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Pacific Stock Assessment Review Committee (PSARC) Annual Report for 1990

S. Farlinger, G. Thomas, D. Anderson,
D. Chalmers and A. Tyler (Editors)

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Canadian Manuscript Report of Fisheries and Aquatic Sciences

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Les rapports manuscrits sont produits à l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

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Fisheries and Aquatic Sciences No. 2095

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PACIFIC STOCK ASSESSMENT REVIEW COMMITTEE
(PSARC)
ANNUAL REPORT FOR 1990

by

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Chairman's Report for 1990

This is the fifth Annual Report of PSARC, summarizing the sixth year of operation of the committee providing scientific advice for management on the status of Pacific Fisheries Resources. In 1990 PSARC completed a full schedule including the Salmon, Herring, Groundfish, Shellfish and Data Subcommittees which produced six Advisory Documents (90-1 to 90-6). 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 1990, 49 Working Papers were prepared, providing the basis for the biological advice offered. Additional information (unreviewed updates) was also presented in the form of 14 fishery updates to the Shellfish Subcommittee and 9 summaries and program updates to the Herring Subcommittee. The resulting six Advisory Documents are contained in this report.

The first Salmon Subcommittee Report (90-1) was reviewed by the Steering Committee on May 24-25, 1990. The resulting Advisory Document was submitted to the Regional Fisheries Management Executive Committee (FMEC) on June 7-8, 1990. Major issues included: i) the need to address decline in Harrison River Chinook abundance, ii) recognition of the need to test cyclic dominance in Fraser sockeye, and identification of steps required to implement a program, iii)an Assessment Priorities Group formed to identify a structure for selecting "major" or "important" stocks for the collection of stock assessment data. Outstanding tasks were noted.

Meetings of the Shellfish, Groundfish and Herring Subcommittees took place on August 28-29, August 30-31, and September 5-6, 1990, respectively. PSARC Steering Committee reviewed the respective Advisory Documents (90-2,3,4)for presentation to the FMEC on September 20. Major issues included: i) the need to review the link/requirements for stock assessment to management for the groundfish fisheries, including the hook and line fishery; ii) a confirmed decline in abalone stock leading to advice to close the fishery; iii) quotas for the herring anad groundfish fisheries; and iv) the erosion of support for assessment data collection for herring.

The Fall Salmon Subcommittee Report was reviewed by the Steering Committee December 10, 1990 and the Advisory Document (90-5) presented December 14. Recommendations were provided for a process to identify major streams/runs for stock assessment and other requirements.

At the fall Salmon meeting a reduced agenda was followed as several scheduled papers were not submitted. In the FMEC review, a

process to identify specific PSARC assignments in Branch workplans was recommended for 1991. Species subcommittees will be requested to present a list of requested papers for 1992 at the December Steering Committee meetings for review by FMEC. Further assignments for the Data and Systems Subcommittee will be identified by the species subcommittees for Steering Committee review.

The Data and Systems Subcommittee reviewed and accepted Terms of Reference for the creation of task force to oversee the orderly, user-driven revision of fisheries management systems in the region. This report was passed on to the Information Management Committee. For the first time the DSSC used the process of the species subcommittee to review a prepared document. Advisory Document 90-6 supported the Fisheries Branch review of spawn assessment support and was included in the December meetings.

PSARC implemented a report from the FMEC review which informs subcommittee members through the Steering Committee. In this report, the intended management response to the advice is documented.

Several changes to subcommittee chairs are noted with thanks to those retiring. Dr. A. Tyler is replaced as chairman of the Groundfish Subcommittee by Dr. B. Leaman (PBS). Mr. D. Chalmers(FB) is replaced by Ms. V. Haist(PBS) as Herring Subcommittee chair. Mr. R.D. Stanley (PBS) replaces Mr. Radford(FB) at the helm of the Data and Systems Subcommittee.

This document represents the efforts of the stock assessment communitity in the Pacific Region. The principal contributors are those authors listed in the Working Paper Index for 1990. Numerous other DFO staff played key roles. Administrative support has been ably provided by J. Hohn and P. McNally (RHQ) and D. Pearce (PBS).

The chair of PSARC returns to Science in 1991. I would like to thank those whom I have worked with in PSARC; it is only through the substantial efforts of participants that the information is provided to support this process. 1989 and 1990 have seen structural and procedural adjustments as PSARC matures; in 1991 and 1992 attention should turn to widening the scope of the reviews in order to continue and develop the quality of work to date.

S. Farlinger
Chairman

Rapport du président - 1990

Ce cinquième rapport annuel de Comité d'examen de l'évaluation des stocks du Pacifique (CEESP) résume la sixième année d'activité du comité chargé de fournir à la direction des conseils de nature scientifique sur la situation des ressources halieutiques dans le Pacifique. En 1990, le CEESP a réalisé tout son programme et, entre autres, les sous-comités sur le saumon, sur le hareng, sur le poisson de fond, sur les coquillages et crustacés et sur les données ont présenté six documents de consultation (90-1 à 90-6). Le CEESP a pu ainsi faire ses recommandations en temps opportun pour les consultations et les prises de décision régionales précédant le début des diverses pêches.

En 1990, nous avons préparé 49 documents de travail, lesquels servent de fondement aux avis offerts. D'autres comptes rendus (mises à jour non révisées) ont été produits, soit 14 mises à jour sur la pêche présentées au Sous-comité sur les coquillages et les crustacés, et 9 résumés et mises à jour du programme présentés au Sous-comité sur le hareng. Les six documents de consultation rédigés par la suite sont contenus dans ce rapport.

Le Comité directeur a étudié le premier compte rendu du Sous-comité sur le saumon (90-1) les 24 et 25 mai 1990. Le document de consultation qui en est résulté a été présenté au Comité exécutif régional sur la gestation des pêches (CEGP) les 7 et 8 juin 1990. Les principaux points abordés sont : i) la nécessité de contrer la diminution des stocks de quinnat dans la rivière Harrison, ii) la reconnaissance de la nécessité de vérifier la dominance cyclique chez le saumon rouge de Fraser et de trouver les mesures à prendre pour mettre en oeuvre un programme à cet égard, iii) la formation d'un Groupe des priorités d'évaluation chargé de définir les modalités de sélection des stocks "principaux" ou "importants" pour la cueillette de données sur l'évaluation des stocks. On y a également noté les travaux qui restaient à faire.

Les comités sur les coquillages et les crustacés, sur le poisson de fond et sur le hareng se sont réunis respectivement les 28 et 29 août, les 30 et 31 août et les 5 et 6 septembre 1990. Le comité directeur de CEESP a étudié les documents de consultation (90-2,3,4) et les a présentés au CEGP le 20 septembre. Les principaux sujets traités comprenaient : i) la nécessité de revoir le lien entre l'évaluation des stocks et le processus de gestion de la pêche du poisson de fond, y compris la pêche à l'hameçon et la pêche à la ligne sans hameçon; ii) la baisse confirmée des stocks d'ormeaux qui nous a amenés à conseiller la fermeture de cette pêche; iii) les quotas de pêche au hareng et au poisson de fond; iv) l'érosion du sontien accordé à la cueillette des données d'évaluation du hareng.

Le Comité directeur a étudié le compte rendu du Sous-comité sur le saumon kéta le 10 décembre 1990 et le document de consultation (90-5) a été présenté le 14 décembre. Le Comité recommandait un processus permettant de déterminer les principaux cours d'eau et les principales remontees devant servir à l'évaluation des stocks, entre autres.

L'ordre du jour de la réunion du Sous-comité sur le saumon kéta a été réduit parce que plusieurs travaux n'y ont pas été présentés. Dans son rapport, le CEGP a recommandé de mettre sur pied en 1991 un mécanisme permettant de préciser dans les plans de travail des services les travaux confiés au CEFSP. Ainsi, les Sous-comités sur les espèces devront présenter une liste des travaux demandés pour 1992, afin que le CEGP puisse les examiner au moment des réunions du Comité directeur, en décembre. Les autres tâches à confier au Sous-comité sur les données et systèmes seront déterminées par les sous-comités sur les espèces, qui les soumettront au Comité directeur.

Le Sous-comité sur les données et les systèms a étudié et accepté les attributions d'un groupe de travail qui serait mis sur pied pour voir à la modification ordonnée, par les usagers, des systèmes régionaux de gestion de la pêche. Son compte rendu a été remis au Comité de gestion de l'information. Ainsi, le SCDS faisait appel pour la première fois à un sous-comité des espèces pour étudier au document présenté. Le document de consultation 90-6, dans lequel on recommandait que la Direction des pêches examine l'appui accordé à l'évaluation du frai, a été étudié lors des réunions tenues en décembre.

Le CEESP a adopté un rapport d'examen du CEGP qui permet de renseigner les membres des sous-comités par l'entremise du Comité directeur. Ce compte rendu indiqui le suivi que la direction entend donner aux recommandations.

Plusieurs présidents de sous-comités ont été remplacés et nous tenons à remercier les présidents sorants. M. B. Leaman (SBP) remplace M. A. Tyler au poste de président du Sous-comité sur le poisson de fond. M^{me} V. Haist (SBP) assume la préidence du Sous-comité sur le hareng en replacement de M. D. Chalmers (DP). M. R.D. Stanley (SBP) prend la place de M. Radford (DP) à la direction du Sous-comité sur les données et les systèmes.

Ce document reflète le travail de l'équipe affectée à l'évaluation des stocks dans la région du Pacifique. Les principaux collaborateurs sont les auteurs énumérés dans l'index des documents de travail de 1990. De nombreux autres employés de P et O ont également joué un rôle très important. Le soutien administatif nous a été offert sous la compétente direction de J. Hohn et P. McNally (AR) et D. Pearce (SBP).

En 1991, la présidence du CESSP retourne à la division des Sciences. J'aimerais remercier toutes les personnes avec lesquelles j'ai eu le plasir de travailler au cours de mon mandat, car on ne saurait obtenir l'information dont le Comité a besoin dans ses délibérations sans leurs efforts soutenus. En 1989 et 1990, le Comité, au fil de l'expérience acquise, a apporté des modifications à son organisation et à son mode de fonctionnement; en 1991 et 1992, il faudrait élargir la portée des études, de façon à maintenir et à améliorer la qualité du travail fait jusqu'à maintenant.

S. Farlinger
Presidente

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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 19 members as follows:

1 Chairman
1 F.R.B. Section Head from Salmon
3 F.R.B. Section Heads from Marine Fish (Groundfish, Herring and Shellfish)
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 Delegate from Ottawa/Biological Science
3 Area Managers

The immediate past Chairman and appointed members will serve on the Steering Committee for a 2 year term.

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.

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LIST OF MEETINGS, 1990

1. PSARC Salmon Subcommittee Meeting - April 23-28, 1990 - Pacific Biological Station, Nanaimo, BC

2. PSARC Steering Committee Meeting - May 24-25, 1990 - Coast Bastion Inn, Nanaimo, BC

3. PSARC FMEC review of Salmon Advisory Document 90-1, June 7-8, 1990 - 555 W. Hastings, Vancouver, BC

4. PSARC Stock Assessment Data System Subcommittee - August 2, 1990 - 555 West Hastings Street, Vancouver, BC

5. PSARC Shellfish Subcommittee Meeting - August 28-29, 1990 - Anchor Inn, Campbell River, BC

6. PSARC Groundfish Subcommittee Meeting - August 30-31, 1990 - Pacific Biological Station, Nanaimo, BC

7. PSARC Herring Subcommittee Meeting - September 5-6, 1990 - Inn at Westminster Quay, New Westminster, BC

8. PSARC Steering Committee Meeting - September 13, 1990 - Coast Bastion Inn, Nanaimo, BC

9. PSARC FMEC review of Herring, Groundfish and Shellfish Advisory Documents (90-2,3,4), September 20, 1990 - 555 W. Hastings, Vancouver, BC

10. PSARC Stock Assessment Data System Subcommittee - November 2, 1990 - Pacific Biological Station, Nanaimo, BC

11. PSARC Salmon Subcommittee meeting, November 13-14, 1990 - Sheraton Landmark Hotel, Vancouver, BC

12. PSARC Steering Committee Meeting - December 10, 1990 - Pacific Biological Station, Nanaimo, BC

13. PSARC FMEC Review of Salmon Advisory Document 90-5 and Review of Herring Advisory Document 90-6, December 14, 1990 - 555 West Hastings, Vancouver, BC

PSARC WORKING PAPER INDEX FOR 1990

Number	Title	Authors
1. Herring		
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	Progress Reports and Updates	
A.	Results of In-Season Tagging in 1990.	
B.	Distribution of herring larvae in the Strait of Georgia.	
C.	Climate Forcing of Pacific Herring recruitment and growth in southern British Columbia.	
D.	Offshore herring distribution and recruitment forecast for the lower west coast Vancouver Island, August, 1990.	
E.	Hydroacoustic survey - Strait of Georgia.	
F.	Growth and size-at-age in B.C. Herring.	
G.	Egg survival in Pacific Herring Spawn.	
H.	Juvenile Herring Recruitment in Georgia Strait.	
I.	Evaluation of the impact of salmon netpens on herring and juvenile salmon.	
2. Groundfish		
G90-2	Lingcod stock assessment for 1990 and recommended yield options for 1991.	L.J. Richards C.M. Hand
G90-3	Pacific cod stock assessment for 1990 and recommended yield options for 1991.	A.V. Tyler R.P. Foucher

Number	Title	Author
2. Goundfish (cont'd)		
G90-4	Flatfish stock assessments for 1990 and recommended yield options for 1991.	Jeff Fargo
G90-5	Sablefish stock assessment for 1990 and recommended yield options for 1991.	M. Saunders G. McFarlane
G90-6	Pacifc hake stock assessment for 1990 and recommended yield options for 1991.	M. Saunders
G90-7	Spiny dogfish stock assessment for 1990 and recommended yield options for 1991.	M. Saunders B.L. Thomson M.S. Smith
G90-8	Walley pollock stock assessment for 1990 and recommended yield options for 1991.	M. Saunders G.D. Workman
G90-9	Slope rockfish stock assessment for 1990 and recommended yield options for 1991.	L. Richards
G90-10	Shelf rockfish stock assessment for 1990 and recommended yield options for 1991.	R. Stanley
G90-11	Inshore rockfish stock assessment for 1990 and recommended yield options for 1991.	L. Richards C.M. Hand
G90-12	Hagfish stock assessment for 1990.	C. Neville R.J. Beamish
3. Invertebrates		
I90-1	Evaluation of escape ring and tunnel enterance trigger characteristics in Dungeness crab (Cancer magister) traps.	G. Jamieson
I90-2	Development of a Clam Farming Policy for the Pacific Region of DFO.	N. Bourne F. Dickson

Number	Title	Author
3. Invertebrates (cont'd)		
I90-3	A preliminary report of an inter-tidal clam survey in the north coast district - 1990.	N. Bourne G. Cawdell
I90-4	Euphausiid fishery review regarding potential expansion concerns.	G. Jamieson
I90-5	Results of the 1990 shrimp survey.	J Boutillier
I90-6	Climatic change and the intertidal: Physical and biological influences on species composition, abundance and recruitment patterns.	D. Noakes G. Jamieson
I90-7	A review of Geoduck quotas and their derivation.	S. Farlinger R. Harbo K. Hobbs
I90-8	Review of the Biological Basis for Management of the British Columbia Abalone Fishery.	S. Farlinger
I90-9	Abalone resurvey in the southeast Queen Charlotte Islands in 1990.	G. Thomas S. Farlinger
I90-10	Growth and size at maturity of the Horseclam Tresus nutallii (Conrad) in southern British Columbia.	A. Campbell N. Bourne W Carolsfeld
I90-11	Size structure of Purple Sea Urchins, Strongylocentrotus purpuratus, in southern British Columbia.	A. Cambell
	Stock Status Reports	
A.	Intertidal Clams	N. Bourne
B.	Geoducks	R. Harbo G. Thomas
C.	Horse Clams	R. Harbo
D.	Oysters	N. Bourne
E.	Scallops	R. Harbo

