconstruction of historical catches, evaluating environmental factors in abundance forecasts, and more thorough documentation of test fishing procedures and procedures for estimating spawning numbers in the mainstem Skeena River.

These suggestions should be incorporated in future assessments but the Sub-committee recommends that the immediate needs are to:

i) evaluate the target escapement goal based on stock-recruitment relationships within cycles, and evaluating various assumptions about the historical catch of Skeena pinks in intercepting fisheries. The impact of various assumptions and returns within cycles on management advice provided should be clearly documented.

ii) evaluate whether Skeena pink salmon demonstrate cycles in productivity that could be used to improve forecasts or other management approaches.

Further the Sub-committee supports the author's recommendation for electrophoretic baseline studies to examine whether the identification of Skeena pinks in mixed-stock fishery catches is feasible.

11. STATUS OF SKEENA AREA 4 CHUM SALMON (Working Paper S89-27):

Statistical Area 4 (Skeena) chum salmon are the least important salmon species with respect to their current contribution to commercial, sport and native food fisheries in the north coast of British Columbia.

The Area 4 chum stock group is composed of 44 spawning populations concentrated in the lower portion of the Skeena drainage from Terrace downstream. The largest single producer is the Ecstall River, averaging 64 percent (1950 to 1988) of the total estimated escapement to Area 4. Area 4 chum salmon have a summer run timing, entering the Skeena as early as the first week of July and peaking in abundance from mid to late August (as recorded by the Skeena test fishery at Tyee). They return predominately at age 4 (80 to 90 percent) with small components of age 3 and 5.

Commercial net fisheries targeting on sockeye and pink salmon in northern B.C. and southern S.E. Alaska are the primary harvesters of Area 4 chum salmon. Area 4 chum returns are monitored annually using the Skeena test fishery at Tyee, catch per unit effort information from the commercial and native subsistence fisheries in Area 4 and visual observations of escapement. This information provides a general indication of the strength of the return, but historically chum returns to Area 4 have had little bearing on the actual management of the commercial net fisheries. At present, management of Area 4 chum salmon is limited to attempts to reduce the harvest rate on chum and other salmon species while maintaining and possibly increasing the harvest rate on sockeye and pink salmon.

Enhancement of Area 4 chum salmon consists of two small spawning channels constructed in the mid-1980's. One is situated on a side channel of the lower Skeena River at Andesite Creek and the other on the Kitwanga River at Kitwancool. There have been no adult returns generated from these channels as yet.

CATCH:

Total catch of Area 4 chum salmon is simply unknown due to the numerous fisheries they are believed to be caught in, and a lack of effort to identify their catch through stock identification studies. Chum caught incidentally during the Northern Tagging programs (1982-85) have shown that Area 4 chum salmon are caught in net and troll fisheries in northern B.C. (Statistical Areas 1, 3, 4 and 5) and in southern Alaska (Districts 101 and 104). Quantitative estimates of stock composition in these fisheries were not developed.

Historical information indicates a steady rise in the Area 4 chum catch from 1905 (16,000) to 1926 (341,000) followed by a decline to an overall average of 60,000 for the period 1930 to

1988. Prior to 1930 the majority of the catch was taken in the Skeena River itself while after 1930 an increasing percentage has been harvested in more outside regions, increasing the proportion of non-Skeena fish. Chum salmon catches in the native food fishery and sport fishery are minimal.

ESCAPEMENT:

Since 1950 annual chum escapement estimates in Area 4 have fluctuated significantly (Fig. 18), but average annual escapements within decades (1950-1987) are much more consistent, varying from 14,500 in the 1950's to 12,300 in the 1960's. The record escapement of 108,900 chums in 1988 will raise the 1980's average to 23,500. Major chum producers in Area 4 in the 1980's are the Ecstall River (average 16,300), Skeena River mainstem (average 3,300) and Kitwanga River (average 2,050). All other systems averaged less than 1,000 chum spawners.

The escapement target for Area 4 chum salmon was developed (55,000 chums) in 1986. This estimate was developed in consultation with Fishery Officers and based on historical escapement estimates, available spawning and rearing habitat, and competition with other species for spawning and rearing habitat. This is a slight increase over the previous undocumented target of 50,000. The methodologies utilized in developing the escapement estimates and the streams surveyed have not been consistent from year to year creating problems when analyzing the data. A more consistent approach is required if Area 4 chum stocks are to be more actively managed, and the escapement target should be reviewed at that time.

ASSESSMENT OF POTENTIAL PRODUCTION:

Historical catch information from 1916 to 1928 indicates a period of sustained high catch of Area 4 chum salmon with an average catch of 202,000. These fish are believed to be almost exclusively of Skeena origin as the fishery during this time period was conducted in the Skeena River itself and the immediate approach area. Assuming this period does not represent an anomalous span of high productivity, an average catch of 200,000 Area 4 chum salmon is potentially available. Using the coastal standard return rate of 1.8 recruits per spawner, an escapement of 250,000 is required to sustain a harvest of 200,000. Recent escapement levels (except 1988) and the present escapement target of 55,000 are well below this level and suggest that the potential for producing substantially more chum in the Skeena River may exist. However, these estimates of historical catch are of uncertain accuracy as they have to be converted to numbers caught based on can-pack statistics.

SUB-COMMITTEE ADVICE:

A thorough stock assessment on chum salmon in the Skeena River can not be undertaken due to inadequate information. Both reviewers acknowledged that the paper was basically a review of catch and escapement data, commented on improvements in information needed to evaluate this stock, and on the potential production of chum. One reviewer did not believe the suggested potential harvest of 200,000 chum annually would be sustainable and that the rapid decline in the stock following these high catches indicated that such catches over-exploited the stock. Following the collapse of the stock, the exploitation rates in sockeye and pink fisheries likely prohibited rebuilding of the stock. The second reviewer approached the potential production issue from a different perspective, and supported the authors suggestion that production could be increased. This support was based on the relatively stable production of chum under high exploitation rates (although these rates are likely biased high due to poor escapement estimates) and recent large returns of chum.

The Sub-committee acknowledged that chum salmon production in the Skeena River could probably be increased but there is not sufficient information to estimate what the potential production could be. However, the fundamental issue with this stock is whether or not to actively manage, develop and evaluate it. Chum salmon are the least productive salmon species (at least in natural spawning populations), therefore, to increase production through increase natural escapements will require significant disruption to fisheries on other species. Alternatively, increased chum enhancement in the area could be used to increase chum productivity. Further, improvements in management of this stock would require development of stock identification methods, in order to locate the stock, identify opportunities for adjusting fisheries, and estimating harvest rates. Unfortunately, the committee cannot, at this time, advise on a technical basis whether the potential production from rebuilding this stock exceeds the costs in fishery disruption and/or enhancement to do so. The committee recommends that a basic stock evaluation program be established to monitor chum returns, particularly the returns from the recent larger escapements. Specifically, we recommend:

i) establishment of consistent escapement monitoring and of standardized methods within each monitored stream; populations which can most reliably and consistently be enumerated should be identified as index populations and procedures used in them documented; and
ii) a review of chum salmon enhancement opportunities in the Skeena area.

PRODUCTION from SALMONID ENHANCEMENT PROGRAM FACILITIES

12. UPDATE ON PRODUCTION OF CHINOOK AND COHO SALMON FROM BRITISH COLUMBIA HATCHERIES 1973-1987 (Working Paper S89-23):

This document updates the release, contribution, and survival data for Salmonid Enhancement Program (SEP) facilities presented in 1988 and presents a slightly re-worked method for calculating the contribution of release groups which are not associated with a tag code. Release data for such unassociated releases from all facilities have been reviewed, verified and entered in the database since last year. Unassociated data included in last year's paper (S88-16) were preliminary and incomplete, and in some cases differ from the data presented in this paper. Since, it is not possible to directly calculate the contribution of unassociated releases, we have used comparable marked releases to estimate the survival and contribution of unassociated releases to each Canadian fishery by recovery year. Changes in databases, data collection methods and repeated and new concerns with data quality are addressed. For example, sport recoveries in this paper for years since 1980 were expanded using the actual sampling data for the months May through September. An average awareness factor based on the creel survey data for these months was used for the remaining months of the year. The sport awareness factor of four was used in every month in last year's paper, and for years previous to 1980 in this paper.

In 1987 and 1988 major expansions were completed for chinook salmon enhancement at Bella Coola, Nitinat, Little Qualicum, and Tenderfoot hatcheries and upgrades were completed at Nanaimo hatchery and are underway at Cowichan hatchery. Work at the latter four sites was a component of the Department's lower Georgia Strait rebuilding program.

Concern was expressed during the preparation of the current report that the data gaps and poor quality data in the Mark Recovery database (MR db) identified last year can result in serious misinterpretations of data by the inexperienced user.

JUVENILE CHINOOK AND COHO RELEASES AT B.C. HATCHERIES:

Releases in 1988 of 1987 brood year chinook (95% of which were smolts) increased by almost 10 million compared to the 1986 brood, continuing an upward trend since the 1982 brood (Figure 19). Further increases are expected during the next few years. This growth reflects some hatcheries rising toward design capacity as more brood stock is available, as well as expansion of incubation and rearing capacity at several sites, especially in the lower Strait Of Georgia.

Coho salmon releases in 1988 consisted of fry from the 1987 brood year and smolts from the 1986 brood year, the latter representing 54% of the coho released in 1988. Smolt production has stabilized at approximately 10 million fish (Figure 19), down from the 1983 brood year peak of 13.8 million, and is not expected to change markedly in the near future. Fry releases have ranged from 8 to 13 million during the past six years reflecting brood stock and egg availability for many of the smaller enhancement projects in the province and reassessment of colonization capacity.

CANADIAN CATCH OF ENHANCED STOCKS:

The Canadian commercial and recreational catch of B.C. hatchery chinook salmon was 70,000 fish in 1987. This represented 7.85% of the total catch, the lowest level since 1980 and down from a peak of 12% in 1983 (Figure 20). Unassociated releases of chinook were estimated to account for 10% or 7,100 chinook of the 1987 catch of enhanced chinooks (Table 3 in S89-23). The sport fishery in the Strait of Georgia was the single largest harvester of enhanced chinook in 1987, catching an estimated 20,300 B.C. hatchery chinook (Table 3 in S89-23).

The decline during the past three years, especially during an era when increasing releases were expected to increase catch contribution, is a major concern. Figure 19 shows increasing releases of juvenile chinook since 1971, and an almost exponential increase since the 1984 brood year. Figure 20, however, shows a declining trend in the percent of the Canadian catch attributed to these releases since the 1983 catch year, and a decrease in the absolute number of pieces since the 1984 catch year. Given regulatory changes, and declining overall catch, it is not surprising that the numbers did not increase, or even declined from the peak of 1983/1984. It is surprising that the relative contribution of Canadian enhanced chinook has declined. This suggests that the marine survivals of other chinook stocks have not declined as severely as Canadian hatchery chinook. However, changes in the catch and timing of the major Canadian fisheries and in chinook production from U.S. hatcheries confound this interpretation.

B.C. hatchery coho have made a steadily increasing contribution to Canadian commercial and sport fisheries. The estimated 1987 catch of 683,000 enhanced coho in 1987 exceeded the previous high by 90,000 fish and accounted for 17.1% of all catches in B.C. saltwater fisheries (Figure 20). Unassociated releases of coho were estimated to account for 15% or 102,000 coho of the total 1987 catch of enhanced coho (Table 4 in S89-23). Most of the dramatic increase in the catch of B.C. hatchery coho in 1987 occurred in the Strait of Georgia sport and troll fisheries. The combined catch for these two fisheries was 410,400 hatchery coho, up from 273,500 in 1986 (Table 4 in S89-23); representing 47.1% of the sport and 49.8% of the troll catches, respectively.

It should also be noted that using the creel survey data to estimate sport catches of hatchery chinook and coho in the Strait of Georgia resulted in substantial changes over previous estimates based on an assumed awareness of 25%. Compared to the estimated contributions to the Strait of Georgia sport catch reported in last year's document (S88-16), the catches of hatchery chinook and coho reported in this paper and based on the actual sampling data differ by (the % change is relative to the contribution estimates reported in S88-16):

	Chinook		Coho	
1980	+8,000	(+48%)	+30,000	(+20%)
1981	+17,500	(+102%)	-4,700	(- 5%)
1982	-2,800	(-12%)	-10,500	(- 9%)
1983	-3,200	(-10%)	-26,500	(-22%)
1984	-4,700	(-10%)	-7,100	(- 7%)
1985	-2,300	(- 7%)	-6,000	(- 2%)
1986	-1,000	(- 3%)	+22,300	(+12%)

SURVIVAL OF B.C. HATCHERY CHINOOK AND COHO SMOLTS:

Long term trends in survival of enhanced chinook (estimated as the U.S. plus Canadian catches plus escapement divided by the numbers released) can only be assessed in 5 pre-SEP facilities with consistent marking programs since the early 1970's (Big Qualicum, Quinsam, Puntledge, Capilano, and Robertson Creek). Chinook survivals were greatest in the mid-1970's, fell to low levels in the 1977 brood year, and have not yet recovered (Fig. 21). Following expansion of chinook enhancement in B.C. through the Salmonid Enhancement Program, estimates of survival rates have been made for releases from 38 facilities (Table 5 in S89-23). Recent average survivals over all these facilities have been between 0.5% and 1.5%. Estimates of marine survival vary greatly between facilities and any result considered over these facilities must be interpreted cautiously. Survival estimates are generally minimum estimates due to incomplete escapement accounting for hatchery fish and missed tag recoveries in facilities, but these concerns are especially important for Upper Fraser and Northern B.C. facilities. Spawning escapements may represent the majority of the adult returns to facilities in these areas due to reduced fishing pressures recently. Further, when comparing survival between geographic areas or over long time periods, estimates of survival will be influenced by fishing patterns, regulatory changes, and age at maturity of the stocks. It is noteworthy, however, that some facilities within the Strait of Georgia (Quinsam, Chemainus, Cowichan,...) have not shown a decreasing survival trend.

Trends in marine survival of enhanced coho salmon has followed a similar pattern as in chinook. Survival declined in the 1978 brood year and has averaged less than 10% since the 1979 brood year

(Fig. 21). Survival rates from facilities along the west coast of Vancouver Island have been consistently lower than for hatcheries within the Strait of Georgia or Fraser River, and their time trend in survivals is also quite different. Coho survival rates for northern B.C. and Upper Fraser facilities are in the same range as for the west coast Vancouver Island stocks (approx. 2-7%). On a facility basis, survival rates for many stocks have been fairly stable since the late 1970's with many experiencing their best return in the most recent time period. However, coho from the Big Qualicum facility are of particular concern due to very poor recent survival rates, likely due to an unexplained health problem prior to release during the past several years.

SURVIVAL OF HATCHERY AND WILD COHO:

The addition of 1988 catch data to the analysis presented last year (in S88-16) re-affirms our conclusion that survivals of wild and hatchery coho salmon have similar trends between years. We suggest that this strongly indicates that factors outside the hatchery, and outside the effect of hatchery production strategies are controlling the productivity of both wild and hatchery coho.

COMMENTS ON RECOMMENDATIONS MADE IN 1988:

Progress was made on recommendations to improve the accuracy of the estimated number of unmarked fish released; development of mass marking techniques; investigations of the problem of missed mark recoveries in hatchery brood stocks; and on continuing the comparative marking of wild and hatchery coho salmon. However, little or no progress has been made for the majority of the recommendations. Of particular concern, is the lack of response to recover of coded-wire tags from poorly sampled catch strata (sport fisheries outside of the Strait of Georgia, and native fisheries), recoveries of coded-wire tags from spawning escapements of hatchery fish not handled as broodstock in facilities, and inclusion of the American data in the Mark Recovery database. The latter issue has been delayed since we have not received the data from the American agencies.

Further, recommendations on some of these issues are presented below but the need for improved recovery information in the fisheries identified and in the escapement of hatchery fish to natural spawning areas continue to be necessary actions.

RECOMMENDATIONS FOR 1989 FROM THE WORKING PAPER:

1. The Regional Mark User's Committee should be requested to address three information items for the Mark Recovery database:

    i) development of warnings in the database to identify missing, estimated, or incomplete data. The access programs to this data are now highly efficient and "user friendly" but this places the uninformed user at risk of incorrectly interpreting the data acquired;

ii) development of an official recommendation on the use of sport expansion factors to be used (this recommendation will become the default option in the database); and

iii) ensuring that Key Stream and test fishery tag recovery and sampling data are incorporated in the database.

2. Analyses should be done to normalize hatchery chinook survival estimates between facilities and over time to compensate for the impact of regulatory changes. This work should be a joint effort by the Stock Assessment and SEP Evaluation programs.

3. Further work to test alternative methods of calculating contribution of unassociated releases should be undertaken before one procedure or estimate is accepted.

SUB-COMMITTEE ADVICE:

Both reviewers agreed with the overall assessment in this paper but provided numerous comments concerning improved presentation of the analyses. Of particular concern was the use of weighted averages without description of the weighting procedures. The authors indicated that weighting between facilities was based on total production releases represented by coded-wire tagged groups but within facilities there was no weighting between tag codes.

The Sub-committee supported the proposed recommendations but emphasized that the development of warnings or flags in the coded-wire database should not be expected to prevent misinterpretation. The onus for proper use must remain with the user. The Mark User's Committee can not possibly anticipate every possible misuse and provide warnings for each. The Sub-committee did agree, however, that missing data type situations should be identified.

13. METHODOLOGY FOR ESTIMATING PRODUCTION OF CHUM AND PINK SALMON, WITH UPDATE ON 1987 PRODUCTION (Working Paper S89-24):

This document was prepared as an update to last year's working paper (S88-11) and provides additional information on the methodology used to estimate SEP contributions to the catch and escapement of pink and chum salmon, as requested by last year's reviewers. Also included are final 1987 (1983 brood) chum and 1988 (1986 brood) pink return data.

METHODOLOGY:

Catch and Escapement Contribution Estimation:

Observed, estimated, and expanded mark recovery data are calculated in the identical manner to the MRP database except that catch estimations are made on a statistical area basis rather than a catch region basis and escapement estimations include more sampling on the spawning grounds than for chinook and coho. Observed fin clip recoveries are adjusted to compensate for unaged marks in a similar manner as lost pins in the MRP database.

Unlike the chinook and coho sampling program, only net catches are consistently sampled for marked chum and pink and then only in areas where marks are likely present. Not all weeks are sampled especially early or late in the season when catches are low and usually incidental to another target species.

Estimated recoveries were adjusted to compensate for missed sampling periods. Three methods of adjustments have included: adding the catch from a missed week to the previous sampled week's catch in major catch areas; adjusting the estimated recoveries by the ratio of total area catch to sampled catch in minor catch areas when several weeks of sampling were missed; and in 1985 when no fin clip sampling occurred, using the recoveries of coded-wire tags in Area 12 and 13 to estimate fin clip recoveries. When duplicate fin clips are present in a fishery then a method of run reconstruction was used to estimate recoveries for each release group. Estimated recoveries of each duplicate fin clip in escapement and each fishing area where no mixing occurred were used to estimate recoveries in the mixed area. This has been used to separate Big from Little Qualicum chum and Big or Little Qualicum from Chilliwack production.

Between 1984 and 1987, 28.7% of the major net fishing areas and 12.7% of the minor areas for chum catch have been sampled, for an overall rate of 26.1%. Pink sampling is confined to Area 12 and 13 and totals only 5.1% of the even year catch between 1984 and 1988. In the odd-year runs it has not been considered cost effective to sample due to the high incidence of Fraser pinks and consequent low mark rates. In these cases, the mean harvest rate estimated from run reconstruction of all pink stocks was used to estimate the contribution of enhanced pinks.

Missing marks during sampling is of more concern than with chinook or coho salmon. Marks are missed because of high speed processing of fish at fish plants, the difficulties in looking for various mark types, and the problems in identification of regenerated ventrals.

Fishery Officer and facility staff estimates of escapement are used to expand sample data. Petersen estimates have been used from tagging programs at Nitinat in 1985 and at Chilliwack in 1986. The proportion of chum escapement sampled for marks between 1984 and 1987 totalled 21.3% with 58.7% of the rack and 11.3% of the spawning ground sampled. Sampling on the Harrison system, Stave, and Nitinat was less than 10%. Quinsam pink sampling has totalled 25.5% from 1984-1988.

Potential for error is high because sampling, especially on the spawning grounds, is temporally biased and there is evidence that marks are being missed during sampling. These missed marks potentially underestimate enhanced contribution and overestimate harvest rate. At Big Qualicum where the escapement mark rate is used to estimate catch, missing marks would overestimate catch. An analysis of Area 14 catch from 1985-1987 indicates that this may be occurring.

Alternate Contribution Estimates:

Blaney and Inch incubation box contribution has been estimated by separating total stock contribution between wild and enhanced based on estimates of fry production. Because of poor mark quality and low mark rates the 1984-1986 Nitinat chum catch and escapement were separated to wild and enhanced in a similar manner. For 1987 and 1988 conventional analysis was used.

Adjustments for Mark Mortality Rates:

Mark mortality refers to any factor which reduces the survival of marked compared to unmarked fry and any factor such as missing marks during sampling or fin regeneration which underestimates the true mark rate. All expanded recoveries of chum and pink are adjusted for a 30% mark mortality based on Big Qualicum data. Snootli chum and Quinsam pink adipose-ventral mark groups were adjusted a further 36% and 37% respectively as a result of experiments comparing the survival of single ventral versus adipose-ventral marks.

Associated Release Groups:

Release groups which were not marked were associated with one or more marked groups from the same hatchery and brood year, and usually with similar release timing and size. Unassociated chum releases accounted for 31% (range 22%-39%) of fed and 2% of unfed releases for the 1978-1987 brood years. Big and Little Qualicum accounted for 98% of all unfed chum releases. Unassociated pink releases have totalled 12% for fed and 33% for unfed fry. In only rare circumstances have chum fry had to be associated with a release from another facility.

UPDATE OF PRODUCTION TO 1987:

Releases:

Fed chum releases for the 1987 brood year continued to drop from the high in 1984 of 99.2 million to 70.5 million. Brood stock collection problems, a chinook production emphasis, and reductions in budgets have all contributed to this reduction. Unfed chum fry releases of 96.4 million are the highest todate and exceeded the target. Fed pink fry releases were 4.7 million, slightly below the target of 5.4 million but unfed pink fry releases were 7.2 million well above the target of 6.6 million.

Fry-to-Adult Survivals:

The fry-to-adult survivals of 0.7% for 1983 fed chum fry was well below the 1978 to 1982 average of 1.8%. The 1978 to 1983 average of 1.7% is the same as the biostandard. Only Snootli and Puntledge 1983 brood survivals were above the biostandard. Pallant, Conuma, and Fraser facilities were below the biostandard for the 1978 to 1983 broods. Unfed 1983 brood chum fry survival at Big Qualicum was 0.38% well below the 1959 to 1982 mean of 0.60% and the 1978 to 1982 mean of 0.75%. The survival of 1983 brood Little Qualicum chum was 0.26%, less than half the 1979 to 1982 mean of 0.66%. Like chum, pink fed and unfed fry survivals of 2.4% and .9% for the 1983 brood were well below average.

Adult Production:

Adult production of 1983 brood year chum met only 45% and pink only 57% of the expected target. Overall the 1978-83 brood chum was still 108% of expected production and the 1979-86 brood pink production was 121% of expected.

Total B.C. chum catch in 1987 was 2.3 million fish. The catch of enhanced chum in 1987 for all broods was estimated at 830,000 or 35% of the B.C. catch, the highest percentage up to that time. With the poor returns of natural stocks in 1987, fishing opportunities would have been very limited especially in the South were it not for target fisheries on enhanced stocks. Because of these target fisheries, harvest rates in 1987 averaged 69%, the highest harvest rate estimated to date on enhanced stocks. A preliminary estimate of enhanced contribution in 1988 based on hail catch data indicates that out of the total B.C. catch of 6.1 million chum, the enhanced catch was 2.35 million or 38% of the total catch.

Increasing returns are being observed to more facilities; particularly the Snootli Hatchery since 1987 and the Nitinat Hatchery. In 1988, the return to the Nitinat Hatchery represented 60% of the total catch of B.C. enhanced chums and an estimated 80% of the total chum catch in Area 22.

RECOMMENDATIONS FROM THE WORKING PAPER:

The authors recommended:

1. Improved measurement of adult mark rate at Big Qualicum by:

   - evaluating below the fence fry production using hydraulic sampling below and above the fence.
   - re-instituting live sampling at the fence or conducting regular dead pitches above the fence throughout the run with a sample size of 20,000.
   - evaluating the missed mark rate in escapement sampling and instituting procedures to reduce it.

2. Evaluate the run reconstruction method of estimating Big Qualicum, Little Qualicum and Chilliwack enhanced contribution where duplicate finclips are involved by using the technique to estimate catch in years where the marks are different.

3. Measurement of the missed mark rate during sampling at all facilities and at the processors, along with improved sampling procedures to reduce the problem.

4. Improve measurement of mark mortality with Quinsam pinks by continuing marking of hatchery and wild fry.

5. Release fed chum fry with various mark types and unfed chum fry into a barren stream to determine the mark mortality of various mark combinations.

6. Increase emphasis on the development of mass marking techniques for chum and pink hatchery releases.

7. Investigate the use of scale characters at Nitinat to separate fed hatchery fry from wild chum. Use to re-evaluate the 1984 to 1987 enhanced chum contribution.

SUB-COMMITTEE ADVICE:

The reviewer of this paper noted that the methods used to estimate mark recoveries in unsampled stata were well documented and the adjustments did not seriously affect the estimates. However, he also noted that key assumptions concerning potential errors among (1) release enumeration methods, (2) mark mortality rates, (3) missed mark rates, (4) escapement methods, and (5) the utility of associated release groups were not adequately supported by references, evaluated, or tested on representative stocks. Assumptions on mark mortality and missed mark rates are particularly important to assessment of pink and chum salmon. Both fin clip and coded-wire tags are used as marks, but the above rates likely differ between tag types. The other assumptions are generic to fisheries data and to estimating stock contributions from mark recovery data. It would be important, however, to maintain consistent procedures until concerns about mark mortality etc. are investigated.

Sub-committee discussion focused on three issues; accessibility to fin clip data, the specificity of the recommendations proposed, and the importance of investigations concerning missed mark rates. While the working paper outlines how the data is collected and maintained the data is not very accessible to other Regional analysts when kept on an Apple microcumputer. Most of the recommendations presented are specific to improving hatchery evaluations of pink and chum production and should be referred back to the Salmonid Enhancement Program for action if their priority warrents support. However, of general Regional concern would be any data on missed marks (in port sampling, and at hatcheries or in natural escapements) and the accuracy of escapement estimates. Errors in this data will likely influence assessments by fishery and resource managers as well as the hatchery assessment personnel. Missed marks and under estimation of the escapement will increase the estimated harvest rates in fisheries and may result in lost opportunities to harvest fish as more conservative actions are taken.

The Sub-committee recommends:

i) that the fin clip database for chum and pink salmon be made more readily available to the Region by incorporating this data in the Mark Recovery database developed at the Pacific Biological Station,

ii) that the recommendations presented by the authors be reviewed within the Salmonid Enhancement Program for action; however, key assessment questions such as estimates of missed mark rates in commerical and escapement sampling must be investigated if this data is to be used more directly for management (such investigations may require joint funding by other Branches), and

iii) research initiated on mass marking of coho and chinook salmon should also consider pink and chum salmon; the development of these techniques would reduce the need for assumptions about fin mark mortalities and provide direct tests of the numbers of marks missed in sampling.

SPECIAL ISSUES and METHODOLOGY

14. ADAPTIVE MANAGEMENT OF FRASER RIVER SOCKEYE: RECOMMENDATIONS FROM THE CYCLIC DOMINANCE WORKING GROUP (Working Paper S89-3)

The potential for increased sockeye salmon production from the Fraser River depends to a large degree on whether historic cyclic trends in abundance were caused by overfishing or by biological processes ("cyclic dominance"). Managers need to understand the cause of these cycles in abundance to set escapement goals for optimium production. A number of explanations for the cycles have been proposed but the following seem most plausible:

Hypothesis 1) low escapements in off-cycle years due to overfishing.

Hypothesis 2) low smolt production in off-cycle years due to predation.

Hypothesis 3) low smolt production in off-cycle years because food supply is reduced by juveniles in the preceding dominant-cycle.

The causes of cyclic dominance are unlikely to be discovered within the next few years owing to extensive natural variability in sockeye run strength. Without well-designed harvest rate goals and enhancement strategies, the mystery of cyclic dominance is likely to remain unsolved for the forseeable future, and opportunities for large increases in sockeye production may be missed. The Cyclic Dominance Working Group (Table 3) was organized by the Salmon Sub-Committee of the Pacific Stock Assessment Review Committee to recommend fisheries management, enhancement and research activities that will reveal the causes of cyclic dominance as quickly as possible. A well designed adaptive management plan for rebuilding the escapements of selected off-cycle runs should lead to a much better understanding of the issue within 10-20 years.

AN ADAPTIVE MANAGEMENT APPROACH:

The initial rebuilding plan proposed by the Fraser River Task Force (F.R.T.F.) in July 1988 recommends that harvest rates be reduced from current levels of 75-80% to 65-70% for all stocks. The experimental approach advocated here provides for additional harvest reductions to 50% on some stock groups to accelerate the rebuilding schedule and test hypothesis 1. There are 12 discrete "management components" that can be harvested more or less independently: the early, mid and late run-timing windows in each of the four cycle years. Off-cycle runs of cyclic stocks return during only 6 of these 12 windows: early 1986 and 1987 (Early Stuart), mid-1987 and 1988 (Horsefly and late Stuart), and late

1988 and 1989 (Adams) (Fig. 22). Only two of these, the late 1988 and mid 1987 components, were selected as suitable candidates for experimental reductions in harvest rate. The early 1986 and 1987 components were eliminated as candidates because the Early Stuart run is really a complex of different stocks that are difficult to study and atypical of other Fraser River stocks. Thus, information about rebuilding rates would be difficult to obtain and may not be applicable to other, more important stocks like Adams and Horsefly. The mid-1988 and the late 1989 components were eliminated as candidates because reductions in harvest rates on these components would be costly in terms of lost catches of dominant-cycle Chilko sockeye, and ood-year Fraser pink salmon, respectively.

Having chosen two suitable management components for experimental management, four alternative harvest policy options were defined as follows:

TABLE 3. PARTICIPANTS IN CYCLIC DOMINANCE WORKING GROUP

DFO PARTICIPANTS

Biological Sciences Branch:
Al Cass, Pacific Biological Station, Nanaimo.
Kim Hyatt, Pacific Biological Station, Nanaimo.
Ken Shortreed, West Vancouver Laboratory, West Vancouver.
David Welch, Pacific Biological Station, Nanaimo.
Ian Williams, Pacific Biological Station, Nanaimo.
Chris Wood (chairman), Pacific Biological Station, Nanaimo.

Fisheries Branch:
Al Gould, 3225 Stephenson Point Rd, Nanaimo.
Robin Harrison, 80 Sixth St., New Westminster.
Bill Masse, 80 Sixth St., New Westminster.
Wayne Saito, 80 Sixth St., New Westminster.

Program Planning and Economics Branch:
Kaarina McGivney, 555 W. Hastings St., Vancouver.
Russell Mylchreest, 555 W. Hastings St., Vancouver.

Salmonoid Enhancement Program:
Cam West, 555 W. Hastings St., Vancouver.

NON-DFO PARTICIPANTS

(*) **Jeremy Collie**, School of Fisheries and Ocean Sciences, University of Alaska, Juneau, Ak 99801.

Carl Walters, Resource Ecology, University of British Columbia, Vancouver, B.C. V6T 1W5.

(*) previously at the School for Natural Resource Management, Simon Fraser University, Vancouver, B.C.

Option 1) Base harvest rates (currently observed rates within cycles and stocks)

Option 2) F.R.T.F. harvest rates

Option 3) F.R.T.F. harvest rates plus 50% harvest rate on the late component of 1988-cycle years

Option 4) F.R.T.F. harvest rates plus 50% harvest rate on the late component of 1988-cycle years and on the summer component of 1987-cycle years

These options were evaluated with respect to a number of performance criteria based on predictions from computer models which incorporate different assumptions about the cause of cyclic dominance. The models and assumptions were:

i) the **"Ricker model"** - no biological interactions causing cyclic dominance
- all cycles have equal productivity (equal _a_ and _b_ parameters)
- model for hypothesis 1

ii) the **"Larkin model"** - as above but including explicit biological interactions between brood years
- general model for hypotheses 2 or 3

iii) the **"South Coast model"** - no explicit biological interactions causing cyclic dominance
- different cycles have different productivities (equal _a_ but unique _b_ parameters) to reflect the overall effect of suspected interactions.
- special model for hypotheses 2 or 3

Once an experimental harvest option is selected and implemented, run sizes of targeted stocks will be monitored to determine which model gives the best predictions about rebuilding rate. The rate of rebuilding will depend on which model is correct, and on how much harvest rates are reduced.

SIMULATION RESULTS: COMPARISON OF HARVEST OPTIONS:

Ability to Distinguish Among Hypotheses:

Ability to Detect Rebuilding: Statistical tests are required to determine whether observed increases in run sizes truly reflect a rebuilding trend because run sizes can vary enormously from year to year through chance variations in survival. By examining the typical variation in survival expected for a static (non-rebuilding) stock, it is possible to calculate the risk of concluding incorrectly that a stock is rebuilding when in fact it is not. Simulations including both optimistic and pessimistic levels of variability in marine survival were conducted to predict our ability to detect rebuilding under each harvest option.

Option 4 permits the accelerated rebuilding for several off-cycle runs (Adams, Horsefly and Late Stuart) whereas option 3 permits accelerated rebuilding for only one stock (Adams). Thus, after two generations of reduced harvest rates, the risk of concluding incorrectly that off-cycle runs can be rebuilt if in fact they cannot is only 6-19% for option 4 compared with 10-24% for option 3 (Table 4). Option 2 has no provision for accelerated rebuilding and the risk of drawing an incorrect conclusion remains relatively high after two generations (17-29%). In other words, researchers would be able to detect (with reasonable assurance) whether rebuilding was successful much more quickly under option 4 than under option 2.

Ability to detect suppression of dominant cycles: If off-cycle runs are rebuilt to levels similar to those observed in dominant or subdominant cycles, hypotheses 2 and 3 predict that production in the dominant year will be suppressed through biological interactions between consecutive year-classes. The time required to detect an impact of rebuilding off-cycles on the dominant year class was also estimated under each experimental harvest option. Again, suppression effects would likely be detected sooner under option 4 ($\geq$16 yr) than under option 3 ($\geq$40 yr), and much sooner than under option 2 (Table 4). However, in all cases, it would be many years before any suppression could be detected statistically.

Implications for the Fishery:

Catch: Reduced harvest rates under all three rebuilding options (2-4) will result in decreased catches during the first cycle (4 yrs) compared with catches at base harvest rates (option 1). The catch foregone during the first cycle is greatest with option 4 (Table 4). All models predicted that options 3 and 4 would require further reductions in sockeye catch during the first cycle of 200,000-300,000 and 600,000 pieces, respectively, over reductions originally proposed by the F.R.T.F. (option 2).

The catch projections indicate that cumulative sockeye catches over 40 years would be greatest with option 4 if either the Ricker or Larkin model is correct. The South Coast model projects similar cumulative catches for options 2, 3, and 4 because in this model off-cycle runs are assumed to have lower production potential than dominant-cycle runs.

Economics: An economic analysis of net present value (discounting the net wholesale value of predicted catches over the next 40 years) shows that both adaptive management options (3 and 4) provide very favourable returns if the Ricker model is correct and only small losses if the South coast model is correct. For

TABLE 4. COMPARISON OF ALTERNATIVE HARVEST POLICY OPTIONS. Catch and value figures indicate differences from base (option 1). Most favourable results are in bold print.