Number	Title	Author
3. Invertebrates (cont'd)		
	<u>Stock Status Reports</u>	
F.	Octopus	R. Harbo
G.	Squid	R. Harbo
H.	Crab	G. Jamieson
I.	Prawn	B. Adkins
J.	Plankton	J.D. Fulton
K.	Gooseneck barnacles	R. Harbo
L.	Green sea urchins	R. Harbo
M.	Red sea urchins	R. Harbo G. Thomas
N.	Sea cucumbers	R. Harbo G.A. Thomas
4. Salmon		
S90-1	Chairman's Report for the 1990 Salmon Sub-committee.	B.Riddell D. Anderson
S90-3	Assessment of Kitimat Arm chinook stocks.	D. Peacock B. Snyder
S90-5	Fraser Sockeye Forecasting Methodologies.	W. Saito G. Smith
S90-6	Experimental Rebuilding of Off-Year Cycles in Selected Fraser River Sockeye Stocks: Further Recommendations from the Cyclic Dominance Working Group.	C. Wood
S90-7	Stock Status of Stikine Sockeye.	C. Wood S. Johnston

Number	Title	Author
4. Salmon (cont'd)		
S90-8	Fraser River Sockeye Interim Escapement Goals.	K. McGivney W. Saito R. Harrison
S90-9	Assessment of Stock Identification Capabilities for Fraser Sockeye.	A. Cass
S90-10	Assessment of Chilko Sockeye.	A. Cass
S90-11	Framework for Estimating Escapement of Naturally Spawning Mark Returns Produced by SEP Facililties.	D. Bailey C. Cross K. Pitre K. West D.Plotnikoff
S90-13	Update Assessment of Harrison River Chinook Salmon.	P. Starr N. Schubert
S90-15	Status of W.C.V.I. Natural Spwning Chinook Populations with a Proposed Method for Evaluating the Reliability of Escapement Counts.	T. Shardlow C. McConnell
S90-16	Report from a P.S.A.R.C. Workshop on Status and Useability of Hook & Line Computer Simulation Models in British Columbia.	T. Shardlow (chairman) P. Ryall
S90-19	Stock Status and 1990 Forecasts of Barkley Sound Sockeye.	K. Hyatt S. Heizer
S90-20	Performance of 1989 Forecast, 1990 Forecast and Fishery Impacts, Smith Inlet Sockeye.	R. Goruk I. Winther
S90-21	Performance of 1989 Forecast, 1990 Forecast and Fishery Impacts, Rivers Inlet Sockeye.	R. Goruk
S90-22	Performance of 1989 Forecast, 1990 Forecast and Fishery Impacts, Skeena River Sockeye.	L. Jantz M. Henderson
S90-23	Performance of 1989 Forecast, 1990 Forecast and Fishery Impacts, Nass River Sockeye.	L. Jantz M. Henderson

Number	Title	Author
4. Salmon (cont'd)		
S90-24	Performance of 1989 Forecast, 1990 Forecast and Fishery Impacts, Fraser River Sockeye.	W. Saito
S90-25	Evaluation of the 1989 Return and the 1900 Forecast and Fishery Impacts, Johnstone Strait - Fraser River Chum.	A. Gould M. Joyce L. HopWo
S90-28	Performance of 1989 Forecast, 1990 Forecasted Fishery Impacts, Bella Coola Chum.	R. Goruk
S90-29	Performance of 1989 Forecast, 1990 Forecast and Estimation of Population Statistics; Big Qualicum Chinook.	P. Starr
S90-30	Evaluation of 1988 Returns, 1990 Forecast and Fishery Impacts, Johnstone Strait - Strait of Georgia Pink.	A. Gould L. HopWo
S90-31	Performance of 1988 Forecast, 1990 Forecast and Fishery Impacts, Skeena River Pink.	L. Jantz
S90-33	Optimal Harvest Rate Policies for Rebuilding the Adams Sockeye.	D. Welch
S90-36	A Recommended Approach to Improving Salmon Spawning Escapement Enumeration.	L.Ottmann L. Lapi
5. Data and Systems		
D90-1	Spawn Data Requirements for Herring Stock Assessment.	L. Hamer

Section II

Advisory Documents

PACIFIC STOCK ASSESSMENT
REVIEW COMMITTEE

PSARC ADVISORY DOCUMENT 90-1
MAY 1990

BIOLOGIAL ADVICE ON PACIFIC SALMON

I. STEERING COMMITTEE REPORT

At its meeting on May 24 and 25 1990, PSARC reviewed the Salmon Subcommittee Report as contained in this document. The Salmon Sub-committee considered 24 working papers summarized in the attached report.

The Stock Assessment Section contains three chapters addressing assessments for Kitimat Arm Chinook, Stikine River Sockeye, and conservation concerns for Harrison River Chinook.

The Methodologies Section contains three chapters addressing methods for estimating SEP production to naturally spawning escapements, forecasting Fraser River sockeye returns, and an evaluation of reliability of escapement counts for WCVI chinook. The Special Issues Sections contains five chapters addressing strategies for the evaluation and assessment capabilities for developing sockeye production in the Fraser River system.

The Workshop Section addresses a review and evaluation of a computer simulation model of the WCVI troll fishery.

The Forecasting Section addresses, briefly for selected stocks, the accuracy of the 1989 returns and forecasts for the 1990 returns. In addition, a concern regarding the quality of spawning escapement data in the Region is presented.

FISHERY IMPACTS

The Salmon Sub-committee report indicates both long and short term impacts on salmon fisheries. The short term impacts refer to the forecasts and the potential impacts in the 1990 fisheries. The longer term impacts concern issues such as the development of Fraser River sockeye as well as the decline of Harrison River chinook and the need to rebuild this stock.

SHORT TERM IMPACTS, STOCK ABUNDANCE FORECASTS

The annual forecasts of salmon returns are routinely developed within the respective Divisions to assist in the planning and conduct of the fisheries. Sub-committee interest concern the development and documentation of forecast methods as opposed to the actual forecast. As such summary information on the performance of forecasts in presented.

The 1989 returns of four of the six salmon stocks for which returns abundances were forecasted in Advisory Document 89-1 were within the range of previously observed forecast deviations. Notable variations occurred for the Fraser River pink and Southern B.C. Inside chum forecasts. The forecasts and observed returns were (deviations are calculated as forecasted return minus the observed returns divided by the observed return):

SUMMARY OF 1989 FORECASTS FOR SELECTED STOCKS

STOCK	1989 FORECAST	1989 RETURN	1989 DEVIATION	AVERAGE ABSOLUTE DEVIATION
Fraser River sockeye	13,000,000	18,400,000	-29%	23%
Barkley Sound Sockeye	387,000	480,000	-19%	49%
Fraser River Pink	20,600,000 ±7,000,000	13,500,000*	+53%	29%
Southern B.C. Oddyear Pink (1987)	1,300,000	1,515,000*	-14%	74%
Southern B.C. Inside Chum	3,200,000	1,654,000	+93%	22%
Big Qualicum Hatchery Chinook	7,200 ADULTS 2,700 FEMALES	7,100 ADULTS 2,737 FEMALES	- 2% + 1%	7%

* Based on preliminary stock identification data.

For 1990, the Salmon Sub-committee was advised of forecasts for eleven major salmon stocks. The forecast methods for each of these stocks have been previously reviewed by the Sub-committee. This information is summarized as follows:

Summary of 1990 Forecasts for Selected Stocks

Species	Stock	Escapement Goal	Expected No. of Spawners	1990 Forecast Return	Expected or Allowable Catch	Absolute(1) Forecast Variability (Years)
Sockeye	Fraser River: (1986 cycle)	7,500,000	5,230,000	16,500,000	11,270,000	22% (7)
	Barkley Sound	400,000	-	342,000	-	4% (3)
	Smith Inlet	200,000	200,000	625,000	425,000	42% (6)
	Rivers Inlet	400,000+	460,000	750,000	290,000	73% (5)
	Skeena River	900,000	1,000,000	2,100,000	1,100,000	45% (10)
	Nass.	200,000	200,000	426,000	226,000	51% (6)
Pink	Skeena	1,000,000	1,000,000	2,200,000	1,200,000	52% (9)
	Southern B.C. Even Year	3,111,000	3,183,000	4,692,000	2,462,000	67% (10)
Chums	Central B.C. Bella Coola	267,000	230,000	890,000	660,000	101% (6)
	Southern B.C. John. St. - Fraser	2,759,000	-	2,835,000	-	37% (21)
Chinook	Southern B.C. Big Qualicum Hatchery(2)	3,800 Females	6,800 Adults 3,600 Females	N/A	N/A	N/A (2)

N/A indicated not available

(1) Absolute values of plus/minus range of historical forecasts. Deviations are calculated as forecasted return minus the observed return divided by the observed return.

(2) Forecast in numbers of total adults (male + female), escapement goal of female only based on 19 million eggs required and 5,000 eggs/female.

LONGER TERM IMPACTS

Long term fishery impacts are likely to involve medium term reductions in fishery harvest rates for the purpose of rebuilding depressed stocks. The two major areas in this regard are the recommendations concerning the Harrison River Chinook and the Fraser River Sockeye. The stock assessment and conservation concerns for the Harrison River Chinook were initially addressed in Advisory Document 89-5. Data presented here supports the conclusion that there has been a decline in abundance of Harrison chinook due to a combination of over-exploitation in ocean fisheries and a reduction in ocean survival. The reduced survival appears to be shared by other chinook stocks. The causes of the decline, and thus the appropriate corrective measures remain unresolved. This data also supports the conclusion that the Harrison stock is very large and a major component of the Strait of Georgia sport, the west coast of Vancouver Island troll and the Strait of Georgia troll fisheries. The contribution of Harrison chinook to these three fisheries may have in some years exceeded one-half of the catch. The present Pacific Salmon Treaty (PST) escapement goal of 241,700[1] was established by policy based on technical evaluation which suggested that chinook stocks in aggregate were about about one half of optimum. This goal cannot be supported nor denied based on available technical data. However, returns in 1989 indicate that good production can be achieved from large escapements such as the 162600 seen in 1986. To date, this return does not suggest a declining productivity, thus agreement that the escapement target is probably substantially greater than the escapements recently observed. A habitat based assessment would provide an independent estimate of the escapement target. To achieve the PST escapement goal is consistent with the Sub-committee advice to increase escapements.

Longer term fishery impacts are also likely to involve reductions in fishing for the purpose of increasing future production of Fraser River sockeye. All technical papers considered to date by the Salmon Sub-committee indicate that recent escapements for many runs, particularly the off-cycle runs, have been below optimum levels. The critical assumption concerns the basis of cyclic dominance. From the biological data presented, large benefits will result from increasing escapements. In 1989, the Cyclic Dominance Working Group of the Salmon Sub-committee identified two opportunities to evaluate the basis of cyclic dominance and recommended that these evaluations should be pursued. New information presented to the Sub-committee in 1990 suggests that a more aggressive experimental rebuilding program is warranted. However, Fraser sockeye runs cannot be managed in isolation. Rebuilding plans must be developed after assessing the potential impacts of reduced harvest rates on the catches of co-migrating salmon runs. A formal analysis of potential cost and benefits of the program is recommended.

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[1]It is worthy of note that escapement data since 1984 and the PST interim escapement goal are expressed in mark-recapture study units. These are not necessarily comparable to other untis such as fence counts, fishway counts or fihery officer estimates.

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 directly by the responsible Branch and Divisions. Therefore, only the major recommendations are summarized in this report. The recommendations are arrayed in three categories: Advice for Fisheries Management, Information Needs and Research Needs.

A) Advice for Fisheries Management

1) The Stock status of Stikine River Sockeye has been reviewed (reference Chapter 3). The Steering Committee supported the Sub-committee recommendations that:
   a) The current escapement of 20,000 to 40,000 be maintained until the results of fry stocking are evaluated.
   b) Proceed with the scheduled sockeye fry releases.
   c) Continue with thermally induced marking procedures.
   d) Modify smolt enumeration with calibration.
   e) Collect additional age composition data.

2) The need to address the decline in Harrison River chinook abundance (reference Chapter 4) is important in that failure to do so could limit Harrison chinook production with reduced catches and other stock impacts for existing fisheries. The Steering Committee restated the recommendations as follows:
   a) Continue programs to identify of the Harrison chinook disease agent and determination of its impact on the natural stock.
   b) Escapement levels must be increased. Achieving the increases in escapement while monitoring the resulting recruitment for apparent density-dependent effects, will be a test of the appropriateness of the current goal. The increments in escapement must be sufficiently large to produce measurable changes. An implementation plan and target date should be established by managers.
   c) Given the potential importance of this stock to Canadian fisheries, the Sub-committee recommends that the Region ensure that a monitoring program is established to fully evaluate production from important life phases of this stock as it rebuilds.

3) While the Steering Committee recognizes the need for documentation and development of forecasting methods presently used in the region (reference chapters 1 and 6), it is able only to recommend the continued documentation of forecasts, in this case of the Fraser River stocks, on a single stock basis. The Steering Committee did not put a high priority on the workshop recommended by the Sub-committee for the purposes of further development.

4) Three Chapters (8,9 and 10) recommend rather different approaches to achieving increased production from Fraser River sockeye runs. These chapters indicate that recent escapements for many runs have been below optimal levels. There is a common thread to the analysis which needs to be developed further to ensure a rational rebuilding plan. The Steering

Committee reformed the Sub-committee recommendation that:

a) Before implementation of the experiment can be considered, the design and evaluation framework must be identified. To this end a formal analysis of potential costs and benefits be undertaken for each interative sockeye stock, cycle line and other comigrating salmon species for several rebuilding scenarios under the three alternative hypotheses.

b) The Steering Committee accepts the biological advice regarding the opportunity to test cyclic dominance and increased production. The implications of implementation of this advice are significant. To this end managers require:

   i) an information session with the Sub-committee for the purposes of a fuller understanding.

   ii) an examination of the social and economic implications of implementation as well as some assessment of risk (outside of PSARC).

   iii) monitoring programs and means to terminate the experiment should the results be undesirable.

B) Information Needs:

1) The Sub-committee will require more time to develop advice and recommendations for the Kitimat Arm Chinook Stocks (reference Chapter 2). The Working Paper as submitted is incomplete and some of the information contained therein maybe misleading. The Steering Committee recommends that a working paper be submitted in autumn 1990 with respect to progress on the assessment.

2) A method for evaluating the reliability of escapement counts for WCVI spawning chinook populations was reviewed (reference Chapter 7). The Sub-committee notes that this paper presents a method for evaluating the reliability of escapement counts and does not conclude as to the status of WCVI chinook stocks. The Steering Committee supports the recommendations that the methodology with suggested modifications be applied, the assessment continue and that a progress paper be prepared for the autumn 1990 Sub-committee meeting.

3) In 1988 PSARC recommended that "major" or "important" stocks be defined for which stock assessment data would be routinely and rigorously collected. The Sub-committee felt that this process should occur at a Regional level so that each Branch could be included in that process. Many of the recommendations would require major investments of resources and personnel and possibly would require a restructuring of the way the Department obtains its basic escapement information. The Sub-committee feels that the current methods of collecting these data are inconsistent within the Region and often of very little rigour and that the disruption is worth the effort and expense to get good stock assessment information (reference Chapter 4 and the section on Quality of Spawning Escapement Data). The Steering Committee supports the Sub-committee recommendations:

   a) The formation of a small Assessment Priorities Working Group (3 or 4 people) to prepare a working paper for the fall/90 PSARC Salmon Sub-

committee meeting describing alternative approaches and time-tables for achieving the following:

i) definition of "priority" or "important" stocks for fishery management, stock assessment, SEP assessment and habitat protection purposes; and
ii) upgrading and standardizing the collection of assessment data (escapement, coded wire tag recoveries, etc.) for these priority stocks.

While the working group could recommend approaches requiring additional resources, their focus should be on those that improve the effectiveness of existing assessment programs within existing Pacific Region resources.

b) that a review and revision of the material in the "Fisheries Officer's Guide to Collection, Recording, and Use of Sub-District Salmon Management Data" occur with the intent of upgrading escapement enumeration techniques in the region. The use of the daily stream inspection log should be made mandatory for stream visits or flights by any DFO personnel. The purpose of the visit should be recorded on the log.

4) Chapter 13 is a report from the workshop that PSARC convened in response to the Director General's request to review and evaluate the computer model simulation for the west coast of Vancouver Island troll fishery. The terms of reference provided to this workshop are detailed in Appendix 3 of Advisory Document 89-5. The Steering Committee recommends that:
   a) Complete the required review of the WCVI model (this would require 3-4 weeks BSB, 1-2 weeks FB)
   b) A regional modelling group (3 -5 people) be established to accomplish the next stage of development. These activities would include development of models for the North Coast and Strait of Georgia fisheries as well as consideration of completely rewriting the WCVI model.

C) Research Needs

1) Chapter 11 continues addressing an important issue concerning how well stocks of Fraser sockeye can be identified by scale pattern analyses alone. Data is presented which indicates that estimates of stock composition can be strongly biased. These conclusions raise serious questions about the adequacy of existing methods for estimating stock compositions and harvest rates on individual Fraser River sockeye stocks. This has important implications for the management, stock assessment and rebuilding of stocks and thus warrant careful attention. In view of the serious implications, the Sub-committee recommends:
   a) that improvements are needed in the ability to allocate Fraser sockeye catches by stock and that a formal working group, consisting of appropriate PSC and DFO staff, be established to develop a consolidated approach to this problem as identified on page 46 of the Sub-committee document.

2) Chapter 12 assesses the uncertainty with which potential effects of lake fertilization on juvenile sockeye production can be detected in Chilko Lake. The Steering Committee notes that: given the information presented in the report it is difficult to detect these effects. The analysis suggest that it will be difficult to measure any changes due to lake fertilization unless a profound effect occurs.

OUTSTANDING TASKS FROM PSARC ADVISORY DOCUMENT 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.

When this was originally presented in 1988 the RMEC 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. This was identified in the 1989 Chairman's Report. However, the Sub-committee was not able to respond 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.

When this was originally presented in 1988 the RMEC agreed with 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 increase pressure for stock allocations and equity measurements in the Pacific Salmon Commission.

OUTSTANDING TASKS FROM PSARC ADVISORY DOCUMENT 89-1

B9) The Steering Committee fully supported 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. The Steering Committee, therefore, supported 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 recommended that the proceedings of this workshop be published for future reference, as a report to PSARC and the Regional Executive. For clarity it is noted, the Sub-committee's concerns are for the methods and documentations and not the annual forecast.

OUTSTANDING TASKS FROM PSARC ADVISORY DOCUMENT 89-5

A1) The Steering Committee endorsed the recommendation of the Sub-committee to replace the present escapement goal for Fraser River coho and further supported pursuing the concept of a "floor" escapement for adaptive management. However the Sub-committee was not able to respond to this assignment.

II. SUBCOMMITTEE REPORT

INTRODUCTION

The Salmon Sub-committee met at the Pacific Biological Station, Nanaimo, B.C. from April 23-27, 1990. The Sub-committee considered 24 working papers on stock assessments, methodologies, special issues and forecasts. 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, reviewers' comments, and the Sub-committee's advice and recommendations.

1. CHAIRMAN'S REPORT FOR THE 1989 SALMON SUB-COMMITTEE (Working Paper S90-1)

1.1 INTRODUCTION

This report provides a summary of the Salmon Sub-committee activities during 1989. The Sub-committee and the Steering Committee have identified a concern about how to monitor progress on the implementation of recommendations. In this regard, information is provided in this report on the outstanding tasks carried forward from the PSARC Advisory Documents 88-1 and 88-5. As well information is provided on actions taken on major recommendations in Advisory Documents 89-1 and 89-5. These documents were presented by the Steering Committee of PSARC to the Regional Management Executive Committee (RMEC) and summarized recommendations of the Sub-committee reports. This report also comments on the accuracy of the 1989 abundance forecasts, outlines the 1990 forecasts for thirteen major salmon stocks, comments on the publication of assessments presented in 1989, and identifies topics needing continued work.

1.2 SUB-COMMITTEE ACTIVITIES, 1989

In 1989, the Salmon Sub-committee submitted two committee reports summarizing 24 working papers. These papers were prepared by staff from the: Bioliogical Science Branch, Fisheries Branch, Salmon Enhancement Program and the Program Planning and Economics Branch. In the spring of 1989, the Sub-committee's report (Advisory Document 89-1) addressed assessments of conservation concerns about southern B.C. chinook and coho salmon, assessment 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 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. In the autumn of 1989, the second report (Advisory Document 89-5) addressed escapement goals for Fraser River coho salmon, the status of Harrison River chinook salmon, and a process for the evaluation of fishery management

computer models. Each of these reports presented recommendations concerning the status of B.C. salmon stocks, data needs, fisheries management actions, and research programs.

1.3 OUTSTANDING TASKS FROM PSARC ADVISORY DOCUMENT 88-1

(recommendations are identified by the numbering system on pages 2-4 of Advisory Document 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.

When this was originally presented in 1988 the RMEC 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. This task was identified in the 1989 Chairman's Report. However, the Sub-committee was not able to respond 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.

When this was originally presented in 1988 the RMEC 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.

1.4 OUTSTANDING TASKS FROM PSARC ADVISORY DOCUMENT 88-5

Sub-committee advice following from the autumn meeting was more of a policy development and negotiating nature than technical recommendations. Several technical recommendations followed from the proposed coho salmon management policy. This work continued in the spring and autumn of 1989 as Working Papers 89-5 and S89-28. The RMEC requested that an action plan be developed before a coho policy was announced. Procedures to establish this plan were developed by the Executive Committee of Fisheries Branch. This resulted in a Regional Task Force, chaired by the South Coast Division Area Manager, to recommend actions on this issue. This task force is external to the Sub-committee and began work in September 1989.

1.5 MAJOR RECOMMENDATIONS IN PSARC ADVISORY DOCUMENT 89-1

(Recommendations are referenced by the numbering system on pages III to VIII of Document 89-1)

A) Advice for Fisheries Management:

1. Conservation concerns for chinook stocks in the Strait of Georgia were presented. Fisheries management plans to reduce the exploitation rates on Lower Strait of Georgia chinook stocks were continued in 1989. An evaluation framework to assess the effectiveness of the Management Plans is currently underway. Additional technical information and recommendations were provided in the spring and autumn as Working Papers S89-4 and S89-29.

2. The Steering Committee supported the Sub-committee's concerns about the Big Qualicum Hatchery chinook stock. A contingency plan for the use of available eggs was reported to the Sub-committee in the autumn of 1989. Technical evaluation of the number of naturally spawning chinook in this river system has yet to be completed.

7. The Cyclic Dominance Working Group of the Salmon Sub-committee identified two opportunities to evaluate the basis of cyclic dominance in Fraser River sockeye salmon. This work continued in 1989. Sub-committee recommendations to the authors of Working Paper S89-26 have been addressed. Further recommendations from the Working Group are presented in the Sub-committee's spring meeting as Working Paper S90-6.

   A high priority was identified on completing assessments of stock identification capabilities for Fraser sockeye. This work will be presented in this Sub-committee's spring meeting as Working Paper S90-9.

B) Information Needs:

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 lengthy time series of smolt production data for sockeye salmon in British Columbia. For 1989 it was agreed that 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.

   Further technical work was left to the discretion of the Sub-committee. No further work was undertaken in 1989 by the Sub-committee. The Babine smolt enumeration program was funded and continued in 1989.

9. The Steering Committee fully supported 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, supported 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 recommended that the proceedings of this workshop be published for future reference, as a report to PSARC and the Regional Executive. The Steering Committee further suggested that a test site and stock(s) be selected where alternative forecasting methods could be compared over a time.

   Methodologies for forecasting Fraser River sockeye will be presented in this Sub-committee's spring meeting of 1990 as Working Paper S90-5.

   Regrettably the A/Director of Fisheries Branch did not support the forecasting workshop. The Sub-committee now needs to address "where to from here".

C) Research Needs:

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.

   Given the number of times this issue arose in the 1989 Working papers it was anticipated that a Regional priority would be assigned to this work. Two research programs are on going to establish appropriate elements for marking and determing error rates in detection methodologies.

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.

   This work has continued and will be presented in this Sub-committee's spring meeting of 1990 as Working Paper S90-9.

1.6 MAJOR RECOMMENDATION IN PSARC ADVISORY DOCUMENT 89-5

A) Advice for Fisheries Management

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

   Further work has been delayed.

Additionally, during 1989 the Sub-committee was directed by RMEC to assess the status of chinook stocks of the Harrison River and of the west coast of Vancouver Island. Initial assessment for the Harrison was presented in Working Paper S89-29. An update assessment for Harrison chinook stocks is presented in the Sub-committee's spring meeting as Working Paper S90-13. For the WCVI chinook stocks an evaluation method is presented in the Sub-committee's spring meeting of 1990 as Working Paper S90-15. Additionally, the Sub-committee was directed to review and evaluate computerized fishery management models for the W.C.V.I. troll fishery. A process was established by the Sub-committee in the autumn of 1989 and the results of the workshop are presented in the Sub-committee's spring meeting of 1990 as Working Paper S90-16.

1.7 STOCK ABUNDANCE FORECASTS

The 1989 returns of the six salmon stocks for which return abundances were forecasted in Advisory Document 89-1 varied around the range of forecast deviations previously observed. Notable variations occurred for the Fraser River pink, Southern B.C. Inside chum forecasts. The forecast and observed returns were (deviations are calculated as forecasted return minus the observed return divided by the observed return):

STOCK	1989 FORECAST	1989 RETURN	1989 DEVIATION	AVERAGE ABSOLUTE DEVIATION
Fraser River sockeye	13,000,000	18,400,000	-29%	23%
Barkley Sound Sockeye	387,000	480,000	-19%	49%
Fraser River Pink	20,600,000 ±7,000,000	13,500,000*	+53%	29%
Southern B.C. Oddyear Pink (1987)	1,300,000	1,515,000*	-14%	74%
Southern B.C. Inside Chum	3,200,000	1,654,000	+93%	22%
Big Qualicum Hatchery Chinook	7,200 ADULTS	7,100 ADULT	-2%	7%
$\bar{X}$=	2,700 FEMALES	2,737 FEMALES	+1%	

* Based on preliminary stock identification data.

1.8 PUBLICATION RECORD

The Salmon Sub-committee report from the 1988 meeting was published in:

Stocker, M., N. Bourne, B. Riddell, J. Schweigert and A. Tyler (editors) 1989. Pacific Stock Assessment Review Committee (PSARC) Annual Report for

The Salmon Sub-committee report from the 1989 meeting is in press:

Farlinger, S., N. Bourne, B. Riddell, D. Chalmers and A. Tyler (editors) 1989. Pacific Stock Assessment Review Committee (PSARC) Annual Report for 1989. Can. Ms. Rep. Fish Aquat. Sci. (in press)

Of the 24 Working Papers submitted to the Sub-committee (20 for the spring meeting and 4 for the autumn meeting), one paper, has been published:

Welch, D.W., and D.J.Noakes. 1990. Cyclic dominance and optimal escapement of Adams River sockeye salmon (Oncorhynchus nerka). Can. J. Fish. Aquat. Sci. 47: 838-849.

Publication of the four papers submitted for autumn 1989 meeting is unlikely because the chinook paper is to be updated and resubmitted for the spring 1990 meeting, the coho paper was a discussion paper on escapement goals, and the two other papers established contingency plans or procedures for future work.

1.9 TOPICS REQUIRING FOLLOW-UP

The Sub-committee should address the outstanding tasks carried forward from the PSARC Advisory Documents 88-1 and 88-5. The tasks requiring attention in 1990 are, by the preceding reference system, items: Document 88-1; A1 and A2; Document 89-1; A2 for naturally spawning chinook; B4, B9 for the forecasting workshop; C1 and for Document 89-5; A1.

Additionally, some working papers considered for the spring 1990 meeting were postponed, while other working papers proposed for the spring 1990 meeting will not be presented. These papers collectively should be reconsidered for the autumn 1990 and or spring 1991 meeting.

STOCK ASSESSMENTS

2. ASSESSMENT OF KITIMAT ARM CHINOOK STOCKS (Working Paper S90-3)

2.1 INTRODUCTION

Area 6 chinook stocks were severely depressed in the mid 1970's. Investigations into the feasibility of a hatchery began in 1975. The pilot hatchery began operation in 1977, and the production facility took over in 1983. Since that time, enhanced chinook returns have become an increasingly important component of the Kitimat Arm stocks. A vigorous sport fishery is conducted on these stocks in the tidal areas and rivers of Kitimat Arm. The Kitimat and other

Area 6 chinook stocks are a topical discussion item because the rapidly escalating Kitimat returns are creating disputes over the allocation of the resource in the terminal harvests. In contrast, the unenhanced non-Kitimat chinooks in Area 6 are considered to be "indeterminate" in their status of rebuilding for the purposes of Pacific Salmon Treaty discussions.

2.2 COMMERCIAL NET AND TROLL FISHERIES

Although we know from recent CWT recoveries that Kitimat chinook are intercepted in Area 6 gillnet, seine and troll fisheries, there are no quantitative estimates of the catch in Area 6 of Kitimat chinook.

2.3 TIDAL SPORT FISHERY

Most of the sport fishing effort for chinook salmon is concentrated in Kitimat Arm-Upper Douglas Channel (Management Unit 6-1). The summer sport fishery continues to grow in popularity and in success. In 1989, an estimated 7,410 chinook were caught in the Kitimat area. This catch represented approximately 20% of the 1989 North Coast (Areas 1-10) tidal sport catch.

Total annual catch has ranged from 700 to 9,000 pieces. Decade averages show a steady increase (1960's 1,014; 1970's 2,413; 1980's 4,833).

2.4 NONTIDAL SPORT FISHERY

The nontidal sport fishery in Area 6 is concentrated mainly in the Kitimat River. Other streams which are fished less frequently and with less effort are the Kildala, Dala, Kitlope and Kemano systems.

The Kitimat area non-tidal catch declined to low levels (<1,000) during the late 1960's due to the combined impacts of low abundance and conservation restrictions. This catch remained low until the last three years (1987-1989) when the abundance in the river has increased dramatically, and the conservation measures have been relaxed to some extent.