		OPTION		
CRITERION	**MODEL**	**2**	**3**	**4**
KNOWLEDGE				
Risk of wrong decision about rebuilding	optimistic pessimistic	17% 29%	10% 24%	**6%** **19%**
Time to detect any suppression of dominant cycle		?	>40 yr	**>16yr**
EFFECTS ON FISHERY				
Lost Catch in first 4 yr (millions)	Ricker Larkin S.Coast	**-2.9** **-2.4** **-2.8**	-3.1 -2.6 -3.1	-3.5 -3.0 -3.5
Cumulative Catch over 40 yr (millions)	Ricker Larkin S.Coast	151 80 73	167 81 70	**174** **91** **74**
Net Present Value ($ millions)	Ricker Larkin S.Coast	362 N/A 178	457 N/A 165	**462** N/A **165**

example, if the Ricker model is correct (i.e. no biological interactions limiting production), the net present value of option 4 is $100 million greater than for option 2 (Table 4). On the other hand, if the South Coast model is correct, the net present value of option 4 is only $13 million less than for option 2. The South Coast model predicts lower returns under option 4 than the Ricker model because it specifies that off-cycle runs will always be less productive than dominant cycle runs. The economic value of options 3 and 4 are similar under both models. It should be noted that there is, as yet, no statistical evidence favouring either the South Coast model or the Ricker model. In any case, all rebuilding options (2-4) showed definite economic advantages over the base option (1), regardless of the model used.

Other Factors: The required reduction in days of fishing opportunity was estimated with the short-term component of the South Coast model. Option 2 is expected to provide approximately the same duration of fishing opportunity as permitted in recent years. Option 4 would require a reduction in fishing time of about 20-30% over option 2 in 1987- and 1988-cycle years. However, fisheries of comparable duration have occurred in some recent years.

Summary of Results:

Collectively, these results indicate that option 4 is most likely to provide the greatest benefits from the perspective of economics, total catch, and especially knowledge about cyclic dominance. Option 4 also requires the greatest reduction in catch and fishing opportunity in the immediate future. However, all of the models considered here suggest that catch foregone in the first cycle would be more than compensated for by increased future catches.

SUB-COMMITTEE ADVICE:

1. An adaptive management plan for Fraser River sockeye salmon should be implemented to maximize knowledge gained in the near future about the causes of cyclic trends in sockeye abundance.

2. Harvest rates should be reduced to 65-70% for all Fraser River sockeye stocks with additional reductions to 50% or less for the late component of 1988-cycle years and for the summer component of 1987-cycle years (option 4). All the models considered predicted that this option would provide the greatest pay-off over the next 40 yr, especially of knowledge about the causes of cyclic trends in abundance.

3. Enhancement activities proposed for Fraser River sockeye should be reviewed to determine whether they will complement or defeat the objectives of the proposed adaptive management

plan. Enhancement could complement the rebuilding experiment in three ways:

i) directly, by accelerating the rebuilding of off-cycle runs;
ii) indirectly, by compensating fishermen for reduced catches in the first 4 yr resulting from harvest rate reductions; and
iii) as an experimental research tool to investigate possible biological limitations to production in off-cycle years.

However, enhancement could defeat the objectives of the proposed management plan if enhancement is directed at:

i) dominant cycles of stocks targeted for rebuilding in off-year cycles (e.g. enrichment of Quesnel Lake in 1990). This would tend to obscure any natural suppression of production in the dominant cycle caused by rebuilding the off-cycles; and
ii) dominant cycles of stocks that must be harvested together with off-cycle runs of stocks targeted for rebuilding if this enhancement precludes reducing harvest rates to 50%.

4. The Cyclic Dominance Working Group should be continued. Recommendations are required on:
   - escapement (or smolt) enumeration and stock identification programs needed to ensure reliable monitoring of stock rebuilding.
   - complementary research programs to identify potential biological limitations to production by off-cycle runs and/or environmental changes which could confound the assessment.

15. SOUTH COAST MANAGEMENT MODEL: THIRD ED. (Working Paper S89-9):

The South Coast Management Model was written because of requirements for simulation modelling which resulted from the signing of the Pacific Salmon Treaty (PST) in 1985. One of the chief reasons for signing this treaty was to obtain full control of sockeye stocks returning to the Fraser River, including setting escapement and enhancement policies. However, it was soon realized that changing these escapement and enhancement policies had many interactive effects with other salmon stocks which are harvested concurrently with the target Fraser sockeye stocks. These interactions were far too complex to be investigated by traditional methods. In this document, an overview of this simulation model is presented, giving its organization and the assumptions used in constructing the model code. As well, much information is given regarding file structure and names and locations of executable files, allowing the document to serve as a handbook for model operation.

The South Coast Management Model consists of three major sub-models: one (the Reconstruction Model) is primarily analytical in nature while the other two are meant to perform simulations under different time horizons. Of the two simulation models, one (the Short-Term Model) is designed to provide detailed simulations (within a single fishing year) of different management regimes overlaid over variations in assumptions regarding run size, timing, escapement goals, etc. The other simulation model (the Long-Term Model) is designed to provide predictions of long term effects of various management scenarios, by varying the assumptions regarding the implementation of enhancement and the productivity of the naturally spawning stocks. The Long Term Model also incorporates information on the economics of salmon harvesting and includes these data in its long term predictions.

RECONSTRUCTION MODEL:

The Run Reconstruction Model provides estimates of mean daily harvest rates, run distribution and run size that are used as a guide for input to the Short Term Model. This model uses historical catch, effort and escapement data in conjunction with assumptions regarding the migration path taken by the stocks and the speed at which they are moving through the fisheries to reconstruct the initial run size prior to fishing. The methodology used to reconstruct salmon runs has been in use for many years; however, it has only been recently described in detail in the literature (Starr and Hilborn, 1988). The equations given by Starr and Hilborn assume that all fish available at the time of fishing are equally vulnerable to fishing gear. However, the input data (primarily the catch data) provided at the time the model was written were only available by week of catch and simulation requirements required daily harvest rates. Therefore, the Reconstruction Model makes the assumption that some fish are only partially vulnerable to fishing gear so that daily harvest rates can be estimated from catch combined over a longer period. This assumption fundamentally changes the equations needed to calculate the underlying harvest rate when compared with those used by Starr and Hilborn.

Short Term Model:

This model is the reverse of the Reconstruction Model. It takes estimates of initial run size and run timing, combined with assumptions of migration routes, migration speeds, and daily harvest patterns to give catch and escapement by stock. The user can perform the following actions in each simulation:

1) create new stocks (e.g., an enhancement facility/this includes passive indicator stocks such as chinook which are taken incidentally in the target fishery);
2) change the expected size of the initial run size;
3) create a terminal fishery on any stock;

4) alter the fishing effort in any fishery (not fully implemented);
5) alter the number of days fishing in any week of the fishery;
6) alter the daily harvest rate in any fishery in any week;
7) alter the status of any stock (e.g., change from being actively fished to passively fished);
8) impose catch quotas (ceilings) on any combination of stocks in any fishery;
9) impose escapement quotas for any combination of stocks in any fishery.

Long Term Model:

The Long Term Model combines assumptions on annual harvest rates, annual diversion rates, and stock-recruitment functions to predict the effect of varying escapement goals, enhancement policies, and harvest policies in the long-term development of fisheries for Fraser River sockeye.

A major sub-model has been developed in conjunction with this model. As the harvest rates are only developed for the major (target) stocks, it was necessary to estimate the effect of harvest strategies on co-mingled but non-target (passive) stocks. The Vulnerability sub-model estimates this concurrent vulnerability by using the degree of overlap in the initial run timing curves. These estimates are used to calculate the size of the catch for the passive stock.

The Long Term Model also simulates scenarios that constrain the catch into predetermined allocations between gear types and between countries. Output from this model, in addition to the usual catch and escapement projections, includes estimates of the net present value of the chosen simulation.

SUB-COMMITTEE ADVICE:

The reviewers noted that full documentation of a complex model such as this one should include all of the following:

i) all input data and the underlying assumptions used in assembling that data;
ii) a full description of the algorithms used in the code, flow diagrams, and all assumptions; and
iii) a sensitivity analysis of the model to error and bias in the input data and to assumptions used to construct the model code.

Both reviewers commented on the fact that the document completely ignores any problems presented by the input data (which are treated as if they have no error). In general, the estimation of so many parameters from data containing known error, especially without any sensitivity analysis, can potentially invalidate all the model output.

Both reviewers felt that the presentation of the algorithms and the sequence of computations were the best parts of the document. One reviewer, however, pointed out that the coverage of both the Long and Short Term Models was inadequate for a full understanding of these models. In addition, both reviewers noted that the document alluded to intermediate analyses of data which were not documented. These analyses then became the bases of changes to data inputs or to model assumptions.

In short, both reviewers were unable to perform a complete scientific review of this model because this document was incomplete in its presentation of model input data, of model algorithms, of model output examples, and model sensitivity to errors of bias and precision in the input data.

The Sub-committee considered several alternatives when preparing advice on this document and the advice presented here stems from the sub-committee's opinion of the Department's requirements concerning this document. Approaching this document from the proposition that the Department requires a full record of all three of the steps outlined above (this is particularly important because different people assembled the data, others wrote the code, and still others are responsible for producing output), the Sub-committee recommends the following:

i) that the existing documentation be rejected on the basis of the reviewers concerns, particularly with regard to input data problems.
ii) that the documentation be expanded to include documentation for all input data and accompanying assumptions, all algorithms and other computations, and any accompanying analyses used to modify or simplify the input data or computations.
iii) that the code be evaluated and sensitivity tests be done on parameter estimates to test the effect on model output.

Departmental who provided the input data must be required to document the data sources and analyses conducted before providing the data for inclusion in the model. Further, the Sub-committee strongly advises that users of the model must establish confidence in it; however, it appears that credibility among end users is inadequate at this time. Credibility can only be achieved through additional documentation, and verification of input data and the model code. Confidence must come with use and evaluation of the model. For the Department to be a responsible user of this model, a qualified long-term employee must be identified who will take over this model. This person should be a user of the model so that they have a need and interest in the model, must be able to understand the code, and must be competent to evaluate the model, its results and interpretation.

16. OVERVIEW OF METHODS AND ISSUES IN THE GSI PROGRAM FOR SOUTHERN B.C. CHUM SALMON (Working Paper S89-14):

The objectives of the South Coast chum genetic stock identification (GSI) program are two fold; to determine chum salmon interceptions of American chum salmon in Canadian fisheries, and to increase knowledge of migration timing and routing of chum salmon, and thereby improve domestic management.

GSI has been used in the southern B.C. chum fisheries since 1982. The GSI methodologies developed since this time include approved sampling regimes, lab techniques, and computer analyses. However, there are some outstanding issues. For managers, the most important issue deals with interpretation of the stock compositions from GSI. How can the estimates be used given the current level of accuracy and precision? What level of precision is required to meet the objectives of the program? There are several more issues regarding estimation procedures used in GSI analysis, including the potential level of discrimination between stocks (e.g. Canada:U.S. or Fraser:non-Fraser:U.S.), the composition of the reference baseline, and the cost and benefit of increasing the number of loci used in the analysis.

Some of these issues are the current focus of work in the international forum. Current GSI methods use 7 loci. Simulations conducted by Canada suggest that GSI estimates are sensitive to the stock composition of the reference baseline, including the number and selection of stocks in each group. The least biased 7-loci baseline for southern B.C. chum fisheries most nearly reflected a preconceived notion of the actual stock composition in that it included relatively few American stocks. Also, it was concluded that the accuracy in estimating small stock components (e.g. less than 15 per cent) is inherently poor. It is not yet apparent that using 21 loci will improve the accuracy and/or precision of the results to the extent that they will be more useable to managers. Additional computer simulation studies are planned for 1989 to determine the costs and benefits of using 21 loci in GSI analysis.

The variability of GSI results has become a concern to fisheries manager. While results on a seasonal scale are broadly consistent with independent assessments (e.g. fisheries manager experience, run reconstruction, and mark recovery), individual sample estimates show considerable variation and often vary significantly from manager preconceived notions of stock composition (e.g. Table 5). As a result the GSI results are often viewed with skepticism. Guidance is required on how to properly use the estimates given the large degree of variation.

In summary, the GSI technique is being used extensively to determine stock composition. However, the results are not completely accepted, and cannot yet be applied with confidence to broader aspects of chum assessment and management. A consistent methodology is required for application of the results to chum management. For example, how should estimates of interceptions incorporate the error term? And how should the stock composition estimates be used to determine interceptions? If weekly estimates are too variable perhaps samples could be pooled over a 2 or 4 week period, or perhaps estimates over several years should be pooled to get an average estimate for a weekly period.

The chum GSI program is currently at a crossroad; on one side, there is pressure from the Washington Department of Fisheries for a more intensive program with greater sampling effort and analyses using 21 loci, while on the other side, some reluctant DFO managers are reflecting on apparent limitations of the technique. Determining a future direction for the GSI program for southern B.C. chum will require resolution of the issues and problems identified in this paper.

TABLE 5. COMPARISON OF GSI ESTIMATES OF STOCK COMPOSITION FOR REPLICATED SAMPLES FROM JOHNSTONE STRAIT TEST FISHERIES IN 1988. None of the replicated estimates except those for the U.S. component in the October 23-29 samples can be considered significantly different owing to the wide 95% confidence intervals for the estimates (roughly ± twice the estimated SD in parentheses). JSt tfv1 and tfv2 indicate Johnstone Strait test fishing vessels 1 and 2.

			Stock Composition, percent (SD)		
Period	Fishery	Sample Size	Fraser	Jst/Gst	US
Sep 19-24	JSt tfv1	150	35.0 (17.6)	53.4 (17.7)	11.6 (9.7)
Sep 19-24	JSt tfv2	150	35.8 (19.4)	47.5 (17.0)	16.8 (8.0)
Sep 28-30	JSt tfv1	150	53.6 (16.6)	46.4 (16.8)	0.1 (2.3)
Sep 28-30	JSt tfv2	150	45.4 (18.9)	50.6 (18.0)	4.0 (4.5)
Oct 02-08	JSt tfv1	150	36.4 (15.9)	61.0 (15.6)	2.7 (3.2)
Oct 02-08	JSt tfv2	150	42.5 (17.2)	57.4 (17.1)	0.1 (2.2)
Oct 09-12	JSt tfv1	75	12.0 (15.0)	83.8 (15.8)	4.2 (7.3)
Oct 09-12	JSt tfv2	75	13.8 (16.1)	74.9 (18.4)	11.4 (10.)
Oct 16-19	JSt tfv1	150	20.9 (14.2)	77.2 (14.1)	1.8 (2.4)
Oct 16-19	JSt tfv2	150	40.5 (16.1)	55.0 (17.4)	4.5 (4.5)
Oct 23-29	JSt tfv1	150	41.8 (14.8)	58.1 (14.5)	0.1 (2.8)
Oct 23-29	JSt tfv2	150	28.4 (15.6)	44.4 (14.0)	27.1 (10.)

SUB-COMMITTEE ADVICE:

Managers have good reason to be concerned about the interpretation and application of stock composition estimates for chum salmon catches based on GSI methods. The authors pointed out high variability between individual catch samples (e.g. Table 5), bias introduced depending on baseline samples used, and concerns that this variability might result from non-random sampling of catches. However, both reviewers indicated that this variability is to be expected owing to inadequate genetic differentiation among the baseline stocks, as evident from the bootstrap estimates of standard deviations. Thus, individual estimates using current procedures must be interpreted with caution; in particular, estimates of U.S. contributions (typically <15%) will tend to be positively biased and may have little utility for assessing interception rates for weekly samples. Both reviewers recommended additional simulation studies to determine the cause of discrepancies between the bootstrap estimates of standard deviations and standard deviations computed from replicated samples. One reviewer suggested that the bootstrap estimates were probably correct and that estimates from replicated samples may be biased owing to the use of non-representative reference samples. This may indicate a potentially serious problem with current methods and warrants thorough investigation.

Both reviewers suggested ways that accuracy and precision of stock composition estimates could be improved. The most obvious way is to increase levels of genetic differentiation by assaying more loci. This would be expensive and, as yet, there is no assurance that increasing the number of loci from 7 to 21 would be sufficient to give satisfactory results. Simulation studies are required to determine the costs and benefits from assaying these additional loci.

Both reviewers also suggested that "problem" stocks (i.e. stocks that resemble each other genetically but occur in different management groupings) could be deleted from the analysis to improve the accuracy of stock composition estimates. GSI methods are unsatisfactory for these stocks, so that other methods (run reconstruction, professional judgements, etc.) should be used to estimate their contribution independently of the GSI analysis. Estimates from GSI analysis could then be "renormalized" so that the estimated proportions for all stocks, including the problem stocks, sum to one. One reviewer recommended further study of the effect of baseline composition, with careful attention to clustering patterns based on genetic differentiation; he suggested that baseline composition would only be a serious issue where genetic clustering patterns conflicted with management groupings.

The Sub-committee recommends:

i) simulation studies be initiated to resolve apparent discrepancies in the variability of stock composition estimates from replicated samples compared with those from bootstrapping procedures.
ii) simulation studies be initiated to determine the benefits and costs of using additional loci to meet domestic and international objectives.
iii) alternative procedures be investigated to obtain unbiased estimates of U.S. contributions to Canadian chum catches.

iv) a similar overview of pink salmon GSI be undertaken since similar issues and problems are likely to arise.

17. PROGRESS REPORT ON THE STATISTICAL ANALYSIS OF SALMON MARK-RECOVERY DATA (Working Paper S89-20):

Work in progress on the statistical analysis of coded-wire tag (CWT) data for salmon is described. An appendix to the paper contains a manuscript submitted for primary publication. This summary provides a summary of three areas of research which are discussed at greater length in the working paper.

BIAS IN CWT ESTIMATES OF HATCHERY RETURNS:

This study compares two methods of assessing the number of salmon that return to their hatchery of origin. One method involves direct counting, while the other is based on fish marked with CWTs. To compare these methods, we have devised a statistical model that allows error in each measurement. Our model, based on a classical errors-in-variables model, specifically includes parameters associated with the relative bias between the two measurements. This errors-in-variables bias model has general applicability, because it could be used to compare two measurements of the same phenomenon in any context. We have developed a full statistical theory for the model, including analytical formulas for confidence intervals that are exact when the error lies in one variable alone and approximate otherwise.

As a result of our analysis of data from six B.C. hatcheries, we conclude that CWT estimates are lower than corresponding counting estimates for coho and chinook returns. We find no compelling evidence that this bias is greatly influenced by hatchery or species, with the exception of Robertson Creek chinook. For the remaining cases combined, the CWT estimates are approximately 22% lower than the counting estimates. Furthermore, this systematic component of error is roughly as large as the random component present in one or both of the methods of measurement.

MULTIPLE MARKING STUDY:

One direct consequence of the work described above was the initiation of an experiment to identify the mechanism responsible for the observed bias. To pinpoint the cause, it is necessary to mark hatchery fish by more than one method. For example, if all fish from a given hatchery were marked before release, then upon their return one could check for the incidence of straying wild fish into the hatchery. In addition, if CWT marked fish also had an additional mark (i.e., in addition to the clipped adipose fin), then returning fish with missing adipose fins could be segregated into the group which had been CWT marked, and the remaining group with naturally missing adipose fins. Thus, the use of multiple marks within a hatchery provides additional information needed to discriminate among some of the potential causes of the bias detected.

This past year we initiated work on marking chinook chemically. A pilot study was begun to make sure that the past results from work with sockeye and coho would also apply to chinook. Two chemical elements, strontium (Sr) and manganese (Mn) were chosen because of their successful past performance. Growth, mortality and retention of the element in the scales was monitored and compared with fish that had been fed a normal diet. A primary paper is planned that will present these results in detail. Our conclusions from this initial pilot study are:

1) Manganese is not an acceptable marking element for chinook salmon, as it has a significant detrimental effect on growth and survival.

2) We still need to find at least one additional mark to use for the multiple marking experiment.

3) Strontium appears to be a useful potential chemical marker for chinook.

4) New techniques of chemical analysis have changed the potential application of chemical marking for hatchery salmon. This method of marking salmon may now be a viable alternative to the current methods of tagging and fin clipping. Further work is under way to investigate this potential.

EMBEDDED REPLICATE TAG CODES:

This study concerns the statistical utility of newly designed tag codes, commonly called imbedded replicates. These involve the use of multiple codes repeated serially on a single roll of tagging wire. If fish are chosen randomly for tagging, then a group of fish tagged from such a roll will have the codes distributed randomly among them. Thus, without changing the mechanics of tagging, it is possible to imbed several codes within a population, rather than just one. The incremental costs are relatively minor, associated with (1) producing wire rolls of imbedded codes and (2) spending extra time in the decoding process.

Because of its simplicity, the idea is alluring. We seem potentially to have increased the information content from a tagging study with minimal extra cost. When the tags are recovered, we can now obtain several estimates (one for each imbedded replicate) of any quantity of interest. Thus, not only can we estimate the quantity itself (as with a single code), but we can also obtain an empirical measure of variance in our estimate. Since variance formulas for tagging parameter estimates are notoriously complex, we seem to have found a trivial solution to an otherwise complex statistical problem. In any case, we apparently can't lose anything by the method, because we can always obtain the usual estimate by treating imbedded replicates as a single code. Unfortunately, on deeper analysis, this hope for an easy variance estimate turns out to be illusory. The fundamental problem with imbedded replicates is that they are not true statistical replicates. In any experiment, some factors are deliberately controlled, while others are uncontrolled or even unknown. The purpose of replication is to identify variability associated with the uncontrolled factors. Thus, replication consists of repeated, independent experiments subject to the same controls. An experiment with imbedded replicates, however, is still only one experiment without repetition. In this case, a single population is merely divided at random into a collection of subpopulations. Each subpopulation is exposed to the identical set of factors, both controlled and uncontrolled. Thus, imbedded replicates do not constitute independent experiments. Imbedded replicates can do no more than verify the laws of chance. Either imbedded tag codes are distributed randomly among the recoveries or they are not. If they are, nothing new is learned. If they are not, then, by the very design of the experiment, we cannot give a reason for the departure from randomness. It makes sense to use multiple tag codes only in contexts where true replication is possible, such as the use of different codes for fish reared in different ponds.

SUB-COMMITTEE ADVICE:

This report is a continuation of work reported at the March, 1988 Sub-committee meeting and a preliminary report of the mass marking experiment recommended by PSARC last year. Both reviewers commented that this report contained essential information for users of the coded-wire tag data but questioned why the authors had not presented any recommendations about how to apply their results. Each reviewer supported the conclusion that a serious bias exists in the determination of escapements at hatcheries based on expanding coded-wire recoveries. The impact of this finding depends on the source of the bias but clearly emphasizes the immediate need to evaluate the alternatives causes and the development of mass marking methods to test these alternatives. They also suggested that the experimental design to be used to evaluate the alternative sources should be reviewed by a Regional group before initiation of the experiment. A number of concerns were expressed about the experimental procedure and a Regional review may prevent future debate about the outcome of the investigation. The reviewers also felt that the arguement against embedded replicate tags was lucid and again questioned why the finding was not emphasized as a recommendation. One reviewer suggested an immediate stop to using these replicates as their use could provide very misleading measures of variance.

Following from these reviews, the Sub-committee recommends:

i) that an immediate warning about the use of replicate tags as a measure of variance be issued in the Region and that Dr. Schnute be directed to complete publication of his work as quickly as possible to increase the scientific peer review of this important result;

ii) that programs to develop alternative marks for hatchery chinook and coho be continued and co-ordinated under one investigation within the Science Branch; and that this group co-ordinate the design and execution of an experiment to evaluate the possible causes of the reported bias (this design might be submitted to PSARC to ensure the Regional acceptance of the design as recommended by the reviewers); this experiment must receive high priority in future funding allocation processes;

iii) that a summary of information from the coded-wire tag bias study be distributed in the Region to inform persons involved in fisheries management using coded-wire tag data and/or persons involved in stock assessments (hatchery and wild stocks).

18. INCORPORATING PRE-SEASON FORECASTS INTO WITHIN SEASON ABUNDANCE ESTIMATES (Working Paper S89-21):

This paper serves two purposes. First and foremost, a simple nonparametric model is proposed for estimating total run size given observed inseason data. The model adopts a probabilistic approach and does not require the user to specify whether the relationship between run size and the explanatory variables is linear or nonlinear. The model implicitly incorporates information on run timing and can easily be modified to explicitly account for variations in run timing. In simplistic terms, the model can be thought of as the extension of commonly employed histograms (possibly multivariate) where the data have been discretized to the situation where the variables are treated as continuous. The statistical theory behind the model is presented as well as various practical aspects associated with estimating the model parameters and generating within season estimates of abundance.

The second result presented is a simplistic approach for combining pre-season forecasts of run size and within season estimates of abundance. The proposed approach examines the relative accuracy of the pre-season and within season forecasts and assigns weights to each on the basis of their relative performance. The weight assigned to within season estimates of abundance gradually increases as the season progresses. The proposed method of assigning weights to each of the forecasts is likely sub-optimal but until more information about the statistical properties of the pre-season and within season forecasts are known, the proposed approach will probably work at least as well as alternative ad hoc procedures.

Data from the Skeena River sockeye salmon fishery are employed to test the utility of the nonparametric within season forecasting model and the procedure for combining pre-season and within season forecasts. Although not a definitive study, the within season model provided an objective and repeatable method of generating believable estimates of run size.

RECOMMENDATIONS FROM WORKING PAPER:

Accurate records of the actual within season estimates of abundance and the methodology used to generate these forecasts must be kept in order to evaluate the relative performance of proposed forecasting schemes. Without this information, it is impossible to identify which model or group of models should be used to forecast run size. Where possible, an effort should be made to collect and document this information.

SUB-COMMITTEE ADVICE:

This paper presented an alternative forecasting model which reduces the need to make assumptions about the statistical distributions underlying the data and one which will reduce the impact of outliers in the data. The reviews supported the procedure as a sensible and practical treatment of the data, however, one reviewer expressed concern about the practical acceptance of such a model by fishery managers. However, use of this model should be encouraged as it incorporates available data into a logical decision framework and provides a repeatable procedure to do so.

This procedure should be considered as an alternative estimation procedure but the Sub-committee recommends that a test situation be developed so that alternatives can be evaluated. The Sub-committee endorsed the recommendation presented by the author, such documentation will be required to evaluate the alternative models. The committee did not recommend a specific fishery within which to evaluate the models since this will be rely heavily on the willingness of the individual manager. However, if interest is expressed in establishing such a test then Dr. Noakes should be requested to provided user documentation for the computer programs.

19. ACCURACY AND PRECISION IN STOCK IDENTIFICATION OF FRASER RIVER SOCKEYE (Working Paper S89-22):

The accuracy and precision of Fraser River sockeye was assessed using the maximum likelihood (mixture) model as developed by Fournier et al. (1984). The principal data used in this analysis were scale circuli traits. Scale circuli traits were historically used to allocated the catch of Fraser River sockeye to individual stocks (Henry 1961). This study is part of a review of Fraser River sockeye data used in resource assessment.

DATA SOURCES:

The principal data used in the present analysis are the numbers of circuli and the distance or width between circuli in the freshwater and spring (plus) growth zones of scales collected from the commercial fishery and the spawning grounds. All data were for age 4_2 sockeye (i.e.sockeye that are four years old and went to sea after one year in freshwater). Data from the commercial fishery analyzed in this paper were from the 1981 Salmon Banks purse seine fishery. All scale impressions were provided by the Pacific Salmon Commission from historical records maintained from the previous International Pacific Salmon Fisheries Commission.

Scale circuli counts used (number of circuli in the freshwater zone and the plus growth zone) were provided by the Pacific Salmon Commission. Additional scale measurements were made by Departmental staff. Five additional parameters were measured and when combined with the circuli counts; these seven traits are referred to as the expanded trait set.

ANALYTICAL PROCEDURES:

Three steps were used to assess the accuracy and precision. In the first step, the mixture model was run using data for circuli counts only. The reference sample contained data for all 23 spawning ground samples collected in 1981. These runs were used to identify the principal stocks and the associated precision of the estimated stock proportions in the mixture samples from the commercial fishery. Both the reference sample and the mixture were randomly resampled (bootstrapped) to simulate sampling error. For each mixture of unknown stock composition 100 simulations were performed and the mean and 95% confidence intervals for the stock proportions calculated.

In the second step, Monte Carlo simulations were performed to measure the accuracy and precision in simulated data with known stock composition. For each of the principal stocks identified in step one, 100 mixtures of known proportion were randomly selected from the range of all possible integer proportions between 1% and 100%. A single stock composition estimate was calculated for each of the 100 known mixtures using the maximum likelihood (mixture) model. The reference sample and the mixture sample were both resampled to simulated sampling error. The total sample size in each of the simulations was held constant at 200 fish; a level comparable to sample sizes in sample sizes from the commercial fishery. A simple linear regression was fit to the simulated data to examine the relationship between the true and estimated stock proportions. Estimates of bias and precision were evaluated at different levels of stock groupings based on the clustering of stocks in similarity dendograms. The second step was repeated to measure the effect of a fewer number of stocks in the reference sample and the effect of including the additional scale measurements on accuracy and precision.

The third step assessed the effect of mixture sample size on accuracy and precision. Following the procedure of Wood et al. (1987), reference samples were generated without error to simulate infinitely large samples. Mixture samples of increasingly smaller sample sizes were generated. The proportion of each stock in the mixture was held constant. The accuracy and precision for each mixture was evaluated from the mean and variance of 100 Monte Carlo simulations.

RESULTS:

With one exception, the principal stocks present in the 1981 Salmon Banks fishery based on a 23 stock reference sample generally agreed with the historical record. For the dominant stocks, 95% confidence intervals of plus or minus two times the mean proportion were not uncommon.

With a reference sample of 23 stocks and known mixtures of nine stocks, the estimates of stock proportions are negatively biased at the unit stock level. The bias, averaged across all stocks in the simulations was 32% (range=14%-47%). At the next level of stock grouping, as determined from the similarity dendogram, the bias decreased to 20% (range=10%-42%).

With a reference sample of 12 and known mixtures of 5 stocks, the resolution of stocks in problem clusters is not improved by reducing the number of stocks in the reference sample. Improvements are gained, however, where stocks with similar traits are excluded through implicit assumptions about run-timing. A comparison of the estimated stock proportions in the August 9, 1981 Salmon Banks fishery using a 12 stock reference sample shows little improvement in precision of the estimate compared to using a 23 stock reference sample (Fig. 23).

Simulations using the expanded trait set resulted in a minor improvement in the accuracy of the estimated stock proportion. Simulations with a 23 stock reference sample and the additional scale traits resulted in bias of 29% (range=3-44%) compared to 32%

for the two trait samples at the unit stock level. Improvements in the precision of the estimate were much greater. At an estimated stock proportion of 50% the 95% confidence interval was ± 29% (range=± 10-40%) of the true proportion compared ± 52% for the two trait samples.

The number of fish per stock in mixture samples improved both the accuracy and precision as sample sizes increased from 25 fish to 100 fish. Increasing the samples sizes beyond 200-300 fish had little effect on accuracy and precision.

DISCUSSION:

Accurate and precise estimates of the stock composition in catches of Fraser River sockeye are particularly important at this time. Stock rebuilding plans for Fraser River sockeye are in the final stages of development and monitoring of catches will play a major role in measuring the response of rebuilding as well as providing accurate and precise estimates of exploitation rates. As minor runs increase in abundance the number of important stocks in the fishery may increase thus complicating stock identification problems. A continuation of studies to evaluated annual variability in accuracy and precision in stock identification of Fraser River sockeye based on historical data is warrented but investigations to improve stock discrimination, using parasites and/or morphometrics, are probably necessary to achieve better accuracy in stock identification of the major unit stocks.

SUB-COMMITTEE ADVICE:

This paper begins to address an important issue concerning how well stocks of Fraser River sockeye salmon can be identified by scale pattern alone. Scale pattern analyses have been used to allocate catch to stocks since 1948 and the results of these analyses directly influence our assessments of stock productivities and exploitation rates. Only very recently have people begun to evaluate how accurately these historical allocations of catches were and how errors may influence our interpretations about stock dynamics. These analyses are difficult because of the numerous factors which can cause error in the estimates of a stock composition.

The response to this paper by the two reviewers differed substantially. One reviewer identified an error in how the simulations were run to estimate the bias in estimating the composition of a known mixture, but generally accepted that there are significant limitations to how well sockeye stocks could be identified based on scale pattern alone, and that there is a positive bias when trying to estimate small contributions from a stock. The error identified will reduce the magnitude of the negative bias reported in the paper. This reviewer also offered two suggestions of how to reduce the positive bias for small stocks:

a Baysian approach of assigning a priori probabilities to the presence of a stock in the mixture, possibly on the basis of run-timing information; or through a heuristic method of imposing a lower limit for a stock's contribution and then reanalyzing the mixture without the stocks below this limit.

The second review was a thorough examination by staff of the Pacific Salmon Commission. The essence of their comments was that the conclusions drawn from this analysis were misleading and under estimated the value of scale pattern analysis for Fraser River sockeye. They were concerned that the conclusions drawn exceeded the analyses since the 1981 cycle year is a particularly difficult set of stocks to resolve; results from the 1981 cycle should not be extrapolated to the other three cycles. Further, they reported that the Commission was undertaking similar studies and that their results did not support the limitations indicated in this paper. Several technical points were presented which can be addressed by the author.

Overall the Sub-committee was concerned that this assessment of the stock identification based on scale characteristics showed such limitations in accuracy and precision. However, they (and the author) also acknowledged the concerns presented by the Commission about generalizing these results to other cycle. The committee recommends, therefore, that examination of other years of data be continued and results reported. The committee also recommends that greater communication be developed between the Commission and Department analysts but that we maintain an independant assessment of the historical data. The issue of over-estimating the contributions from small stocks has significant ramifications on our interpretations of cyclic dominance and on opportunities for rebuilding small stocks of Fraser River sockeye salmon. The development of accurate stock identification techniques is essential to the evaluation of the Department's objective of increasing Fraser sockeye production and examining the causes of cyclic dominance.

20. AN EVALUATION OF OPTIMAL STOCK SIZE STRATEGIES FOR ADAMS RIVER SOCKEYE (Working Paper S89-26):

The number of adult sockeye salmon returning to the Adams River varies from several million to only a few hundred adults over a four year cycle. The cause of this cycle remains uncertain. One hypothesis is that biological mechanisms that might supress production in the subdominant years because of high egg and smolt production from the dominant brood year. We developed a new stock-recruitment model with a between-year density-dependent regulatory term and fit it to the Adams River sockeye data. This model has fewer parameters than the other model used to describe cyclic dominance (the Larkin model), yet appears to fit as well. Estimation of the model's parameters indicates that strong between-year density-dependent interaction may indeed occur in this stock.

An unstated assumption in biologically-based hypotheses is that maximum production is obtained by holding the returns in roughly the current cyclical pattern. Mathematical examination of this assumption shows that this assumption is false for our model no matter what level of interaction is present, and that maximum production should always be achieved by choosing an equal escapement policy. This will not only maximize the biological production from the system, but also stabilize annual catch as the level of returns become more even across the cycle.

Despite the evidence that there is significant between year density-dependent interaction, the statistical uncertainty in these estimates is extremely large, and will remain so for many years. Even large fluctuations in recruitment within cycle lines is small compared to the between cycle line differences in mean recruitment levels, because of the amplitude of the current 4 year cycle. This sets fundamental limits on our ability to statistically resolve the level of density-dependent interaction unless recruitment levels increase in the sub-dominant years.

Until returns in the low years of the cycle are raised by 1 or 2 orders of magnitude, stock densities will be insufficient to allow clear-cut evaluation of the level of interaction present. If current parameter estimates are correct, recruitment increases as high as those expected by the Fraser Task Force may not be possible. We stress, however, that the intrinsic uncertainty in parameter estimates based on current data for the Adams stock are so large that an informed decision cannot currently be made, and estimates of the level of interaction are also probably biased upwards. The possible benefits of increasing recruitment therefore clearly outweigh the risks. At worst, the gain from equalizing escapement across all years of the cycle will be only a small increase in total catch and a stabilization of annual catch levels. This in itself would have significant economic benefits. The potential benefits are much larger if the level of interaction is in fact low.

We therefore recommend support for: (1) improved monitoring of the off cycle runs to identify whether significant interactions are occurring as quickly as possible, (2) field experiments designed to reject some of the possible biological mechanisms (for example, increases in predator abundance in years following the return of the dominant run), and (3) analytical work on the effects of between year density-dependence on the rate of population rebuilding, in order to better assess the potential for between year interactions to disrupt the benefits of planned rebuilding efforts.

SUB-COMMITTEE ADVICE:

Both reviewers acknowledged that the model was novel and merits further examination. However, both reviewers identified concerns about mathematical interpretations and recommended further analyses. This is particularly important given the conclusion by the authors that the optimal escapement strategy is to have equal escapements in each cycle year, obviously a substantial deviation from the existing strong cycle returns. Given the concerns identified by the reviewers, the Sub-committee could only recommend that the authors re-examine their work. Once the comments of the reviewers have been addressed this model should be considered by the Cyclic Dominance Working Group as an alternative model of rebuilding in the Fraser sockeye stocks.