In 1989, a creel survey conducted for the non-tidal waters estimated a total chinook catch of 3,719. The 1989 chinook catch comprises 38.5% of the North Coast chinook nontidal sport catch.

2.5 INDIAN FOOD FISHERY

The Kitimat River was closed to all IFF in 1966 by mutual agreement between the Department of Fisheries and Oceans and the Kitamaat Band for conservation of weak chinook stocks to the Kitimat River and Kitimat Arm. A tidal water fishery has continued, peaking in mid-June. Food fishery landings have demonstrated an increasing trend over the last three decades but remain at relatively low levels (generally less than 1,000 fish).

The Hartley Bay band gillnet chinook in June (usually less than 500) and the the Kitasoo Band catch chinook incidentally to sockeye (usually less than 500).

2.6 ESCAPEMENT

The Chinook Technical Committee (CTC) uses an escapement goal which is different from the local Fishery Officer estimate. The CTC goal was established as an interim target for the Pacific Salmon Treaty's rebuilding program. This target is simply a doubling of the base period average (1979-1982) escapements. Originally, all Area 6 streams were pooled to represent the indicator stock for Pacific Salmon Treaty purposes. In 1988, the Area 6 indicator stock set was revised to exclude systems where enhancement contributes substantially to current escapements. Therefore, the Kitimat Arm "enhanced" chinook stocks are excluded from the indicator stocks used by the CTC.

The average base period escapement for the non-Kitimat Arm "natural" streams in Area 6 is 2,761. Doubling this provides the interim target escapement used by the CTC of 5,521. The post-Treaty average (years 1985-1989) is 1,971. In Pacific Salmon Treaty jargon, the rebuilding classification (Pacific Salmon Commission 1989) for these streams to 1988 is 'indeterminate'.

The Fishery Officer chinook target escapement for Kitimat Arm chinook is 40,125 with 26,625 of that for the Kitimat River system. The estimate of target escapement for the rest of Area 6 is 30,500. These estimates are derived by subjective evaluation of the adult spawning and juvenile rearing capacity of Area 6 rivers and estuaries.

2.7 TERMINAL RUN

The terminal run of Kitimat chinook is approximated by summing the Kitamaat Band IFF, the tidal sport catch of chinook >5 lbs, the non-tidal sport catch and the escapement. The terminal run increased slowly during the period 1977 through 1985, and has shown a dramatic increase from 1986 (10,030) through 1989 (47,250).

2.8 REVIEWER'S COMMENTS

Both reviewers indicated that this was a worthy first attempt at constructing a comprehensive review of the stock assessment data available for these chinook stocks, however further documentation is required in many areas. These include: the importance of the estuarine habitat and changes to it over time, life history types of chinook in the various Kitimat Arm streams, the rationale behind the Fishery Officer's escapement goal and the reliability of escapement estimates, and additional annual biological information which should be available from SEP.

The goal of such a report should be to fulfil two functions:

1. It should provide a source reference on the stock group arranged in a convenient manner; and
2. It should provide the technical basis underlying all stock management actions. Both reviewers recommended that further documentation was necessary to fulfil the two objectives above.

The reviewers agreed that the conclusions reached in the original Working Paper on hatchery contributions to the Kitimat return, on exploitation rate and on the escapement goal were not supportable and should be deleted from the Sub-committee report.

2.9 SUB-COMMITTEE ADVICE AND RECOMMENDATIONS

The Sub-committee generally agreed with the detailed comments of the two reviewers. The working paper as submitted is incomplete and may be misleading. The Sub-committee agrees with the reviewers' recommendations that the major conclusions presented in the working paper are not adequately supported by the data presented. The Sub-committee recommends that the paper be resubmitted, for the autumn 1990 meeting. When redrafting this paper particular attention should be given to:

1. A more detailed rationale for an escapement goal as well as an investigation of the reliability of escapement estimates. This may include consideration of the life history of these stocks and the environmental factors affecting them.

2. An exploration of how these stocks could be actively managed in the terminal area, for example, there is a need to evaluate potential relationships between terminal CPUE's and either run size or escapement estimates.

3. Development of a sport fish awareness factor through the Kitimat Arm sport creel survey program and further analysis of CWT information for the purposes of assessment of catch distribution.

The Sub-committee notes that better information on these stocks could have bearing on Canada-US treaty discussions relating to the Alaskan winter troll fishery as well as rationale for terminal exclusions. The Sub-committee also cautions against the interim use of the exploitation rate estimates as presented in the working paper.

3.0 STOCK STATUS OF STIKINE RIVER SOCKEYE (Working Paper S90-7)

3.1 INTRODUCTION

Sockeye salmon in the Stikine River are harvested by both Canada and the United States, and managed and enhanced according to recommendations from the joint Transboundary River Technical Committee (TCTR) of the Pacific Salmon Commission. Two stocks are defined based on practical aspects of their management: the Tahltan Lake stock, and a conglomerate of runs to other parts of the drianage referred to as the "non-Tahltan stock". Spawning escapements to Tahltan Lake are known from weir counts since 1959 (Fig. 3.1); those to the non-Tahltan stock have been estimated indirectly using a test fishery, but only since 1979. Catch and age data (and hence total return data by brood year) are available from 1979-1989; before 1979, there was no Canadian commercial fishery, and Alaskan catches of Stikine sockeye were not estimated. Much of the Alaskan catch of Stikine sockeye is incidental to other fisheries, and therefore difficult to estimate reliably. Smolt production in Tahltan Lake has been

monitored carefully since 1984. Sockeye fry reared in an Alaskan hatchery from Tahltan broodstock are scheduled to be planted back into Tahltan Lake in 1990 in an effort to increase sockeye production from the Stikine.

3.2 PRODUCTIVITY EVALUATIONS

Stock-recruitment analyses with total return data acquired since 1979 suggest that optimal escapements for the Tahltan and non-Tahltan stocks are 15,000 and 20,000 spawners, respectively. A similar analysis based on Tahltan escapement data from 1959-1989 excluding catch but with an assumed historic exploitation rate of 0.3-0.5 suggests an optimal escapement range of 15,000-20,000. Stock-recruitment analyses using presmolt production data from the 1982-1987 brood years (Fig. 3.2) and assuming presmolt-to-adult survival rates of 0.02-0.05 suggest an optimal escapement range of 14,000-22,000. Thus, the recommended escapement goal for the Tahltan stock is 20,000 spawners, at the low end of the target range (20,000-40,000) set by the TCTR.

3.3 PRESEASON FORECASTS

Forecasts of Stikine sockeye returns have been very unreliable. The sibling age class method using age 4 returns to predict combined ages 4-6 returns in the following year appears to have merit for the Tahltan stock. The sibling method has been used to develop a "best" Tahltan forecast for 1990; stock-recruitment curves have been used to forecast Tahltan returns in 1991 and non-Tahltan in 1990 and 1991. The "best" 1990 forecasts are 30,200, 66,100, and 96,300 sockeye for the Tahltan, non-Tahltan, and total Stikine runs, respectively; the best 1991 forecasts are 33,100, 60,200, and 93,300, respectively.

3.4 STOCK STATUS

The total sockeye return to the Stikine River in 1989 was 95,718, slightly above the 1979-1988 average of 91,839 sockeye. Although run sizes have fluctuated since 1979, there is no evidence of a trend in overall Stikine sockeye abundance (Fig. 3.3). However, the return to the Tahltan stock in 1989 was only 14,111, well below the 1979-1988 average of 29,149; Tahltan returns have been below average since 1987. In contrast, the non-Tahltan return in 1989 was 81,607 and above the 1979-1988 average of 62,690.

Sockeye escapements to Tahltan Lake have been below the target range set by the TCTR (20,000-40,000), and the estimated optimal levels reported here (15,000-20,000) since 1987, ranging from 2,536-8,316. The non-Tahltan escapement in 1989 was within the target range (20,000-40,000) and slightly above the optimal level reported here (20,000); non-Tahltan escapements in 1987 and 1988 were very close (19,353 and 22,840, respectively) to the estimated optimum.

Sockeye returns to the Tahltan and non-Tahltan stocks tend to be correlated. However, the non-Tahtlan stock has been relatively more productive in recent years. The poor returns of Tahltan sockeye since 1987 clearly result from poor survival after smolts have left Tahltan Lake; age 1+ smolt survival has ranged from only 1.1-6.9%. Poor Tahltan smolt survival appears to coincide with the initiation of the smolt enumeration program. However, estimates of smolt

survival prior to smolt enumeration (based on calculated smolt production), together with empirical observations regarding the survival of smolts held in cages after enumeration, suggests that the smolt enumeration program is not responsible for recent poor rates of returns. If this is true, and conditions for smolt survival have since improved, Tahltan returns in 1990 and 1991 should be considerably greater than forecasted, because the 1985-1986 brood years produced record numbers of smolts.

3.5 REVIEWERS COMMENTS

Both reviewers were impressed by the quality of the report in general and with the analyses performed given the limited data available. Although the authors were forced to make a number of assumptions, whenever possible, they tried to corroborate results by approaching problems in more than one way.

While the authors presented analyses suggesting that a 20,000 spawning escapement goal for Tahltan Lake would be appropriate, one reviewer felt that it was premature to recommend a reduction because of the potential for a downward bias in the optimal escapement estimate derived from stock recruitment analysis. Serially correlated time series errors will cause this underestimation which is particularly marked with short autocorrelated time series. This same reviewer noted that the analysis showing the sudden drop in egg-to-smolt survival at spawning escapements above 20,000 is weak because it was based on only six years data. He suggested that the pattern might be spurious and caused by a confounding of survival with time as well as escapement. The reviewer recommended against modifying the escapement goal until further data are collected at higher escapement levels. However, he was intrigued by the author's approach of generating a Ricker curve based on the decline in smolt survival for comparison with empirical parameter estimates reported in the text, and suggested that it might be worthy of publication.

The other reviewer agreed with the authors' recommendation to reduce the escapement goal because several methods of deriving optimum escapement indicated similar levels.

Both reviewers considered that the sibling forecast procedure for Tahltan stock appeared promising and should be pursued. Forecasts for Tahltan sockeye are particularly important during the first few weeks of the season when they are used to establish the initial fishing pattern. One reviewer felt that efforts to improve forecasts for age 4 sockeye may not be worthwhile since only about 13% of the fish return at age 4, on average.

Although the analyses presented suggest that the smolt counting program was not responsible for the poor smolt-to-adult survival of recent years, the authors recommended, as a precautionary measure, modifying the program so that only a subsample of the smolts is handled. One reviewer argued against modifying it because the data quality could be reduced. The other reviewer thought that caution in the enumeration technique was still warranted and accepted the authors' recommendation.

Both reviewers concurred with the authors' recommendation that thermal-induced marking of juvenile sockeye otoliths proceed.

3.6 SUB-COMMITTEE ADVICE AND RECOMMENDATIONS

The Sub-committee felt that it was premature to modify the Tahltan Lake escapement goal of 20,000 to 40,000 because the short time series of data on which the analyses were based makes estimates of optimum escapement uncertain. As the authors point out, stocking fry into Tahltan Lake should help to determine whether or not the spawning area is limiting. If the stocked fry survive and grow well it could be concluded that the limitation to production is occurring during spawning or incubation rather than during lake rearing. A decision to alter the escapement goal should wait at least until the results of this experiment are available.

The occurence of Tahltan sockeye with thermally induced otoliths mark in Alaskan catches should provide a means for improving interception estimates of Stikine River sockeye. This is especially true for "outside" fishing areas such as Districts 101 and 104 where sockeye catches are large but present techniques and sampling levels are inadequate to detect Tahltan sockeye. If Tahltan production is increased and thermal marks prove effective, the portion of this stock in "outside" fisheries should increase to measurable levels. Additionally, if successful, better information on smolt survival would be gained.

The Subcommittee recognizes the importance of the smolt enumeration program, but is also concerned about the potential for the counting procedure to affect survival. The possibility of simultaneously using both the current technique and a subsampling method for a few years in order to calibrate the subsampling procedure was suggested. Other considerations on this matter are the expected large increases in smolt numbers because of enhancement and the tendency for large numbers of smolts to periodically migrate out of the lake over a short period of time, making complete counts difficult. Sonic counting of smolts was suggested as a alternate approach.

The following recommendations were made:

1. Proceed with the scheduled release of sockeye fry to Tahltan Lake from the Snettisham Hatchery in Alaska. These Tahltan fry are being marked at the hatchery by varying the incubation temperature to put thermally-induced marks on the otoliths.

2. Maintain the current spawning escapement goal range of 20,000 to 40,000 for each of the Tahltan and non-Tahltan stocks until the results of fry stocking are fully evaluated.

3. Modify the smolt enumeration procedures at Tahltan Lake so that only a subsample of the run is handled in order to minimize the risk of injuring or stressing the smolts. When the procedure is changed, appropriate calibration methods will be required to maintain continuity between "old" and "new" procedures.

4. Collect additional non-Tahltan age composition data from the Stikine River test fishery samples. This would assist in the management of the stock.

4. UPDATED ASSESSMENT OF HARRISON RIVER CHINOOK SALMON (Working Paper S90-13)

4.1 INTRODUCTION

The Harrison River is part of a complex system which drains a mountainous coastal watershed in southern British Columbia. The river supports one of the largest naturally spawning chinook stocks on the Pacific Coast. Harrison chinook are a white flesh fall stock which returns to the river in September and October and spawns in stable main channel areas which are protected from flow fluctuations by Harrison Lake. The stock is notable in that the fry emigrate immediately after emergence and rear in side channels and sloughs in the Fraser estuary. Harrison chinook are harvested in the hook and line fisheries in the Strait of Georgia and the west coast of Vancouver Island. Other fisheries of importance include the net fisheries in Juan de Fuca Strait, Johnstone Strait, northern Puget Sound and the Fraser River. The Harrison chinook escapement goal is 241,700.

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 declined to a low of only 15% of the escapement goal in 1988, recovering to 31% of goal in 1989. 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 1989). The status of this stock, therefore, presents serious domestic and international concerns.

Working Paper S89-29, presented in November 1989, provided a comprehensive stock assessment statement for Harrison chinook. The current paper updates that statement by incorporating 1989 data in the review of trends in terminal abundance and in harvest distribution and survival estimated from coded wire tag data. The paper also provided additional biological sample data and an evaluation of escapement estimation techniques and of the escapement goal.

4.2 EVIDENCE FOR DECLINE IN ABUNDANCE

Several indices of terminal abundance were available for Harrison chinook, including CPUE in the commercial gill net, Indian food and Albion test fisheries. As well, trends in the escapement and total return measured terminal abundance, and the Mission fry program provided an index of spawning and incubation success. A comparison of all these trends are presented in Table 4.1 for 1981-89, a period when estimates are available for most abundance indicators. While correlation between some indices was poor, each index showed a similar negative trend averaging 16% (range 14% to 20%) and 26% (range 20% to 36%) per year in 1981-89 and 1984-89, respectively. The authors concluded, therefore, that the terminal abundance of Harrison chinook declined since 1981, and that sharp declines occurred in 1987, 1988 and 1989.

Table 4.1. Summary of terminal abundance indicators and estimated proportional change over two recent periods (1981-89 and 1984-89). Percent change per year was calculated by fitting an exponential model.

Year	Area 29 commercial gill net CPUE	Indian food fishery CPUE	Escapement	Total return to the river	Test fishery index	Mission fry index
1981	1.23	0.61	n/a	n/a	24.10	107.82
1982	2.17	1.52	n/a	n/a	74.01	342.93
1983	1.06	0.59	n/a	n/a	39.04	172.31
1984	2.27	1.97	120,836	131,756	63.70	258.79
1985	1.12	0.54	174,777	179,254	59.45	55.36
1986	1.69	0.34	162,598	176,537	30.29	122.84
1987	0.43	0.22	79,039	81,680	11.93	63.43
1988	0.51	0.52	35,116	40,071	22.04	80.63
1989	0.21	0.08	75,057	75,857	14.73	n/a
Average percent change/year:						
1981-89:	-20.2	-15.1%	n/a	n/a	-13.5%	-14.4%
1984-89:	-36.1	-30.0%	-20.2%	-20.5%	-27.4%	-19.7%

Note 1. Because IFF gill net mesh size was restricted in 1989, that year was excluded from mean % change/year.
Note 2. Escapement and total return were from the mark-recapture study.

4.3 EVALUATION OF ESCAPEMENT DATA

Escapement estimated from visual observations were available for 1951-86, with a record of daily observations and sighting conditions available for 1976-88. From an evaluation of the annual escapement and peak live counts (Fig. 4.1), the authors noted a) a discontinuity in the data trends beginning in 1985, and b) that less variability was present in the counts relative to the estimates. The authors concluded that the estimates were largely subjective and of questionable value, and that the 1985-88 data were biased by the mark-recapture study and were not comparable to previous years.

The 1984-89 mark-recapture data were evaluated for violations of the assumptions underlying the technique. While biases were identified in the mark-recapture study, there was no indication of either a large or a systematic bias. The authors concluded that the mark-recapture study provided a realistic estimate of trends and probably magnitude of escapement.

4.4 ESCAPEMENT GOAL

The interim escapement goal of 241,700 was established under the guidelines developed by the Chinook Technical Committee of the Pacific Salmon Commission. The authors evaluated this goal in terms of: a) potential bias in the mark-recapture estimate; b) suitability of 1984 as a base period; and c) habitat limitations to spawning and rearing. The authors noted that, when evaluated against visual survey data, 1984 was a year of relatively low escapement and that little variability was noted in the 1979-82 base period. The authors concluded, therefore, that the use of 1984 did not introduce a positive bias in the goal and that the use of a single year adequately represented the variability in the visual base period. The evaluation of habitat capacity was made difficult by the

absence of reliable data. The authors concluded, based on a subjective evaluation, that there was no indication habitat limitation in the spawning grounds or the estuary, but that further research was required to evaluate this factor.

Overall, the authors concluded that there was no technical basis to support a change in the interim escapement target for Harrison chinook.

4.5 STOCK PRODUCTIVITY

The authors evaluated stock productivity on the basis of sample data from the Fraser River chinook test fishery. The authors noted that, relative to other Fraser River chinook stocks, Harrison chinook were a year younger at maturity but were larger, both on average and at age, and that there was little annual variability in size at age. The authors concluded that Harrison chinook have a larger spawning potential at an earlier age than any other major chinook stock in the Fraser River and that there was little evidence of declining productivity per spawner.

4.6 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 4.2). 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 4.2). The authors concluded, therefore, that the survival of the Chilliwack releases were atypically high. The unusually high survivals in the Chilliwack Hatchery may result from the warmer water and larger size at release typical at this hatchery.

Table 4.2. Comparison of survivals (% recovery from release to catch without estimates of incidental mortalities due to fishing) for seven recent brood years in two lower Strait of Georgia and two lower Fraser hatcheries. Brood years 85 to 87 are incomplete.

Year	Big Qualicum	Capilano	Chehalis	Chilliwack
81	0.69%	1.47%	7.61%	8.40%
82	0.86%	0.20%	1.07%	1.35%
83	0.70%	0.25%	0.18%	2.12%
84	0.08%	0.14%	0.25%	2.72%
85	0.09%	0.02%	0.26%	0.78%
86	0.17%	0.35%	0.86%	4.35%
87	0.02%	0.00%	0.07%	0.09%

Both hatcheries showed a similar pattern of initially high survivals in the first two brood years followed by steep declines in survival in the middle 1980's. Similar patterns were recorded for other B.C. hatcheries (Table 4.2). The 1986 brood year was the most successful brood year since the early 1980's. This was also true for the Big Qualicum and Capilano hatcheries, although survivals at these hatcheries were lower than for Harrison chinook. Survivals for the 1987 brood chinook at all these hatcheries will probably decline relative to 1986.

Escapement by age arranged by brood year in the naturally spawning Harrison population follows a similar pattern as in Table 4.2 above. Very few age 3's escaped in 1986, in spite of the large total escapement. This correlated well with the collapse of the Strait of Georgia fishery in 1986, which is largely dependent on three-year olds. The 1983, 1984 and 1985 brood years all show poor escapements, similar to the drop in survival shown by some of the hatchery stocks in Table 4.2 (especially the Chehalis). However, given that the 1989 escapement is almost entirely composed of three-year olds, it appears that the 1986 brood year will provide good escapements, correlating with the increase in survival shown by all the hatchery stocks (Table 4.2).

4.7 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 Strait of Georgia sport, the west coast Vancouver Island troll, and the Strait of Georgia troll (Table 4.3). 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 was a substantial increase in the relative importance of the west coast of Vancouver Island troll fishery in 1989 relative to the most recent few years.

Table 4.3. Distribution of reported catch for the Chehalis hatchery coded wire tag releases.

Year	Geo St Sport	Geo St Troll	WCVI Troll	Other Troll	Canad Net	US Net	Canad Sport	US Sport	Fraser Net	Fraser Sport
1984	30%	17%	32%	8%	3%	3%	0%	4%	3%	0%
1985	35%	9%	32%	5%	7%	5%	0%	5%	1%	0%
1986	30%	21%	19%	7%	9%	1%	0%	6%	6%	0%
1987	49%	9%	11%	2%	6%	17%	0%	3%	3%	0%
1988	25%	21%	5%	7%	11%	19%	4%	4%	3%	1%
1989	30%	7%	30%	6%	7%	6%	0%	9%	4%	0%
84-89 Avg	33%	14%	21%	6%	7%	9%	1%	5%	3%	0%

4.8 STOCK CONTRIBUTION

Stock contribution was estimated from observed CWT recoveries in the spawning ground recovery samples expanded by the mark-recapture estimates for the escapement of each age class to provide an estimate of total escapement for each code. Contribution to catch by fishery is then calculated by expanding the estimated distribution of CWT recoveries for the Chehalis Hatchery by the ratio of the CWT recoveries in the escapement to the total escapement at age (Table 4.4). The values presented in Table 4.4 are probably biased high because of the likelihood of missing CWT in the escapement recovery.

Table 4.4 demonstrates that large escapements of Harrison chinook translate into substantial catches in the three primary fisheries which harvest this stock. Even given the uncertainty associated with this analysis, it is probable that Harrison chinook made up a large fraction (probably greater than 1/2) of the Strait of Georgia troll catch. The Strait of Georgia sport fishery was probably made up of 1/4 to 1/3 of this stock, and about 1/4 of the west coast of Vancouver Island troll fishery may be composed of this stock in years of high abundance. The 1989 harvest of Harrison chinook in this fishery was large due to high survivals of the 1986 brood year.

Table 4.4. Calculated contribution index (in thousands) to catch for the Harrison chinook using exploitation rates derived from CWT recoveries on the spawning grounds and an estimated stock distribution from Chehalis tag codes for each recovery year.

Exploit	Total Stock Catch	Geo St Troll Stock Catch	Geo St Sport Stock Catch	WCVI Troll Stock Catch	Geo St Troll % of Ttl Catch	Geo St Sport % of Ttl Catch	WCVI Troll % of Ttl Catch	Annual Rates
1984	652	122	200	228	139%	54%	49%	93%
1985	118	10	39	43	19%	17%	12%	53%
1986	516	116	139	130	264%	76%	38%	77%
1987	72	10	32	10	26%	26%	3%	52%
1988	91	26	24	11	130%	20%	3%	72%
1989	297	23	87	100	82%	64%	50%	80%
Avg:	291	51	87	87	114%	45%	24%	78%

Notes for each year:
1984: only age 3's recovered in CWT escapement.
1985: only age 4's recovered in CWT escapement.
1986: only age 4's & 5's recovered in CWT escapement.
1987: age 2's, 4's & 5's in the CWT escapement.
1988: all ages represented in the CWT escapement.
1989: no age 2's in the CWT escapement.
Average: a weighted average summing all valid catches and escapements.

The lack of some age classes in the escapement has biased the annual exploitation rate estimates (Table 4.4). Exploitation rates in 1985 and 1987 were low because only the older age classes were used in the analysis. On the other hand, the high exploitation rate in 1984 resulted from using only age 3's. Only 1988 and 1989 have all age classes represented. The calculated exploitation rates, although high, were similar to those calculated for the Big Qualicum Hatchery, where almost all the escapement was examined for CWT returns. The similarity in exploitation rates for these two stocks provided indirect evidence that the mark-recapture escapement estimates were not large overestimates for those two years.

4.9 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 hypothesized 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, but it does not appear to be in the water supply. The agent can be transmitted to other chinook stocks, but not to other salmon species. Of the stocks tested, Harrison chinook were the most susceptible to the agent. The agent appears to be carried within the reproductive products; however, not all fertilized eggs from an individual female are infected. Although the agent exists in wild spawners, activity under natural conditions has not been demonstrated.

4.10 DISCUSSION

The data presented in this report support the conclusion that there has been a recent decline in the abundance of Harrison chinook. Table 4.5 presents a series of alternate hypotheses for the cause of the decline, the underlying assumptions for each hypothesis, and the recommended subsequent management actions.

Only the hypothesis of overescapement permits the maintenance of current exploitation rates. However, the authors reject this hypothesis because the production of three year olds from the 1986 brood escapement of 162,600 chinook has been high, indicating that good production can be obtained from a large escapement. The remaining three hypotheses require reductions in current exploitation rates regardless of stock productivity assumptions. Given the sum of the evidence presented in the working paper, the authors cannot conclude that the Harrison stock is small and unproductive. The contribution of Harrison chinook to the three primary fisheries may have, in some years, exceeded one-half the fishery catch (Table 4.4). Conservation actions are required, therefore, to rebuild this stock to goal levels in order to achieve the potential benefits available to these fisheries.

The discussion presented with Table 4.2 (above) indicated that survival trends observed in lower Strait of Georgia hatchery stocks were correlated with trends in Harrison escapements arranged by brood year. Brood years showing high

survival coincided with brood years showing good escapements, and the reverse was also true. Therefore, the authors concluded that, if the disease agent were active in the wild population, it was not the primary cause of the variations in escapement and, if the disease agent were the cause of the recent decline in returns, it was a very recent phenomenon.

Table 4.5. 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	Over-escapement
Recruits Per Spawner	High	Reduced	Low	Unknown
Probable Optimum Escapement	Large	Large	Large or Small (depends on method of transmission)	Smaller
Contribution to Ocean Fisheries	Low	Low	Low	Low
Recommended Action	Lower Exploitation	Lower Exploitation	Lower Exploitation	Reduce Target Escapement

Given these observations, the authors concluded that the observed decline in Harrison chinook was due to a combination of overexploitation in ocean fisheries and to a reduction in ocean survival which appeared to be shared by other chinook stocks harvested in the same fisheries. Given this conclusion, the authors suggest that exploitation rates on this stock should be reduced to a level sustainable at current survival rates.

4.11 REVIEWERS' COMMENTS

There was agreement that the Harrison chinook stock comprises a major component of fisheries in southern B.C. despite some obvious inconsistencies in the estimated fisheries contributions. The decline in abundance in terminal area catches including Fraser River net, food, sport and test fisheries during the 1980's and especially since 1986 was well documented. One reviewer suggested the post-1986 decline represented a natural cycling in productivity rather than a symptom of overfishing. He implied the stock will naturally rebound. Both reviewers cited increased escapement in 1989 and the inconsistency of this observation with continued decreases in terminal fishery indicators. This, combined with optimistic forecasts for age 4 fish in 1990 based on age 3 returns in 1989, raised doubts, particularly in one reviewer's opinion, on the need to reduce exploitation to rebuild Harrison chinook.

One reviewer suggested the escapement goal of 241,700 had no technical foundation and that reported returns and migrant fry production from selected

broods with large or small spawning populations indicated optimum escapement may be substantially less than 241,700. The reviewer calculated the target escapement based on the original CTC criterion would be 174,000. The authors choice of a 1988-89 base period for exploitation rate was also questioned by the same reviewer. This reviewer recommended that further analyses be done to determine optimum escapement and sustainable exploitation rate. He did not support the authors' recommendation to reduce exploitation but would support a recommendation not to increase the exploitation of Harrison chinook.

4.12 SUB-COMMITTEE ADVICE

The Sub-committee agreed that data supported the conclusion that the Harrison chinook stock is very large and a major component of southern B.C. chinook catches, and that terminal fishery abundance indicators have declined since 1986. The need to address this decline is important in that failure to do so could limit Harrison chinook production with reduced catches and other stock impacts for existing fisheries.

The cause(s) of the decline, and thus the appropriate corrective measures, remain unclear. A matrix of possible alternate hypotheses was developed by the Sub-committee in Advisory Document 89-5 (Table 4.5 above). All probable causes with the exception of overescapement necessitate exploitation rate reductions to rebuild the stock. If overescapement is the cause, the target escapement should be reduced.

The interim escapement goal of 241,700 chinook was established by policy decision as for all other B.C. chinook stocks. This goal cannot be supported nor rejected based on available technical data. There was, however, agreement that the escapement target is probably substantially greater than the recent observed escapements. Completion of analyses on the freshwater and environmental factors which affect the production of this stock and of the Mission downstream fry data may assist in estimating optimum escapement. However, the Sub-committee notes that the only way to determine correctly the optimum escapement is to increase escapements until density dependent effects are observed.

Exploitation rate data provided for natural Harrison chinook are weak due to uncertainty on the representativeness of coded wire tagged hatchery fish and low numbers of CWT recoveries among spawners. It is not clear what period of years would be an appropriate base upon which to assess possible management actions. The effect of conservation actions for lower Strait of Georgia chinook on the Harrison stock is not yet known. Exploitation rate reductions are most likely necessary to rebuild this stock. Decisions on the base period and extent of change for exploitation rate management and a time frame for rebuilding are required. These decisions must consider issues beyond the mandate of PSARC and a process to reach them should be identified. It was noted that while the Sub-committee recommends conservation actions, it does not select specific target fisheries.

The need to identify the Harrison chinook disease agent and the impact of this agent on natural reproduction remains a high priority. Studies during 1989/90 demonstrated the disease could occur in the Harrison River but under artificial conditions.

4.13 RECOMMENDATIONS

1. Identification of the Harrison chinook disease agent and determination of its impact on the natural stock is a high priority; further study is strongly recommended.

2. The present Pacific Salmon Treaty (PST) escapement goal (241,700) is consistant with the Sub-committee advice to increase escapements. Achieving this goal by the PST target date (1998), while monitoring the resulting recruitment for apparent density-dependent effects, will be a test of the appropriateness of the current goal. Exploitation rate reductions are most likely necessary to achieve this target. Decisions are required on the specific management actions required. These decisions must consider issues beyond the mandate of PSARC and a process to reach them should be identified.

3. Given the potential importance of this stock to Canadian fisheries, the Sub-committee recommends that the Region ensure that a monitoring program is established to fully evaluate production from important life phases of this stock as it rebuilds.