The discussion of this paper identified two major issues in evaluating the rebuilding of Fraser River sockeye. First, errors in assigning catch to small stocks, as identified in chapter 19 of this report, may mislead the Department in believing that small cycle abundances can increase rapidly if the high fishing pressures are alleviated. This interpretation is derived from the estimated high productivity of these stocks and the high exploitation rate on them. Accurate stock identification methods and improved escapement monitoring on these low cycle stocks will be required to evaluate this concern. If these small stock or cycle returns are simply due to statistical errors then proving this error actually provides more support for a biological basis for cyclic dominance. Secondly, Dr. C. Walters revealed that an error in his previous (and his co-workers) calculation of the Ricker 'a' value when combining the four cycles within a stock generates a substantial positive bias for the productivity value. Correcting this error will substantially reduce the number of recruits expected, increase the optimal spawning stock size, and prolong the rebuilding rate. Dr. Walters is working to evaluate the magnitude of this bias. However, in the interim the Departmental staff working on the Fraser River sockeye rebuilding plans should be cautious in their projections of stock rebuilding benefits and evaluate the impact of this bias.

SUB-COMMITTEE COMMENTS ON FORECASTING

The Sub-committee noted that a major objective of the stock assessment process was to provide predictions of return abundances for the next fishing year (i.e. forecasts). However, of the stock assessments presented this year only two forecasts (Fraser River pink and Barkley Sound sockeye) could be considered to have a documented and rigorous methodology. For the remaining stocks, forecasts were either not presented, concensus was not achieved on the methodology, or the documentation was inadequate to evaluate the basis of the forecast. Specific concerns discussed by the Sub-committee included:

i) that in several stocks arguments are presented that stock and recruitment relationships are curvilinear, but when forecasts are presented the non-linear relationship is forgotten. Frequently, an average return per spawner is simply multiplied by the brood year escapement and expected age composition of the return to provide a forecast. This procedure has been applied even when escapements exceed the estimated optimum escapement and we would expect the return per spawner to begin to decrease;

ii) the frequent presentation of a point estimate for the forecast without any recognition of the uncertainty in the data used to develop the estimate. Confidence limits about the estimate should also be presented when they can be calculated, or at least a range of estimates could be presented based on varying assumptions about the data;

iii) the use of subjective adjustment factors to account for environmental variations or to allow for "expert judgement" in a forecasting decision. The use of these factors reduces the likelihood of repeatable forecasting methodology and precludes the calculation of confidence limits about the forecast;

iv) recent interests in using oceanographic parameters to improve forecasts but, in some cases, a rather informal process involved in evaluating alternative procedures before a new procedure is applied; and

v) the need to establish and evaluate the forecast methodologies being used for each major salmon stock, and to encourage the examination of new and/or alternative methods.

To address these concerns, the Sub-committee recommends that:

a) assignments be made to each Division of Fisheries Branch to prepare working papers, for the autumn 1989 Sub-committee meeting, which document the forecasting methods used for each major salmon stock in their geographic area; and

b) a Regional workshop, to be held through PSARC, to review and evaluate the existing methods, examine alternative ones, and to instruct persons developing the forecasts. This instruction should include estimation procedures for each method, how to evaluate alternative methods, calculate statistical confidence, and annually document the forecast presented. This workshop could be held in conjunction with the autumn 1989 meetings of the Sub-committee.

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Figure 9. Catch distribution of Fraser River hatchery coho stocks for catch years, 1985 to 1988. Key to fisheries: NWTR - Northwest Vancouver Island troll, SWTR - Southwest Vancouver Island troll, GSTR - Georgia Strait troll, Inside Net - Johnstone St., Georgia Strait, Juan de Fuca and Fraser River net, GSSP - Georgia Strait sport.

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Figure 22. Management components for Fraser River sockeye by cycle years and run timing groups. Size of the type reflects the size of the cycle run (large type = dominant runs in the cycle and run timing strata).

Figure 23. Stock proportions and associated 95% confidence intervals for Fraser River sockeye estimated from the August 9, 1981 mixture sample from the Salmon Banks seine fishery based on (a) a 23 stock reference sample and (b) a 12 stock reference sample.

Fraser River Pink Salmon Prediction

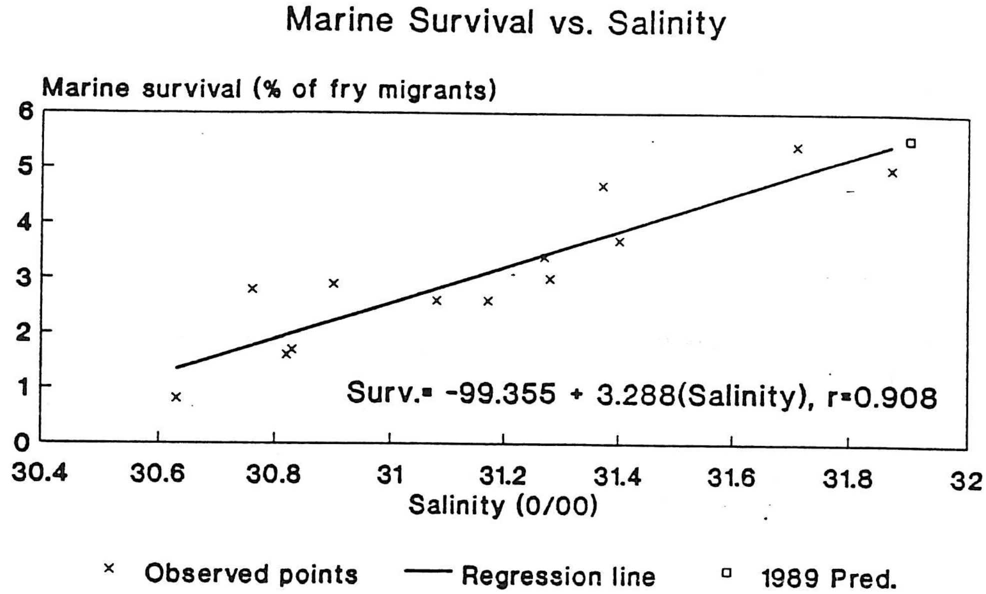


Figure 1a

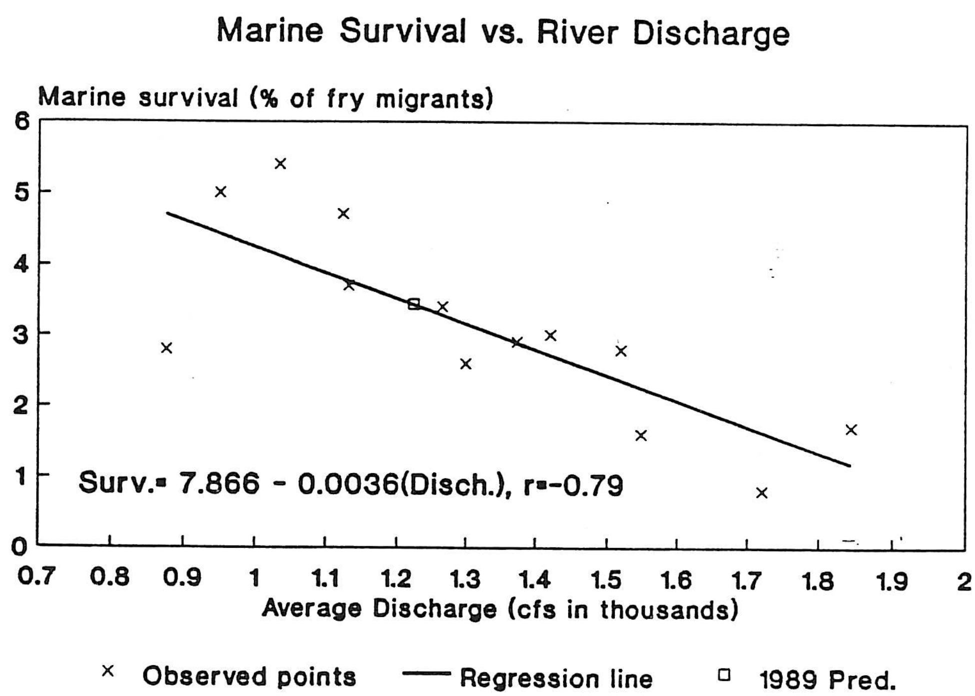


Figure 1b

Historical Escapement of Lower Georgia Strait Chinook & Catches in Fisheries Which Harvest LGS Chinook

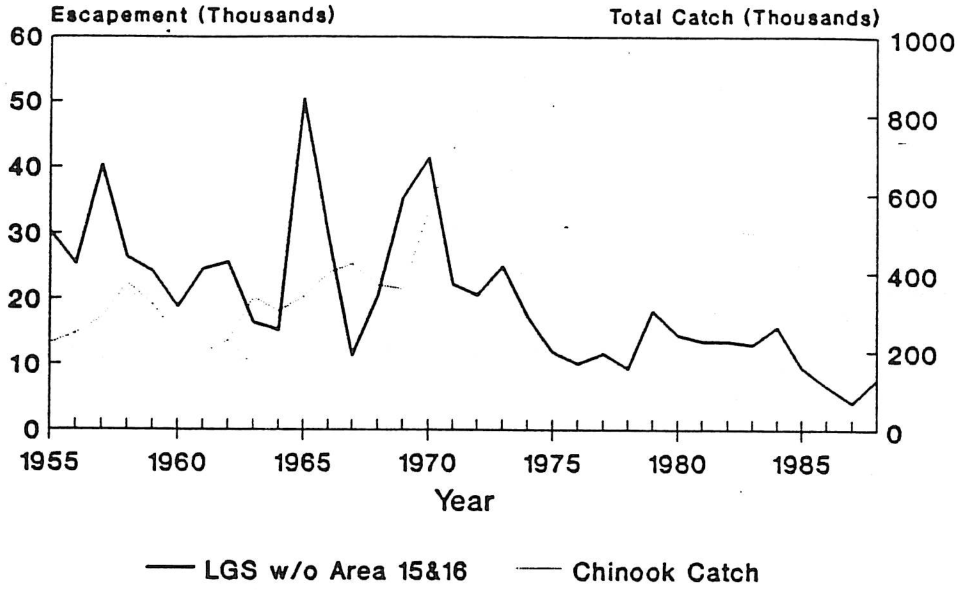
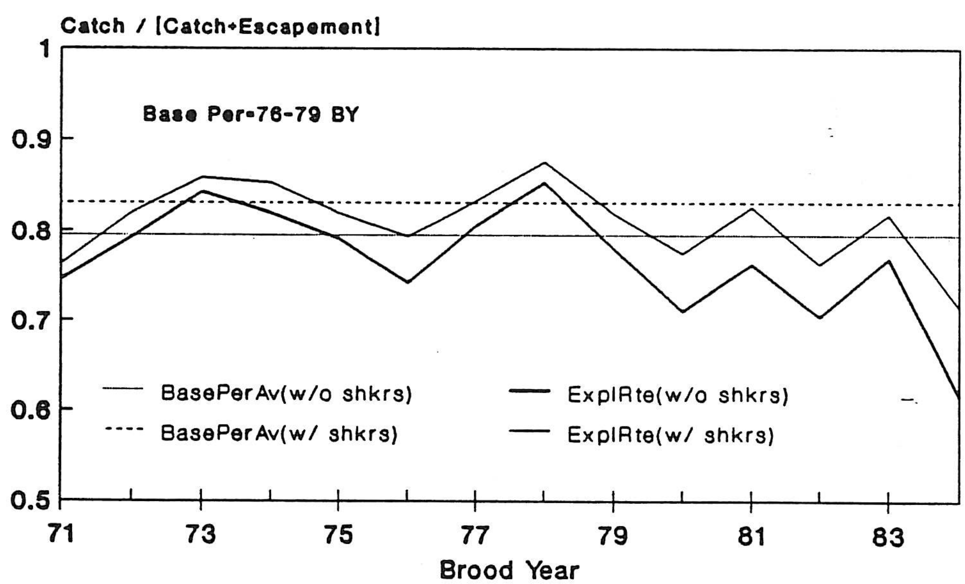


Figure 2

BQR Chinook
Brood Year Exploitation Rates (from CWT Analysis)



All catches (including shakers) are in adult equivalents.

Figure 3

Exploitation Rate Analysis
Big Qualicum Chinook

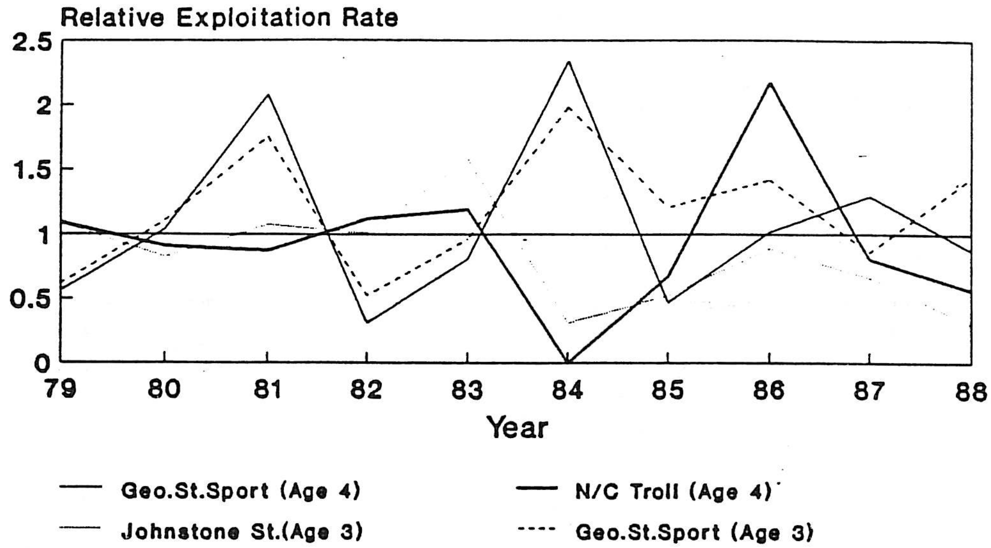
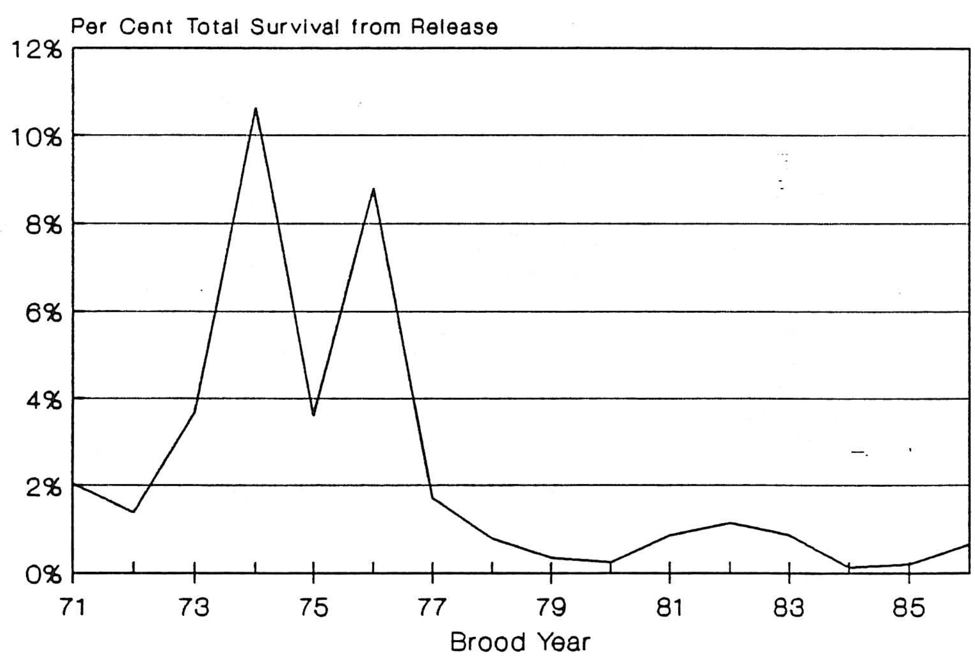