METHODOLOGIES

5. FRAMEWORK FOR ESTIMATING ESCAPEMENT OF NATURALLY SPAWNING MARK RETURNS PRODUCED BY S.E.P. FACILITIES (Working Report S90-11)

5.1 INTRODUCTION

The purpose of this working paper is to describe an approach to be used by the Salmonid Enhancement Program (SEP) assessment staff to estimate the number of marked fish in the naturally spawning escapement. These estimates are termed "soft" data and are complementary to the actual recoveries or "hard data" presently available from the Mark Recovery Program (MRP) data base.

In order to make these estimates two types of data are required; first of all, an accurate estimate of total escapement and secondly, an estimate of the mark rate generated by adequate representative mark sampling.

5.2 RESULTS

Total escapement estimates include quantitative estimates such as total fence counts and Petersen mark-recapture estimates, and various sorts of qualitative estimates such as Fishery Officer counts of different kinds, and indices of abundance. These escapement enumeration methodologies have varying degrees of reliability. As well, there are inconsistencies in the SEDS reporting of hatchery return and naturally spawning escapement data.

The second required data component, mark rate, is generated by SEP facility and keystream sampling. It varies greatly in quality as some facilities have a permanent fence or attraction fishway which allows diversion of most of the escapement into the hatchery for sampling. Other facilities, however, obtain

broodstock directly from the stream such that the resulting mark recoveries represent only a very small "snapshot" of the system return and may not be temporally or spatially representative of the total population. The report documents the various escapement enumeration and mark sampling methodologies in use at Enhancement Operations (EOD) and Community Program (CPD) facilities.

The working paper rates the reliability of these escapement enumeration and mark sampling methodologies,(Fig. 5.1) and recommends the development of a rating system to report this reliability in conjunction with the "soft" mark recovery data. It is hoped to make "soft" mark recovery data available in a regional database within the next two years, possibly as an optional adjunct to the present MRP data base.

5.3 REVIEWERS' COMMENTS

The reviewers noted that the estimation of salmon escapements and of the marked fish in the escapement is critically important to SEP assessment, to fisheries management, and to stock assessment. The intent of this document is to make the collection of these data more rigorous and at a high standard so that stock assessment issues can be addressed in a scientific manner. The implementation of such a program should be done not just for the collection of better data to assess SEP contributions, but for a set of regional goals arrived at by a consensus of DFO representatives.

5.4 SUB-COMMITTEE DISCUSSION

In 1988, PSARC recommended that "major" or "important" stocks be defined for which stock assessment data would be routinely and rigorously collected. Once these stocks are identified, data requirements and associated sampling specific for each river system could be designed for each stock. The Sub-committee felt that this process should occur at a regional level so that each branch could be included in the process. This is especially important in a period when resources are limited and there may be conflicting objectives. As several of the recommendations made in this document concern regional issues, the Sub-committee felt that those recommendations should be elevated to the more general discussion on the same topic (Quality of spawning escapement data).

Many of the recommendations in this document would require major investments of resources and personnel and possibly would require a restructuring of the way the Department obtains its basic escapement information. The Sub-committee feels that the current methods of collecting these data are inconsistent within the region and that the disruption of restructing would be justified in obtaining better stock assessment information.

5.5 RECOMMENDATIONS

1. Review and revise the material in the "Fisheries Officer's Guide to Collection, Recording, and Use of Sub-District Salmon Management Data" with the intent of upgrading escapement enumeration techniques in the region. The use of the daily stream inspection log should be made mandatory for all stream visits.

2. Define more rigorously the data to be provided for the Salmon Escapement Data Base (SEDS). In particular, conflicting data sets for the same system should be resolved.

3. Criteria should be developed, where possible, to evaluate the reliability associated future estimates in the SEDS database.

4. Investigate the desirability of creating a data base for storing estimates of the recoveries of marks in naturally spawning systems. These estimates would also have an associated reliability index. SEP already has developed such estimates and would take the lead in making these data available to the region.

6. FRASER SOCKEYE FORECASTING METHODOLOGIES (Working Paper 90-5)

6.1 INTRODUCTION

From 1986 to the present, the Department of Fisheries and Oceans (DFO) has been responsible for developing the annual forecasts for Fraser River sockeye. They have been reported in unpublished documents for the 1987 - 1990 returns (Saito, unpubl.). The techniques employed to forecast Fraser River sockeye returns have not changed significantly from the general approach developed by the I.P.S.F.C., except that in recent years, spawner-recruit relationships have played an increasingly larger role in the forecast considerations. Rather than forecasting the adult returns by interpolating and extrapolating average adult returns per spawner, consideration has been given to the impacts of spawner, fry or smolt densities on adult survival rates. In forecasts for earlier years average returns per spawner were probably appropriate as the spawning populations were generally so far below optimum or maximum carrying capacities that it was not necessary to consider density dependent effects as the populations were probably still in the linear portions of their spawner-recruit relationships. As the Fraser sockeye stocks become rebuilt, it will become increasingly more important to consider the potential of density dependant effects when forecasting returning adult populations.

6.2 FORECAST APPROACH FOR ALL STOCKS

If a sockeye return forecast were to be developed solely from brood year spawner data, the forecast would not be capable of taking into account significant variations in survival rates that could occur at subsequent life history stages. For that reason, the preferred approach is to establish correlations between 3_2 jacks and subsequent 4_2 adult returns. All the inter-stock and environmental factors affecting the stock up to that point should have manifested themselves in the jack population. The forecaster's challenge is to identify sufficiently reliable information from the jack data so as to make a reliable forecast. Because of scarcity of data or the lack of statistically

significant relationships, data sets from alternate life history stages may be used. The order of preferred life history stages when making the final prediction are:

i. 3_2 jacks
ii. smolts/pre-smolts
iii fry
iv. spawners (from Ricker spawner-recruit analyses)
v. spawners (from average returns per spawner)

In the absence of superior, chronologically advanced relationships, adult return forecasts are developed from Ricker spawner-recruit relationships. Estimates based on average return per spawner are only used in situations where Ricker estimates are not available.

6.3 SUMMARY

Annual and longer term forecasts for salmon stocks in the Pacific region are valued and demanded by the user group community and fishery managers. If forecasts can be made to be more consistent and accurate, there can be better planning by all the respective users of the information.

More data and information has been collected on Fraser River sockeye salmon than for any other salmon population in the Pacific region. Yet, few data sets can be consistently relied upon to provide accurate forecasts of adult returns. As a result, forecasters have had to accept a measure of subjectivity when considering what is the "best" forecast for a given stock. The essential requirement of any successful forecasting technique is consistency. Forecasters continually search for credible models of processes and relationships that explain Fraser sockeye population dynamics. However, as frequently as operational relationships are identified (e.g. Adams fingerlings), other relationships are observed to be disintegrating (e.g. Adams-Birkenhead adult:jack return ratios). This is probably indicative of how dynamic salmon populations are in response to their changing environments. This may also signal a possible need to review current and alternative analytical techniques to improve upon the consistency and accuracy of individual stock and overall Fraser sockeye forecasts. Perhaps there could be consideration for multivariate analyses of the existing or alternative forecast parameters.

The forecast procedure developed by the IPSFC, and continued within DFO, has a history of underestimating Fraser sockeye returns. The 1989 return forecast performance was consistent with this history. The forecast predicted a return of 13 million pieces (Saito, unpubl.) compared to the current estimate of 18.4 million pieces (Pacific Salmon Commission,1990). Figure 6.1 updates the long term forecast performance graph originally presented in the 1989 forecast (Saito, unpubl.). As is illustrated, the 1989 forecast deviation from the actual was slightly greater than the overall or the cycle year averages. Perhaps it is significant to also note that nearly all international and domestic catch objectives were achieved despite an under-forecast of 5.4 million pieces. Although not all escapement goals for late runs were met, the desired levels of spawners for the Fraser run as a whole were observed on the spawning grounds.

The 1989 forecast-to-actual return situation illustrates a relationship that appears to have developed between Fraser sockeye forecasts and in-season management response systems that exists within DFO and the Fraser River Panel. Despite the actual return being nearly 30% greater than forecasted, managers and fishermen were able to respond to rapidly changing circumstances and still achieve most catch and spawner escapement objectives. Although it is always the goal to develop accurate forecasts, the in-season management system appears to have evolved to respond well to in-season run size upgrades. However, this has not always been the case when run sizes have been downgraded from expected levels. There has been a history of instances where difficulties were experienced in adjusting fishing regimes to achieve reduced catch and escapement objectives.

6.4 REVIEWERS' COMMENTS

This paper is submitted in response to the Sub-committee recommendations in 1989 regarding Working Paper S89-10, 1989 Forecast for Fraser River Sockeye Salmon. At that time, the Sub-committee could not endorse the methods used in preparing the 1989 forecast since the analytical procedures were not adequately described. Therefore, the Sub-committee recommended 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.

The Sub-committee's concerns were that subjective interpretations of the data should be minimized and more objective criteria used for selecting one forecast from several alternative ones. The Sub-committee recognized 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.

This paper represents an improvement over that presented in 1989. One reviewer categorized this paper as providing a interesting compendium of the range of forecasting relationships available for Fraser sockeye and outlines in a general way the methodologies are employed to make the forecasts. However, both reviewers noted that the 1989 recommendations were not completely satisfied and as such, considerable scope still exists for improvement in technical content and for reducing the more subjective aspects of forecasting.

One reviewer identified a technical concern regarding the tendency in the paper to evaluate forecasting success by judging the fit of current data sets used to forecast historical runs. A more appropriate methodology would be to forecast a time series of runs using only the data available to that year, then incorporate that information in the subsequent year forecast, and so on.

The other reviewer expressed a concern regarding the absence of any comparisons which will permit selection of the best forecasting procedure from several alternatives under consideration. A ranked preference to forecast models could be identified and that which has the greater statistical significance be given preference. This reviewer was also concerned with the adherence to cycle specific forecasts in the absence of either strong statistical or biological evidence to support such a practice.

Sub-committee discussion focused on the advice and recommendations made last year and concluded, given the large number of stocks (22) for which forecasts are made, that the task was too large of an undertaking and indeed presented a daunting task for a single individual. This task may have been accomplishable with assistance and in a workshop atmosphere. A recommendation to conduct a forecasting workshop was made by the Sub-committee and supported by the Steering Committee in 1989 (PSARC Advisory Document 89-1, recommendation B)9) page VII). This recommendation was not supported as a high priority by the A/Director of Fisheries Branch.

6.5 SUB-COMMITTEE ADVICE

The Sub-committee continues its concern regarding the importance of developing and documenting rigorous, repeatable methods for salmon forecasting. This must be considered an essential aspect of the biological advice for management. To this end the Sub-committee specifically recommends:

1) The advice and recommendation made in 1989 regarding forecasts for Fraser sockeye be undertaken. However, that this be undertaken on a single stock basis. Rather than undertaking this task for <u>all</u> Fraser sockeye stocks in one Working Paper, undertake this task for a single stock only. For example, forecasts for the Adams River sockeye return in 1991 should be undertaken and the Working Paper be presented to the Sub-committee in the spring of 1991.

2) The Forecasting Workshop as recommended by the Sub-committee and supported by the Steering Committee in 1989 be reconsidered. Full details of the Sub-committee's concern and recommendations are provided in Advisory Document 89-1 on pages 85 and 86.

Forecasts are an integral component of annual fishing regimes and an essential aspect of biological advice for management. Such forecasts are provided now on an individual and/or Divisional basis. In many cases these forecasts do not have the full documentation of rigorous repeatable methods. A workshop would bring together the forecasters/managers with a selection of multi-discipline Departmental personnel. This approach would yield technical improvements in the current methods, develop new methods and provide objective procedures for forecasting by statistical models using existing data.

7. A PROPOSED METHOD FOR EVALUATING THE RELIABILITY OF ESCAPEMENT COUNTS FOR WCVI SPAWNING CHINOOK POPULATIONS (Working Paper S90-15)

7.1 INTRODUCTION

In 1988, the west coast of Vancouver Island (WCVI) indicator stocks were analyzed for trends in spawner populations over time by the PSC Chinook Technical Committee (Pacific Salmon Commission 1989). The results indicated that the WCVI stocks were not rebuilding.

The purpose of this current report is to review the information available on WCVI chinook spawners in further detail than the previous analysis and to re-examine the trends. The first step was to review the escapement records for all rivers with chinook spawning in the WCVI. This step was taken to see if alternative or additional rivers to the original selection could be used as indicators of spawning escapement trends.

Fifteen years ago, in 1975, there were over twice as many rivers (57) where chinook spawning was reported. The majority of other rivers (38) accommodated small populations of under 100. The reduction in the number of rivers having reports of chinook from 57 in 1975 to 22 in 1988 is almost entirely in rivers with populations less than 100. The reason for this reduction is due to the reduction in survey effort.

The original selection of rivers selected by the Chinook Technical Committee included all the major chinook producing rivers on the WCVI except for the Leiner River which was added in this report. The Artlish River was also included in this analysis because of its proximity to the Kaouk and Tahsish rivers. The addition of these later three rivers will provide a complete representation of the Tahsish Inlet chinook. The Kennedy River was omitted due to quality of information.

The originally selected rivers plus an additional two rivers were used in this evaluation. In total these eight rivers account for mor than 90% of the WCVI chinook excapements. The final selection of rivers and their excapements for years 1975 to 1989 are provided in Talble 7.1.

7.2 PROCEDURE FOR WEIGHTING ESCAPEMENT ESTIMATES

It is generally believed that escapement data are of poor quality. However, some rivers are sampled frequently and systematically for spawners and in some years a great deal of effort is expended to obtain a count.

The following procedure was intended to evaluate the reliability of each escapement estimate for the rivers listed. The procedure outlined a method of weighting each estimate based on four criteria: number of visits, timing of visits, enumeration method and countability index.

The rank value R for each visit i to river j was calculated by multiplying each visit by the factor for timing t_{ij}, method m_{ij} and countability c_{ij} .

$$R_{ij}=t_{ij}\times m_{ij}\times c_{ij}$$

The final weighting for a year k escapement estimate W_{jk} was:

$$W_{jk}=[\sum_{i=1}^{n} R_i]+v_j$$

where v_j is a fixed minimum value for any year where an escapement estimate was provided. This last component, v_j , is useful in cases where an estimate was recorded for a given year but no information on method, timing of visit, or countability was provided.

The results of the weighting analysis are shown in Figure 7.1. The weighted values shown have been converted to diameter of a circle (D) using the following calculation so that the weights W_{jk} could be presented graphically. The weights correspond to the surface area of the circles plotted on the figures.

$$D=2\times\sqrt{\frac{W_{jk}}{\pi}}\times s$$

where s is a scaling factor.

7.3 RESULTS

Annual escapement estimates for each river were weighted for reliablity (Table 7.2).

The results from the current analysis were evaluated using the same procedures as outlined in the Pacific Salmon Commission 1989. The escapements were summed across the revised indicator rivers to provide a weighted total escapement for each year. The results of this evaluation would indicate that the status of the stock would be indeterminate as defined by the PSC Chinook Technical Committee.

Table 7.1. WCVI chinook revised escapement indicator rivers.