Figure 4

BQR Chinook Survivals by Brood Year



Returns up to 1988 are included. Incompl
ages for 84 to 86 brood years are estmd

Figure 5

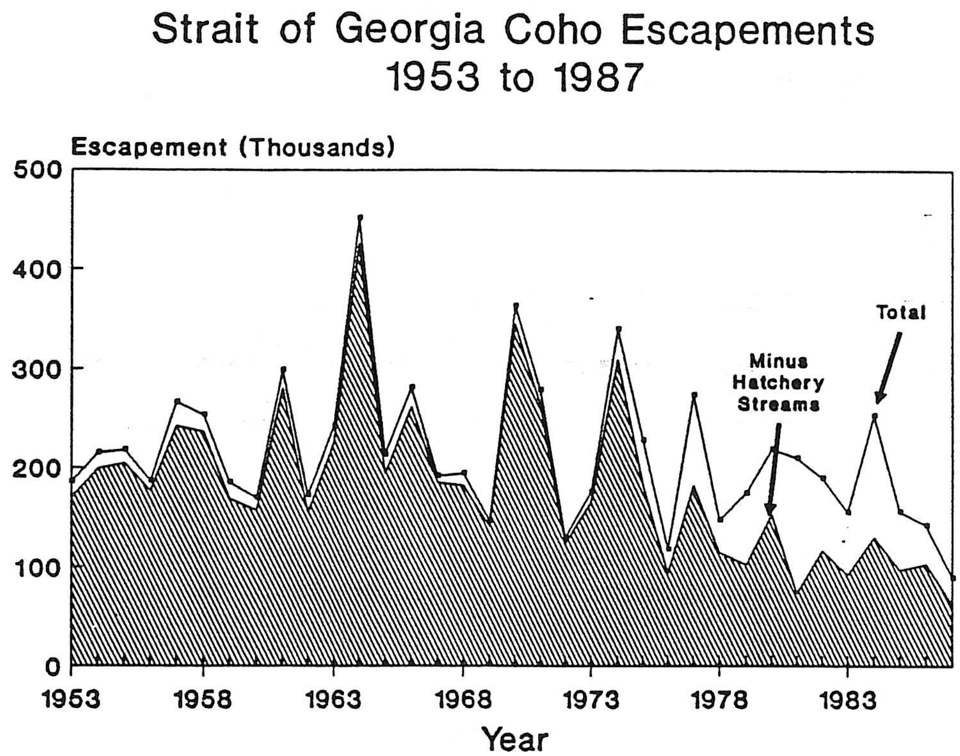


Figure 6a

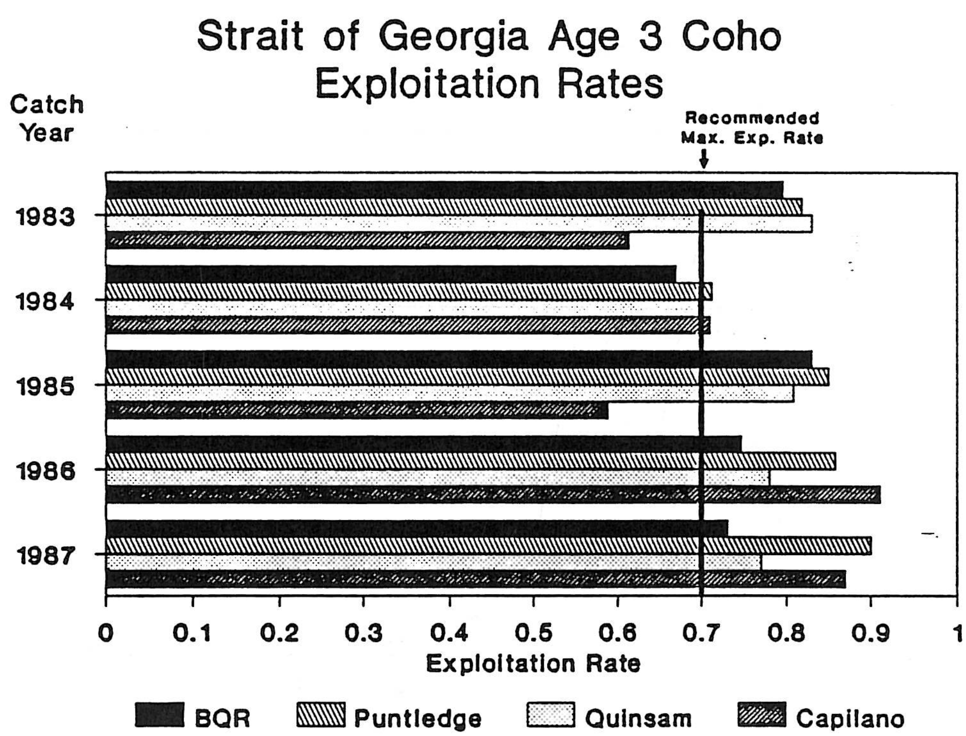


Figure 6b

Strait of Georgia Coho Catch Distribution

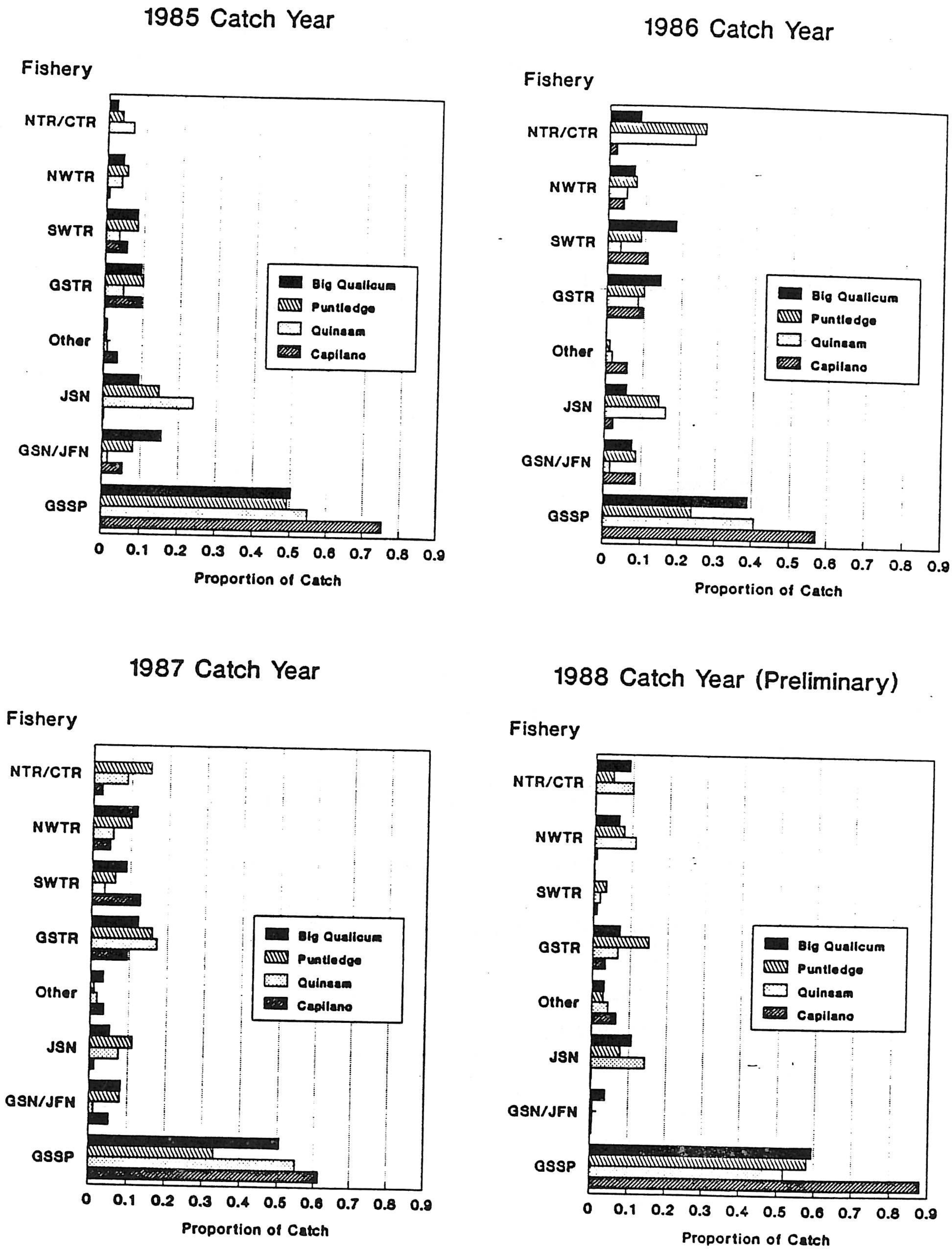


Figure 7

Fraser River Coho Escapements 1951 to 1987

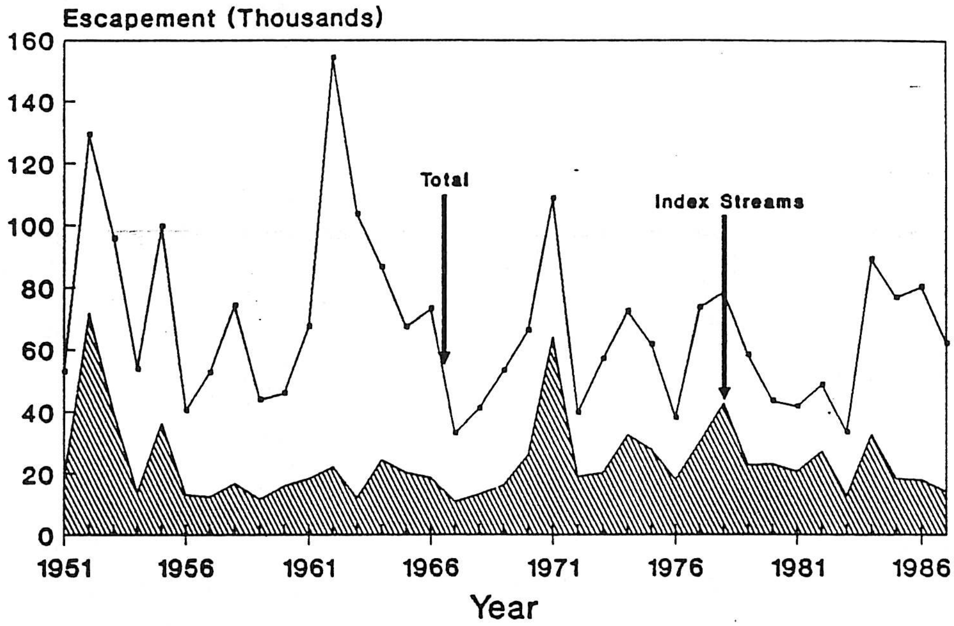


Figure 8a

Fraser River Age 3 Coho Exploitation Rates

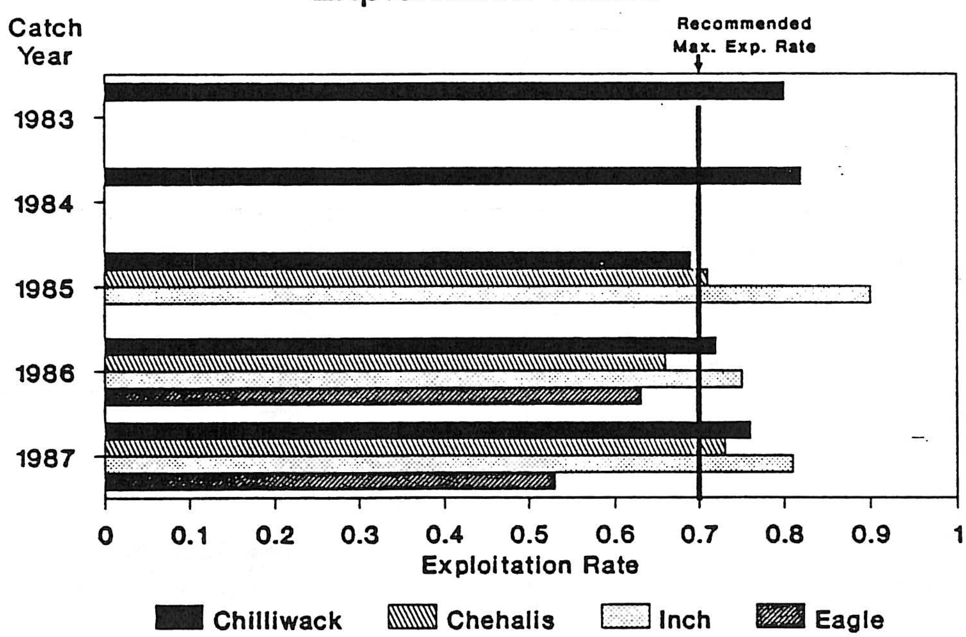


Figure 8b

Fraser River Coho Catch Distribution

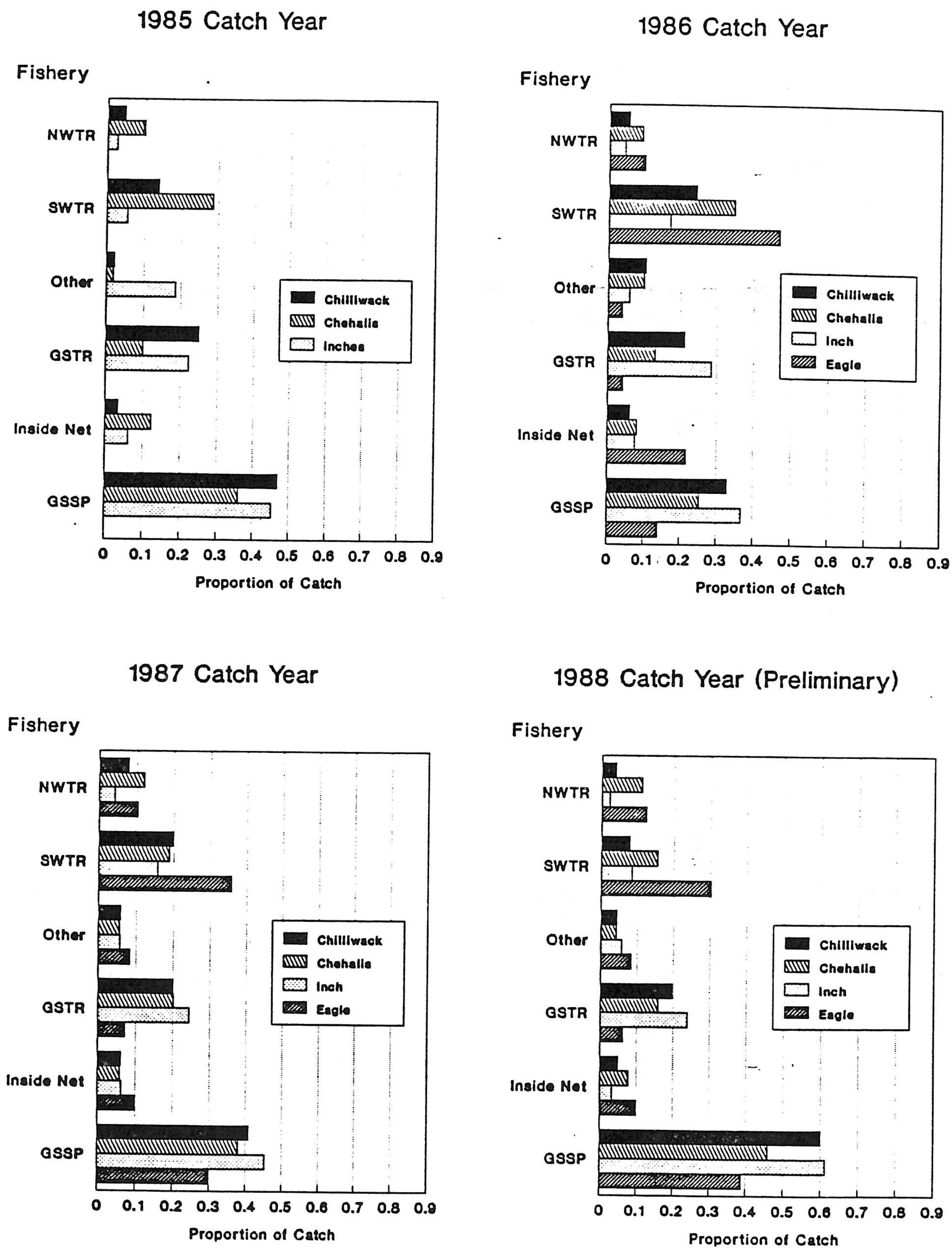


Figure 9

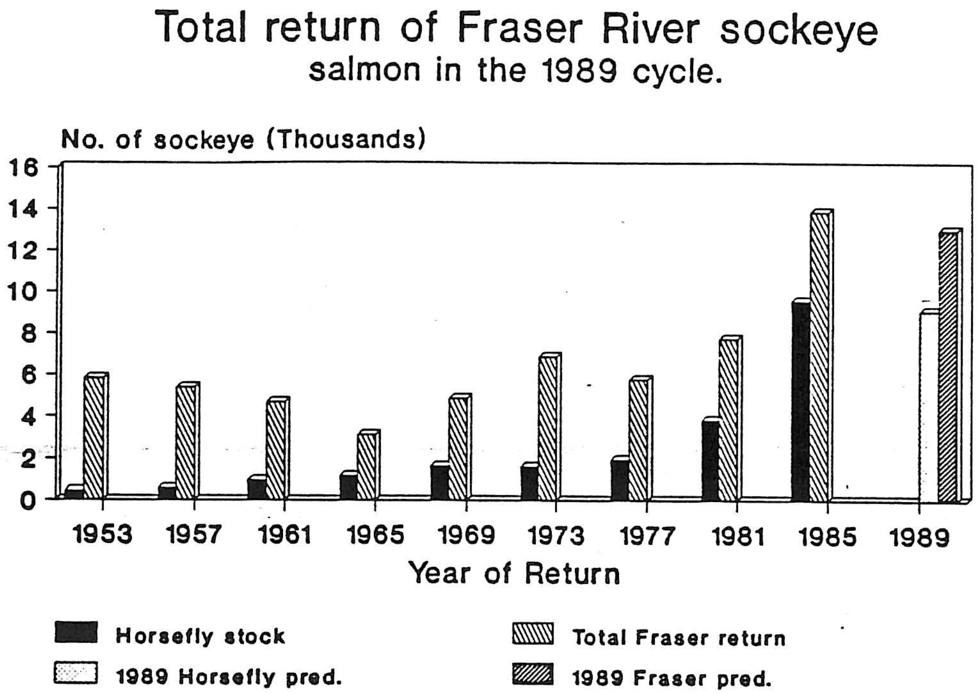


Figure 10

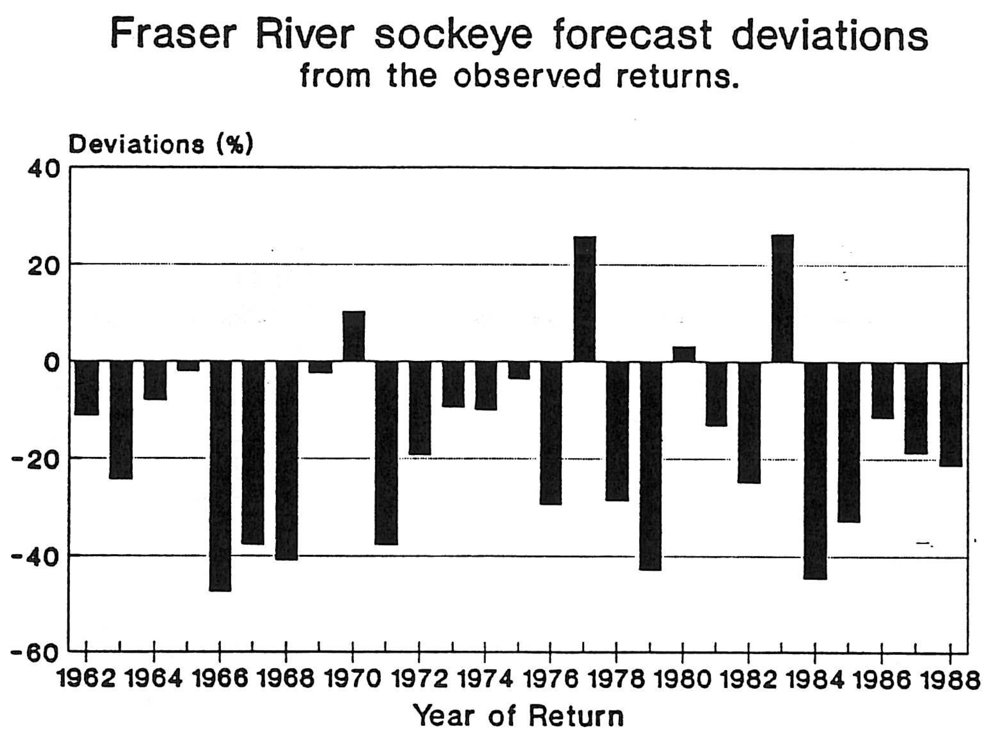


Figure 11

Total Return of Skeena River Sockeye

Three Calculation Methods for Estimating Interceptions

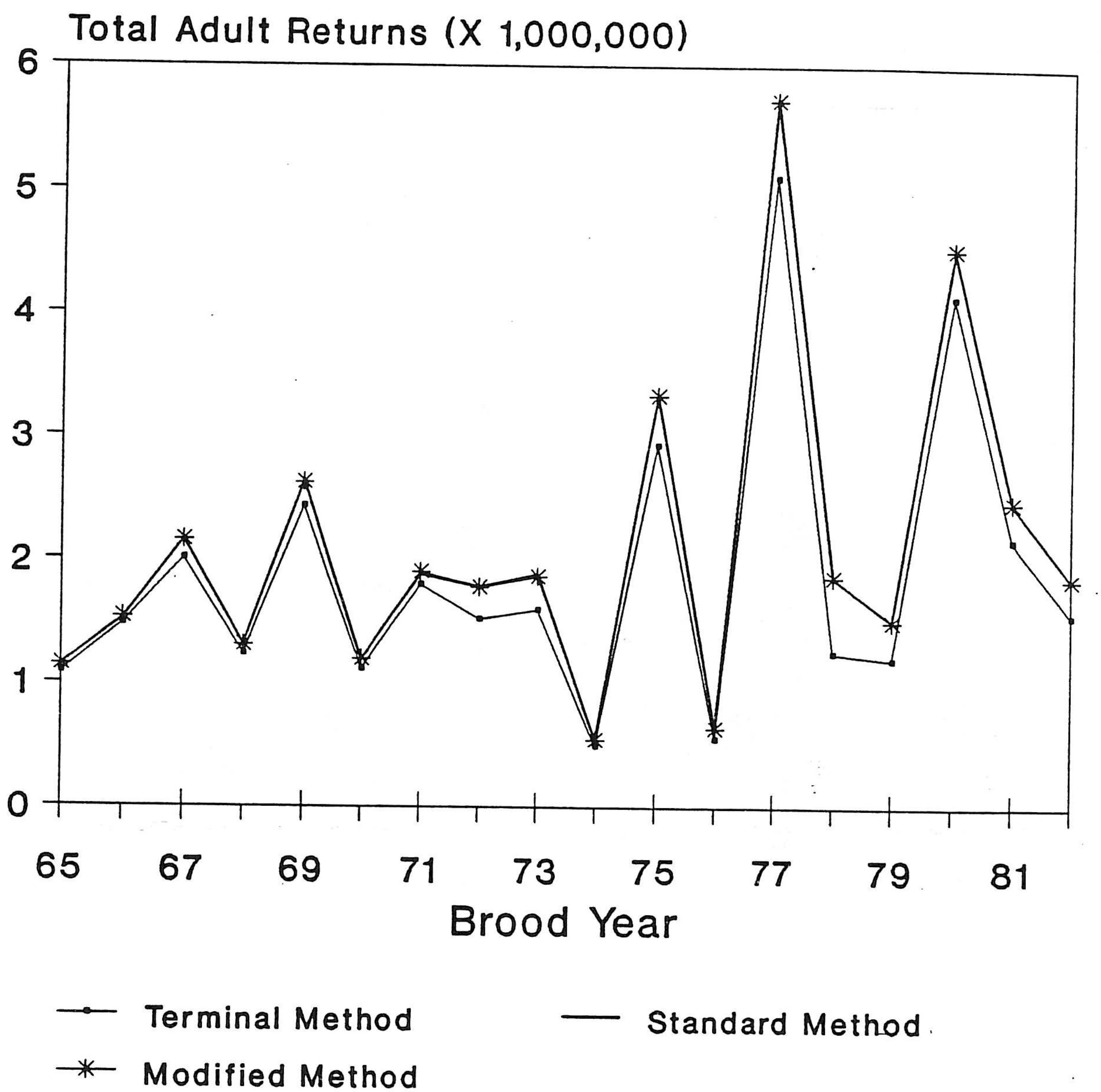


Figure 12

Total Return and Exploitation Rate of Skeena River Sockeye Salmon

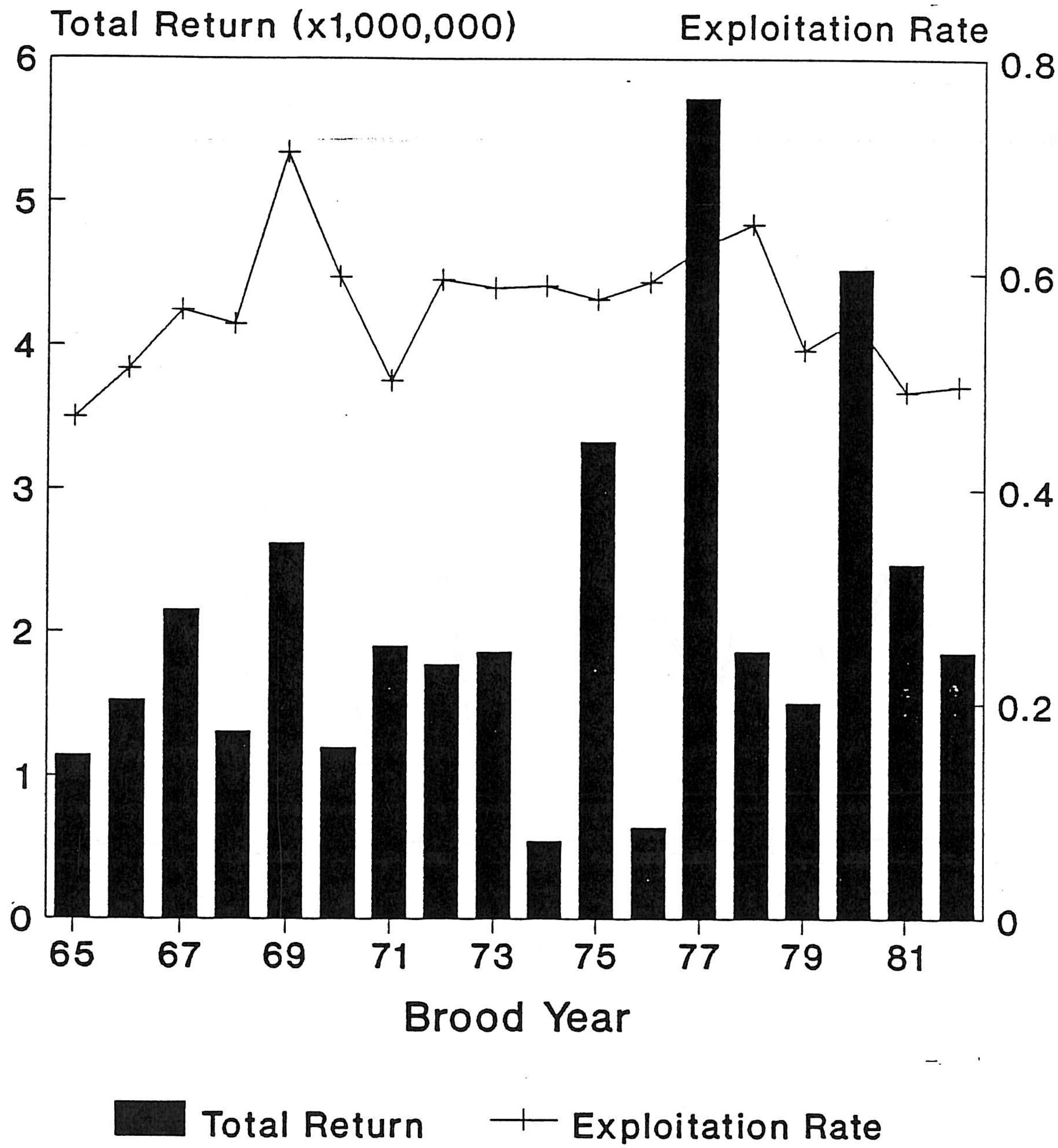
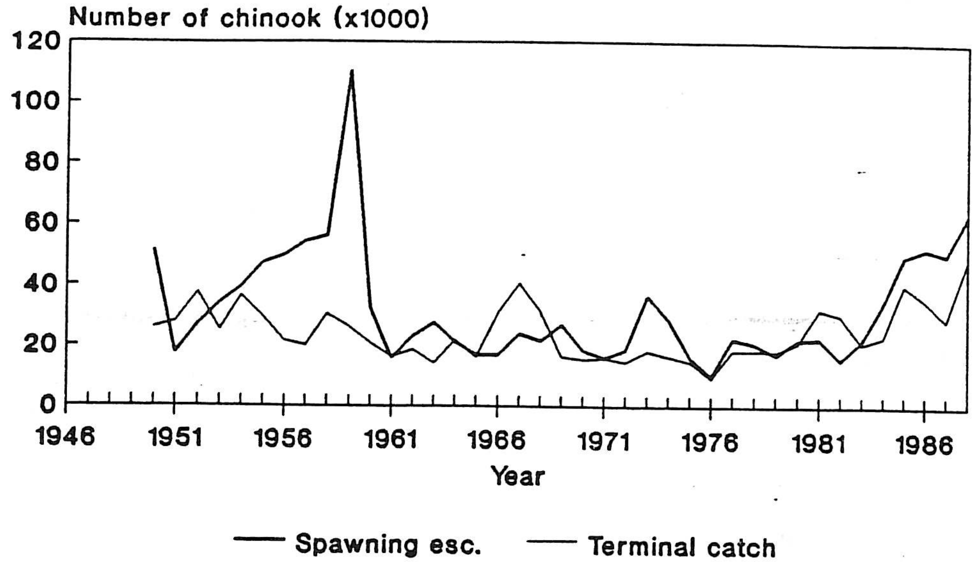


Figure 13

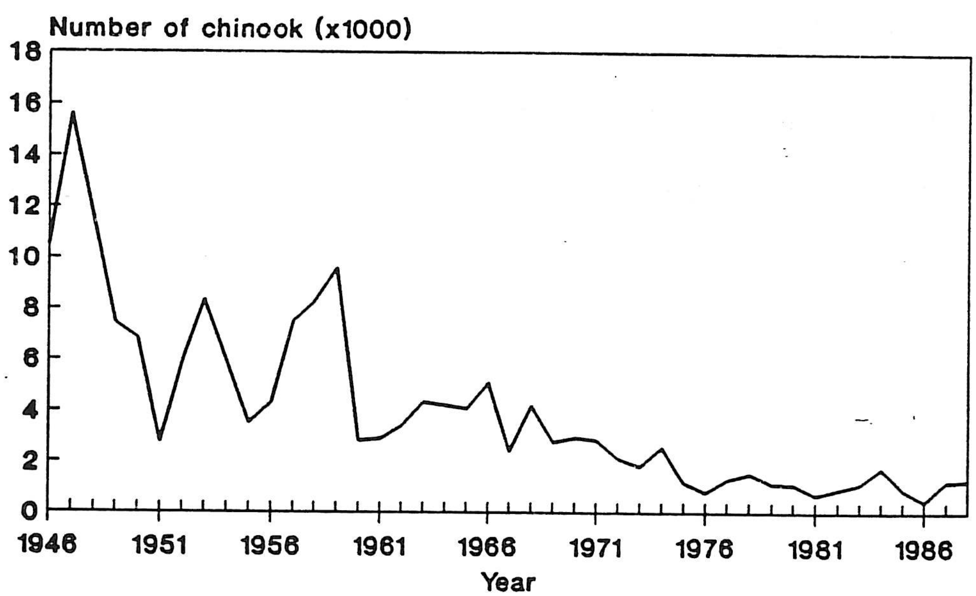
Terminal catch and spawning escapement of Skeena River chinook salmon.



Catch includes gillnet,sport,and native

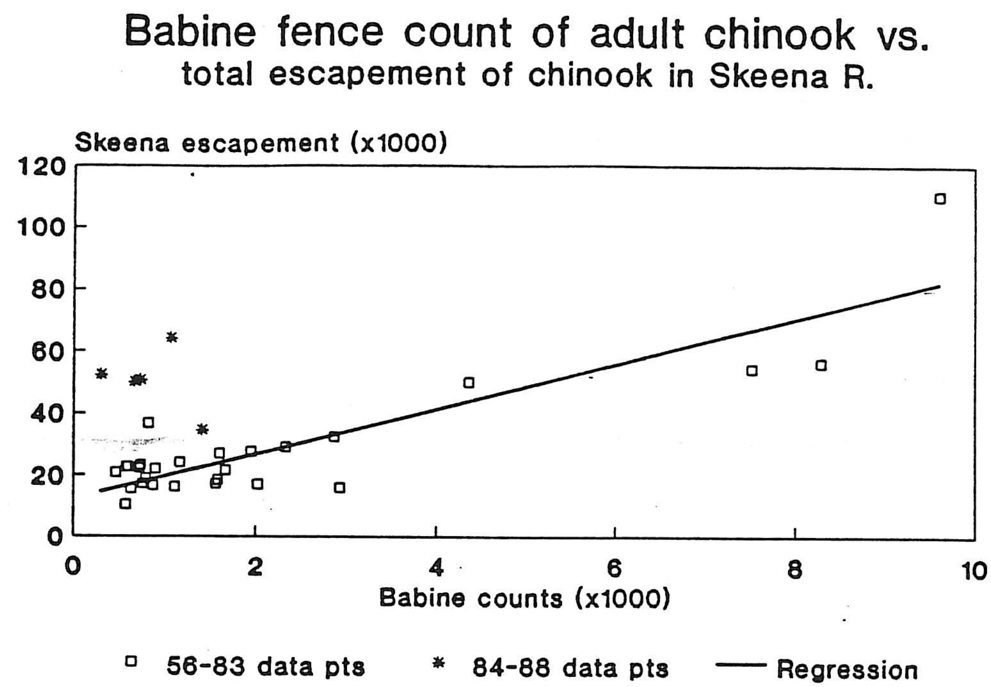
Figure 14a

Chinook escapement past the Babine fence since 1946, annually until Sept. 30.



no counts for 1948 and 1964

Figure 14b



regression calc. for 1956-83 only.

Figure 15a

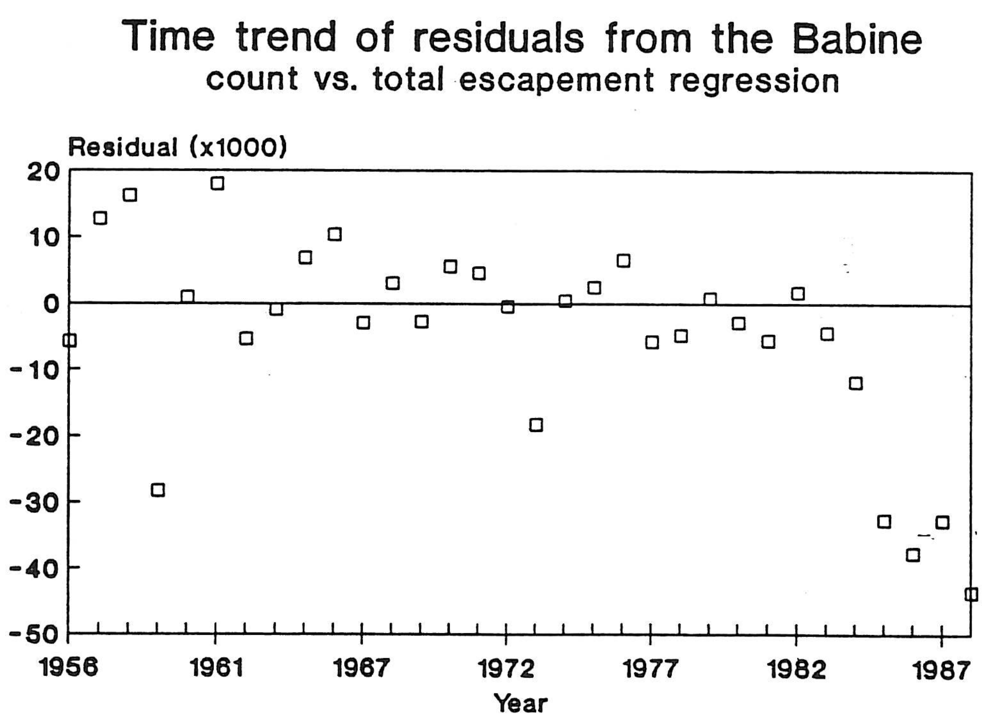


Figure 15b

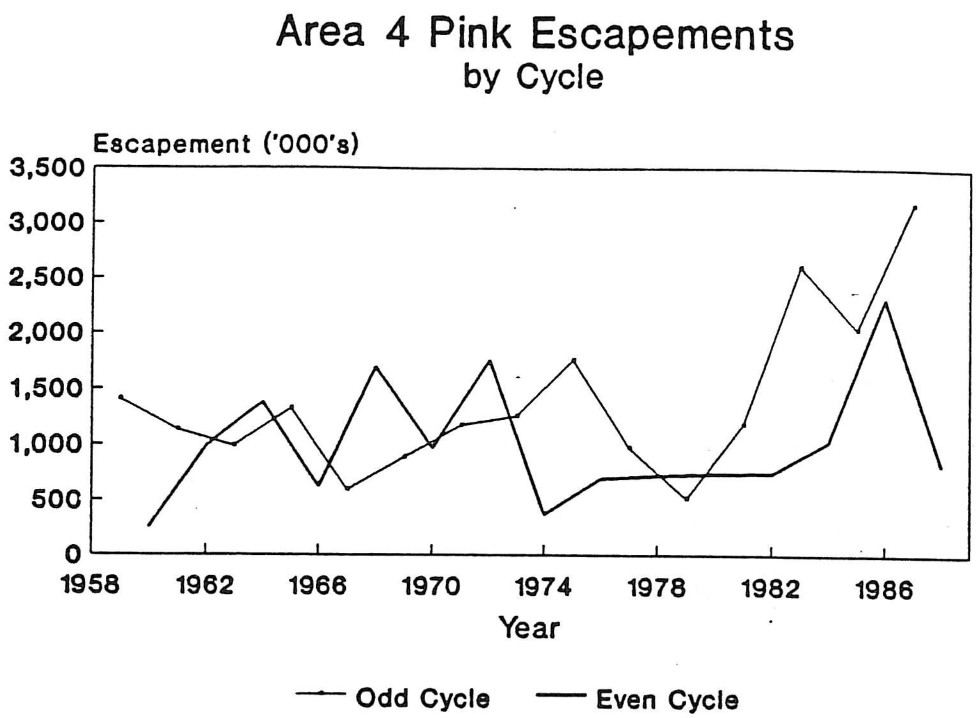


Figure 16

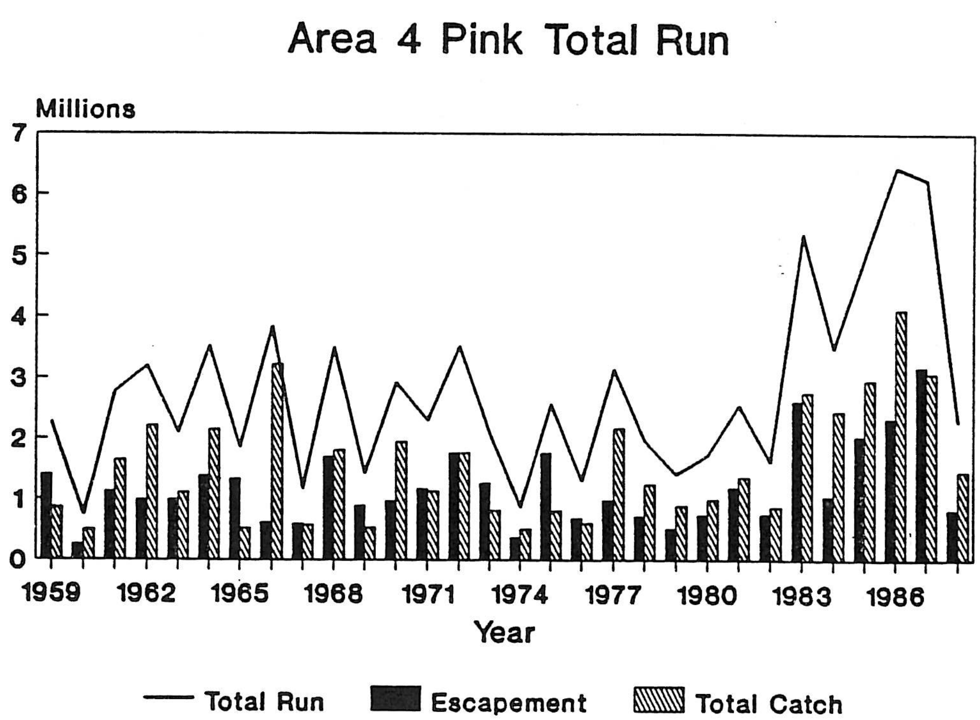


Figure 17

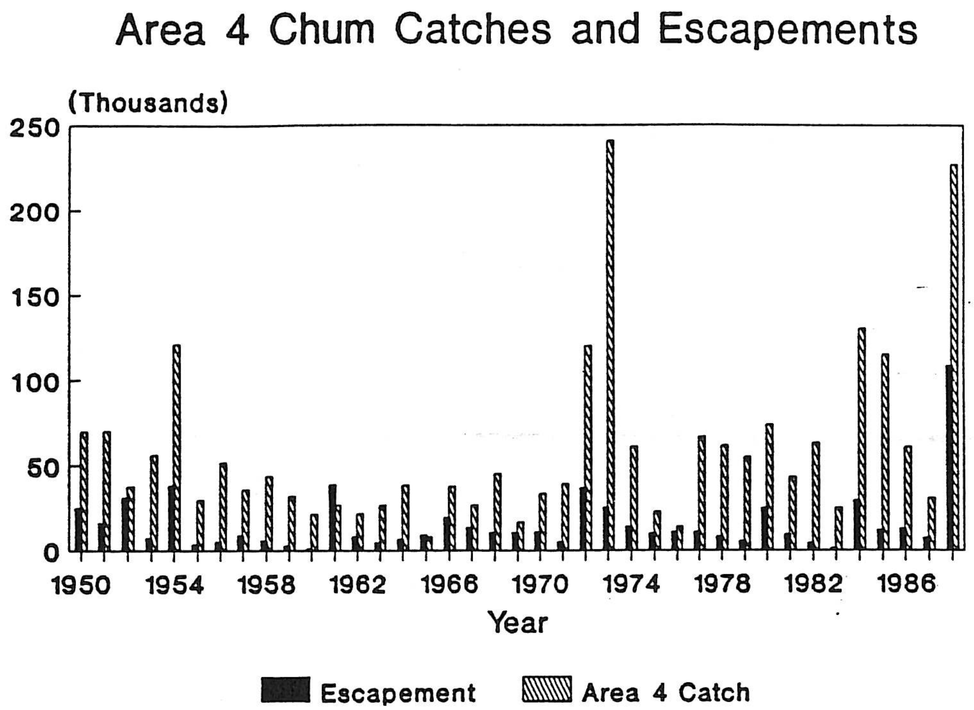


Figure 18

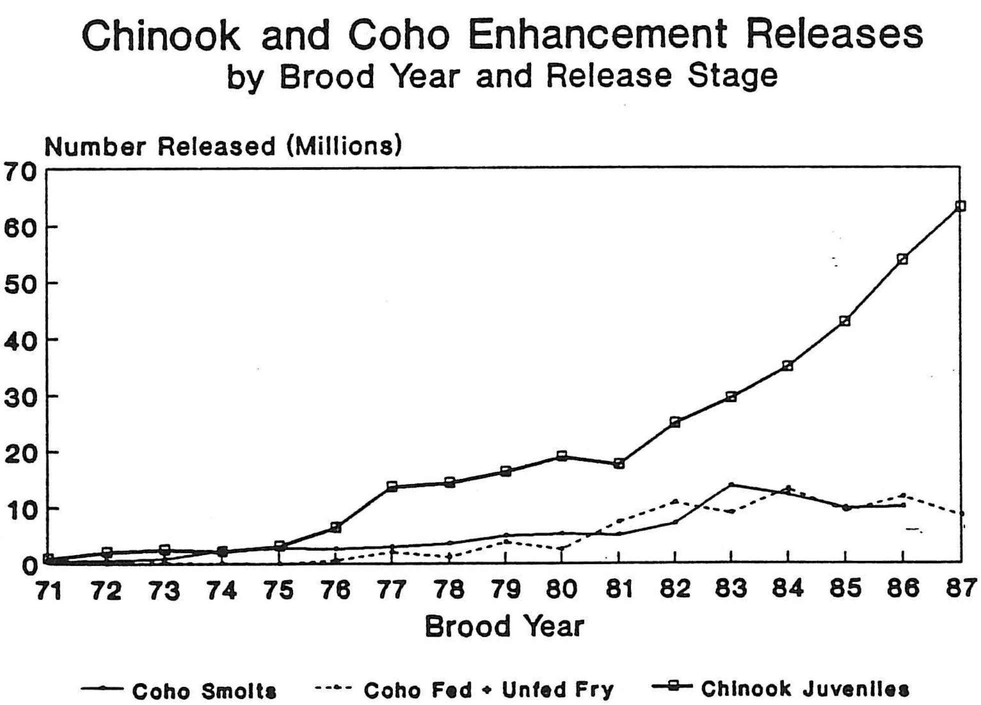
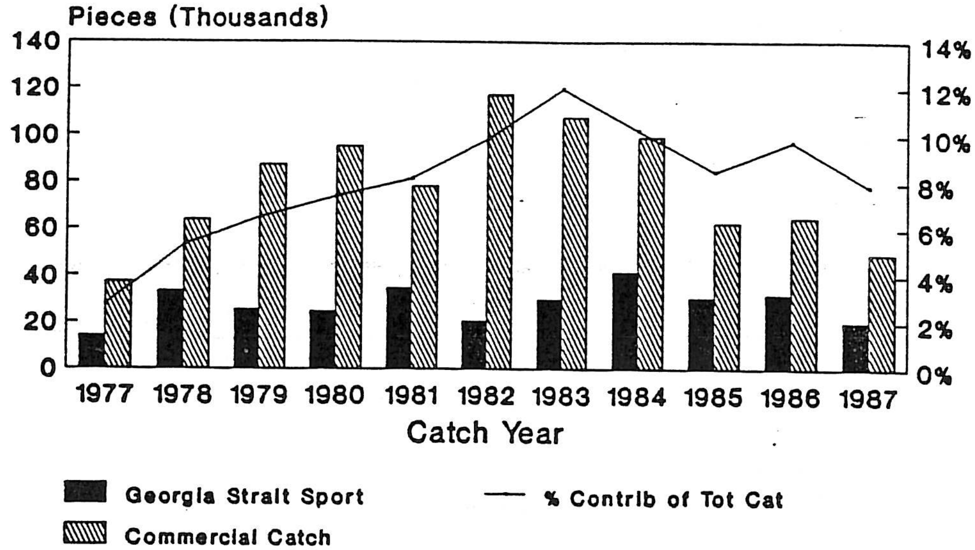


Figure 19

Contribution of British Columbia hatchery chinook salmon to Canadian fisheries



Contribution of B.C. hatchery coho salmon to Canadian fisheries

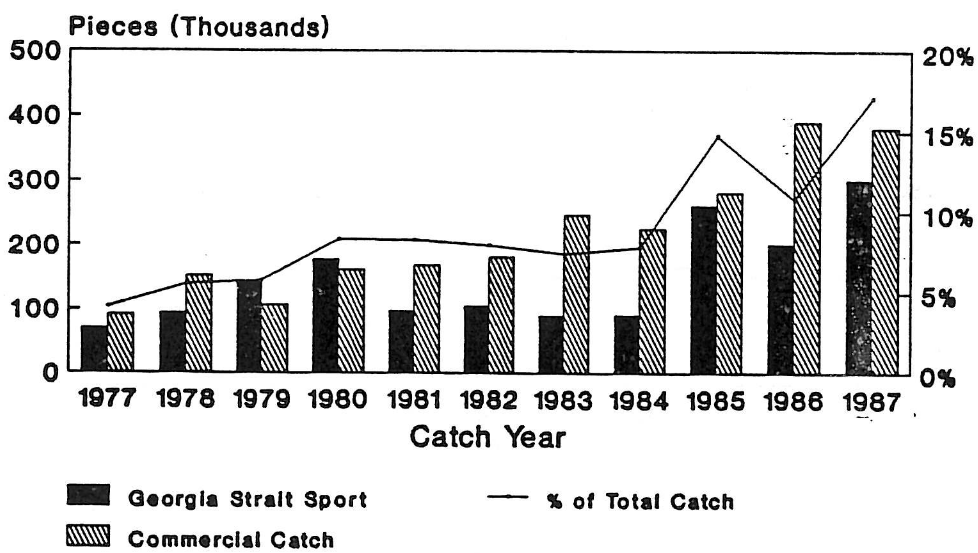
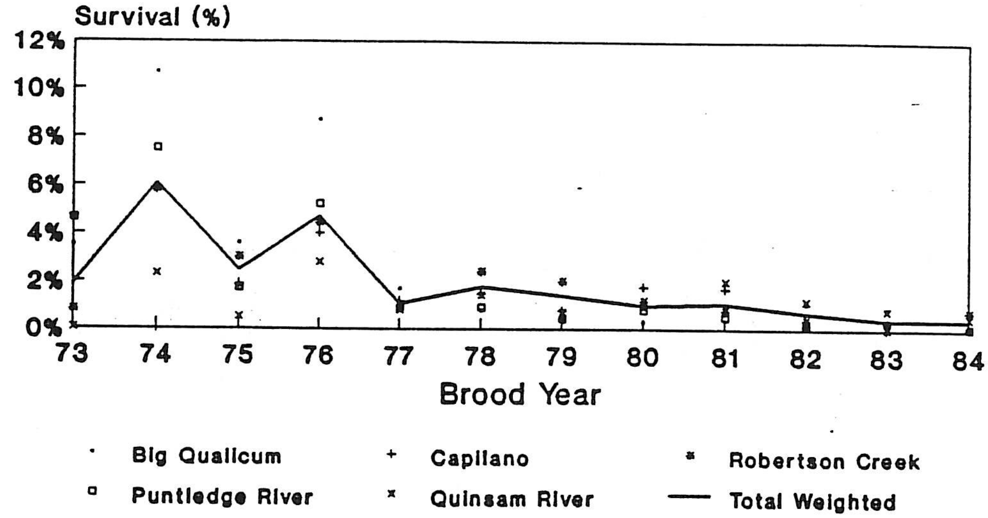


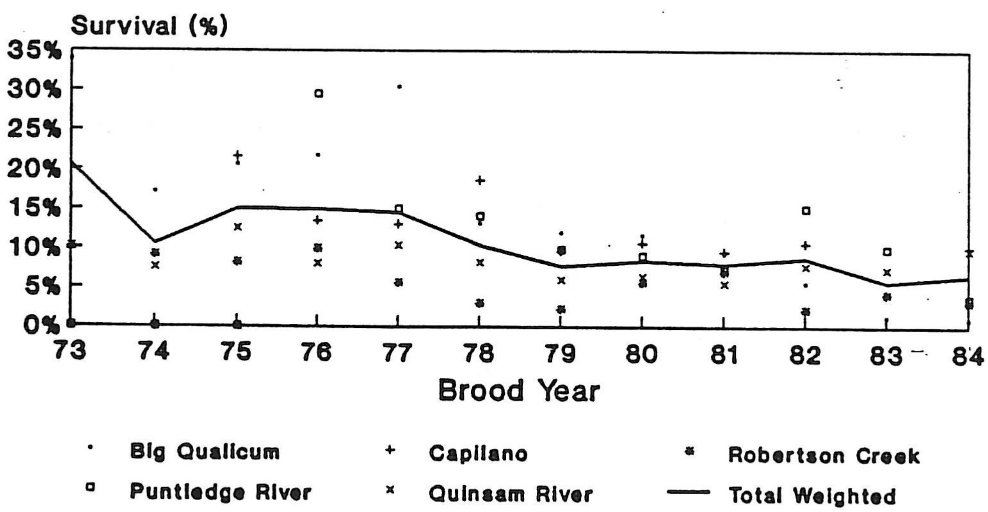
Figure 20

Total survival of chinook releases from British Columbia hatcheries by brood year



1988 recovery year does not include U.S. recoveries/83 and 84 brood years are incomplete

Total survival of coho releases from British Columbia hatcheries by brood year



1985 brood year not included because escapement recoveries not available

Figure 21

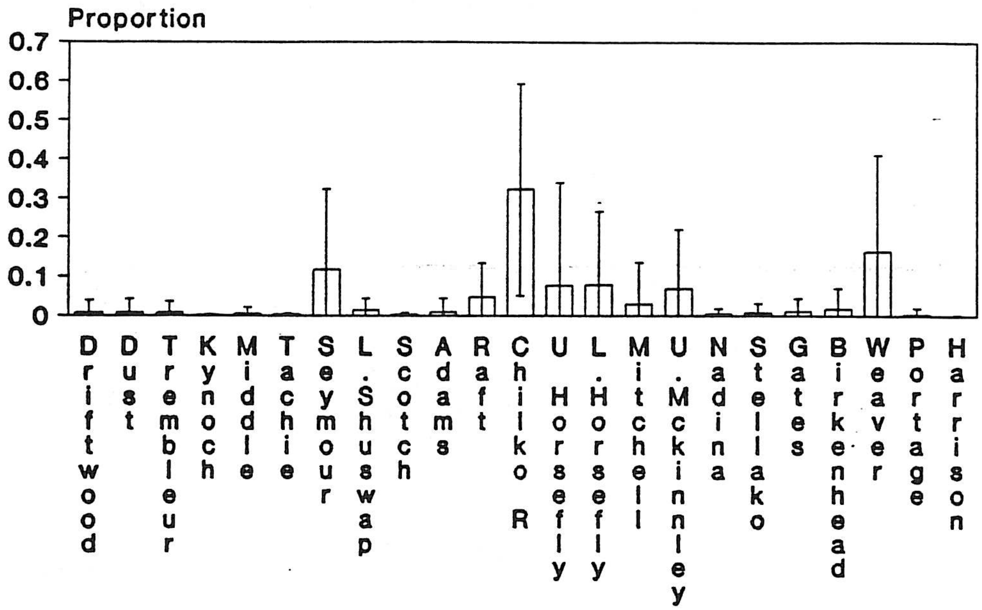
Management Components for Fraser sockeye
Size of type reflects cycle (large=dominant etc.)

	Run Timing Groups		
Cycle line years	Early	Middle	Late
1986	EARLY STUART	BIRKENHEAD HORSEFLY STELLAKO LATE STUART	ADAMS
1987	EARLY STUART	STELLAKO CHILKO LATE STUART HORSEFLY	ADAMS
1988	EARLY STUART	CHILKO LATE STUART HORSEFLY	WEAVER ADAMS
1989	EARLY STUART	LATE STUART HORSEFLY	WEAVER ADAMS

Figure 22

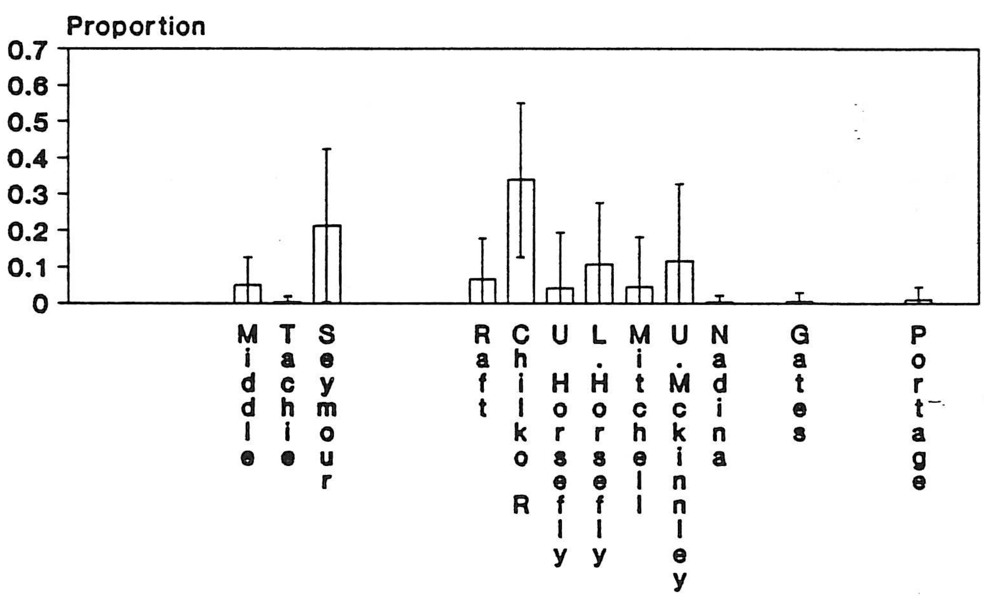
Fraser River sockeye stock proportions

23 stock reference sample



95% confidence intervals indicated

12 stock reference sample



95% confidence intervals indicated

Figure 23

APPENDIX 1. LIST OF PARTICIPANTS

Members:

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C. MacKinnon (for K. McGivney)
R. Harrison
D. Anderson
P. Starr
D. Peacock
R. Kadowaki
D. Meerburg

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G. Steer
K. Hyatt
B. Snyder
L. Jantz
M. Henderson
R. Diewert
L. Hop Wo
W. Luedke
A. Gould
J. Schnute
K. Wilson
D. Bailey
L. Lapi
S. Heizer
C. Cross
D. Noakes
D. Welch
B. Kuhn
B. Gazey
T. Mulligan

Reviewers (* indicates not present to present review):

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R. Diewert
D. Blackburn
K. Wilson
D. Nagtegaal

APPENDIX 2. LIST OF WORKING PAPERS PRESENTED to the SALMON SUB-COMMITTEE, APRIL 10 - 14, 1989

Paper No.	Title	Authors
S89-2	Sub-committee chairman's report on progress on 1988 committee recommendations.	B.Riddell
S89-3	Adaptive management of Fraser sockeye.	C. Wood & K. McGivney
S89-4	1988 status of the lower Strait of Georgia chinook stock.	P.Starr & B.Riddell
S89-5	1988 Strait of Georgia coho salmon assessment.	K.Wilson & R.Kadowaki
S89-9	South coast management model.	K. McGivney (scientific authority)
S89-10	1989 Fraser River sockeye forecasts.	W. Saito
S89-11	Stock status and assessment of southern B.C. chum salmon in 1988 and forecast for 1989.	W. Luedke, S. Heizer & L. Hop Wo
S89-12	Status of southern B.C. (non-Fraser) pink salmon and 1989 forecasts.	L. Hop Wo & A. Gould
S89-13	Stock status and 1989 forecasts of Barkley Sound sockeye (with appendix).	K.Hyatt & G. Steer
S89-14	Overview of methods and issues in the GSI program of southern B.C. chum salmon. fisheries.	W. Luedke & D. Anderson
S89-15	Stock status of Skeena River sockeye salmon (<u>Oncorhynchus</u> <u>nerka</u>) (with appendix).	M. Henderson & R. Diewert
S89-18	Stock assessment of Skeena River chinook salmon.	B.Riddell & B. Snyder
S89-19	Stock assessment of Skeena River pink.	L. Jantz
S89-20	Progress report on the statistical analysis of salmon mark-recovery data (with appendix).	J.Schnute, T.Mulligan, B. Kuhn, & L. Lapi
S89-21	Incorporating pre-season forecasts into within season abundance estimates.	D. Noakes

BIOLOGICAL ADVICE ON MANAGEMENT OF BRITISH COLUMBIA SHELLFISH FOR 1990

The PSARC Steering Committee met September 14, 1989 to review the Shellfish Subcommittee report as contained in this document. The Steering Committee endorsed the report and made the following recommendations:

1) Data presented indicates a substantial long term decline in sublegal abalone abundance. A reduction in catch is recommended for all user groups. Management actions should be taken to curtail illegal landings.

2) Harvest logs should be maintained to build a long term catch and effort data base for stock assessment. For many of these species they will provide the only estimate of landings and index of stock size.

3) Calculations and rationale for geoduck and abalone quotas should be documented for PSARC.

This report is a summary of advice and recommendations resulting from the PSARC Shellfish Subcommittee, held August 29-30, 1989 at the Anchor Inn, Campbell River, B.C. A list of the seven working papers submitted and sixteen fisheries 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 and South Coast divisions of the Fisheries Branch and by a biologist of the Provincial Ministry of Agriculture and Fisheries, Aquaculture and Commercial Fisheries Branch. D. McKone represented the Biological Sciences Directorate, Ottawa.

Invertebrate landings have increased rapidly over the past five years but declined slightly in 1988 compared to the previous year (Table 1). This decline was due mostly to small declines in landings of geoducks, shrimp, crab and sea cucumbers. Almost half the landings were comprised of intertidal clams and geoducks (Fig 1). Over 500 vessels participated in invertebrate fisheries. In the intertidal clam fishery alone, there are over two thousand intertidal harvesters. Many people rely on shellfish fisheries for a major part of their income. 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 $40 million (including oysters, $3.6 million) in 1989, an increase of 14% over the previous year (Table 2). This increase was due primarily to a significant increase in the price paid for intertidal clams (mostly manila clams) and geoducks. Intertidal clams and geoducks accounted for almost half the total landed value of invertebrates in 1989 (Fig 2).

Recommendations from this subcommittee in 1988 formed the basis of 1989 fishing plan and a similar situation will pertain for formation of the 1990 fishing plan as well as for research work for 1990. 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.

MANAGEMENT POLICY

Management policies have been outlined, based on discussion and advice set by the Regional Shellfish Working Group.

MAJOR FISHERIES

Dungeness Crab Fisheries: Entry is not limited

- A minimum size limit protects a breeding stock of males and females.
- Some closures are set for time periods, when many crabs have soft shells, to improve quality and reduce handling mortality.

Prawn Trap Fisheries: Entry is not limited.

- 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.

Geoducks: This is a limited entry fishery with 55 vessel equal quota licences.

- Management by maximum sustained yield proposed at annual exploitation levels of 1-2% 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.
- There are rotational quotas, most areas are fished once every three years.
- P licences have been issued in the north coast, where shore-based processing is not available.

Red Sea Urchin: Entry is not limited.

- Area and subarea quotas have been set to limit growth of the fishery while biological data is obtained.
- Quotas for some 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, traditionally the period of peak demand and highest prices.
- The north coast has been open year round, with only minor landings. A minimum and maximum size limit and rotational fisheries are in effect rather than quotas.

Green Sea Urchins: Entry is not limited.

- Season is limited October 1 to February 28, following the period of market demand. A minimum size limit of 55 mm is set as a condition of licence.

Abalone: This is a limited entry fishery with 26 individual and equal quota licences.

- A single, coastwise quota was originally set, based on sustained yield (from preliminary estimates of the original biomass and turnover rates). Quotas have been reduced and maintained at low levels, based on surveys of relative abundance and recruitment as compared to earlier surveys.

- The current size limit is intended to allow abalone to spawn two to three times before being taken in the fishery.

Sea Cucumber: Entry is not limited.

- Arbitrary quotas have been set for three regions of the coast (500 t for each) 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.

- 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.
- Quotas have been developed for the offshore stocks on the assumption that there may be a stock-recruitment relationship and a sustained yield is possible. However, they were not recpmmended as offshore stocks have shown high fluctuations in abundance. Further research is required to determine the optimal size or age to harvest in periods of peak 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.

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).

Euphausiids - Plankton: A conservative quota (500 t) has been set for inshore waters (Strait of Georgia and adjacent waters). The quota is based on a harvest rate of 0.1% of the estimated standing stock of euphausiids in the Strait of Georgia. Quotas have been set for individual inlets. Exploitation at this low level should not impact on the stock.

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

MAJOR FISHERY CONCERNS (1989)

Market demand and subsequently prices remain strong for most species. Because of the number of invertebrate species, their unique biology, and limited resources available for research and management, arbitrary quotas have been established for many developing fisheries until such time as sufficient biological information exits to suggest alternative management strategies. A successful vessel quota system was initiated for geoduck clams in 1989, funded primarily by industry.

Fisheries for invertebrates continue to expand. Many of the specific fishery concerns identified in 1988 remain unchanged for 1989.

1. Closures for soft shell crabs were implemented in the major fishing areas. Concerns were expressed about the increase in effort and number of traps and suggestions were made about the possibility of limited entry for this fishery. Concerns were expressed about conflicts between United States and Canadian crab fishermen in the Boundary Bay area.

2. Reduced quotas set for the sea cucumber fishery resulted in a very short seasons.

3. Offshore shrimp abundance showed a decline which resulted in a slight decline in landings. This fishery has been a boom or bust fishery and there are concerns that investment in vessels, licences, and equipment may exceed levels that could be realistically supported by the fishery. Catch and effort should be closely monitored for this fishery and an annual survey done to determine recruitment of marketable shrimp for the following year.

4. Increasing effort in the prawn fishery is of concern and there have been requests from industry for licence limitation. Some conflicts were reported between trap and trawl fishermen because of incidental catches of prawns in trawls. Effects of dioxins from pulp mill effluents have caused closure of some fisheries. Substantially increased effort in the central coast where resources for monitoring the spawner index are not available may result in overexploitation of the stocks in that area.

5. Survey results show a continued decline in sublegal as well as total abalone abundance. Recommendations to reduce catch and poaching. There is also concern that the pattern of fishing may be exacerbating the problem.

6. A major concern in the intertidal clam fishery is the effect of repeated digging on juvenile and pre-recruit clams. Effort continues at high levels. Some beaches are being dug as many as five times in a single year. A clam licence was instituted in 1989 and has had an ameliorating effect on some issues. Conflicts between oyster growers and clam diggers were largely alleviated with controlled digging on oyster leases.

7. The status of euphausiid stocks, particularly in the Strait of Georgia is uncertain. Hydroacoustic techniques to assess stocks should be evaluated and a survey undertaken to determine the biomass and production of euphausiids in the Strait of Georgia and contiguous waters. Research studies should be undertaken to compare day/night catches to verify existing biomass estimates.

SUMMARY OF ADVICE FOR INVERTEBRATE FISHERIES IN 1990

Section 1 discusses the fisheries of major economic importance in 1989 (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 Section 2. 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 1990

Major Fishery	Biological Advice and Information
TRAP	
Dungeness crab	1. No change in advice to management. 2. Effects of fishing effort on prerecruits should be examined. 3. Research on escape mechanisms in progess.
Prawn	1. No change in advice to management. 2. Continue experimental management in study areas. 3. Continue mandatory harvest log program.
INTERTIDAL	
Intertidal clams	1. No change in advice to management. 2. Working Groupd to review effectiveness of new management areas. 3. Research in progress to examine effects of digging on juvenile clams.
DIVE	
Geoduck	1. No change in advice to management. Growth analyses supports present conservative 1-2% harvest rate. 2. Continue harvest log program.
Sea Urchin	1. No change in advice to management. 2. Contiue harvest log system. 3. Reiterate 1988 recommendation to undertake reasearch to obtain biological information required to manage resource (size limit and other).
Abalone	1. Continue resurveys in study areas, particularly QCI survey for 1990. 2. Recommend reduction in catch by all user groups. Management strategies to reduce poaching are needed. Explore the potential to

SUMMARY OF BIOLOGICAL ADVICE AND INFORMATION NEEDS FOR MANAGEMENT OF MAJOR INVERTEBRATE FISHERIES IN 1990 CONT'D

Major Fishery	Biological Advice and Information
Abalone continued	change fishing patterns. 3. Continue harvest log program.
Sea cucumber	1. No change in advice to management. 2. Continue harvest log program.
NET	
Shrimp trawl	1. Undertake survey to assess biomass of shrimp on WCVI. 2. Continue mandatory log program. 3. Delay opening until June or July to maximize yield per recruit.

SUMMARY OF BIOLOGICAL ADVICE FOR MANAGEMENT OF MINOR INVERTEBRATE FISHERIES IN 1990

Minor Fishery	Biological Advice
Trap	
Tanner, king, and galatheid crab	1. Maintain experimental fishery for tanner crab. 2. Maintain harvest logbook program.
Shrimp by trap	1. Continue harvest log program
NET	
Squid inshore	1. Continue harvest logbook program
Plankton	1. Continue harvest logbook program. 2. Continue existing inside waters quota of 500 tons.
DIVE	
Scallops	1. Continue harvest logbook program
Horse clams	1. Undertake assessment to determine species being harvested. 2. Continue biological program for information to manage fishery. 3. Continue harvest logbook program.
Octopus	1. Continue harvest logbook program.
INTERTIDAL	
Gooseneck barnacle	1. Continue harvest logbook program. 2. Resurvey study sites for recruitment
Mussels	1. Minor fishery. Monitor landings.

POSITION PAPERS AND RECOMMENDATIONS

SHRIMP (I89-1)

Historically there have been three main areas of shrimp trawling in B.C.: 1. off the west coast of Vancouver Island, 2. in the Strait of Georgia, and 3. in Chatham Sound. Recently however more emphasis has been directed at isolated stocks of shrimp in some of central coast mainland inlets. This report will summarize assessment results and trends that are evident in the data from trawl surveys, logbooks and sale slips.

In comparison with the 1988 trawl survey results, the 1989 survey results off the west coast of Vancouver Island shows about a 9% decline in shrimp on the grounds. The major difference between the two assessments was a shift in the proportions of 2+ and 3+ animals. The combined totals of 2+ and 3+ animals (the major year classes targeted on in the fishery) for the 1988 and 1989 surveys was 9.5×10^8 and 8.6×10^8 respectively. Between 1988 and 1989, however, the 2+ index has shown almost a 47% increase with indices of 3.7×10^8 to 5.4×10^8 for 1988 and 1989 respectively. On the other hand the relatively weak 2+ year class in 1988 has resulted in a weak 3+ year class in 1989 which translated into a 45% decrease in indices from 5.8×10^8 to 3.2×10^8.

The average CPUE in Area 14 declined from 1987 to 1988. However, part of this may be explained by a targeting on less abundant more valuable Sidestripes. In Area 17 the CPUE stayed relatively stable between 1987 and 1988. The catch in 1988 was made up of 60% pinks, 23% sidestripe, and 17% prawns. This is the highest percentage of prawns caught in a trawl fishery and indicates that the fishery is targeting on this less abundant more valuable shrimp. For Areas 28 and 29 combined a time-series analysis after Noakes (1986) of the 1951-1988 reported sales slip catches gave the same trend as was evident in the increasing average CPUE from logbooks. The estimated forecast for 1989 for both areas combined is 143 t.

A time-series analysis of the 1951-1988 reported sales slip catches from area 4 gave a estimated naive forecast for 1989 of 9 t (see Table 3) which is a decline similar to CPUE trends seen in the logbooks.

Recommendations

1. Investigate the exent and effect of removal of sublegal and legal prawns by trawl fishing. Shellfish Working Group to consider alternative methods to minimize trawl fishery capturing small prawns.

2. Opening of fishery off west coast of Vancouver Island should be delayed so that maximum yield is obtained.

3. Survey of west coast of Vancouver Island shrimp stocks should be undertaken every year in periods of high abundance.

Reviewers Comments

Two reviews of this paper are available.

One reviewer stated the shrimp survey provides an excellent basis for ongoing assessment and monitoring of these stocks. The suggestion was made to provide a brief description of current management strategies, regulations and objectives and provide tables of historic catches in the fishery.

The other reviewer indicated more detail on the methodology should be provided, particularly in the time-series analysis of the prawn fisheries. It was also stated there was little information on appropriate fishing mortalities for various stocks. Further, part of the assessment process should be the provision of advice on the consequences of various yields or exploitation strategies applied to the stocks.

Shrimp and Prawn - Catch and effort data (I89-2)

Reports of shrimp trap landings by logbook are compared with those reported by saleslips over the past six years. About 70% of the total are reported by saleslips and about 90% by logbook. Corrections to both data bases are made using a SAS programme. Reporting of catch could be improved if shrimp trap licences were attached to the vessel rather than a fisherman. Fishing activity logs should be more fully utilized to check the data base and a standard format should be adopted for field monitoring by Fisheries Branch and Biological Sciences Branch.

Recommendations

1. Licences should be attached to vessel rather than fishermen to improve sales slip and logbook data.

2. Emphasis should be given to obtaining information from fishing activity logs reporting on commercial fishing. These logs should be standardized.

Reviewers Comments

Two reviews of this paper are available.

The first reviewer stated there are two issues that need to be dealt with in more detail. The first is there is no complete record of total catch. The second issue involves resolving one data base against the other.

The second reviewer suggested a comparison of the relative values of each method might be attempted, e.g. compare cpue values from each licence using both sales slips and logbooks including an analysis of variation between fishermen, location, season, etc.

Dungeness Crab (I89-3)

The Dungeness crab (Cancer magister) fishery is important to the British columbia shellfish fisheries. Based on DFO statistics, total fishing effort in all areas has increased substantially over the last decade with no corresponding increase in landings:

	Days fished	Landings (t)
1977	8,577	2,259
1981	12,336	1,315
1987	22,232	1,631

Obviously, more effort is required now to catch similar numbers of crabs than was required earlier. An analysis of the possible effects of increased effort on crab stocks is presented in the paper. In addition a graphical analysis for estimating the effect of the fishery on survival was presented at the meeting.

In summary the analysis indicated that, current fishing effort is excessive, in Tofino, and Queen Charlotte Strait, pointing to a need to reduce days fished.

The analysis suggests that effort should be reduced to optimal levels in the Tofino, Queen Charlotte Strait and Fraser estuary fisheries.

Recommendations

1. Continuation of the work was recommended although the analyses and conclusions were not accepted by the subcommittee for advice to management in their present form. Better quality

catch and effort data for the crab fishery is required for further analysis. Biological sampling should be combined with catch sampling.

2. The effect of fishing effort on incidental mortalities to pre-recruit crabs should be examined. Reduction of mortalities to pre-recruits by such means as increasing the escape port size or putting more escape ports in traps should be examined.

Reviewers Comments

Two reviews of this paper are available.

The first reviewer felt the model described didn't fit the data for most of the various fishing areas very well. This means that some of the conclusions and suggestions in the paper may be questionable. He suggested other models might be more suitable for analyzing the data.

The second reviewer stated there was insufficient information in the paper to adequately evaluate the conclusions. The Schaeffer model can vary dramatically depending on whether the error is considered to be in the catch, effort, or cpue. Other methods of analyzing the data are suggested.

Geoducks (I89-4)

Geoduck clam (Panope abrupta) shells collected from Ladysmith Harbour, British Columbia, November 1981, were analyzed to determine the age composition of this population and the average annual growth rate of individuals at this site. Acetate peels made from cross-sections of the right valve of each clam were examined to determine the ages of the clams. Distances between the annuli in the hinges were used as surrogate measures of growth. The annual growth of each specimen in this sample was standardized and combined with growth measurements from all other animals to reconstruct an average annual index of growth back to the early 1900's. Analysis of these standardized growth indices resulted in an estimate of Ford's growth coefficient of 0.8 (von Bertalannfy k = 0.22). An interesting aspect of the analysis was the distinct decline in growth rate between 1964 and 1980. A 30% decrease in growth appears to coincide with the initiation of log booming and storage in Ladysmith Harbour.

The methodology presented in this paper could be used to determine growth rates for other bivalves at this location or from other areas on the coast. These reconstructed growth indices could possible be used to study the effects of long term climatic change (ie. global warming) or to determine the impact of specific habitat or environmental changes (ie. fishery/logging interactions, fishery/mining interactions, lake fertilization, etc.).

Recommendations

1. Longevity, low recruitment, and vigorous initial growth suggest continuation of a conservative harvest policy for geoducks with the goal of removing 1-2% of the estimated virgin biomass.

2. Analyses should be expanded to include geoduck shells from various areas of B.C. to provide a better picture of growth patterns during this century. A site in the neighbourhood of Ladysmith Harbour should be included to compare growth after 1960.

3. The method employed in this study could be utilized to determine the impacts of environmental and/or habitat perturbations.

Reviewers Comments

One review of this paper is available.

The reviewer stated the method of using distance between annual rings on the hinge plate of geoducks to measure growth, as is done with trees, should be verified. It was also stated the decline in growth occurred very soon after log storage activities began in Ladysmith Harbour and it is questionable if this was the cause of decreased growth.

Abalone (I89-7)

Twenty five sites were resurveyed in the Central Coast (area 6) in June 1989 using the 16 quadrat method of previous surveys. Results were compared to those surveyed in 1979/80, 1983 and 1985. Number of abalone, legal abalone, recruit and pre-recruit abalone per square meter were less than in previous surveys. Prerecruit indices are:

.46	abalone 94-101mm/m2 for	1979/80
.23		1983
.20		1985
.13		1989

Fishing since the 1985 survey would not account for the decline in prerecruits since that time. For all size groupings, there had been no apparent decline between 1983 and 1985, although 1983 results were 50% less than earlier surveys.

Recommendations:

1. There is substantial evidence for a long term decline in abundance of prerecruit abalone. The committee recommends

reduction in catch for all user groups, and marking of all commercial catch. Options for changing the fishing pattern must be explored.

2. Surveys should continue, particularly the Queen Charlotte Islands survey in 1990. Survey design should be examined, and the results of this review presented at PSARC in 1990.

Reviewers Comments

Two reviews of this paper are available.

The first reviewer stated the results show there has been a real decline in recruitment and a decline in prerecruit abundance which may be due to fishing. Future research should include better estimates of the sport fishery, survey methodology and the effect of removing large reproductively active adults on local larval settlement and juvenile survival.

The second reviewer stated the evidence presented in the paper suggests a serious decline in abalone abundance. The results should be further substantiated by redoing analyses of previous surveys to verify declines detected here. This along with results of the Queen Charlotte Islands survey could make a strong case for apparently much needed conservations measures.

Invertebrate logbook systems (I89-5)

A summary of invertebrate logbooks currently maintained by the Department, including the types of information recorded and the contact person, is presented. These logbook systems have become long term commitments. The costs associated with maintaining these systems are identified. The benefits are, however, less tangible and depend on types of information gleaned from these systems and the purpose(s) of the system. The authors recommend that a set of criteria be developed to assess the benefit(s) of each system. In addition, serious evaluation of proposed logbook programs (ie. crab) should be done before committing resource to these long term projects. This should include a precise definition of the systems purpose, the criteria to be used in evaluation, and the direct and indirect impacts on other programs.

Recommendations:

1. Long term commitments, such as compulsory logbook programs and biological monitoring, must be evaluated regularly to determine if performance is satisfactory and benefits meet or

exceed costs. A set of criteria for database evaluation should be established and an evaluation of invertebrate logbook systems should be conducted.

2. The Shellfish Working Group should investigate alternatives to current funding schemes that will ensure the continuation of crucial logbook systems at minimal cost to the Department (possibly some form of cost recovery/user pay system).

3. Evaluation of proposed logbook programs (e.g. crab) should be carried out before committing resources to these long term projects. This should include a precise definition of the systems purpose, the criteria to be used in evaluation and the direct and indirect impacts on other programs.

Reviewers Comments

Two reviews of this paper are available.

The first reviewer stated that the cost of logbooks seemed like a bargain compared to the information obtained. He suggested an examination be made also of the value where logbooks provide useful benefits beyond that for which they were designed.

The second reviewer also stated the cost to maintain invertebrate logbooks seemed well justified.

Marine Plants, Salicornia (I89-6)

Salicornia virginica, commonly called sea asparagus, is a perennial salt marsh herb which is found in the high intertidal zone in British Columbia. Management of these stocks is carried out by the Ministry of Agriculture and Fisheries under the Fisheries Act (B.C.). Harvest is currently controlled through licence limitation and an annual quota. The South Coast is divided into five management areas with each area requiring a separate harvesting permit. There is currently no restriction on the number of harvesters allowed under each permit.

The major issue currently facing managers is the lack of information on the contribution of S. virginica to estuarine productivity and the impacts commercial harvesting may have on this system. Studies are being conducted to examine some of these questions. Also, with the exception of Boundary Bay, no inventories exist to determine total harvestable stock within the five management areas. As product acceptance and market development expand, pressure will increase for higher quotas. Current harvest rates do not appear to be having significant impacts on standing stocks.

Recommendations:

1. The current quota of 22.5 t be maintained in 1990. Study of chronically harvested areas such as Sooke Basin should be initiated.

2. Licences should continue to be limited to six and the number of harvesters for each permit should be limited.

3. Research studies should focus on the contribution of Salicornia to the estuarine food chain.

Reviewers Comments

Two reviews of this paper are available.

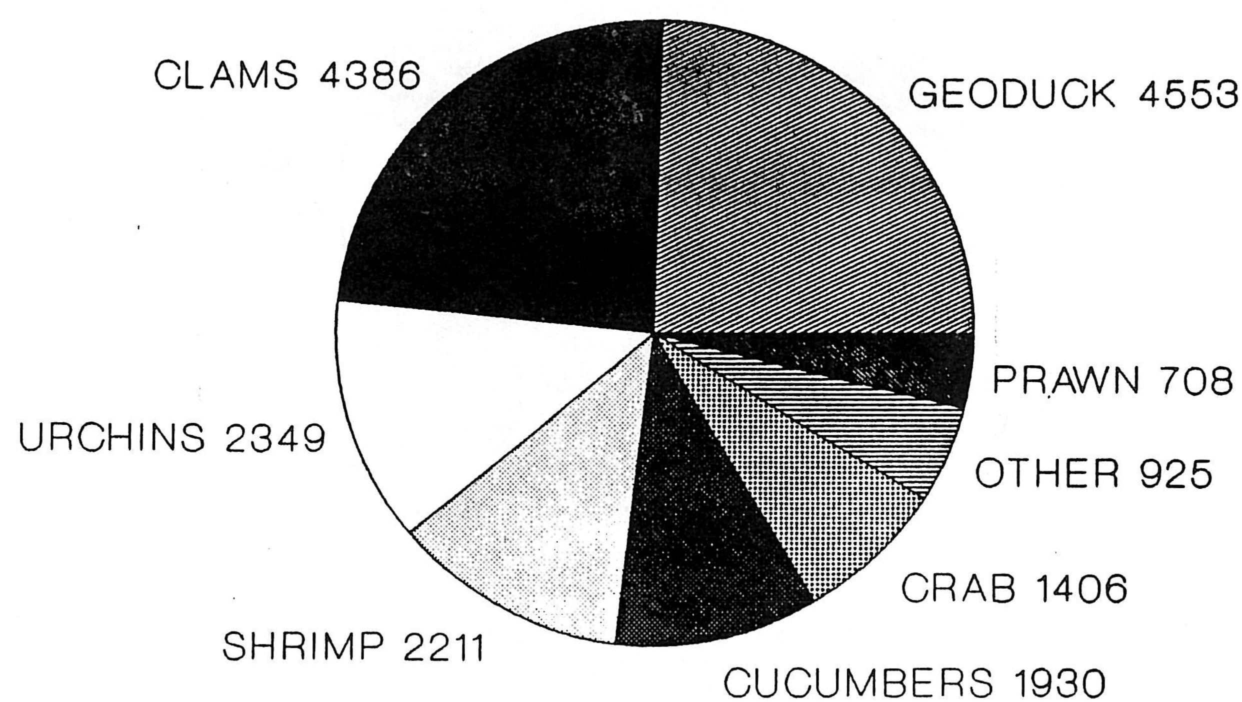
Both reviewers stated that this was an informative summary of the harvest of this plant. They both agreed with the recommendations that were proposed.

FISHERIES UPDATE REPORTS

In addition to the seven position papers, sixteen fishery update papers were presented along with one other report. These provide a convenient summary of the state of invertebrate fisheries (Appendix 2).

All papers presented will appear in a later publication.

SHELLFISH LANDINGS 1988
LANDED WEIGHT
18,070 TONNES



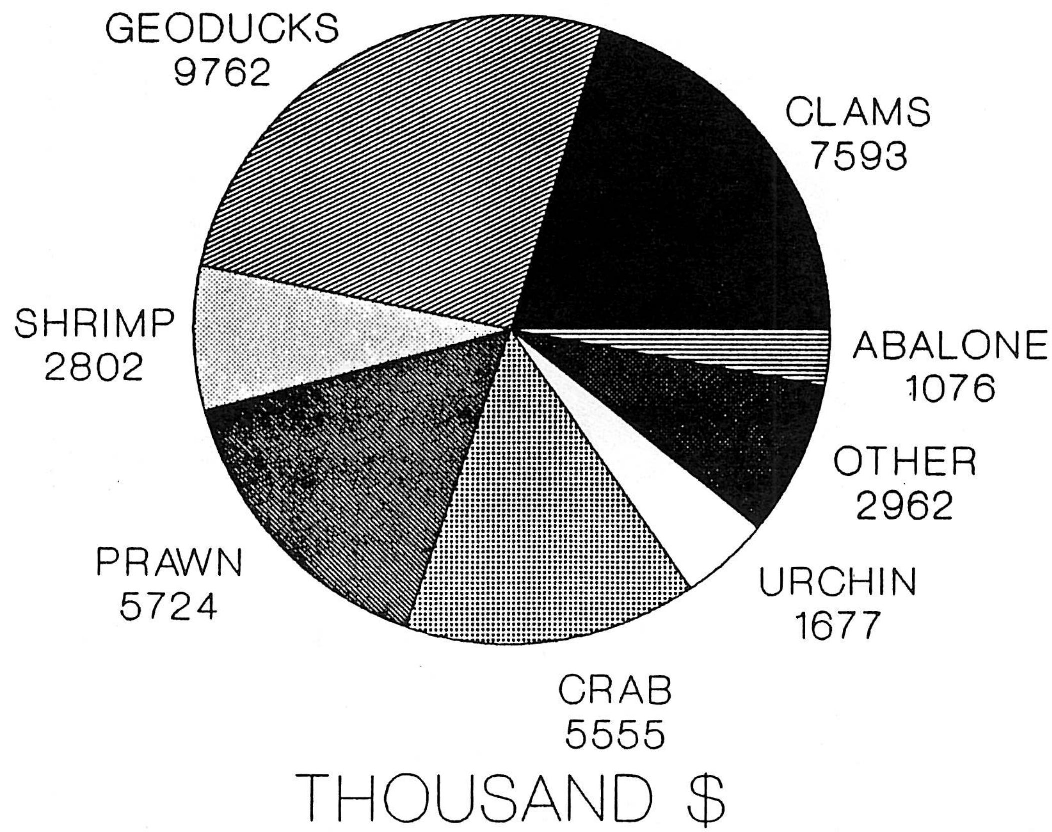
Tonnes

saleslip data (data incomplete)

SHELLFISH LANDINGS 1988

LANDED VALUE

$ 36,582,000



saleslip data (data incomplete)

Table 1. Landings of invertebrates in tonnes in British Columbia, 1981-1988

	1981	1982	1983	1984	1985	1986	1987	1988
INTERTIDAL CLAMS								
Razor	30	68	31	101	90	142	87	27
Butter	120	103	77	131	252	159	142	155
Manila	317	597	1049	1677	1914	1894	69	83
Nat. Ln.	179	241	325	295	192	285	3608	3833
Mixed	161	155	280	409	478	369	373	288
TOTAL INTERTIDAL C	807	1164	1762	2613	2926	2849	4279	4386
GEODUCK	2704	3135	2636	3483	5370	5006	5734	4553
HORSE CLAM	57	321	21	7	6	96	355	328
SHRIMP	581	415	411	408	678	768	2644	2211
PRAWN	358	274	331	381	514	550	620	708
CRAB	1317	1002	960	1155	1165	1321	1631	1406
ABALONE	85	54	56	58	42	52	49	48
OCTOPUS			37	25	34	53	130	205
SEA URCHIN								
RED			982	1764	1815	2067	2223	1951
GREEN								434
SEA CUCUMBER				95	346	786	1722	1930
SCALLOP		8	11	18	53	68	66	66
PLANKTON	19	0	47	103	131	166	130	249
SQUID			71	14	111	79	86	8
MUSSELS			tr	1	tr	2	2	3
GOOSENECK BARNACLES						2	32	18
TOTAL TONNES	5928	6373	7325	10125	13191	13865	19703	18070

Table 2. Landings in thousands of dollars of invertebrates in British Columbia, 1981-1988

	1981	1982	1983	1984	1985	1986	1987	1988
INTERTIDAL CLAMS								
RAZOR	24	55	24	123	95	127	126	137
BUTTER	42	36	33	55	138	75	40	40
MANILA	323	611	1043	1813	2278	2762	6003	7023
NAT. LN	195	263	329	311	202	327	474	357
MIXED	175	169	293	455	575	510	132	36
TOTAL INTERTIDAL C	759	1134	1722	2757	3288	3801	6775	7593
GEODUCK	2434	2814	1818	2937	4777	4294	6184	9762
HORSE CLAMS	42	235	12	5	6	63	309	300
SHRIMP	912	652	1095	1022	1180	1240	4609	2802
PRAWN	2019	1545	2154	2464	3379	3734	4326	5724
CRAB	3556	2703	3320	4558	4719	5661	6452	5555
ABALONE	721	457	464	530	442	734	973	1076
OCTOPUS			80	56	82	136	381	629
SEA URCHIN								
RED			358	712	763	1011	1276	1108
GREEN								569
SEA CUCUMBER				22	94	236	768	961
SCALLOP		17	45	56	139	212	244	285
PLANKTON	6	0	19	42	89	113	102	192
SQUID			95	17	184	127	132	113
MUSSELS		1	tr	1	0	4	3	4
GOOSENECK BARNACLES						5	221	478
TOTAL VALUE	10449	9558	11182	15179	19142	21371	32755	36582

Appendix 1. Participants

1989 PSARC-Invertebrate Subcommittee Meeting

List of participants

August 29-30, 1989

Biological Sciences Branch, Pacific Biological station

Neil Bourne (Chairman)
Jim Boutillier
Terry Butler (Aug 29)
Alan Campbell
John Fulton
Glen Jamieson
Wayne Harling (Aug. 30)
Don Noakes
Max Stocker (Aug 29)

Fisheries Branch

Barry Ackerman
Doug Brouwer
Frances Dickson
Sue Farlinger
Rick Harbo
Cindy Harlow
Kerry Hobbs
Marilyn Joyce
Scottie Roxburgh
Greg Thomas

Doug McKone, Biological Sciences Directorate, Ottawa

R. Cox, Ministry of Agriculture and Fisheries, Aquaculture and Commercial Fisheries Branch

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Appendix 2. List of position papers and fisheries updates submitted to 1989 PSARC Shellfish (Invertebrate) Subcommittee

Number	Title	Authors
	POSITION PAPERS	
189-1	Review of the 1988 shrimp trawl fishery and results of the 1989 trawl survey	J. Boutillier
189-2	Comparison of catch and effort data from sales slips and logbooks for prawns	J.D. Fulton D.J. Noakes
189-3	Stock assessment of British Columbia crab (<u>Cancer magister</u> Dana) fisheries	M. Stocker T.H. Butler
189-4	Preliminary analysis of geoduck growth data in British Columbia	D.J. Noakes A. Campbell
189-5	Invertebrate logbook systems: a review	D. Noakes J. Fulton J. Boutillier
189-6	<u>Salicornia</u> harvesting in British Columbia	R.K. Cox
189-7	Abalone resurvey in the Estevan Group and Aristazabal Island, June 1989	S. Farlinger G.A. Thomas W. Carolsfeld

FISHERIES UPDATES

<u>Molluscs</u>

Intertidal clams	N. Bourne R. Harbo K. Hobbs
Geoducks	R. Harbo K. Hobbs G. Thomas

Appendix 2 (cont'd)

FISHERIES UPDATES CONT'D

Horse Clams	R. Harbo K. Hobbs A. Campbell
Oysters	R. Cox
Scallops	N. Bourne R. Harbo
Mussels	G. Jamieson
Abalone	G. Thomas S. Farlinger
Octopus	R. Harbo K. Hobbs
Squid	R. Harbo K. Hobbs

Crustaceans

Crab	G. Jamieson
Prawn	R. Harbo K. Hobbs J. Fulton
Plankton	J. Fulton
Gooseneck barnacles	R. Harbo K. Hobbs

Echinoderms

Green sea urchins	R. Harbo K. Hobbs G. Thomas
Red sea urchins	R. Harbo K. Hobbs
Sea cucumbers	R. Harbo K. Hobbs G. Thomas

Appendix 2 (cont'd)

FISHERIES UPDATES CONT'D

Other

Pacific Stock Assessment
Review Committee

PSARC Advisory Document 89-3

Biological Advice on Management of British Columbia Groundfish for 1990

The PSARC Steering Committee met to review the Groundfish Subcommittee Report as contained in this document. The Committee notes two important issues:

1) Lingcod in the Strait of Georgia are determined to be at an extremely low level. The Committee strongly supports the options regarding the commercial and sport fishery and/or implementation of a 65 cm size limit. The size limit should be implemented coastwide.
2) Inshore rockfish fisheries are escalating. Concerns that this resource could be fished out in a short period are supported as are the recommended quotas.