Area	26	25	25	26	25	25	26	27	West
	Artlish	Burman	Gold	Kaouk	Leiner	Tahsis	Tahsish	Marble	Coast
Year	River	River	River	River	River	River	River	River	Total
1975	25	200	400	75	200	75	25	400	1400
1976	25	400	25	25	25	200	25	400	1125
1977	60	500	2000	75	70	150	100	950	3905
1978	0	1000	3500	50	60	100	50	1500	6260
1979	40	650	800	60	200	348	200	750	3048
1980	100	345	750	0	400	249	200	5000	7044
1981	500	300	560	100	0	150	1000	3000	5610
1982	100	387	1000	0	15	125	1000	5000	7627
1983	375	475	1500	300	50	50	500	1000	4250
1984	650	700	1500	400	195	12	1500	600	5557
1985	400	500	1500	300	100	50	1200	1250	5300
1986	100	400	1900	100	190	60	1000	1200	4950
1987	100	100	600	100	125	20	500	2000	3545
1988	0	400	1000	0	300	125	400	3275	5500
1989	40	700	2000	40	500	500	450	4500	8730
Total	2515	7057	19035	1625	2430	2214	8150	30825	73851

Table 7.2. Weighted values for the revised WCVI chinook indicator rivers.

Area	26	25	25	26	25	25	26	27	West
	Artlish	Burman	Gold	Kaouk	Leiner	Tahsis	Tahsish	Marble	Coast
Year	River	River	River	River	River	River	River	River	Total
1975	1.01	0.95	0.36	1.29	0.83	0.83	0.45	0.20	5.91
1976	0.76	0.51	0.20	0.20	0.20	0.20	0.45	0.20	2.73
1977	0.51	1.61	1.76	1.26	0.51	0.83	0.45	0.73	7.67
1978	0.63	1.29	1.26	0.83	0.51	0.83	0.92	1.76	8.03
1979	0.83	1.40	1.48	1.29	1.26	2.70	0.83	3.01	12.80
1980	1.14	1.14	0.83	0.00	0.51	0.38	1.08	0.20	5.26
1981	0.20	1.76	0.83	0.33	0.13	0.33	0.83	2.26	6.65
1982	0.20	0.44	0.26	0.13	0.51	0.20	0.83	0.20	2.76
1983	0.20	1.11	1.45	0.20	0.98	2.08	0.20	0.20	6.41
1984	0.83	0.98	1.45	1.89	0.51	0.83	1.76	0.51	8.76
1985	0.83	0.95	0.61	0.95	0.20	1.56	1.11	1.99	8.19
1986	1.80	1.65	3.39	1.20	1.48	2.89	1.20	3.86	17.46
1987	2.70	2.83	2.91	2.08	2.95	1.35	3.23	3.26	21.29
1988	0.63	2.08	2.79	0.83	0.83	0.83	1.39	5.99	15.35
1989	3.60	3.13	2.51	2.20	2.70	1.95	3.16	7.33	26.58
Total	15.85	21.82	22.08	14.66	14.11	17.74	17.86	31.71	155.84

7.4 REVIEWERS COMMENTS

The reviewers were complementary of the imaginitive approach used to analyse the selected WCVI chinook spawning escapement data, and with some minor modification endorsed its application. One reviewer suggested that it be considered in analyzing escapement data for other stocks as well.

Both reviewers, however, were concerned about whether a consistent methodology was used to translate the visual observations made by fishery officers into the reported estimate. This is important because the proposed weighting scheme considers data reliability only to be a function of the number and quality of observations and not on the quality of the integration of these observations by the fishery officers into an escapement estimate. There was also a general comment that the procedures for assessing escapement status developed by the PSC Chinook Technical Committee should have been described more fully so that the base period comparisons can be better understood.

7.5 SUB-COMMITTEE ADVICE

The Sub-committee generally shared the reviewers' appreciation of the proposed weighting scheme for spawning escapement data. However the Sub-committee also shares the reviewers' concern about how escapement estimates are derived from observational data. Future assessments of the stock should include an examination of the observation data.

The Sub-committee does not believe that the escapement data presented are sufficient to draw conclusions on the status of natural spawning WCVI chinook stocks. An assessment of the data presented, indicated an increasing trend for enhanced stocks and a declining trend for unenhanced stocks. Many of the streams with the more reliable data have significant enhancement, while the three unenhanced stocks (ARTLISH, KAOUK and TAHSISH) are located in one inlet. Natural stocks in more southerly WCVI areas should be reviewed for inclusion in this aggregate of indicator stocks.

The Sub-committee notes that this paper presents a method for evaluating the reliability of escapement counts and does not conclude as to the status of WCVI chinook stocks. The Sub-committee recommends:

1) That the methodolgy, with the minor modification recommended including the adjustment for observation data, be applied.
2) That the assessment of status for WCVI chinook stocks be continued, and
3) Prepare a Working Paper with respect to progress on this assessment for presentation to the Sub-committee in the autumn of 1990.

SPECIAL ISSUES

8. EXPERIMENTAL REBUILDING OF OFF-YEAR CYCLES IN SELECTED FRASER RIVER SOCKEYE STOCKS: FURTHER RECOMMENDATIONS FROM THE CYCLIC DOMINANCE WORKING GROUP (Working Paper S90-6)

8.1 INTRODUCTION

Most of the principal sockeye stocks in the Fraser River watershed upstream of Hell's Gate presently exhibit 4-yr cycles in abundance (Cass 1989). In some stocks like the Adams River run, these cycles are very dramatic with returns in the "dominant years" exceeding those in the "off-years" by more than two orders of magnitude. Historic evidence suggests that persistent 4-yr cycles have been a characteristic of Fraser River sockeye since the early 1800's (Ward and Larkin 1964). A number of explanations for these cycles have been proposed and tested (e.g. Ricker 1950; Ward and Larkin 1964; Walters and Staley 1987; Collie and Walters 1987), but a fundamental question remains unsolved: are the cycles maintained by fishing patterns or by biological processes (i.e. "cyclic dominance")? Management decisions for achieving optimium production (e.g. escapement goals) depend to a large degree on which alternative is correct (Walters and Staley 1987; Wood and McGivney unpubl.; Collie et al. 1990; Welch and Noakes 1990).

The Cyclic Dominance Working Group was organized by the Salmon Sub-Committee of the Pacific Stock Assessment Review Committee in 1988 to recommend fisheries management, enhancement and research activities that will reveal the causes of the 4-yr cycles in Fraser sockeye abundance as quickly as possible. In particular, it was recognized that harvest rate goals and enhancement activities should be coordinated in an "adaptive management plan" to facilitate interpretation of trends in future catch and escapement data. In March 1989, the Working Group submitted to P.S.A.R.C., its recommendations on developing an experimental approach to harvest rate manipulation (Wood and McGivney unpubl.).

During 1989, the Working Group continued to discuss the implications of these recommendations with the Fraser River Task Force. This report contains further recommendations from the Working Group on how the formulation of escapement goals and enhancement activities should be coordinated so as not to compromise the proposed rebuilding experiments.

8.2 OBJECTIVES OF THE EXPERIMENTAL REBUILDING PLAN

The experimental rebuilding (adaptive management) plan for Fraser River sockeye recommended in PSARC Salmon Sub-committee report 89-1 has two objectives: first, to determine whether non-dominant lines can be built up simply by increasing escapements, and second, if non-dominant lines are built up, to determine whether production by the dominant line will be suppressed. Biological interactions between lines ("cyclic dominance") would be indicated if off-year lines failed to rebuild despite increased escapements, or if the productivity of dominant lines was suppressed because of increased production from other lines.

Conversely, if off-cycle lines are increased without any loss of production from the dominant lines, then the case for cyclic dominance is weakened considerably, and the overfishing hypothesis would appear to be the best explanation for historic cycles in abundance.

8.3 RECOMMENDATIONS ON HARVEST RATES

Reduced harvest rates (to 50%) were recommended for two of twelve possible management units defined by run timing - the mid '87 and late '88 runs. These are referred to as the mid '87 and late '88 "experiments", respectively. The mid '87 experiment would accelerate the rebuilding of off-year lines in the Quesnel and "late Stuart" runs, as well as dominant runs to Chilko and Fraser lakes. The late '88 experiment would accelerate the rebuilding of the off-year run to Shuswap Lake, but would also affect a larger run to Weaver Creek.

The Working Group expects that both objectives of the experimental rebuilding plan could be realized in the late '88 experiment. Production by the dominant Shuswap Lake cycle has continued at a high level for many generations, thus providing a satisfactory control period by which to evaluate any suppression effects that might result from building up an off-year cycle (Fig. 8.1A). In contrast, it is doubtful that the second objective could be satisfied in the mid '87 experiment because there are too few data to indicate the present productivity of the dominant line in Quesnel Lake (i.e. while non-dominant lines are relatively small) (Fig. 8.1B). Rather than delay the rebuilding of non-dominant Quesnel runs to gather these data, the Working Group recommends restricting attention to the first objective, that of determining whether the non-dominant lines can be increased despite the recent development of a large dominant (1989) line. Since any suppression of the dominant line could not be monitored accurately, the Working Group recommends that escapements on the 1989 cycle be increased cautiously, depending on the growth and survival of juveniles as determined by surveys by the Fraser Lakes Unit (Biological Sciences Branch). Increased escapements on the dominant 1989 cycle should only exaggerate biological interactions between lines, if they exist, and so increase the power of the mid '87 experiment. In contrast, the Working Group recommends that escapements on the dominant 1986 cycle to Shuswap Lake be held relatively constant (within the range of previous observations) so that any suppression of production will be evident over time.

8.4 RECOMMENDATIONS ON ENHANCEMENT

Enhancement of a dominant line would clearly preclude attempts to detect any suppression of its productivity as a consequence of increased production by other lines. Thus, the Working Group recommends against enhancement of the dominant 1986 line in Shuswap Lake. This argument does not apply to Quesnel Lake where suppression effects probably could not be detected anyway.

Enhancement initiatives designed to increase fry recruitment would not conflict with the objectives of the rebuilding experiments (except on the dominant cycle at Shuswap Lake, for the reason given above). In fact, spawning channel and incubation facilities may be used to complement the experimental

design by increasing fry recruitment in off-year lines for which it is not feasible to reduce harvest rates (e.g. the 1989 Shuswap line). Fry recruitment (or its surrogate, spawning escapement) is the variable being manipulated in the rebuilding experiments, and it does not matter which technique is used to manipulate fry recruitment, providing it can be measured with reasonable accuracy. However, simulations show that increases in fry recruitment on off-year cycles can be achieved much more quickly by reductions in harvest rate than by artificial propagation (Wood and McGivney, unpubl.)

Lake enrichment enhances the production of sockeye by increasing a lake's capacity to produce food. Thus, lake enrichment alters many natural processes within the lake, other than the variable being manipulated experimentally. Moreover, treatment with fertilizer in one year may affect, indirectly, food production or predator size and abundance in subsequent years. If fry recruitment were manipulated in a "treated" lake, it would be impossible to ascertain with any rigour, whether changes from historic cyclic trends in production resulted from the manipulation of fry recruitment, or other biological changes within the lakes resulting from enrichment. Clearly, this would defeat the objectives of the rebuilding experiment and also preclude evaluation of the lake enrichment program. Therefore, the Working Group generally agreed that neither Shuswap or Quesnel lake be fertilized on any cycle during the rebuilding experiment. However, one member of the Working Group argued that fertilization of Quesnel Lake on the dominant year (only) should not be ruled out completely, because available data suggest that there are no measurable effects of fertilization two years following treatment. In any case, because the objective in Quesnel Lake is only to monitor the rebuilding of off-year lines, lake enrichment could be initiated once the rate of rebuilding has been determined (probably 8 to 12 years).

8.5 REVIEWER'S COMMENTS

The reviewers requested that more consideration be given to specific programs required to assess rebuilding under the experimental design (e.g. stock ID), the timetable for implementation, and to complementary research programs (e.g. predator removal). One reviewer suggested that the potential economic advantages of enrichment in Quesnel Lake be considered more formally; if the potential benefits are large enough, enrichment may be advisable even though it will tend to confound results from the rebuilding experiment. The other reviewer was concerned about the possibility of a disease epidemic in Quesnel Lake if we continue to increase fry recruitment on the dominant cycle.

8.6 SUB-COMMITTEE ADVICE

(See section 10.6)

9. FRASER RIVER SOCKEYE INTERIM ESCAPEMENT GOALS (Working Paper S90-8)

9.1 INTRODUCTION

There is evidence that the Fraser River watershed has the potential to produce average sockeye runs much larger than current levels. To take advantage of this opportunity, the Fraser River Sockeye Task Force was assigned the responsibility of developing a rebuilding plan for Fraser sockeye stocks.

First the Task Force needed to estimate the potential of the sockeye stocks in the system. This was done using existing information on stock recruit analysis and spawning and rearing habitat capacity estimates. The conclusion was that most of the stocks did have potential for greater production but there was considerable uncertainty on the ultimate production levels that could be achieved.

Estimates of potential production for Fraser sockeye vary widely (Ricker 1987; Walters and Staley 1987; Cass 1989; Collie et al. 1990; Williams pers. comm. and Woodey pers. comm.). The greatest source of uncertainty is the question of whether production is limited by biological factors resulting in cyclic dominance (i.e. can all cycles be built to the same level?). The stock recruitment data suggest there is no statistical basis for different goals by cycle (Walters & Staley 1987). However, there are data on some stocks to support the view that year class interactions may exist (J.Woodey, pers.comm.). A policy of equal spawning goals for each cycle may be risky since it is such a major departure from the historical pattern and it could lead to reduced production. This policy would also require significant disruption to fisheries to actively build all cycles to the dominant level within a reasonable timeframe.

Faced with the uncertainties regarding the true potential of the system, the Task Force recommended a conservative approach based on the adoption of interim escapement goals and incorporating a flexible management strategy. Interim escapment goals were set for twelve major stocks or stock groups assuming unequal production potential amongst cycles. These goals provide the opportunity for growth and the testing of various escapement levels for dominant, subdominant and low cycles. It is intended that these goals remain flexible and can be modified as circumstances warrant. By acquiring and analyzing new information as the rebuilding program proceeds, the interim goals will be re-evaluated and modified as appropriate.

9.2 DEVELOPMENT OF GOALS

The interim goals for each timing group, stock and cycle were developed on the basis of the estimated escapement potential, current stock levels and professional judgement. The escapement potential was estimated from a review of the stock recruitment data (Cass, 1989; Collie et.al., 1990; DFO files) and spawning habitat capacity assessments (Ian Williams, pers.comm.). The current stock levels were considered in setting the interim goals such that they could be achieved within a reasonable time frame. Professional judgement was a key

component in deriving interim goals. The current escapement levels, the escapement potentials based on stock recruitment and habitat capacity data and opinions of Dr. Jim Woodey (PSC, Chief Biologist) were all considered.

The recommended interim escapement goals on the dominant and subdominant years are, for most stocks, similar to the habitat estimate of spawning capacity. For those stocks exhibiting a cyclic pattern of abundance, it is usually recommended that at least two cycle years have interim goals at the dominant level, and that the interim escapement goals of the other two cycles be at much lower levels. The relative levels between the dominant, subdominant and off-cycles generally reflect the cyclic patterns observed for that stock. For stocks not demonstrating these cyclic patterns, (eg. Birkenhead) the interim escapement goals for all cycle years are identical. For some stocks, such as the Upper Adams, the interim goals are entirely arbitrary since the stock is very small at present.

The interim goals by stock and cycle are shown in Table 9.1. Detailed rationale for the goals are discussed by stock in the working paper.

9.3 USE OF GOALS

These interim goals were established for purposes of management and planning. They form the basis of the Fraser River Sockeye Task Force analysis and recommendations. The goals have not been defined through a rigorous analysis or rigid application of scientific principles. Professional judgement played an important role in setting these goals and, therefore, they must be flexible. As new information becomes available, the goals will be re-evaluated and adjusted as circumstances warrant.