This document contains brief summaries of stock conditions of the important groundfish stocks, and recommendations for their management to the Offshore Division of the Field Services Branch. The report is based on the more extensive report prepared by the staff of the Groundfish Section of the Fisheries Research Branch, located at the Pacific Biological Station, Nanaimo, British Columbia, Canada V9R 5K6.

Department biologists begin their assessments in the spring of the year using a multi-year data base for fishery statistics and biological research. A variety of assessment models are used including several sequential analysis models, age-independent surplus production models, yield-per-recruit, and linear models. Assessments are completed in August after review by a committee of DFO Groundfish scientists. Review may also incorporate outside investigators (government or non-government), where desired by the DFO Research Branch. Assessments are then reviewed by the DFO Pacific Stock Assessment Review Committee and recommended yield options are collated and sent to the Offshore Division of Fisheries Branch for consideration.

LIST OF ASSESSMENTS

Assessment texts are presented as chapters in a single Groundfish Document.

Lingcod--L. J. Richards and C. M. Hand
Pacific cod--A. V. Tyler and R. P. Foucher
Flatfish--J. Fargo
Sablefish--M. W. Saunders and G. A. McFarlane
Pacific hake--M. W. Saunders
Dogfish--M. W. Saunders
Walleye pollock--M. W. Saunders
Slope rockfish--B. M. Leaman
Shelf rockfish--R. D. Stanley
Inshore rockfish--L. J. Richards and C. M. Hand

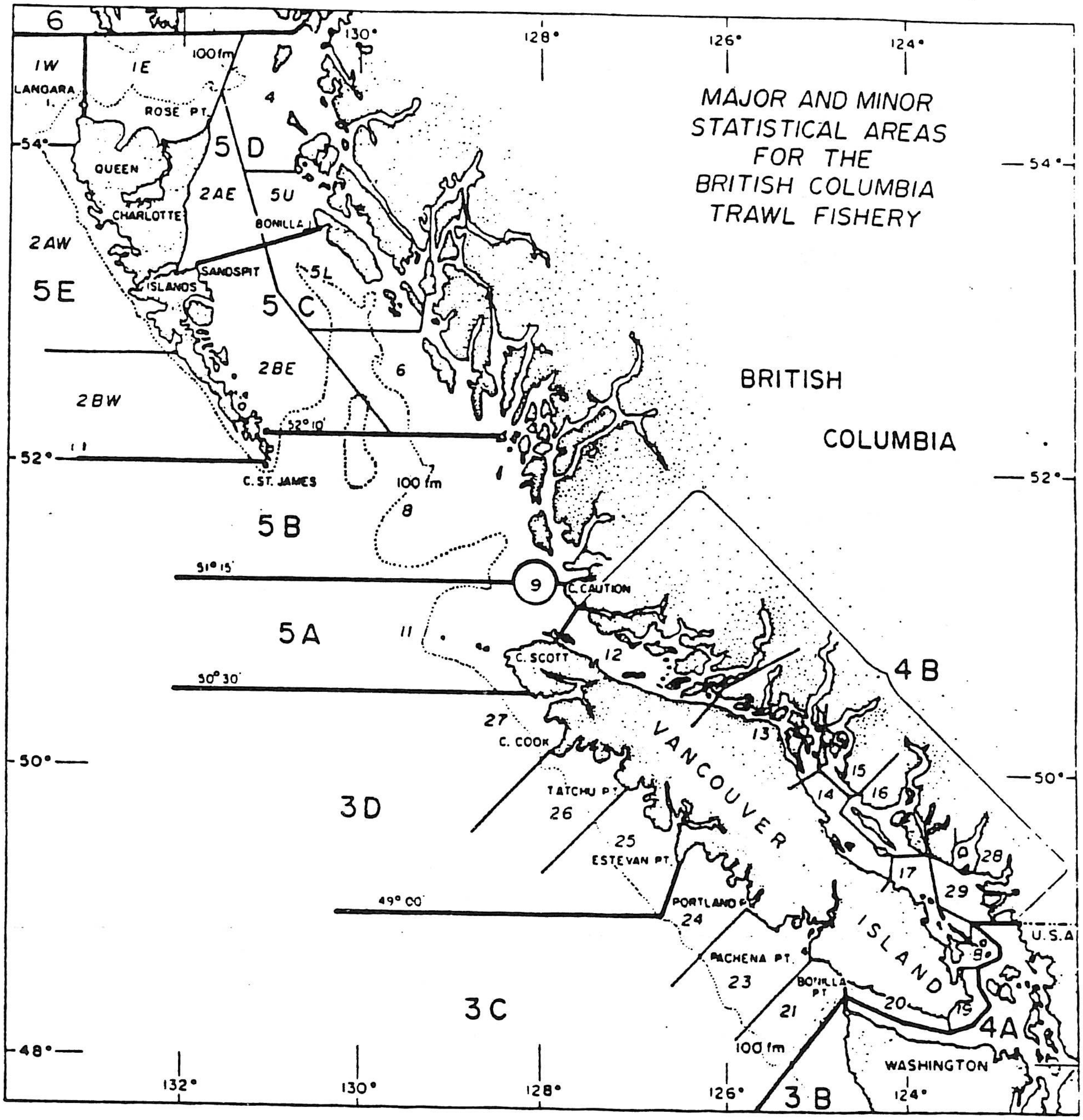

Fig. 1. International (Pacific Marine Fisheries Commission) Major and Minor Statistical Areas along the British Columbia coast.

Views on current condition of groundfish species/species groups on the west coast of Canada.

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

MANAGEMENT POLICY

While management policy is not set by the stock assessment process, a statement on policy as it exists should help to provide the setting to understand the assessments. Policy is set by the managers in consultation with representatives from industry. The analyses conducted by assessment biologists address items of policy, and specific problems brought forward by management and industry.

This year the stock assessment biologists and managers have formed task oriented committees to develop statements on long-term objectives.

YIELD OPTIONS

A number of levels of yield options are presented. All may not be appropriate to apply to a particular species or stock. The seven yield options are: (i) zero yield; (ii) rebuilding yield; (iii) sustainable; (iv) low risk-sustainable; (v) high risk-sustainable; (vi) non-sustainable and (vii) unrestricted yield.

(i) Zero yield

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

(ii) Rebuilding yield

Under this option the probability of overfishing is minimized while that of rehabilitating depleted stocks is increased. With the exception of option (i), this approach will incur the lowest risk of deleterious effects on stock biomass and dynamics. It is also true that it represents a lower yield than could be taken out of the stock on a sustainable basis. The most common application of this option is for stock rebuilding although for rockfish stocks this should be the approach to developing fisheries, because of the detection, response and corrective time frames (10-20 y) for rockfish species.

(iii) Sustainable 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. This option should be taken to mean that the probabilities of either decline or increase in yield (biomass) are approximately equal. The term "sustainable" should be understood in its broad sense, i.e., that the stock will oscillate around the expected level as a result of oscillation in recruitment, rather than be maintained at a fixed level. The amplitude and frequency of these oscillations may vary considerably among and within stocks at different levels of biomass. In the simplest terms, this is our best estimate of the highest yield at existing stock levels.

(iv) Low-risk sustainable yield

Like the Sustainable Option this is an estimate of the tonnage that can be caught during the year and leave enough of the biomass for the stock to replenish itself through reproduction and body growth. However, data are often not as complete as should be for calculation of a single, firm estimate of the true value of the sustainable yield. When there is a high degree of uncertainity about the estimate, a cautious approach to setting the catch limits should be taken. The cautious or conservative estimate is often set simply as 50% or 75% of the calculated sustainable yield, depending on the biologist's understanding of the reliability of the estimate.

(v) High-risk sustainable yield

This catch limit has some small chance of being a sustainable yield. The estimate is at the other end of the range from the low risk-sustainable yield, and is above the Sustainable yield estimate. The level is often set simply as 25% or 50% higher than the sustainable yield value. Sometimes a central value for the sustainable yield is not given, only the low risk and high risk levels. Risk levels should only be selected to provide relief from a specific case of economic hardship, with conscious recognition being made that decreases to sustainable levels in the near future might be the result of selecting this option.

(vi) Non-sustainable yield

While the sustainable option is derived from the biological properties of the species and stock composition, the non-sustainable level is largely an economic and management concept. The benefits of increased yield over the short term must be weighed against the lowered future yields resulting from overfishing. Employment of this option implies either experimental or non-biological management, since stock declines are highly probable with such a policy in effect over a significant part of the average life of a population cohort. This option might be considered when: socio/economic conditions require short-term yields in excess of sustainable harvest; experiments concerning well-defined and disparate exploitation rates are necessary; or, management policy requires sequential, pulsed fishing on several stocks.

This option requires that management will have to shift to a conservative policy to offset deleterious effects prior to major and irreversible stocks changes. Thus, this option either guarantees a pulsed exploitation pattern if the stock is to be maintained at the most productive level, or accepts short-term gains over long-term productivity.

The hazard associated with this option will vary with the biological characters of the target stocks. In particular, the residence time of a cohort in the vulnerable stock will be a key determinant in the time for detection and response. Where residency is long, higher than sustainable yields may be maintained over several years in spite of strongly deleterious, yet undetected effects on subsequent cohorts. Conversely, a short residency may permit more rapid detection of adverse effects although incremental increases in quotas should be small if uncertainty about effects is high.

(vii) Unrestricted yield

Few conditions 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 stock eradication in the case of competing species.

(viii) Other measures

The trawl fishery for groundfish is characterized by a multi-species catch. Managers, biologists, and vessel captains have noted that there are two principal difficulties created because of the multi-species characteristics. (1) Biological interactions among species may interfere with the simultaneous maximization of fisheries potential yield in all co-existing species. (2) Where there are several annual quotas on a group of co-existing species, the species quota that is taken first could close down fishing on the entire group. At present biological interactions are not explicitly built into the stock assessments. This is cause for avoiding the risk-sustainable options if at all possible. On the other hand, regarding problem 2, multi-species yield options are arranged so that premature closure for a whole group of species is unlikely. Trip limits have been used to spread the take of lower production species through the year. 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 is adjusted the following year.

DEFINITIONS FOR CATCH STATISTICS

In the past we have used the terminology "Landings" to mean round weight of fish landed by vessels in port. This has logically led to the term "Landings per unit effort" as an index of catch rate. Because some confusion has resulted from use of these terms, and because other standard terms are used by FAO, ICES, NAFO, as well as most marine fisheries biologists of the Canadian Atlantic community, we have decided to shift to the FAO standard terms, starting last year. In this stock assessment document we have used the terms NOMINAL CATCH and NOMINAL CPUE (or just CPUE) following the FAO definitions.

We take the following definition from the FAO Yearbook of Fishery Statistics: "The concept of NOMINAL CATCH refers to the landings converted to a live weight basis. The closely related concept LANDINGS refers to the quantities on a landed weight basis... There are many instances where the catches on board fishing vessels or factory ships are gutted, eviscerated, filleted, salted, dried, etc." Thus, landings come in a variety of forms.

We recognized that whole, or round fish weight measured in port as nominal catch is not preciselty the live weight of the fish as specified in the FAO statistics yearbook. When fish are iced, or refrigerated in chilled brine as is the custom with many vessels of the west coast of Canada, an individual fish takes on a small amount of extra weight due to an increase in water content.

MAJOR FISHERY CONCERNS

Major fishery concerns in the past year relate to the rockfishes. There is a disagreement between fishermen and biologists regarding the size of the standing stocks. The trawler captains believe that the stocks will support more catch than the annual quotas allow. Biologists have pointed out that the stocks are so slow-growing, that a large biomass is necessary in order to maintain the existing catch. There is both demonstrated and high potential risk of overfishing. The species are very slow-growing and the populations have a slow turnover rate. For example, individuals are 8-15 years old before they spawn for the first time. If a quota is set too high on a trial basis for 5-6 years, and overfishing occurs, it will take 25 to 30 years to repair the stock. Pacific ocean perch and yellowtail rockfish are among the species of concern.

Groundfish research staff have met with the industry's Deep Sea Trawlers Association (DSTA) to try to develop a joint DFO-DSTA rockfish survey. The minimum objective is to form a relative abundance trend series that both industry and fisheries staff will believe. The procedures that are jointly agreeable are now in place. Discussions are being carried out to establish an industry fund for the surveys.

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, but that the sports fishery now accounts for much of the present take, and must be controlled if rehabilitation is to ensue.

With the adoption of a coastwide management plan for Pacific ocean perch, the biologists and managers agreed to make special provisions for the Goose Island Gully stock in Queen Charlotte Sound, since this stock is below the standing biomass level that would produce maximum yield. Yet the stock is being fished at levels that are probably not sustainable. The high-risk sustainable level for the combined Goose Island-Mitchells Gullies is 1000 t, while the low-risk sustainable level is 700 t. The estimated perch catch for this area in 1988 was 1186 t. The fishery was not yet complete for 1989 at the time of writing, but the catch is expected to be about the same in 1989. Trawler captains have been very vocal on keeping the area open for a summer fishery despite the high catches that were made by July 1 in each of the last 2 years.

Yellowtail rockfish assessments were subject to a major review this year by a joint committee of U.S. and Canadian assessment biologists because of a transboundary issue. The main findings were that the fish do not mix on a coastwide basis as was thought. The Southwest Vancouver Island fish seem to mix with yellowtail rockfish in the U.S. fishery zone off Washington. The fish off Northwest Vancouver Island are subject to an active domestic trawl fishery, but the rate of mixing with either the U.S. portion of the distribution, or into Queen Charlotte Sound, remains indeterminate. The combined potential yield for Queen Charlotte Sound and Northwest Vancouver Island would range from 1900-4600 t, whereas the take from the domestic fishery off Southwest Vancouver Island should be limited to 300 t, in addition to the quantity taken in the Pacific hake fishery. In 1988 the trawl fishery took 4766 t. A controversy will continue with U.S. managers regarding the magnitude of the total catch until the nature of the Northwest Vancouver Island distribution is resolved.

The sablefish fishery ran into difficulty this year when the 4000 t quota was taken prior to all K-licence vessels fishing in their registered, chosen openings. Managers decided to allow a quota overrun as an economic stop-gap measure. Alternative management approaches are being considered. Biologists are under pressure to increase recommended annual quota because of increased CPUE. They are regarding this increase cautiously because the increase coincides with a change in management strategy for the fishery. An investigation of factors that could cause the increase is underway.

The recommendations for west coast groundfish for 1990 are summarized below:

Area	Species	Management options
4B	Lingcod	1. Experimental Sub-area closures. 2. Total closure of sport and commercial fisheries. 3. Introduce minimum size limit of 65 cm for commercial and sport-caught lingcod to protect immatures.
3C	Lingcod	1. Winter closure Nov. 15-Apr. 30. 2. Low risk-sustainable: 1000 t. 3. Sustainable: 1400 t 4. High risk-sustainable: 2000 t. 5. Size limit of 65 cm.
3D	Lingcod	1. Winter closure Nov. 15-Apr. 30. 2. Size limit of 65 cm. 3. Low risk: 300 t. 4. Sustainable: 400 t. 5. High risk: 600 t.
5A/B	Lingcod	1. Size limit of 65 cm for commercial fishery. 2. Low risk: 600 t 3. Sustainable: 900 t 4. High risk: 1400 t
5C/D/E	Lingcod	No options proposed.
4B	Pacific cod	No options proposed.

Area	Species	Management options
3C/3D	Pacific cod	Open fishing due to high abundance.
5A/5B	Pacific cod	No options proposed.
5C/5D	Pacific cod	1. Low risk sustainable: 2800 t. 2. Sustainable: 3800 t. 3. High risk sustainable: 4860 t.
5E	Pacific cod	No options proposed.
Coastwide	Petrale sole	1. Sustainable: trip limit 4,000 lb.
4B	Flatfish	No options proposed.
3C/D	Dover sole	1. Low risk sustainable: 1000 t. 2. Sustainable: 1500 t. 3. High risk sustainable: 2000 t.
5A	Rock sole	1. Low risk sustainable: 100 t (with 30,000 lb trip limit). 2. Sustainable: 175 t. 3. High risk sustainable: 250 t.
5B	Rock sole	1. Low risk-sustainable: 200 t, 30,000 lb trip limit. 2. Sustainable: 300 t, 30,000 lb trip limit. 3. High risk-sustainable: 400 t.

Area	Species	Management options
5C	Rock sole	1. Low risk-sustainable: 500 t, 30,000 lb trip limit. 2. Sustainable: 550 t, 30,000 lb trip limit. 3. High risk-sustainable: 700 t.
5D	Rock sole	1. Low risk-sustainable: 700 t, 20,000 lb. trip limit; or 30,000 lb, 2 trips/mo. 2. Sustainable: 850 t, trip limits as in 1. 3. High risk-sustainable: 850 t.
5C/D	English sole	1. Low risk sustainable: 700t. 2. Sustainable: 750 t 3. High risk-sustainable: 800 t.
5C/5D/5E	Dover sole	1. Low risk-sustainable: 800t quota, 20,000 lb/trip permitted <u>after</u> 75% of the quota is reached. 2. High risk-sustainable: 1,000 t quota 20,000 lb/trip permitted after 75% of the quota is reached.
Coastwide	Sablefish	1. Low risk-sustainable: 2,900 t quota. 2. Sustainable: 4,000 t. 3. High risk-sustainable: 5,000 t quota.
4B, not including MSA 19, 20	Pacific hake	1. Low risk-sustainable: 8,000 t. 2. Sustainable: 11,000 t. 3. High risk-sustainable: 14,000 t.

Area	Species	Management options
3C	Pacific hake	1. Low-risk sustainable 32,000 t. 2. Sustainable 50,000 t. 3. High-risk sustainable 70,000 t* *As high as 84,000 t depending on Can/U.S. % allocation.
Coastwide	Dogfish	1. Pulse fishing: variable annual (not including 4B) quota until non-nuisance abundance reached. 2. Low risk-sustainable: 15,000 t in 3 and 4 quarter of year only. 3. Low risk-sustainable alternative: 9,000 t in 1 and 2 quarter of years only. 4. High risk-sustainable: 25,000 t in 3 and 4 quarter only. 5. High risk-sustainable alternative: 15,000 t in 1 and 2 quarter of years only.
4B, not including annual MSA 12, 19, 20.	Dogfish	1. Low risk sustainable: 2,000 t. 2. Sustainable: 2,500 t. 3. High risk-sustainable: 3,000 t.
4B	Walleye pollock	1. Low risk-sustainable: 2,500 t quota. 2. High risk-sustainable: 5,400 t quota.
3C/3D	Walleye pollock	Options not proposed.
5A/5B	Walleye pollock	Options not proposed.

Area	Species	Management
5C/5D	Walleye pollock	Open fishing option proposed.
5E	Walleye pollock	Options not proposed.
3C	Yellowtail rockfish	Joint management with U.S. (Interim domestic fishery ceiling quota): 300 t.
5A/5B	Yellowtail rockfish	Low risk sustainable: 1400 t. High risk sustainable: 3600 t.
5C/5D/5E	Yellowtail rockfish	Low risk sustainable: 160 t. High risk sustainable: 500 t.
3C/3D	Silvergray rockfish	Low risk-sustainable: 400 t. High risk-sustainable: 600 t.
5A/5B	Silvergray rockfish	Low risk sustainable 700 t High risk-sustainable: 850 t
5C/5D	Silvergray rockfish	Low risk sustainable 400 t High risk-sustainable: 600 t.
5E-S	Silvergray rockfish	No recommendation. Currently an incidental fishery.

Area	Species	Management options
5E-N	Silvergray rockfish	No recommendation. Currently an incidental fishery.
3C/3D	Canary rockfish	Low risk-sustainable: 400 t. High risk-sustainable: 600 t.
5A/5B	Canary rockfish	Low risk-sustainable: 350 t High risk-sustainable: 500 t
5C/5D	Canary rockfish	Low risk-sustainable: Unknown High risk-sustainable: 500 t
5E-N/S	Canary rockfish	Low risk-sustainable: Unknown High risk-sustainable: 500 t
3C options (including Area 125)	Pacific ocean perch	1. Rebuilding:<100 t 2. Low risk-management sustainable:100 t 3. High risk-sustainable 200 t
3C	Redstripe rockfish	Low risk-sustainable:200 t High risk sustainable: 1,000 t
3D	Pacific ocean perch	Low risk-sustainable:200 t High risk-sustainable:600t
3D/5A	Yellowmouth	Low risk-sustainable:250 t High risk-sustainable:750t

Area	Species	Management options
3D/5A	Redstripe	Low risk-sustainable:350 t High risk-sustainable:900t
5A/5B	Pacific ocean perch	Rebuilding:<700 t Low risk-sustainable:700 t High risk-sustainable: 1,000 t
5C/5D	Pacific ocean perch	Low risk-sustainable: 1,900 t High risk-sustainable 3,000 t
5C/5D	Yellowmouth	Low risk-sustainable:160 t High risk-sustainable:500t
5C/5D	Redstripe	Low risk-sustainable:350 t High risk-sustainable:570t
5E-S	Pacific ocean perch	Low risk-sustainable:300 t High risk-sustainable:500t
5E-S	Yellowmouth	Low risk-sustainable:400 t High risk-sustainable:700t
5E-S	Rougheye	Low risk-sustainable:200 t High risk-sustainable:300t
5E-S	Grouped slope rockfish (Pacific ocean perch, yellow-mouth and rougheye)	January-June Low risk-sustainable:300 t High risk-sustainable:500t September-December Low risk-sustainable:600 t High risk-sustainable: 1,000t
5E-S	Redstripe	Low risk-sustainable:50 t High risk-sustainable:100t

Area	Species	Management options
5E-N	Pacific ocean perch	Low risk-sustainable:150 t High risk-sustainable:170t
5E-N	Yellowmouth	Low risk-sustainable:350 t High risk-sustainable:500t
5E-N	Rougheye	Low risk-sustainable:50 t High risk-sustainable:100t
5E-N	Redstripe	Low risk-sustainable:500 t High risk-sustainable:700t
4B-MSA-12	Copper/ Quillback	Low risk-sustainable:75 t High risk-sustainable:125t
4B-MSA-13	Copper/ Quillback	Low risk-sustainable:50 t High risk-sustainable:100t
4B-MSA-14-20, 28,29	Copper/ Quillback	Low risk-sustainable:100 t High risk-sustainable:150t
4B	Yelloweye	Low risk-sustainable:25 t High risk-sustainable: 75t
3C/D	Grouped line rockfish	Low risk-sustainable:60 t High risk-sustainable:370t
5A/B/C/D/E	Grouped line rockfish	Low risk sustainable:120 t High risk sustainable: 770 t

TEXT SUMMARIES OF ASSESSMENTS

Lingcod

Lingcod stocks were assessed with a size-structured model and by historical trends in CPUE. In addition, a new analysis indicated that size at 50% maturity is near 65 cm for female lingcod, well above the commercial size limit of 58 cm. Stocks were determined to be at extremely low levels in the Strait of Georgia portion of the Vancouver Area, and at moderate-high levels in the remainder of the Charlotte Vancouver Region. Yield projections were 1900-4000 t. An increase in the size limit from 58 cm to 65 cm is recommended coastwide, to be applied to all gear types. The increase is based on an analysis of size at maturity.

Pacific cod

The stocks of Pacific cod in the Canadian Fishing Zone were all at higher than average abundance levels. A new model was developed for the Hecate Strait stock, which produced 65% of the Canadian Pacific cod landings. All stock assessments, including the new age-structured model, are heavily based on standardized, commercial catch-at-age and catch per unit effort data. The special aspect of the new model was the use of a multivariate, second-order fitting technique that could account for the influence of water-mass advection and stock size on recruitment. The stock size fluctuated from 8,800 t to 17,600 t, but had a parent stock size of only 3,200 t that produced maximum annual surplus production (potential yield). This yield was estimated at 5,600 t in 1989, and 3,700 t in 1990. No catch limitations have been placed on the other Pacific cod stocks for 1990. The coastwide catch is not expected to exceed 7,000 t in 1990.

Flatfish

Flatfish stocks in 1989 were assessed on the basis of surplus production analysis of standardized landing statistics, trends in CPUE, and yield per recruit analysis. Petrale sole stocks were determined to be at low levels, rock sole stocks at high levels, and English sole and Dover sole stocks at moderate levels. Landing statistics for all rock sole stocks were standardized using a multiplicative model accounting for effects of vessel horsepower on CPUE. Recruitment of the 1985 year-class resulted in a significant increase in rock sole yield and sustainable yield estimates. English sole were assessed as a single stock in Hecate Strait for the first time. Yield per recruit analysis for

English sole indicated that yield could be increased 30% if age of recruitment were 4 as opposed to 3. Yields for various stocks of each species have the following coastwide ranges: Dover sole 800-2000 t, rock sole 100-1000 t, English sole 700-800 t.

Sablefish

Coastwide standardized CPUE values increased from 11.2 kg/trap in 1987 to 21.1 kg/trap in 1988. While this suggested that the stock was increasing in abundance, the change coincided with a change in management strategy for the fishery. An investigation of whether the increase was a result of increased recruitment, changing availability or an artifact of the new management scheme is currently underway.

Overall the condition of the sablefish stock in the Charlotte-Vancouver area is good. An age-structured forward simulation model was used to project biomass and yield, incorporating numbers-at-age from Virtual Population Analysis (VPA) as the starting vector for the population. Yields ranging from 2,900 to 5,000 t were presented as low to high risk sustainable yield options for 1990.

Pacific hake

In the Strait of Georgia portion of the Vancouver area, estimates of biomass during 1988, from swept-volume trawl and hydroacoustic surveys were 112,000 t and 73,300 t, respectively. These estimates compare favourably with identical surveys conducted in 1981. An assessment conducted using Virtual Population Analysis (VPA) and a forward simulation model, indicated that yields up to 14,000 t may be sustainable. Assessment information for the offshore stock is not yet available.

Dogfish

Dogfish continued to support modest longline and trawl fisheries with a combined catch in the Vancouver and Charlotte areas of 4,904 t. Dogfish stocks were assessed using a deterministic age-structured model. The biomass in the Charlotte/Vancouver areas was estimated to be between 150,000-200,000 t. At current levels of harvest the stock was predicted to increase over the next 5-10 years. Coastwide yield levels ranged from 11,000 to 28,000 t.

Walleye pollock

The 1988 pollock catch in the Canadian domestic fishery decreased from 1275 t in 1987 to 681 t in 1988. The 1988 incidental joint-venture and foreign catch decreased to 228 t from 1168 t in 1987. Canadian scientists surveyed the Strait of Georgia portion of the Vancouver zone in 1988, using swept-volume trawl and hydroacoustic techniques. Biomass was estimated to be between 9,069 and 22,500 t. Yields up to 5400 t are considered sustainable.

Slope rockfish

Condition and yield potential of slope rockfishes (Sebastes alutus, S. reedi, S. aleutianus, and S. proriger) were assessed with methods including sequential age-structured, length-frequency simulation and stochastic recruitment models. In addition, some stocks were assessed solely on the basis of trends in fishery statistics or biological characteristics, due to data limitations. Stocks of Pacific ocean perch (S. alutus) were generally depressed and have shown no recovery from lowered abundances caused by high fishing mortalities applied during the mid-1960s. Coastwide yield estimates range from 3350-5470 t. Yellowmouth (S. reedi), rougheye (S. aleutianus) and redstripe (S. proriger) rockfishes were in moderate to poor condition with coastwide yield estimates of 1160-2450 t, 250-400 t, and 1450-3270 t, respectively. Redstripe rockfish was not subject to a management control program.

Shelf rockfish

The yellowtail rockfish assessment was conducted with age-structured analysis. Yellowtail rockfish abundance in Queen Charlotte Sound appears to be increasing to virgin biomass levels following increased recruitment since 1974. The recommended yield range for this stock is 1400-3600t. Joint management with the U.S. is recommended for the southernmost population. Canary and silvergray rockfish stocks were assessed by examination of catch rates and length frequency simulation. Traditional fisheries for these stocks are minor (<1000 t/yr). Size and age composition indicates that they are already being harvested at rates equal to or greater than what is sustainable. Recommended yield ranges for 3 of the 5 major stocks are lowered slightly. The total recommended yield range for the five stocks is 2250-3150 t.

Inshore rockfish

There has been a continued escalation of the line fishery for rockfish in the Vancouver-Charlotte Region. Stocks were assessed by historical trends in CPUE and by changing size and age structure of populations from commercial samples. Stock condition was determined to be poor in heavily exploited areas. Yields were estimated to range from 430-1590 t in 1989.

REVIEWER ASSIGNMENTS FOR GROUNDFISH STOCK ASSESSMENTS

Title	Authors	Reviewers
Lingcod	L. Richards, C. Hand	J. Fargo, M. Saunders
Pacific cod	A. Tyler, R. Foucher	R. Stanley, C. Wood
Flatfish	J. Fargo	L. Richards, R. Stanley
Sablefish	M. Saunders	C. Hand, B. Leaman
Dogfish, walleye pollock	M. Saunders	A. Tyler
Pacific hake	M. Saunders	L. Richards, A. Tyler
Slope rockfish	B. Leaman	J. Fargo, M. Saunders
Shelf rockfish	R. Stanley	R. Foucher, D. Noakes
Inshore rockfish	L. Richards, C. Hand	R. Foucher, B. Leaman

PARTICIPANTS AT THE GROUNDFISH SUBCOMMITTEE MEETING
August 31-September 1, 1989

A. Tyler, Chairman
D. Adams
G. Beuchler
J. Fargo
S. Farlinger
R. Foucher
C. Hand
R. Harbo
B. Leaman
D. McKone
G. McFarlane
M. Saunders
R. Stanley
L. Richards
N. Venables
C. Wood
E. Zyblut

Appendix 1.

Table 1. Total Canadian landings [a] (t) of groundfish by species, taken from all areas on the Pacific Coast, 1978-88.

Species	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1978-87	1988 [b]
English sole	809	1,069	1,244	1,500	559	532	812	692	452	755	842	878
Rock sole	1,312	1,874	1,843	1,059	745	668	525	430	454	887	980	1,965
Petrale sole	230	202	222	290	367	439	417	336	416	445	336	790
Dover sole	736	861	1,273	1,245	914	871	1,148	963	1,167	633	981	1,281
Rex sole	102	203	145	190	74	49	219	205	87	83	136	145
Starry flounder	74	296	118	198	168	66	170	66	54	65	128	110
Turbot	2,326	1,826	1,448	946	525	323	369	764	895	1,193	1,062	375
Other flatfish	25	59	57	183	220	199	141	161	215	232	149	146
Pacific cod	6,750	9,554	8,703	6,708	4,810	4,505	3,465	2,342	3,650	13,917	6,440	11,015
Lingcod	2,004	2,098	2,151	2,467	4,162	3,755	3,688	5,668	3,827	3,591	3,341	3,434
Sablefish	831	2,031	3,793	3,888	3,976	4,414	3,855	4,275	4,668	4,719	3,645	5,716
Pollock	2,407	3,387	2,201	1,251	924	1,070	800	1,895	577	1,270	1,578	1,111
Hake	2	818	606	5,691	2,826	3,122	4,600	6,055	6,802	13,275	4,380	6,054
Ocean perch	3,864	2,819	5,290	5,103	5,983	5,655	6,698	6,069	5,914	6,335	5,373	6,920
Other rockfish	6,608	5,962	4,476	4,857	5,093	7,024	8,512	11,709	19,040	18,177	9,146	20,367
Misc. species	163	215	303	266	141	156	175	192	245	344	220	351
Dogfish	3,126	4,757	4,547	1,151	3,875	3,274	2,510	2,815	3,289	3,801	3,315	5,144
Animal food	112	214	191	42	65	94	161	309	255	188	163	130
Reduction	302	240	528	302	450	321	244	214	175	210	299	563
Total	31,783	38,485	39,139	37,337	35,877	36,537	38,509	45,160	52,182	70,120	42,513	66,495

[a] Does not include catches from joint-venture or foreign fishery, see Table 54.
[b] Preliminary data.

Appendix 1.

Table 2 . Joint-venture and foreign catches [a] (t) of groundfish from international Area 3C -- southwest coast of Vancouver Island in 1988.

Nation and species	Joint-venture	National	Supplemental	Total
Poland				
Pacific hake	26,314	23,712	2,673	52,699
Walleye pollock	177	tr.	tr.	177
Pacific ocean perch	tr.	56	3	59
Other rockfish	36	216	44	295
Other species	2	47	tr.	49
USSR				
Pacific hake	22,818	11,270	2,060	36,148
Walleye pollock	50	-	-	50
Pacific ocean perch	2	7	69	78
Other rockfish	67	59	25	151
Other species	35	tr.	tr.	35
Japan				
Pacific hake	1,050	-	-	1,050
Walleye pollock	-	-	-	0
Pacific ocean perch	2	-	-	2
Other rockfish	6	-	-	6
Other species	tr.	-	-	0
Total				
Pacific hake	50,182	34,982	4,733	89,897
Walleye pollock	227	0	0	227
Pacific ocean perch	4	63	72	139
Other rockfish	109	275	68	453
Other species	37	47	tr.	84

[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 89-4

**BIOLOGICAL ADVICE ON MANAGEMENT OF
BRITISH COLUMBIA HERRING FOR 1990**

On September 14, 1989 the PSARC Steering Committee reviewed the Herring Subcommittee Report as contained in this document. Apart from minor editorial points, the report was endorsed as it stood.

The Subcommittee met at the Blackcomb Lodge in Whistler during September 6-7, 1989 to derive a consensus on the status of herring stocks in 1989 and expectations for 1990. The list of working papers (Appendix 1) and Participants (Appendix 2) are attached. The primary objectives for the meeting were:

1. Reach a consensus regarding the status of stocks relative to the 1989/1990 fishing season.

2. Review the stock assessment source documents prepared by staff of the herring section and make recommendations regarding 1989/90 catch, for consideration by the PSARC steering committee.

3. Identify areas where further biological research is most needed for management purposes and develop recommendations regarding these problem areas (Appendix 5).

The following 8 criteria were evaluated for each stock in order to make recommendations regarding stock status and potential catch levels:

1. SPAWN AND STOCK TRENDS - age-structured model, escapement model, spawn indices

2. RECRUITMENT TRENDS - age-structured model, escapement model

3. RECRUITMENT FORECASTS - analytical models, juvenile surveys

4. FORECAST WEIGHTED RUN SIZE

5. SOUNDING SURVEYS - in-season, winter surveys

6. CUTOFF LEVELS

7. CHARTER SKIPPER COMMENTS

8. ADDITIONAL INFORMATION FOR SPECIFIC STOCKS

Based on the evaluation of these criteria for each stock, conclusions were drawn on the current biological status of the stock and recommendations made as to the potential catch levels for each.

Biological and Management Objectives

British Columbia herring are currently managed by a fixed harvest rate policy in conjunction with a CUTOFF level of 25 percent of the long-term average biomass. To ensure conservation of the stocks 20 percent of the forecast biomass of each of seven recognized distinct stocks is harvested annually unless the run falls below the CUTOFF level in which case 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 commercial fisheries since 1877, although reliable records of place, date, and quantity caught are available only since 1950. There was a fishery for a dry salted market from 1904-1934, with catches up to 85,000 tonnes in a year. A reduction fishery, mainly by purse seining followed (1935-1967). Fish were taken during their inshore spawning migrations from October to February. Very large catches, of 200,000 tonnes annually, in the early 1960s followed by a series of poor recruitments led to the collapse of the reduction fishery, with a 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. Roe herring landings have averaged 29,040 tonnes for the last five years.

The roe fishery first came under quota regulations in 1983. Prior to this, guidelines of anticipated roe catches were given. Roe catches since 1980 are tabled below (for 1989 data are hailed; catches and quotas are in thousands of tonnes):

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Queen Charlotte Islands										
Catch	3.4	6.4	5.3	8.1	5.0	6.3	3.6	2.0	0.3[a]	1.4
Quota				*	4.6	5.0	3.8	1.4	0.0	0.9
Prince Rupert District										
Catch	2.7	1.4	0.1[a]	0.0	3.5	6.5	8.3	6.1	7.9	8.0
Quota				*	4.0	5.0	6.4	5.4	7.5	7.3
Central Coast										
Catch	0.5	2.6	6.3	5.6	7.2	5.2	3.3	3.6	4.5	8.5
Quota				*	6.6	4.1	2.3	3.4	3.7	7.8
Strait of Georgia										
Catch	3.3	7.1	8.9	16.4	10.2	6.2	0.2[a]	9.1	7.5	7.3
Quota				11.7	11.6	4.7	0.0	8.1	6.4	7.4
W. Coast Vancouver Is.										
Catch	4.5	8.8	6.1	8.7	6.7	0.2[a]	0.2[a]	15.9	9.7	13.4
Quota				4.5	4.5	0.0	0.0	9.4	8.1	10.3
Total Coast										
Catch	14.4	26.3	26.5	38.8	32.6	24.4	15.6	36.7	29.9	38.6
Quota				28.0	31.3	18.8	12.5	27.7	25.8	33.7

* North of Cape Caution the quota for 1983 was 11.8.
[a] Charter boat removals.

<u>Stock Status in 1989</u>

Herring abundance along the B.C. coast increased slightly in 1989. The estimated spawning biomass for the seven assessment regions is 190,300 tonnes, a 4% increase over 1988 spawn levels. The 1985 year class was dominant in all assessment regions. This year class is well above average in size throughout the coast. The following discussion of stock trends and 1989 spawning biomass are based on the weighted escapement estimates of both assessment methods. Stock trends and other assessment criteria are listed in Appendix Table 3.

The assessment regions used for the 1989 stock assessments have changed somewhat from those used in previous years. These changes had been suggested at the 1988 PSARC herring subcommittee meeting. In the Queen Charlotte Islands the assessment region has been expanded to incorporate spawning stocks in Louscoone and Cumshewa Inlets. This expanded assessment region is consistent with the stock concept used for this area during both the reduction and earlier roe fishing periods. Spawn timing is similar in Louscoone and Skincuttle Inlets suggesting some commonality between fish spawning in these two areas.

The second area where the stock concept has changed for the 1989 assessments is the northern west coast of Vancouver Island. In the past this assessment region has encompassed statistical areas 25 to 27. However there have never been substantial roe fisheries in areas 26 and 27, and no spawn has been reported for area 26 since 1977. Area 27 has maintained a small spawning stock. Because of concern that by setting quotas for the larger (area 25 to 27) assessment region but consistently harvesting fish only in the southern part of that region the stocks in area 25 would be overexploited, the assessment region was modified to include only area 25.

For the remaining areas of the coast there has been no change for this years stock assessments. That is: the Prince Rupert District encompasses areas 3 to 5; the Central Coast contains area 7, Kitasu Bay in area 6 and Kwakshua Channel in area 8; the Strait of Georgia is separated into a northern and southern stock with the boundary between the two at Dodd Narrows; the southern west coast of Vancouver Islands encompasses areas 23 and 24.

North Coast Stocks

Spawning stocks in the Queen Charlotte Islands increased substantially in 1989; the estimated biomass of 25,500 tonnes represents a 55% increase over 1988 spawn levels. Four year olds (1985 year class) comprised 50% of the stock and 3 year olds (1986 year class) 28% of the stock. The 1985 year class is estimated to be double the 1951-1989 average and the 1986 year class is estimated as average.

The two assessment models produce significantly different estimates of stock size for the Prince Rupert District. The escapement model estimate of 12,900 tonnes of spawners is down substantially from 1988, whereas age-structured model analysis suggests an increase in spawners to 47,800 tonnes. The reason for such major differences in stock estimates is not apparent. One reason which was suggested at the subcommittee meeting pertains to a major shift in size at age in the Prince Rupert stocks. Currently, average weight at age is about 20% lower than it was in the mid 1970'3 and gillnet gear is selective for only the larger fish at all ages. In earlier years of the roe fishery all age 5 and older herring in the Prince Rupert District were large enough to be caught by gillnets. This shift in selectivity could bias the age-structured stock assessments for this area. Another explanation for the large differences in biomass estimates could be that stocks holding in the area prior to spawning moved elsewhere to spawn. The majority of spawns in this region were surveyed by SCUBA divers in 1989 so estimates from the escapement model should be reasonably accurate.

The 1989 weighted spawning biomass estimate for the central coast stock is 40,800 tonnes, a 9% decrease from 1988. The 1985 year-class was particularly dominant in this region; 4 year olds comprised 76% of the stock. This cohort is one of the largest over the 1951-1989 time period.

South Coast Stocks

Spawning biomass in the Strait of Georgia increased in 1989. The weighted biomass estimate was 52,500 tonnes, with 45,160 tonnes spawning in the northern area and 7,360 tonnes spawning in the southern area.

On the west coast of Vancouver Island the 1985 year class comprised 63% of the southern stock and 51% of the northern stock. In both assessment regions this year class is estimated to be double the long term average year class size. Spawning stocks in the southern area remained stable at 27,500 tonnes while stocks in the northern area decreased slightly to 13,600 tonnes. Stock estimates from the age-structured model continue to be unrealistically high for the northern assessment region so estimates from this model are weighted less than those from the escapement model.

Recruitment Forecasting and Prognoses for 1990

The dynamic nature of herring stocks is a function of recruitment variability. However, because of the many biological and environmental factors involved it is very difficult to estimate recruitment accurately. Ongoing research projects on LaPerouse Bank and in Georgia Strait are attempting to elucidate the effects of some of these factors on recruitment.

The potential recruitment to each stock is calculated as the mean of the third best, the middle third, and the third poorest recruitments observed in the historical time series. The expectation for the forecast year is average unless there are other indications that recruitment is expected to be better or worse than usual. However, there is rarely any objective information on recruitment expectations and the actual recruitment level chosen by the subcommittee invariably reflects the expectation for the change in stock status rather than recruitment, per se. This has the effect of moderating the actual harvest rate on particular stocks. For example, if a stock is in decline, the expected recruitment may be changed from average to poor to effect a lower harvest rate and hopefully ameliorate the decline in the stock level. The reverse can occur on an upward trend to take advantage of the larger potential catch from a healthy stock.

Recruitments are added to expected return spawners and when the forecast run exceeds the CUTOFF level a 20% harvest rate is recommended. The CUTOFF levels for each stock are established at one-fourth of the estimated long term unfished average biomass. For six areas on the coast, the following CUTOFF levels have been established:

	CUTOFF (tonnes)
Queen Charlotte Islands[a]	10,600
Prince Rupert District	12,100
Central Coast	10,600
Strait of Georgia	22,100
W. coast Vancouver Island - south	15,100
W. coast Vancouver Island - north[a]	8,700

[a] The CUTOFF levels for the Queen Charlotte Islands and the northern west coast of Vancouver Island have not yet been recalculated for the revised assessment regions.

The recruitment assumption, the corresponding 1990 runs, and recommended catches ('000 tonnes) area shown below (also see Appendix 3):

Stock Assessment Region	Recruitment	1990 Forecast	Recommended Catch
Queen Charlotte Islands	average	35.3	7.06
Prince Rupert District	average	23.3	4.66
Central Coast	average	43.2	8.64
Strait of Georgia			
North	average	47.8	9.56
South	poor	7.4	1.48
W. coast Vancouver Island			
South	average	28.8	5.76
North	poor	7.1	1.42
Total Coast		192.9	38.63

The forecast stock size for the Queen Charlotte Islands is 35,300 tonnes with an assumption of average recruitment. This stock has recovered substantially from the low levels observed in 1987 and 1988 and should support reasonable fisheries in 1990. The recommended catch for this region is 7,060 tonnes.

For the Prince Rupert District there is conflicting evidence regarding stock status in 1989. The data suggest that spawn levels are down substantially, however there are some indications that greater stocks were in the area prior to spawning. The committee recommended that the escapement model, which is primarily based on spawn data, be weighted more heavily than the age-structured model for stock forecasts. The stock forecast for the Prince Rupert District, assuming average recruitment is 23,300 tonnes for a recommended catch level of 4,660 tonnes.

For both the Central Coast and Northern Strait of Georgia herring stocks an assumption of average recruitment for 1990 was adopted. The forecast pre-fishery biomass for these two stocks is 43,200 and 47,800 tonnes, respectively. The recommended catches are 8,640 tonnes for the Central Coast and 9,560 tonnes for the Northern Strait of Georgia.

Escapement model stock reconstructions indicate a steady decline in spawning biomass for the Southern Strait of Georgia herring stock since 1979. This downward trend is consistent with spawn index trends and warrants some concern. For this reason a poor recruitment assumption was adopted for this area. The forecast 1990 pre-fishery biomass is 7,400 tonnes yielding a recommended catch of 1,480 tonnes.

The herring stock on the southern west coast of Vancouver Island has been relatively constant over the past 3 years. There is no indication that stocks are rebuilding to the very high levels observed in the mid 1970's. The committee adopted an assumption of average recruitment for a forecast of 28,800 tonnes for 1990. This yields a recommended catch of 5,760 tonnes.

Stocks on the northern west coast of Vancouver Island continue to be at low levels. The committee recommended a poor recruitment assumption for this area as there is no indication that stocks are rebuilding. The forecast stock biomass is 7,100 tonnes yielding a recommended catch of 1,420 tonnes.

Fisheries Issues

Stocks on the west coast of the Queen Charlotte Islands have been building over the past few years and the herring subcommittee recognized that potentials for fisheries exist in this area. Stock estimates for 1989 were 9,300 tonnes from spawn surveys and 12,000 tonnes from charter vessel sounding surveys. Unfortunately, there is not a consistent data series for this area to allow stock forecasts for 1990. The subcommittee recommended that a quota, set at 10% of the estimated 1989 stock (ie. 1000 tonnes), be established for this area. This quota level should ensure conservation of the stocks, even if recruitment in 1990 is poor. In addition, recognizing that the various inlets on the west coast of the Charlottes may support separate and distinct stocks, the subcommittee also recommended that no more that 50% of the biomass estimated for a location in 1990 be taken by the fishery.

Herring in the Prince Rupert District had been at historically high levels through the mid 1980's. However, the past two years have seen substantial decreases in the spawning stocks. If this trend continues fishing opportunities for this area will be reduced.

Summary of Reviewed Working Papers

H89-1 Stock assessment for British Columbia herring in 1989 and forecasts of the potential catch in 1990.
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 1990. Revisions to the escapement model which are described in the document include a stratified egg prediction model and estimation procedures for egg densities on Macrocystis sp. Comparisons of egg density estimates from the predictive model and actual egg counts for 1989 are presented. No modifications have been made to the age structured model for the 1989 assessments. The accuracy of the confidence limits on stock forecasts, which had been estimated by bootstrap methods for the past two years, are evaluated. The bootstrap method appears to produce reasonable confidence limits for forecasts of fish aged 5 and older but is not accurate for confidence limits on 4 year old fish.

Summary of reviewers comments:

The first reviewer complemented the authors on a clear presentation of the assessment and forecasts. It was suggested that the authors attempt to evaluate past forecasts with a view to determining a more objective approach to the weighting of the two assessment models. It was also felt that the treatment of the prediction of weight at age be expanded and clarified.

The second reviewer felt that the authors had made great progress in documenting the methodology from the previous year but felt that additional documentation was still required, particularly the likelihood equations underlying the age structured model. The reviewer also wanted to see extensive graphical presentation of the data series in addition to the tables which are presently in the document. It was felt that a time series approach to the prediction of weight at age in the forecast year should be investigated. The current method of predicting recruitment as the mean of the third poor, average, and good recruitments should be replaced with an explicit distribution function for which specific percentiles could be calculated. The effects of the choice of variances in the log-likelihood needs to be documented to show the effects of the values chosen on the results. The approach taken in implementing the theoretical sample sizes requires further documentation before it can be evaluated.

The reviewer suggested a more objective weighting criterion was required for the two assessment models. Some of the ICES methods of quantifying the effects of recruitment variation on stock size should be examined. Finally, the reviewer felt that some research be devoted to examining the extent to which the parameter estimation requirements of the model can be reduced without degrading estimates of stock biomass. This could include an in depth analysis of the statistical validity of the model parameter estimates and the importance of violation of the underlying assumptions which are made about the error structures that determine the objective function. These latter problems cannot be addressed currently without additional documentation.

H89-2 Forecasting Recruitment of Pacific herring to the spawning stock from the escapement model.
by J.F. Schweigert and D.G. Noakes

The objective of this study was to evaluate three classes of models for forecasting recruitment of 3 year old herring to the spawning stock as estimated by the escapement model. The models examined were time series, discriminant function, and nonparametric stock and recruitment. The models were fitted to the first 30 years of each recruitment series and one step ahead forecasts conducted, the models refit and reforecast, etc. The variables used in the analysis consisted of quarterly sea temperatures, salinities, sea level, Ekman transport, and annual river discharge for the time series and discriminant function analyses. The nonparametric model used only the estimated spawning stock biomass. Forecasting models were derived for the five major herring stocks for the three sets of models and forecasts by each evaluated relative to the observed recruitment. The models were ranked in terms of relative accuracy of prediction in each area over the past 9 years. The nonparametric stock recruitment model produced the most accurate forecasts over all stocks. The two other classes of models produced forecasts which were worse than simply using the long term mean. Other models which contain both stock biomass and environmental variables should be evaluated to determine whether they are able to produce forecasts superior to the simple nonparametric stock recruitment model.

Summary of reviewer's comments:

No serious criticisms were noted. It was suggested that further documentation of the analytical procedures would have been helpful. The reviewer felt that although the discriminant function analysis did not predict recruitment well, it did separate average from poor or good recruitments reasonably well and so may actually do well at predicting the variance around average recruitment which could be useful for management. The reviewer wondered whether the poor performance of the environmental variables as recruitment predictors was due to the lack of coherence between the process being forecast and the variables used in the analysis or whether there was simply too much error in the data. Further investigation of models which combine stock biomass and environmental data was encouraged.

H89-5 Hydroacoustic herring survey results from Hecate Strait, December 7-18, 1988.
by B. McCarter, R. Kieser and D. E. Hay

Coastal waters within the 50-200 m bottom contour of Hecate Strait were surveyed to determine Pacific herring abundance and distribution. Echo integration biomass estimates of midwater herring were 6,230 tonnes at Browning Entrance, 17,500 tonnes SW of Bonilla Island, 8,270 tonnes in Juan Perez Sound, 7,910 tonnes in Sedgwick Bay and 2,160 tonnes in mid-Hecate Strait. These estimates are roughly similar to biomass estimates that rely on spawn escapement data and age structure analyses. Diurnal migrations complicate echo integration of Pacific herring. Herring schools were difficult to integrate acoustically because of bottom echo interference during the day and a limited echo integration window near the surface at night. Best estimates were obtained just before dawn when herring were descending in the water column.

Summary of reviewers comments:

The reviewer felt that the paper contained considerable worthwhile information regarding the collection of hydroacoustic data and the estimation of pre-spawning herring abundance. That the results obtained fit with those derived from independent techniques gives credence to the estimates derived via the hydroacoustic surveys. The reviewer felt that a more thorough description of the equipment and methods used is required. He also suggested that confidence limits be estimated for the biomass estimates. Additional questions raised relate to problems with identifying species on echograms, equipment calibration, and effects of vessel avoidance on abundance estimates.

H89-6 Offshore herring distribution, length composition and recruitment forecast for the lower west coast Vancouver Island.
by D. M. Ware and R. W. Tanasichuk

A bottom and midwater trawl survey of the herring, hake and groundfish stocks off the lower west coast of Vancouver Island was conducted aboard the F/V Ocean King between August 13-22, 1989. Most of the herring biomass was concentrated on 40-mile and Swiftsure Banks. Young-of-the-year herring were most abundant near the Firing Range and in Trevor Channel. This age group appears to be less abundant this year than it was last year.

The sounding survey indicated that the medium and heavy concentrations of hake were smaller this year, which is consistent with our general impression that the overall abundance of hake in the survey area was lower this August. Eight percent of the hake sampled contained herring.

The length composition of herring concentrations in the area indicate that age 2+ fish account for roughly 25% of the age 1+ stock biomass. Assuming all the age 2+ fish spawn next spring, we estimate that about 29% of the spawning biomass in Area 23 and 24 next spring should consist of age 3 recruits. According to the age structure model, recruitment to the lower west coast of Vancouver Island should be average in 1990.

Summary of reviewer's comments:

The reviewer complimented the authors on their organization and analytical capabilities which allowed preparation of this report within days of their return from the cruise. Two weak points in the analysis were pointed out. These are the inability to measure fish density and the assumed shape of herring schools. Additionally, it was suggested that confidence limits be placed on the predicted percentage of age 3 fish.

Summary of Non-reviewed Working Papers

H89-3 Summary of spawn time prediction work in Barkley Sound, 1987-89.
by R. W. Tanasichuk and D. M. Ware

This paper documents a procedure for forecasting when female herring will ripen and presumably begin to spawn. The final version for the method was field tested in Barkley Sound during the 1987 through 1989 roe herring seasons. Dates of maximum ripeness were predicted within two days and at least six days in advance. Predicted adjusted peak roe yields equalled those observed. Barkley Sound herring generally spawn within three days of the neap tide; consequently they usually reach peak maturity and hold until the tidal window is reached. Considering the interaction between the tidal influences and the forecasted dates of ripening, spawning time was accurately predicted in 1987 and 1989, when spawning occurred within three days of the neap tide. We made an apparently reasonable forecast for Clayoquot Sound although data were limited.

H89-4 Size-at-age trends for B.C. herring, 1929-89.
by R.W.Tanasichuk and D. M. Ware

This paper documents a data base of mean weight-at-age for about 600,000 fish collected coastwide since 1929. Data analysis to disclose the influence of biomass and other biotic and abiotic factors has begun. The objective is to explore the use of size-at-age as an indicator of stock abundances. A comparison of size-at-age trends shows an affinity between Queen Charlotte Islands and Central Coast herring, and some difference between Northern and Southern Strait of Georgia fish.

H89-7 In-season Herring (Clupea harengus) Tagging Program Report to the Herring PSARC subcommittee.
by S. Farlinger

70,241 anchor tags were applied to herring during the 1989 pre-fishery charter program in the central coast, the Strait of Georgia and the west coast of Vancouver Island (WCVI). Of these, 551 were returned from the following herring fishing areas: Queen Charlotte Islands (7), Prince Rupert District (29), Central Coast (272), Strait of Georgia (105) and WCVI (107). Recovery rates were highest for fish tagged in the Central Coast (1.57%) and similar (about .5%) for the other areas. Most tags were recovered in the district in which they were tagged and showed movement throughout the area. Seven Central Coast tags were recovered from the fishery in QCI-2W (Louscoone Inlet); 12 were brought in from the Prince Rupert area. Of the 116 tags returned from Strait of Georgia taggings, 8 were reported from the WCVI. Nine WCVI tags were brought in from Gulf fisheries. Three tags were recovered by sport fishermen in the Gulf.

H89-8 Report on 1989 Seabound charter to assess herring stocks in Johnstone Strait and Central coast inlets.
by V. Haist and L. Hamer

During the 1989 herring season an additional vessel was chartered to assess herring stocks in Johnstone Strait and southern central coast inlets, areas which had not been regularly surveyed during the herring pre-fishery charter program. Herring were located and sampled in all areas surveyed with the exception of the head of Rivers Inlet where spawning had already occurred. Substantial biomasses were located in Fish Egg Inlet (2000+ tons), Takush Harbour (3500+ tons), and Bond Sound/Tribune Channel (1900 tons). The sampled fish were all a smaller size at age than both the central coast and Strait of Georgia seine samples in 1989. Size at age was similar to Kwakshua fish in Fish Egg Inlet, Goose Bay and Takush Harbour. Extremely small mature fish were sampled in a number of locations (Knight Inlet, Seymour Inlet, Simoom Sound, and Grappler Inlet) suggesting that these were resident stocks.

Appendix 1. 1989 PSARC Herring Subcommittee working papers.

Number Authors	Title
* H89-1	Stock Assessments for British Columbia herring in 1989 and forecasts of the potential catch in 1990. by V. Haist and J. Schweigert
* H89-2	Forecasting Recruitment of Pacific Herring to the Spawning Stock from the Escapement Model. by J. Schweigert and D. Noakes
H89-3	Summary of spawning time prediction work in Barkley Sound, 1987-89. by R. Tanansichuk and D. M. Ware
H89-4	Size-at-age trends for B.C herring 1929-89 R. Tanasichuck and D. M. Ware
* H89-5	Hydroacoustic herring survey results from Hecate Strait, December 7-18,1988. by B. McCarter, R. Kieser and D. E. Hay
* H89-6	Offshore herring distribution, length composition and recruitment for the Lower West Coast of Vancouver Island. D. M. Ware and R. Tanasichuck
H89-7	In-season herring tagging program report by S. Farlinger
H89-8	Report on 1989 Seabound charter to assess herring stocks in Johnstone Strait and Central Coast inlets. by V. Haist and L. Hamer

* Reviewed Papers

Appendix 2. List of Participants.

Name	Association
Dennis Chalmers (Chairman)	Department of Fisheries and Oceans, Nanaimo
W.D. McKone	Biological Sciences Directorate, HQ, Ottawa
Doug Hay	Pacific Biological Station, Nanaimo
Ron Tanasichuk	Pacific Biological Station, Nanaimo
Don McCulloch	Department of Fisheries and Oceans, Pt. Alberni
Carl Haegele	Pacific Biological Station, Nanaimo
Jack Broome	Department of Fisheries and Oceans, Nanaimo
Susan Farlinger	Department of Fisheries and Oceans, Prince Rupert
Lorena Hamer	Pacific Biological Station, Nanaimo
Vivian Haist	Pacific Biological Station, Nanaimo
Jake Schweigert	Pacific Biological Station, Nanaimo
Bob Armstrong	Department of Fisheries and Oceans, Nanaimo
John Greenlee	Department of Fisheries and Oceans, Central Coast
Lloyd Webb	Department of Fisheries and Oceans, Vancouver
Dan Ware	Department of Fisheries and Oceans, Vancouver
David Welch	Pacific Biological Station, Nanaimo
Bruce McCarter	Pacific Biological Station, Nanaimo
Chuck Fort	Pacific Biological Station, Nanaimo
Ed Safarick	Fisheries Council, Vancouver
Rob Wilson	Department of Fisheries, Prince Rupert
Bill Procopation	U.F.A.W.U., Vancouver
Gary Cardinal	Department of Fisheries and Oceans, Q.C.I.
Ian Joyce	Douglas College, New Westminister

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

	Criteria	Status
1.	Spawn and Stock Trends	
	a) Age-structure Model	Substantial increase in spawning stock.
	b) Escapement Model	Substantial increase in spawning stock
	c) Spawn Indices	Increasing
2.	Recruitment Trends	
	a) Age-structure Model	1985 yr-class strong; 1986 yr-class average
	b) Escapement Model	Average, 1986 yr-class similar to 1985
3.	Recruitment Indices	
	a) Analytical Models	ranges from poor to good
4.	Forecast Weighted Run Size	35,300 t., assuming average recruitment Two models weighted equally
5.	Sounding Surveys	
	a) Hydroacoustics (winter)	Similar as last year
	b) In Season	Increased over last year
6.	CUTOFF	10,600 mt.
7.	Charter Skipper Comments	Very Positive re stocks
8.	Additional Information	Tags recovered in Louscoone tagged in Central Coast.

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

	Criteria	Status
1.	Spawn and Stock Trends	
	a) Age-structure Model	Increase in spawning stock
	b) Escapement Model	Decrease in spawning stock
	c) Spawn Indices	Decreasing
2.	Recruitment Trends	
	a) Age-structure Model	1985 yr-class above average, 1986 yr-class average
	b) Escapement Model	Average, down in 1989
3.	Recruitment Indices	
	a) Analytical Models	Poor to Good
4.	Forecast Weighted Run Size	23,300 t., assuming average recruitment Weighting of 80/20 for escapement - age structure models.
5.	Sounding Surveys	
	a) Hydroacoustics (winter)	17,500 t. SW of Bonilla Is.
	b) In Season	Sounding not a good indicator, more fish sounded than spawned
6.	CUTOFF	12,000 t.
7.	Charter Skipper Comments	No consensus between charter skippers.
8.	Additional Information	N/A

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

	Criteria		Status
1.	Spawn and Stock Trends		
	a)	Age-structure Model	High but slight decrease
	b)	Escapement Model	High but slight decrease
	c)	Spawn Indices	High but slight decrease
2.	Recruitment Trends		
	a)	Age-structure Model	1985 yr-class one of best ever; 1986 yr-class is poor
	b)	Escapement Model	poor 1986 yr-class, down sharply from 1985
3.	Recruitment Indices		
	a)	Analytical Models	Poor to average
4.	Forecast Weighted Run Size		43,200 t., assuming average recruitment Both models weighted equally
5.	Sounding Surveys		
	a)	Hydroacoustics (winter)	N/A
	b)	In Season	Down slightly but one of highest on record. (24,000 tons)
6.	CUTOFF		10,600 t.
7.	Charter Skipper Comments		No consensus between skippers
8.	Additional Information		N/A

Appendix 3. Criteria used in the assessment of stock status for the Georgia Strait North Stock.

	Criteria		Status
1.	Spawn and Stock Trends		
	a)	Age-structure Model	slight decrease in 1989
	b)	Escapement Model	substantial increase in 1989
	c)	Spawn Indices	Increasing over 1988
2.	Recruitment Trends		
	a)	Age-structure Model	1986 yr-class is poor
	b)	Escapement Model	poor 1986 yr-class
3.	Recruitment Indices		
	a)	Analytical Models	Average recruitment
4.	Forecast Weighted Run Size		47,800 t., assuming average recruitment Both models weighted equally
5.	Sounding Surveys		
	a)	Hydroacoustics (winter)	Index up from previous year
	b)	In Season	Very high abundance
6.	CUTOFF		22,100 t. for entire Gulf
7.	Charter Skipper Comments		Very optimistic regarding amount of stocks in Straits.
8.	Additional Information		Very protracted spawning this year.

Appendix 3. Criteria used in the assessment of stock status for the Georgia Strait South stock.

	Criteria	Status
1.	Spawn and Stock Trends	
	a) Age-structure Model	Indicates slight increase in abundance
	b) Escapement Model	Indicates decrease in abundance
	c) Spawn Indices	Length of spawn is up from 1988 but area has decreased.
2.	Recruitment Trends	
	a) Age-structure Model	Poor recruitment in 1989
	b) Escapement Model	1986 yr-class lowest on record
3.	Recruitment Indices	
	a) Analytical Models	Average for entire Strait of Georgia
4.	Forecast Weighted Run Size	7,400 t., assuming poor recruitment Both models weighted equally
5.	Sounding Surveys	
	a) Hydroacoustics (winter)	Soundings indicate increased stock levels in 1989 for combined Gulf.
	b) In Season	Soundings are up from 1988 for the entire Gulf.
6.	CUTOFF	22,100 t. for entire Gulf.
7.	Charter Skipper Comments	Lots of fish seen during assessment period.
8.	Additional Information	N/A

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

	Criteria	Status
1.	Spawn and Stock Trends	
	a) Age-structure Model	Indicates decreasing stock
	b) Escapement Model	Indicates increasing stock
	c) Spawn Indices	Same as 1988.
2.	Recruitment Trends	
	a) Age-structure Model	Strong 1985 yr-class, poor 1986 yr-class
	b) Escapement Model	average 1986 yr-class, 1985 yr-class is stronger
3.	Recruitment Indices	
	a) Analytical Models	Average
	b) Offshore Survey	Average
4.	Forecast Weighted Run Size	28,800 t., assuming average recruitment Both models weighted equally
5.	Sounding Surveys	
	a) Hydroacoustics (winter)	N/A
	b) In Season	Increased over 1988
6.	CUTOFF	15,100 t.
7.	Charter Skipper Comments	Very optimistic re stock abundance in Area 23.
8.	Additional Information	N/A

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

	Criteria	Status
1.	Spawn and Stock Trends	
	a) Age-structure Model	Indicates decreasing stock.
	b) Escapement Model	Indicates decreasing stock.
	c) Spawn Indices	Same as in 1988.
2.	Recruitment Trends	
	a) Age-structure Model	Poor recruitment in 1989.
	b) Escapement Model	Poor recruitment in 1989, down from 1988.
3.	Recruitment Indices	
	a) Analytical Models	N/A
4.	Forecast Weighted Run Size	7,100 t., assuming poor recruitment Weighting of 80-20 for escapement - age structured models.
5.	Sounding Surveys	
	a) Hydroacoustics (winter)	N/A
	b) In Season	down in 1989.
6.	CUTOFF	8,700 t. This cutoff does not reflect revised stock grouping for W.C.V.I. North. It is to be re-done for the coming year.
7.	Charter Skipper Comments	Very poor coverage in 1989 due to fishery requirements in Area 23.
8.	Additional Information	N/A

Appendix 4. Stock assessment related activities recommended in 1988 and action taken in 1989

Recommendations	Action
1. A regionally funded diving spawn survey be carried out in all areas. Fishery Officer Diving Survey should be continued for all areas in 1989.	50% of herring spawns surveyed by divers in 1989. Regional funding not obtained.
2. Document to be prepared on the source of CUTOFF levels and the background for the current change in levels, in particular with respect to the Queen Charlotte Islands.	Completed
3. The proposed presentation to HIAB of the harvest rate analysis and it's implications should be reviewed by the Working Group.	Completed
4. Working Group to review charter boat coverage in all areas.	Continuing
5. Continue work on the standardization of sounding methods. Develop standard bottom for sounder calibration for all areas.	Work continuing
6. Working Group to identify areas in which to continue short term tagging.	Continuing
7. Continuation of fall and winter echo-sounding and hydroacoustic assessments for Georgia Strait and the north coast, respectively.	Completed
8. Continuation of juvenile herring survey of Georgia Strait to develop an index of recruitment and recommend involvement of Fisheries Branch.	Completed, but minimal F.B. involvement.
9. Research be initiated to investigate habitat degradation in Georgia Strait, and identify possible effects of spawning ground degradation on recruitment.	Effects of net pens on juvenile herring looked at. Work continuing.
10. Stock identification is an integral part of assessment and management. Therefore the acquisition of coded wire tagging equipment should be pursued and a study design developed.	Submission made to the omni-bus package on fisheries management, sent to Ottawa
11. Working Group to develop guidelines in relation to the situation of sea water intakes and plumes adjacent to or in herring spawning grounds.	Draft document developed.
12. Spawn timing prediction work to be pursued in 1989 in conjunction with Fisheriess Branch to effect transtef of this technique.	Completed
13. Herring stock assessment group to re-examine the stock concept for Area 2E and the West Coast of Vancouver Island for 1989 assessment. In particular, to include Cumshewa Inlet and Louscoone Inlets in teh Queen Charlotte Islands; and to redefine the west coast of Vancouver Island to maintain Areas 23 and 24 in the southern stock assessment region and to include only Area 25 in the northern region. Areas 26 and 27 would become minor stocks.	Completed
14. Working Group to examine the potential for roe fisheries in Area 2W for 1989.	Completed
15. Offshore recruitment prediction work should be supported and continued.	Continuing

Appendix 5. Recommendations for stock assessment and related activities

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1. A regionally funded diving spawn survey be carried out in all areas. Fishery Officer Diving Survey should be continued for all areas in 1990.

2. Working Group to review charter boat coverage in all areas.

3. Continue work on the standardization of sounding methods. Develop standard bottom for echo-sounder calibration in all areas.

4. Working Group to identify areas in which to continue short term tagging.

5. Continuation of fall and winter echo-sounding and hydroacoustic assessments for Georgia Strait and the north coast, respectively.

6. Continuation of juvenile herring studies in Georgia Strait to develop an index of recruitment and recommend involvement of Fisheries Branch.

7. Continue research to investigate habitat degradation in Georgia Strait, and identify possible effects of spawning ground degradation on recruitment.

8. Stock identification is an integral part of assessment and management. Therefore the acquisition of coded wire tagging equipment should be pursued and a study design developed.

9. Working Group to prepare a final guideline document in relation to the situation of sea water intakes and plumes adjacent to or in herring spawning grounds.

10. Spawn timing prediction work be continued in 1989 by Fisheries Branch.

11. A catch of 10% of the estimated biomass on the west coast of the Queen Charlotte Islands is recommended. The estimated stock in 1989 by both spawn and sounding surveys was 10,000 tons. This would provide for a potential fishery of 1,000 tons. A further recommendation is made that no more than 50% of the stock in any one location be harvested.

12. To investigate the gillnet and seine size-at-age information to see if gillnets are affecting fish size.

Pacific Stock Assessment Review Committee

Salmon Advisory Document S89-5

STEERING COMMITTEE REPORT
DECEMBER 6, 1989

A) The P.S.A.R.C. Steering Committee met to review the Salmon Subcommittee Report 89-5 attached below. Topics included:

1) Advice for development of Coho Salmon Escapement Goals for the Fraser River.

2) Assessment of the Harrison River Chinook Stock (Lower Fraser River).

3) Big Qualicum Chinook Egg Allocation for 1989 - Report.

4) P.S.A.R.C. review of WCVI troll model.

The WCVI Chinook paper will be presented to the Subcommittee in January for use at the February meeting of the Pacific Salmon Commission. The results of the review of the WCVI Troll Model as requested by FRMEC will also be presented.

Recommendations of the Steering Committee

FRASER RIVER COHO. The Steering Committee endorsed the recommendations of the subcommittee to replace the present escapement goal of 175,000. The adoption of a "floor" for adaptive management should be pursued based on the results of the report to be prepared for the April Salmon subcommittee meeting. Rules for management decisions should be developed before implementation. A habitat based approach to develop an escapement goal is supported; a task force/working group should be formed and supported in the workplan. In particular, the Steering Committee wishes to emphasize recommendation 4 to significantly improve assessment programs. Findings of the coho task force with respect to key streams or other assessment tools should be acted upon; until this information is available fishery officer counts are required at least at pre-1987 levels. The coho test fishery should continue and could provide an in-season estimate of escapement if fishery officer estimates are available for calibration.

The Steering Committee specifically wishes to recommend that the scientific basis for desired harvest rates should be established; present research with respect to this question should be reviewed, and the appropriate branches tasked to address this problem.

HARRISON RIVER CHINOOK. All terminal abundance indices show declines in this decade. Analysis shows that this stock contributes substantially to the Georgia Strait troll and sport and WCVI troll. Decreases in survival have occurred in the 1980s in 2 lower Georgia Strait and 1 lower Fraser hatchery, although Chilliwack hatchery returns remain higher. A disease agent has been active in the Chehalis hatchery. The Steering Committee supports the recommendations of the subcommittee to continue and appropriately fund research to examine and identify the disease agent including examination of the reasons for the absence of the agent at Chilliwack facility. The magnitude of the decline argues against the disease as the single causative agent. Based on the decline in indices, this stock is identified as a stock of concern; therefore, Harrison chinook is identified as a stock of concern; no increase in exploitation should be considered in fisheries which have an important impact on this stock. When the working paper is resubmitted with the 1989 data, there will be some indication of the effect of current LGS management strategies.[1] At that time the committee may recommend reduction in exploitation on this stock.

BIG QUALICUM EGG ALLOCATION. The report was accepted, including recommendations to review the natural spawning target and the balance of use between hatchery and wild stock. The unique opportunities for studies afforded by this situation will be reviewed and developed by applicable subcommittee members.

REVIEW AND APPLICATION OF COMPUTER MODELS. In anticipation of the request from FRMEC to review the WCVI troll model, a workshop has been planned including DFO and external personnel to identify the applicability and modifications required to the models and recommendations for future development. External assistance will require 6 to 9 man days at $4-500/day. Discussion with the appropriate committees/task groups will be required at this point to determine their time requirements and P.S.A.R.C. ability to deliver supported working models in that time. As noted in the 89-1 advisory document, documentation for the South Coast Model is still incomplete. The Steering Committee recommends that the documentation be acquired.

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[1] The Harrison is a major contributor to some of the same fisheries which LGS contributes to. A decline in Harrison abundance may, given no other changes in those fisheries, negate the benefits of those management strategies designed for LGS.

P.S.A.R.C. DATA SUBCOMMITTEE REPORT. As no response has been forthcoming to the recommendations of the 1988 report, it has been updated . The Steering Committee recognized the many areas of concern in catch data identified in the report. The chairman was directed to consolidate the recommendations of the report, and to solicit proposals from the subcommittees for improved catch reporting to be provided to the Steering Committee.

Pacific Stock Assesment
Review Committee

Sub-Committee Report 89-5

SALMON SUB-COMMITTEE REPORT
NOVEMBER 14 - 15, 1989

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INTRODUCTION

The Salmon Sub-Committee of the Pacific Stock Assessment Review Committee met on November 14 and 15, 1989 at 555 West Hastings Street, Vancouver. The committee was chaired by the newly appointed chairman Don Anderson.

The objectives for this meeting were:

1) to review the working papers presented for the purpose of advising on technical issues expected in the 1989 Pacific Salmon Commission negotiations;

2) to develop consensus on advice and recommendations from these papers;

3) to review requirements and identify assignments for the sub-committee meeting of April 1990; and

4) to obtain member's views regarding the future emphasis and membership of the sub-committee.

Four papers were established as priorities for this meeting by the Salmon Advisory Document, 89-1. Of these, three papers were considered by the sub-committee. The fourth paper was to address the status of the West Coast Vancouver Island chinook stock. Preparation of this paper continues and will be reviewed by the sub-committee in time for the February meeting of the Pacific Salmon Commission.

Additionally the sub-committee developed a process to review and evaluate computer models of the West Coast Vancouver Island and Strait of Georgia troll fisheries. Such models are currently used by South Coast Division personnel when evaluating fishery management plans. This discussion, although not part of the original objectives for meeting, was necessitated by the anticipation that the committee would be requested to provide advice regarding these models.

Regrettably, the sub-committee ran out of time and was unable to review requirements and identify assignments for the April 1990 meeting and to discuss views regarding emphasis and membership. These outstanding items, including the fourth working paper and the requests to provide advice regarding the troll models will be addressed by January 1990.

DISCUSSION PAPERS

1) Advice for Establishing Coho Salmon Escapement Goals for the Fraser River (P.S.A.R.C. Working Paper S89-28 by R.K. Kadowaki, R.H. Wilson and N.D. Schubert).

In addition to the committee members two additional reviewers were invited to participate, so that the review and advice given would encompass a broader spectrum of the Region's stock assessment expertise. The additional reviewers were Otto Langer (F.R.D., H.M.U.) and Paul Ryall (S.C.D., M.B.U.). Participation was obtained from Paul Ryall and his contribution is incorporated in the sub-committee's discussion and advice.

SUMMARY

The preparation of a working paper on the development of a management goal for Fraser River coho salmon was recommended by the Salmon Sub-committee of P.S.A.R.C. in Advisory Document 89-1 and subsequently supported by the P.S.A.R.C. Steering Committee and the regional senior executive.

This working paper addresses the above noted recommendation by;

1) reviewing the technical basis for the current escapement goal,
2) revising the stock-recruit analysis in P.S.A.R.C. working paper S89-5, using adjusted data from brood years 1970 to 1984,
3) describing a habitat based approach to arriving at an escapement goal,
4) making recommendations on the best estimate of a Fraser River coho management goal, and
5) making recommendations for on-going and additional work required to monitor Fraser River coho stocks for stock assessment and fishery management purposes.

THE EXISTING ESCAPEMENT GOAL

The escapement goal for Fraser River coho salmon of 175,000 (as measured by fishery officer escapement estimates) has been in existence since at least 1981, when it was published in the Department of Fisheries and Oceans Commercial Fishing Guide. However, the source of the goal and it's method of derivation have never been documented.

After reviewing pertinent file archives at the New Westminster DFO office, we conclude that the published goal of 175,000 was likely based on subjective estimates of spawning ground capacity. Because spawning ground capacity is rarely related to optimum in coho salmon, and since escapements above the goal have never been recorded, we conclude that the existing goal of 175,000 is likely unrealistic and should be replaced.

STOCK RECRUIT ANALYSIS

Stock and recruit data for Fraser River coho salmon from brood years 1970 to 1984 (Table 1) was analyzed using a Ricker model. Data prior to 1970 were not used since their reliability was less certain than the more recent data, for which we have test fishery data to evaluate fishery officer escapement estimates against. Data for the 1988 return year (1985 brood) were also not used because of their uncertain reliability.

Spawning escapement data was adjusted to reflect actual escapements (mark-recapture estimate of total escapement to the Fraser in 1986 was possible because of the high mark rate in hatchery fish released for EXPO) and gradual improvement in the proportion of spawners enumerated between 1970 and 1986. Recruitment was calculated by expanding return year escapement using exploitation rates calculated for the Chilliwack hatchery; actual exploitation rates were used for the return years 1983 to 1987 while previous years expansions were based on an average of these five years.

The estimated maximum sustained yield (MSY) escapement for Fraser River coho based on the Ricker stock-recruit model varied between 249,000 and 399,000 depending upon the assumptions used in constructing the data set (Table 2). Based on our evaluation of the range of assumptions examined, 300,000 wild coho salmon is our best estimate of MSY escapement. This would equate to approximately 100,000 1986 fishery officer escapement units. (The total actual numbers of spawners in 1986 was calculated using mark-recapture data. This estimate was approximately three times the estimate made by fishery officers in 1986.) The sustainable exploitation rate at this level of escapement would be 72 percent.

However, since there are uncertainties both in the source data and the assumptions made in correcting them, and in the types of models and techniques chosen for this analysis, we do not feel that a fixed escapement goal can be supported with the degree of confidence necessary for fishery management (see Recommendations for further detail). Rather, we feel that an estimate of the lower bound of the range in which MSY is believed to occur can be developed and would be a more reasonable management objective given the available data. Returns above this "floor" level could be harvested according to a predetermined sliding scale permitting both a limited harvest when the run exceeds the floor level, and large escapements when returns are large. This approach would provide the information necessary to determine if production per spawner diminishes significantly at higher escapement levels, and in time would provide the scientific basis for the development of a defensible escapement goal.

HABITAT ANALYSIS

Habitat based estimates of coho carrying capacity have been used to derive estimates of optimum spawning escapement in coastal Oregon, the northern coast of Washington and in Puget Sound. In these studies, accessible stream lengths were multiplied by smolt production "bio-standards" to produce estimates of potential smolt production. Smolt production per female spawner standards, estimated from several intensive studies in Oregon and British Columbia were then used to transform the smolt production target into a spawning escapement goal. In two areas where stock-recruit analysis was also performed (coastal Oregon and the Skagit River in Puget Sound) the two estimates of MSY escapement were reasonably close to each other.

Although there are limitations to applying it to a river system as large and complex as the Fraser, we believe that a habitat based approach to estimating spawning escapement goals should continue to be developed. It could provide an independent estimate against which to compare the stock-recruit estimate, and at the very least should provide some basis for apportioning the stock-recruit escapement goal among the individual systems within the Fraser River watershed.

RECOMMENDATIONS

1) The existing Fraser River coho escapement goal of 175,000 can not be supported with the degree of confidence necessary for fishery management. We recommend that a replacement be developed.

2) Given the quality of the available data, we recommend that a "floor" escapement approach to managing Fraser River coho salmon should be considered rather than employing a fixed escapement goal. Terminal runs above the escapement floor would be divided between catch and escapement with the understanding that escapements well above the floor are a necessary and desirable part of the management program. The development of an appropriate floor escapement level will require additional analysis, specifically;

a) a thorough review of alternative stock-recruit models, and their sensitivity to bias and error in the input data,

b) a definition of what we mean by 'wild' coho stocks, consideration of alternative assumptions about wild stock status (i.e. whether wild stock are stable or declining under existing harvest levels), and a review of potential impacts of hatchery development on estimates of wild stock escapement,

c) the development of separate escapement floors for the Thompson and Fraser Rivers if technically feasible, and

d) rules for management decisions regarding the harvesting of returns above the floor level.

3) We support the development of a habitat based coho escapement goal (or goals) for the Fraser drainage. This will provide a method of evaluating the escapement goal developed by stock recruit analysis, a technique for establishing escapement goals for smaller systems within the Fraser watershed, and could also form the basis for enhancement planning.

4) If either a floor or fixed escapement goal is adopted, assessment programs will have to be significantly upgraded to provide effective in-season and post-season escapement monitoring. To this end, spawning ground assessments in the lower Fraser River need to be improved considerably over 1987 and 1988 levels (see P.S.A.R.C. Advisory Document 89-1 for details). A coho test fishery (also recommended in P.S.A.R.C. Advisory Document 89-1) could provide an in-season estimate of escapement if fishery officer escapement estimates are available for calibration.

Table 1. Fraser River coho stock and recruit data used in Ricker analysis. Fishery officer (FO) escapement estimate and historical escapement scaler and assumed exploitation rates are included for information. (recruits = catch + escapement)

Brood Year	Stock	Recruits	FO Esc'ment Scaler	Exp. Rate	FO Esc'ment
1970	396750	1289231	6		66125
1971	630982	1578806	5.8125		108556
1972	222868	1300409	5.625		39621
1973	309416	770636	5.4375	0.76	56904
1974	378914	1433145	5.25	0.76	72174
1975	312098	1472588	5.0625	0.76	61649
1976	184953	1046967	4.875	0.76	37939
1977	343955	745628	4.6875	0.76	73377
1978	353421	683911	4.5	0.76	78538
1979	251272	759109	4.3125	0.76	58266
1980	178951	594421	4.125	0.76	43382
1981	164139	1670963	3.9375	0.76	41686
1982	182186	790500	3.75	0.76	48583
1983	118884	860561	3.5625	0.80	33371
1984	300773	955750	3.37	0.82	89118
1985	245055		3.1875	0.69	76880
1986	240957		3	0.72	80319
1987	229380		3.00	0.76	76460

Table 2. Results of Ricker stock - recruit analysis for Fraser River wild coho salmon using a range of assumptions about historical exploitation rate (1970 to 79 brood years) and fishery officer (FO) escapement scalers.

Assumptions		MSY		MSY	Ricker	
FO Scaler	Historical E.R.	Escapement	MSY	Exp. Rate	A	B
3 to 6	=80-84 avg.	311000	1124000	0.72	2.01	-2.32E-06
3 to 5	=80-84 avg.	249000	993000	0.75	2.13	-3.00E-06
3 to 7	=80-84 avg.	379000	1267000	0.70	1.91	-1.85E-06
3 to 6	(80-84 avg.)-0.05	262000	947000	0.72	2.00	-2.78E-06
3 to 6	(80-84 avg.)+0.05	399000	1453000	0.73	2.02	-1.82E-06

2) Assessment of the Harrison River Chinook Stock (Lower Fraser River). (P.S.A.R.C. Working Paper S89-29 by P.J. Starr and N.D. Schubert)

In addition to the committee members, Sandy Argue was invited to participate as a reviewer. Brian Riddell, considering his needs as chairman of the Chinook Technical Committee, also served as a specific reviewer. These additional contributions are incorporated in the sub-committee's discussion and advice.

SUMMARY

The Harrison River is the second largest tributary in the Fraser River (based on average flows) and supports what may be one of the largest naturally spawning chinook stocks on the Pacific coast. This stock is a white flesh fall chinook stock which enters the Fraser primarily in September and October. The Harrison stock is also notable in that it appears to migrate out of the spawning grounds as fry immediately after emergence and to utilize side channels, sloughs and the Fraser estuary during the rearing phase. Harrison chinook contribute significantly to hook and line fisheries in the Strait of Georgia and to the west coast of Vancouver Island troll fishery. Other fisheries of importance include the net fisheries in Juan de Fuca Strait, Johnstone Strait, Northern Puget Sound and the Fraser River gill net fishery.

The Harrison River was selected as a "key stream" to evaluate stock responses to chinook management actions resulting from the Pacific Salmon Treaty. Since 1984, escapement to the Harrison River has been monitored by a mark-recapture study. After an initial increase, escapements have progressively declined to a 1988 level of only 15% of the escapement goal. In

the 1989 review of the progress toward rebuilding of depressed chinook stocks, the Chinook Technical Committee of the Pacific Salmon Commission classified the Harrison chinook as "Probably Not Rebuilding" (Pacific Salmon Commission, in prep.). The status of this stock, therefore, presents serious domestic and international concerns.

The working paper contains most of the current fisheries data that are pertinent to this stock and applies various analytic techniques to present a comprehensive assessment of Harrison River chinook. Topics reviewed included: trends in abundance in the terminal area, harvest distribution, trends in exploitation rates, and survivals from coded wire tag (CWT) recoveries of enhanced Harrison River chinook.

EVIDENCE FOR DECLINE IN ABUNDANCE

There are several indices of terminal abundance available for Harrison chinook: CPUE's in the terminal gillnet fishery, in the indian food fishery, and in the terminal sport fishery, and the test fishing index. As well, trends in the estimated escapements are also a measure of terminal abundance. The Mission fry program provides an index of spawning success, including egg to fry survival. A comparison of all these trends are presented in Table 1 for 1981-88, a period when estimates are available for most abundance indicators. In general, these trends show poor correlation between the data sets; but each index is in decline, and the magnitude of the decline varies from 6% to 31% per year since 1981. The only exception is in visual escapement estimates, which terminated before major declines in abundance were noted in the other indices. We conclude, therefore, that the terminal abundance of Harrison chinook has declined since 1981, and that sharp declines occurred in 1987 and 1988.

Table 1. Summary of abundance indicators and estimated proportional change over two recent periods (1981 to 1988 and 1984 to 1988). Percent change per year is calculated by fitting an exponential model.

Year	Area 29 commercial net: Harvest	Area 29 commercial net: CPUE	Indian food fishery: Harvest	Indian food fishery: CPUE	Terminal sport fishery: Harvest	Terminal sport fishery: CPUE	Escapement: Visual estimate	Escapement: Mark-recapture index	Test fishery	Mission fry
1981	3,103	1.227	1,797	0.61	n/a	n/a	20,000	n/a	24.10	107.82
1982	10,500	2.169	5,557	1.52	n/a	n/a	22,000	n/a	74.01	342.93
1983	9,979	1.058	1,606	0.59	n/a	n/a	6,000	n/a	39.04	172.31
1984	4,282	2.269	6,638	1.97	n/a	n/a	15,000	119,733	63.70	258.79
1985	3,412	1.118	1,065	0.54	584	0.0012	50,000	174,908	59.45	55.36
1986	12,344	1.694	1,592	0.34	742	0.0015	35,000	162,452	30.29	122.84
1987	1,590	0.433	1,051	0.22	692	0.0012	n/a	82,168	11.93	63.43
1988	1,416	0.460	3,510	0.52	462	0.0010	n/a	35,116	22.04	80.63
Average % change/year:										
81-88:	-15.9%	-15.6%	-6.3%	-15.1%	n/a	n/a	+19.3%	n/a	-11.8%	-14.4%
84-88:	-25.7%	-33.9%	-12.1%	-30.0%	-7.4%	-7.4%	n/a	-27.4%	-31.1%	-19.9%

SURVIVAL TRENDS

There are two hatcheries using the Harrison River chinook brood stock. These are the Chehalis (a tributary of the Harrison) hatchery and the Chilliwack (south side of the Fraser) hatchery. Except for the 1981 and 1982 brood years, the Chehalis hatchery survivals to catch have been from 5 to 12 times lower than the equivalent survivals for the Chilliwack hatchery (Table 2). As both of these hatcheries have similar catch distributions, differential fishery effects are probably not the cause for this observed variation in survival. Comparisons of the Chehalis survival rates to similar rates calculated for the Big Qualicum and Capilano hatcheries show that the Chehalis hatchery survivals are comparable to these other older, more established hatcheries (Table 2). Therefore, the hatchery with the anomalous survivals is the Chilliwack, which are unusually high. The high survivals for the Harrison stock in the Chilliwack hatchery also far exceed the survivals for other stocks released at the same hatchery. Survivals to catch for these stocks range from 0.4% for the 1981 and 1982 brood years to 0.02% for the 1985 brood year (there are no recoveries for the 1986 brood year).

Table 2. Comparison of "survivals" (% recovery from release to catch) for 6 recent brood years in 2 lower Georgia Strait and 2 lower Fraser hatcheries. Brood years 84 to 86 are necessarily incomplete as the data are compiled only up to 1988.

	Big Qualicum	Capilano	Chehalis	Chilli-wack
81	0.71%	1.52%	7.75%	8.54%
82	0.86%	0.20%	1.08%	1.35%
83	0.70%	0.26%	0.17%	2.13%
84	0.08%	0.13%	0.24%	2.65%
85	0.06%	0.01%	0.18%	0.67%
86	0.05%	0.14%	0.15%	1.04%

One reviewer of the working paper noted that the survival trends in the Big Qualicum, Capilano, and Chehalis hatcheries appeared to be correlated. He postulated that an alternate hypothesis for the observed declines in terminal abundance for the Harrison might be a change in ocean conditions causing a lowering of the overall survival rate. A decline in the abundance for lower Georgia Strait hatcheries has been documented. The decline in survivals for Big Qualicum and Capilano are similar to that for Chehalis. The decline in the Harrison may be related and the reason(s) for decline may be external to the Harrison.

STOCK DISTRIBUTION

The catch distributions for the Chehalis hatchery show that up to 70% of the total catch is taken in three fisheries (in order of importance): the Georgia Strait sport, the west coast Vancouver Island troll, and the Georgia Strait troll (Table 3). The rest of the catch is divided between various fisheries, particularly Canadian and US net fisheries. The US net fisheries which have an impact on this stock are those in northern Puget Sound, particularly off Point Roberts, near the mouth of the Fraser. It is notable that there appears to be a decline in the relative importance of the west coast of Vancouver Island troll fishery.

Table 3. Distribution of reported catch for the Chehalis hatchery coded wire tag releases.

	Geo St Sport	Geo St Troll	WCVI Troll	Other Troll	Canada Net	US Net	Canada Sport	US Sport	Fraser Net	Fraser Sport
1984	32%	17%	31%	7%	3%	3%	0%	4%	3%	0%
1985	35%	9%	32%	5%	7%	5%	0%	5%	1%	0%
1986	30%	21%	19%	7%	9%	1%	1%	6%	6%	0%
1987	48%	10%	11%	2%	6%	18%	0%	3%	3%	0%
1988	24%	20%	5%	7%	11%	20%	4%	4%	4%	1%
84-88 Avg	34%	15%	20%	6%	7%	9%	1%	4%	3%	0%

STOCK CONTRIBUTION

A stock contribution estimate was constructed from estimates of tag recoveries in the escapement based on expansions from the Petersen mark/recovery experiments. Exploitation rates by catch year are then calculated by summing all tagged catches from all fisheries within a year across all ages present and then dividing by the sum of the catches and escapement (summed across all ages). The total (Petersen) escapement is then expanded to generate the total catch associated with the escapement by the following formula:

$$\text{Total Catch}_{Petersen} = \{\text{Escapement}_{Petersen} / (1 - \text{Exploitation Rate}_{CWT})\} - \text{Escapement}_{Petersen}$$

Contribution to catch by fishery is then calculated by using the estimated distribution for the Chehalis hatchery presented in Table 4. Because the exploitation rate estimates in some years are clearly too high (notably 1984), the expansions to catch were repeated using exploitation rates calculated for the Big Qualicum hatchery (which has a more complete recovery of escapement tags).

Table 4. Calculated contribution (in thousands) to catch for the Harrison chinook using two different exploitation rates and estimated stock distribution from Chehalis tags in each recovery year.

Year	Total Catch	Geo St Troll	Geo St Sport	WCVI Troll	Geo St Sport	Geo St Troll	WCVI
	---------Stock Catches----------				---% Contributions to:-		
Catch expansion using Petersen exploitation rates							
84	1664	532	283	516	605%	77%	112%
85	201	70	18	64	135%	8%	18%
86	572	172	120	109	390%	66%	32%
87	88	42	9	10	111%	7%	3%
88	109	26	22	5	131%	18%	1%
Avg:	527	168	90	141	274%	35%	33%
Catch expansion using BQR exploitation rates							
84	700	224	119	217	255%	32%	47%
85	428	150	39	137	288%	16%	38%
86	648	194	136	123	442%	75%	36%
87	141	67	14	15	178%	12%	4%
88	61	15	12	3	74%	10%	1%
Avg:	396	130	64	99	247%	29%	25%

Table 4 shows that even the more conservative estimates of exploitation rate as provided by the Big Qualicum hatchery indicate that, assuming the Petersen escapement estimates are accurate, the Harrison could be the single most important contributing stock in the Georgia Strait troll and sport fisheries and has been an extremely important stock in the west coast Vancouver Island troll fishery. The estimates for the Georgia Strait troll fishery are obviously too high, probably indicating a bias in the recovery of tags for this stock in this fishery. Although this analysis is dependent on the accuracy of the Petersen escapement estimate, recent declines in both of the Georgia Strait fisheries at the same time that the Harrison is in decline are probably not a coincidence.

DISEASE AGENT

There have been considerable problems in the Chehalis hatchery from a disease agent which causes mortality in both the eggs and alevins during the rearing phase. Studies undertaken since 1982 have confirmed the existence of an infectious agent (Alderdice and Harding, 1987), with adult infection rates ranging from 3% to 40%. The agent produces high mortality in alevins and, under hatchery conditions, infected alevins are contagious. Although the identity of the agent remains unknown, some conclusions about the agent can be made:

1) the agent does not appear to be in the water supply.

2) the agent has not been transmitted to other salmon species but it has been transmitted to other chinook stocks. Of the stocks tested, Harrison chinook were the most susceptible to the agent.

3) the syndrome has not occurred in Harrison River chinook transferred to Chilliwack (1981-84) or Capilano (1970) rivers. Water quality may play a role in activating the agent.

4) the agent appears to be carried within the reproductive products. However, not all fertilized eggs from an individual female are infected.

We concluded from the above that an infectious agent of unknown origin exists in chinook adults returning to the Harrison River. However, although the agent exists in wild spawners, activity under natural conditions has not been demonstrated.

SUB-COMMITTEE DISCUSSION

The sub-committee agreed that the data supported the conclusion that there has been a recent decline in the abundance of this stock. However, based on the information provided, the causes of the decline are unclear. Several alternate hypotheses could account for the decline and, depending on which hypothesis is correct, different management responses would be required. The sub-committee prepared a table of alternate hypotheses, the underlying assumptions for each hypothesis, and the recommended subsequent management actions (Table 5). The sub-committee also prepared a graph showing how stocks of different productivity could have the same optimum escapement (Figure 1).

Table 5. Matrix of possible alternate hypotheses for observed stock decline in the Harrison, some of the underlying assumptions for each hypothesis, and the expected consequences of these hypotheses in terms of the performance of the stock in the ocean fisheries.

	Overfishing in Ocean Fisheries	Poor Ocean Survival	Disease Agent	Overescapement
Recruits Per Spawner	Maximal	Temporarily Reduced	Low	Low
Probable Optimum Escapement	Large	Large	Large or Small (depends on method of transmission)	Smaller
Contribution to Ocean Fisheries	Temporary Low	Temporary Low	Low	Low
Recommended Action	Lower Exploitation	Lower Exploitation	Lower Exploitation	Reduce Target Escapement

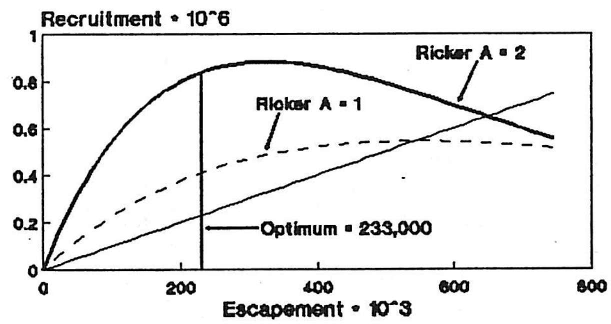

Figure 1. Example of Two Recruitment Curves with Same Optimum and Different Productivities

The fourth hypothesis (over-escapement in 1984 to 1986) requires that the contribution estimates developed in Table 4 (above) be erroneous, that this stock not be an important contributor to the Georgia Strait fisheries and that recent declines in catch are not attributable to the loss of this stock. While this hypothesis may be true, the risk of being incorrect is that the Georgia Strait fisheries will never rebuild.

CONCLUSIONS AND RECOMMENDATIONS

The sub-committee agreed on supporting the following conclusions and recommendations from the working paper:

1. All the terminal abundance indicators and fry downstream indices show declines in this decade with a "collapse" since 1986.

2. A serious mortality agent is active on Harrison chinook within the Chehalis Hatchery. The development of an overall approach to address declining returns in the Harrison River is impossible until two questions are addressed:

- is the agent active under Harrison River water quality conditions?

- if active, how virulent (contagious) is it under natural incubation conditions?

3. There are two potential management impacts of the disease, if active:

   - Reduced recruits per spawner:
     the appropriate management action would be a reduction in exploitation rate regardless of method of transmission.
   - Potential adjustment of the escapement goal:
     the appropriate adjustment is dependent upon the method of transmission, i.e. how virulent is it? Is it density dependent?

   The answer to these questions will determine (1) what level (if any) of fishery action is necessary to rebuild Harrison chinook and (2) what adjustment (if any) is necessary to the Harrison chinook escapement goal.

4. A priority must be given to the identification of the disease agent and the determination of whether it is active in the wild Harrison stock. If it is active, then the degree of transmissibility under natural conditions must be determined. Also, the variability of the level of infection in the hatchery from one year to next implies that the disease agent is not uniformly active. Therefore, research should also indicate if there is any way to predict prior to spawning the expected level of infection.

   Until this research is completed, no final recommendations can be made regarding management actions to restore the productivity of this stock.

5. There are several recommendations to improve the assessment data:

   - undertake a thorough analysis of the Mission fry data.

   - analyze and correct the Test Fishing index for un-assessed time periods in 1981-85; develop a procedure to correct for gear saturation and the effects of tides.

In addition, the sub-committee added several recommendations of its own:

1. Although most of the evidence points to recommending a reduction in the exploitation rate on this stock, there is enough uncertainty regarding the effect of the disease agent

and bias from the Petersen escapement assessment, that the sub-committee is reluctant to embark on major ocean fishery restructuring. As well, it is hoped that the reductions put in place to restore lower Georgia Strait chinook stocks should also benefit the Harrison. However, the sub-committee reached consenus that no increase in exploitation should be considered in fisheries which have an important impact on this stock. This has important implications in any changes being contemplated for the west coast Vancouver Island troll fishery ceiling or for expected declines in overall abundance in that fishery.

2. The sub-committee also recommended that the working paper be resubmitted in the spring of 1990. In particular, the sub-committee requested the following be included:

-a review of the current escapement goal;

-a review of the current escapement assessment procedures;

-documentation and review of the environmental factors (freshwater and estuarine) which may affect the productivity of this stock;

-a summary of the biological data available for this stock.

LITERATURE CITED:

Alderdice, D.F. and D.R. Harding (editors). 1987. Studies to determine the cause of mortality in alevins of chinook salmon (Oncorhynchus tshawytscha) at Chehalis Hatchery, British Columbia. Can. Tech. Rep. Fish. Aquat. Sci. 1590: 96 p.

3) Big Qualicum Chinook Egg Allocation and Natural Spawning Target (Discussion Document by T. Perry).

SUMMARY

The Advisory Document 89-1, recommended; contingency planning for allocation of Big Qualicum chinook eggs, if 1989 returns were not adequate to meet all demands and re-evaluation of the natural spawning target.

Contingency Plan

The sub-committee was informed as to the contingency plan developed for 1989. The development criteria included:

1) allocation priorities established by the Regional Executive Committee in 1988;
2) known egg requirements;
3) research and major hatcheries were assigned priority over C.P.D. hatcheries;
    a) major hatcheries were assigned a minimum level at the most pessimistic level,
    b) major hatcheries were ranked at subsequent levels.
    c) CPD ranked in season if required,
4) forecast of B.Q.R. eggs from all sources were pooled for allocation purposes.

The pre-season allocation scheme was prepared in increments of 1 million starting at 11.2 million. This scheme is detailed in a table at the end of this section.

As the season progressed, late October, it was evident that the supply of B.Q.R. eggs would be about 1.0 million less than demand. This shortage was resolved by supplementing Capilano requirements with 1.25 million eggs from Quinsam.

The current status, to November 10, is detailed in a table at the end of this section.

Table 2

1989 BIG QUALICUM FALL CHINOOK EGG ALLOCATION
(000'S)

Eggs Available (% 10**6)	Research	Major Hatcheries				Community Programs						
		BQR	LQR	CAPILANO	PUNTLEDGE	ENGLISHMAN	TSABLE	VANCOUVER BAY	SECHELT	SEYMOUR	RICHARDS	PIP SEAPENS
11.2	18	6500	3500	1000	500	0	0	-	-	-	-	200[4]
12.2	18	6500*	4000	1000	500	0	0	-	-	-	-	200
13.2	18	6500	4500	1500	500	0	0	-	-	-	-	200
14.2	18	6500	5000*	2000	500	0	0	-	-	-	-	200
15.2	18	6500	5000	3000	500	0	0	-	-	-	-	200
16.2	18	6500	5000	3500*	500	200*	63*	222*	133*	128*	56*	200
17.2	18	6500	5000	3500	500	200	63	222	133	128	56	438*

1. Eggs available includes all eggs taken at BQR, LQR, Puntledge and Capilano.
2. Surplus Quinsam eggs could reduce requirement for Qualicum stock eggs at Puntledge and Capilano.
3. Capilano includes Wigwam and Deep Cove Seapens.
4. Eggs from stock raised to maturity at PBS to be incubated at Capilano.

* Facility full
0 No eggs available
\- Some eggs may be available from locally returning stock

Table 3 Big Qualicum Chinook Egg Distribution 1989 To Nov 10/89

Project	Green Egg Equivalents (,000's) Eggs Required	Expected Egg-Take	Transplant Required	Transplant BQ Eggs	Transplant Quinsam Eggs	Locations Prior to Final Destination	Transfer Stage	Transfer Number (,000's)
Big Qual	6500	13300	0	N/A	0	N/A	N/A	N/A
L Qual	4500	3200	1300	1300	0	BQR	Fry	1200
Capilano	3375	200	3175	2000	1250	BQ/Quinsam	Green	3250
Puntledge	3000	1000	2000	0	2000	Quinsam	Green	2000
Englishman	200	0	200	200	0	BQR	Smolt	150
Tsable	63	0	63	63	0	BQR	Smolt	50
Van Bay	222	0	222	222	0	BQR	Eyed	200
Powell River	166	0	166	166	0	BQR	Eyed	150
Sechelt	133	50	83	83	0	BQR	Eyed	75
Seymour	128	0	128	128	0	BQR	Eyed	115
Richards	56	56	0	0	0	N/A	N/A	0
Bowen	56	0	56	Supply from PBS Seapens		Capilano	Eyed	50
PIP seapens (Burrard)	375	0	375	375	0	BQR	Smolt	300
Research	73	0	73	73	N/A	BQR	Green	73
PBS seapens	0	70	0	0	0			
TOTAL	18847	17876	7841	4610	3250			

Natural Spawning Target

Prior to 1989 the target for natural spawning chinook salmon above the fence was 500 pairs. In 1989 the sub-committee noted in its review, that fewer and fewer spawners were allowed access upstream of the counting fence in Big Qualicum River. For 1989, a 600 pair target, with a 50 pair target minimum given shortfalls, was established.

The importances of spawners above the fence include production from river gravel, genetic reserve banking, and unique opportunities to evaluate fresh water production capacities and differential survivals between the wild and hatchery components for both fresh water and marine environments.

In years of good returns the escapement target is achievable. In years of poor returns, they are not. A greater rate of production is possible from the hatchery. At issue then, is the balance between wild and hatchery spawning in years of shortage. Each side of the balance has its costs.

The sub-committee was made aware of the unique opportunities at Big Qualicum for the evaluation of hatchery/wild and fresh water/marine survivals. To do this, a higher standard of data collection would be required. The data collection needs would require modification of the counting fence to improve downstream trapping.

This unique opportunity is further enhanced when existing data collections are considered. Existing data collections describe production from pre-flow control of 1959, versus post-flow control periods and pre-hatchery versus hatchery periods.

The committee was presented the results of preliminary information regarding female spawners versus smolt and fry production for chinooks spawning, above the counting fence. This information indicates a 600 pair target may be too high.

Sub-Committee Advice

1) The natural spawning target should be reviewed. The results of this review can be presented during the sub-committee's spring meeting.

2) The "balance of use, "between hatchery and wild spawning, needs to be investigated. This would permit discussions regarding optimum use under conditions of poor returns.

3) Regarding the unique opportunities, applicable sub-committee members will review and develop potential projects. Such projects would include modification of the fence to increase the downstream trapping of wild smolts/fry for the purpose of improved population estimates and supplemental marking of smolts for the purpose of evaluating differential survivals.

4) Review and Evaluation of Computer Models

Summary

In anticipation of receiving a request to provide advice regarding the application of the currently used computer models, the committee addressed this topic. Such models, if supported by a review and evaluation process, could be an extremely useful analytical tool in the evaluation of both domestic and international chinook and coho issues and fishery management plans.

The sub-committee concluded that this task would be best accomplished by a modelling workshop. The written results of this workshop would form the basis of a working paper to the sub-committee.

In its discussion, the sub-committee developed terms of reference, workshop attendance, and chairmanship requirements. The terms of reference include a requirement for the presentation of recommended procedures for use and for future development of these models, particularly concerning how to evaluate management options. The attendance requirements reflected the need to have external to D.F.O. personnel participation. This would include the consultants originally involved in the development of these models.

The initial workshop could be conducted by January, 1990. This would clarify the dimensions of the task, particularly the applicability and modifications required of the models and, if required, recommendations for future development. Subsequent to this, discussion with the various WCVI Troll Fishery Reshaping, L.G.S. Evaluation and Strait of Georgia Coho committees/task groups will be required to determine their time requirements for the deliverability of supported working models.

APPENDIX 1 **PARTICIPANTS, SALMON SUB-COMMITTEE MEETING**

Members:

D. Anderson - Chairman
B. Riddell
T. Beacham
C. Wood
T. Perry
R. Semple (alternative for D. Schutz)
C. MacKinnon (alterative for K. McGivney)
R. Harrison
P. Starr
D. Peacock (the 15th only)
R. Kadowaki

Note; D. Meerburg; unable to attend

Reviewers:

S. Argue (the 15th only)
P. Ryall (the 14th only)

Observers:

S. Farlinger - Chairman, P.S.A.R.C.
M. Henderson

APPENDIX 2 LIST OF WORKING PAPERS

Paper No.	Title	Author(s)
S89-28	Advice for Establishing Coho Salmon Escapement Goals for the Fraser River	R. Kadowaki K. Wilson N. Schubert
S89-29	Assessment of the Harrison River Chinook Stock (Lower Fraser River)	P. Starr N. Schubert

LIST OF REVIEWERS

S89-28	P. Ryall O. Langer (review not presented)
S89-29	B. Riddell S. Argue

OTHER PAPERS

Title	Author(s)
Big Qualicum Chinook Egg Allocation	T. Perry

APPENDIX 3 TERMS OF REFERENCE AND POTENTIAL PARTICIPANTS FOR THE REVIEW AND EVALUATION OF TROLL FISHERY MODELS

Terms of Reference:

To review and evaluate the W.C.V.I. troll fishery model and the Georgia Strait version.

1. Identify the intended uses and analytical needs.

2. Review appropriateness of model's algorithms used in the W.C.V.I. model for incorporation in the Georgia Strait model. Of particular concern are:

   a) model structure
   b) calibration procedures
   c) time/area steps
   d) effort (switching)
   e) stock biology
      - growth
      - movement
      - maturation
      - natural mortality
      - total fishing mortality

3. Identify model input and output.

4. Identify linkages between models.

5. Present recommended procedures for use and for future development of these models, particularly concerning how to evaluate management options this winter for chinook and coho in the Strait of Georgia.

Potential Attendees:

D.F.O.:

B. Riddell
P. Starr
D. Welch
L. Lapi
D. Peacock
N. Schubert
R. Kadowaki
T. Shardlow
P. Ryall
S. Argue
K. Wilson
K. Pitre
M. Healey
Sport Fish Div.

INDUSTRY:

K. English
B. Gazey
T. Webb
R. Hilborn
J. Siebert

CHAIRPERSON: T. Shardlow

SEQUENCE OF PROCESS:

- This will be an initial meeting which needs to be held as soon as possible. Although dates in mid December have been suggested, dates in January may be required.

- The outcome of the initial meeting, given recommendations, will establish the future workload and schedule.

- The outcome of the initial meeting, the write-up of this workshop and its recommendations, will be the "Reviewed Working Paper" to the P.S.A.R.C. Salmon Sub-committee.