These goals provide the opportunity to rebuild all stocks and cycles. Fishery managers have the interim goals as immediate objectives for rebuilding the stocks. Once these levels are achieved, the return data may suggest that the goals should be increased and the expectations of future production will also increase. In some cases, the goals may need to be lowered if escapements have not produced as expected.

In the planning process, these goals were used to define the recruitment function used in modelling various management options to achieve increased production.

The disadvantage of using these goals is that future production estimates may be overly conservative if cyclic dominance is not a limitation to production and it will take longer to achieve the full potential by not taking an aggressive approach. However, if managers promote the growth of off-cycles to interim goals, and the adaptive management approach which is incorporated into the plan to specifically address the question of cyclic dominance is implemented (Working Paper S89-3), we will be much further ahead in the rebuilding process than we are now and we will have gotten there at a reasonable rate with minimal risks.

9.4 REVIEWER'S COMMENTS

Both reviewers indicated that the escapement goals presented in the working paper are based on professional judgements or undocumented analyses, and are therefore not technically defensible. One reviewer suggested that existing escapement goals should be presented to indicate the magnitude of proposed changes in the goals. The word "interim" implies a timetable for reaching these goals but no such timetable was presented. He also points out that existing escapement goals are based on at least 35-40 years of data, and that presumably many as more years would be required to justify changes to these interim goals. The other reviewer argued that procedures for revising escapement goals should be identified a priori to ensure objectivity. He also questioned the need for separate escapement goals for two runs to Chilko Lake ("North End" and "South End").

Table 9.1. Interim escapement goals for Fraser River Sockeye stocks as established by the Fraser River Sockeye Task Force.

Timing group	Stock	Cycle Year 1985	1986	1987	1988
Early	Early Stuart	500,000	150,000	280,000	150,000
Summer	Early Misc.	350,000	350,000	350,000	350,000
	Upper Adams	200,000	200,000	100,000	500,000
	Quesnel	2,200,000	2,200,000	250,000	250,000
	Late Stuart	500,000	50,000	200,000	50,000
	Chilko	100,000	300,000	600,000	600,000
	Stellako	100,000	300,000	300,000	100,000
	TOTAL	3,450,000	3,400,000	1,800,000	1,850,000
Late	Birkenhead	300,000	300,000	300,000	300,000
	Adams	100,000	2,300,000	2,300,000	100,000
	Shuswap	50,000	1,200,000	1,200,000	50,000
	Weaver	45,000	45,000	45,000	45,000
	Late Misc.	100,000	100,000	100,000	100,000
	TOTAL	595,000	3,945,000	3,945,000	595,000
TOTAL		4,545,000	7,495,000	6,025,000	2,595,000

9.5 SUB-COMMITTEE ADVICE

(See section 10.6)

10. OPTIMAL HARVEST RATE POLICIES FOR REBUILDING THE ADAMS SOCKEYE (Working Paper S90-33)

10.1 INTRODUCTION

This paper looks at the issue of optimally rebuilding the Adams River sockeye population. The Fraser River Task Force (FRTF) and the Cyclic Dominance Working Group have identified a need to rebuild the weak runs to the Adams River. Welch and Noakes (1990) show that the optimal escapement policy for the Adams R. stock is to maintain equal escapement to all four cycle years regardless of whether or not between-run biological interaction occurs. They also report negligible statistical evidence in support of some form of biological interaction between runs.

Amongst four specific escapement policies examined by Welch and Noakes, an equal escapement policy netted the greatest economic benefits from the Adams stock, and the current management policy led to the worst economic benefits. In the present study dynamic optimization methods are used to determine how harvest rates should change over time in order to obtain the greatest economic benefit from the Adams, since the weakest runs require much greater rebuilding efforts. The results show that the net economic benefit from the Adams stock, including the costs incurred by rebuilding, is worth on the order of *4 billion dollars* over a period of 100 years.

The optimal harvest policy turns out to be very different from current draft policy proposals for the Adams, and appears to be robust to the major sources of uncertainty identified in the study. The optimal policy is largely unaffected by uncertainty about the stock-recruitment (SR) parameter estimates or the discount rate used for calculating the value of future economic benefits. The optimal policy also remains unchanged when the co-migrating Weaver Creek sockeye and Fraser pink salmon are factored into the analysis. The next section briefly describes the policy and highlights the costs of straying from the identified optimum.

10.2 THE OPTIMAL POLICY

The next four cycle years 1990... 1993 correspond to the return of the dominant, subdominant, and two off-year runs to the Adams River. For the Adams River sockeye alone, the optimal harvest rate policy is to slightly reduce harvest rates on this years's dominant run to achieve the estimated optimum harvest rate, $h^*_{opt}=0.74$, and to reduce next year's harvest rate to 50% in order to increase the rate of rebuilding (Fig. 10.1). The optimal policy for the off-year runs is to close the fishery and prevent all harvesting while these runs rebuild.

Under this policy the dominant and subdominant runs rebuild to the escapement level producing maximum yields in one cycle, while the off cycle years take approximately three cycles. The full PSARC paper shows that this policy remains optimal when uncertainty in the stock-recruitment parameters and the economic discount rate is considered, and does not change when the Weaver Creek sockeye and Fraser River pink runs are factored into the analysis.

10.3 EFFECT OF IMPOSING A HARVEST RATE FLOOR

A complete fishing moratorium during migration of the off year Adams R stocks is a substantial change from past practice. Choosing such a management strategy will also require other changes to fishing plans if fishing times are to be kept within recent limits.

To examine the loss in value entailed in choosing a sub-optimal policy where harvest rates are not allowed to drop to their optimal levels, a floor value was specified below which harvest rates must never fall. The remaining parameters were then optimized subject to these constraints.

The net present value initially declines by about $40M (Million) for each increase of 10% in the harvest rate floor (Fig. 10.2). Applying a minimum floor of 50% to the subdominant and off year runs results in a net loss of $166M in yield relative to the optimal policy.

Losses under the draft FRTF plan are even larger. It is currently thought that senior management might consider harvest rate floors for the two off years of 50% and 65%, but any reduction below the long-run optimal harvest rate is not countenanced for the subdominant run (R. Harrison, *pers. comm*). After imposing these harvest rate floors, the net loss in yield jumps to approximately $240M. Finally, simply reducing harvest rates on all cycle lines to the long-term optimal harvest levels, and allowing the population to rebuild at the slowest possible rate, (roughly the current situation), results in a net loss relative to the optimal policy of $850M.

10.4 REVIEWER'S COMMENTS

Both reviewers agreed that the technical analyses in this paper appear sound, and that the potential benefits from rebuilding off-year runs to Shuswap Lake were enormous. However, both reviewers also pointed out that implementation of the suggested policies (harvest rates of 74%, 50%, and 0% on the dominant, subdominant, and off-year cycles, respectively) could seriously reduce the harvest of other co-migrating sockeye stocks not considered in this analysis. Thus, the author's recommended harvest policies would be socially and politically disruptive. The reviewers also commented that the author has assumed there is no biological basis for cycles in abundance; thus, the predicted benefits are optimistic with respect to other models which include potential biological interactions between year-classes. One reviewer suggested that if potential benefits are lower than predicted in the paper (because of cyclic dominance), then the relative value of the co-migrating pink and sockeye stocks would necessarily be higher. He also suggested that present stock identification procedures are not reliable enough to monitor or regulate stock-specific harvest rates as would be required under the author's proposal to trade increased catches

of "healthy" stocks for decreased catches of "unhealthy" stocks. The other reviewer suggested that production from pink salmon runs might be expected to suffer from compensatory mortality on the spawning grounds under the proposed harvest policy in view of increased run sizes predicted for the next cycle. Therefore, he recommended that every effort be made to increase fry recruitment in the off-year Shuswap lines through enhancement to minimize the need for reducing harvest rates.

10.5 SUB-COMMITTEE ADVICE

(See section 10.6)

10.6 SUB-COMMITTEE ADVICE ON REBUILDING FRASER SOCKEYE (sections 8, 9 and 10)

These three working papers recommend rather different approaches to achieving increased production from Fraser River sockeye runs. However, there is a common thread to the analyses which needs to be developed further to ensure a rational rebuilding plan. All papers indicate that recent escapements for many runs have been below optimal levels.

The critical assumption in modeling rebuilding strategies concerns the relative productivity of dominant and off-year lines, and thus, the explanation for historic cycles in abundance. Three different hypotheses were considered in Working Paper S89-3: the "Ricker model", the "Larkin model", and the professional judgements of the Fraser River Task Force (previously termed the "South Coast model"). For convenience, these are referred to as hypotheses A, B, and C, respectively. Hypothesis A assumes that cycles are caused only by fishing rates, historic escapements, and natural, random variations in recruitment (i.e. no cyclic dominance). This hypothesis is the most optimistic because it predicts that all lines can be rebuilt independently to the same (dominant) level without one line suppressing another. Hypothesis B allows for biological interactions between lines which can suppress production in consecutive year classes, but assigns each line the same potential productivity. It predicts that all lines can rebuild to the same, high level, but that this level will be less than that possible under hypothesis A because previous large runs tend to suppress production from subsequent lines. Hypothesis C is the most pessimistic because it describes the dominant line as being intrinsically more productive than the off-year lines. It predicts that production from off-year lines can be increased but only to a point, well below that which can be achieved on the dominant or subdominant lines.

Escapement goals in Cass (1989) and Working Paper S90-33 were estimated under the optimistic hypothesis (A) whereas those in Working Paper S90-8 were estimated under the pessimistic hypothesis (C). Escapement goals in Cass (1989) and Working Paper S90-33 are technically defensible because hypothesis A has been documented and reviewed; those in Working Paper S90-8 are not technically defensible because hypothesis C comprises subjective judgements which have not been documented or reviewed by PSARC. Nevertheless, these documents provide us with a range of escapement goals based on logical arguments under both optimistic and pessimistic scenarios. The Sub-committee points out that the escapement goals in Working Paper S90-8 should be considered as escapement goals under the

pessimistic hypothesis, not as interim goals, since "interim" implies a timetable for achieving these particular goals. The Sub-committee endorses the escapement goals recommended for dominant cycles because they tend to be very similar under both hypotheses A and C. Where escapement goals in Working Paper S90-8 are less than those in Cass (1989) for off year cycles, the Sub-committee suggests the former goals be regarded as minimum estimates that are not technically defensible.

For many runs, current escapements are well below the goals under either hypotheses A or C, and these runs must be considered as depressed. Working Paper S89-3 and S89-26 both conclude that large benefits will result from increasing escapements to these depressed runs, regardless of which hypothesis is correct. Working Paper S90-33 emphasizes that if hypothesis A is correct, enormous benefits can be achieved by rebuilding subdominant and off-year lines as quickly as possible (i.e. 0% harvest rate on off-year lines). However, Fraser sockeye runs cannot be managed in isolation. Rebuilding plans for these stocks must be developed after assessing the potential impact of reduced harvest rates on the catches of co-migrating salmon runs through formal analyses of potential costs and benefits similar to those in Working Paper S90-33 (see Table 10.1 by way of example). Evaluation of complementary enhancement options should be included in such analyses.

The Sub-committee also agreed that the experimental harvest reductions proposed in S90-6 be implemented as soon as possible. Two of these experimental proposals were previously endorsed (Salmon Sub-committee Report 89-1). New information presented in Working Paper S90-33 suggests that a more aggressive experimental rebuilding program is warranted for the three stocks identified. If this experimental rebuilding plan is endorsed by the RMEC, the Cyclic Dominance Working Group should proceed to develop specific programs to monitor the success of rebuilding off-year runs.

The Sub-committee also supports recommendations in Working Paper S90-6 to increase sockeye fry recruitment from non-dominant lines through appropriate enhancement techniques (excluding lake enrichment). Enhancement to increase fry recruitment will supplement increases expected by reducing harvest rates, but enhancement probably cannot be used alone as a substitute for harvest rate reductions. In working paper S89-3 preliminary simulations suggest that for very small runs under intense exploitation, decreasing harvest rates is considerably more effective than enhancement owing to constraints on the fraction of the run, and hence the number of fish that can be taken as broodstock. Decisions to enhance the dominant Quesnel line, either by increasing fry recruitment or lake enrichment, should be deferred to the fall of 1990 to permit an evaluation of hydroacoustic and trawl survey data during this year of record high fry density in Quesnel Lake.

The Sub-committee is also very concerned about the drastic decline in escapements (excluding jacks) to the lower Adams River between 1981 and 1989 (6218 in 1981, 460 in 1985, and 75 in 1989). A similar trend is evident for the Lower Shuswap River. This line faces extinction at current harvest rates, apparently as a result of intense exploitation of co-migrating sockeye and pink salmon stocks. Clearly, this trend is contrary to the intent expressed in the

three working papers reviewed here. This decline also highlights the difficulty of harvesting co-migrating stocks independently, and raises doubts about the validity of assumed run-timing curves used to manage Fraser sockeye stocks.

The Sub-committee recommends that:

1) formal analyses of potential costs and benefits (similar to those in Working Paper S90-33) be undertaken for each major stock and cycle line, for several rebuilding scenarios under the three alternative hypotheses. This work should be coordinated by the Cyclic Dominance Working Group which has completed similar analyses for the Shuswap and Quesnel sockeye runs in Working Paper S89-3. A report should be submitted for review by the Sub-committee in the spring of 1991.

2) the proposed experimental rebuilding plan be implemented by:

   a) reducing harvest rates on the mid '87 cycle run-timing stocks to 50% beginning in 1991 to permit rebuilding of the off-year line to Quesnel Lake.

   b) reducing harvest rates on the late '88 cycle run-timing stocks to 50% beginning in 1992 to permit rebuilding of the off-year line to Shuswap Lake.

   c) equalizing sockeye fry recruitment to Fraser Lake either by reducing harvest rates on the Stellako run or by increasing fry recruitment through enhancement. In recent years, escapements of the non-dominant ('86 cycle and '89 cycle) lines have been about half those of the dominant lines.

3) enhancement facilities that will increase fry recruitment to Shuswap and Quesnel lakes during the non-dominant years (e.g. spawning channels, incubation techniques, etc.) be planned and developed.

4) decisions about enhancement of the dominant run to Quesnel Lake be postponed until the fall of 1990 to permit evaluation of juvenile survey data collected during a summer of record fry density in Quesnel Lake.

Table 10.1. Example of analyses required to evaluate rebuilding options for Fraser River sockeye stocks.

Stock: Stellako
Line: 1989

0% HARVEST RATE

hypothesis	est. optimal escape.	escape. in 12 yr	cumul. catch in 40 yr	net present value
A (optimistic)	294,850	?	?	?
B	?	?	?	?
C (pessimistic)	100,000	?	?	?

50% HARVEST RATE

		escape. in 12 yr	cumul. catch in 40 yr	net present value
A (optimistic)	294,850	?	?	?
B	?	?	?	?
C (pessimistic)	100,000	?	?	?

70% HARVEST RATE

		escape. in 12 yr	cumul. catch in 40 yr	net present value
A (optimistic)	294,850	?	?	?
B	?	?	?	?
C (pessimistic)	100,000	?	?	?

11. ASSESSMENT OF STOCK IDENTIFICATION CAPABILITIES FOR FRASER SOCKEYE (Working Paper S90-09)

11.1 INTRODUCTION

The objective of this analysis is to assess the accuracy and precision in estimates of stock composition for major Fraser sockeye stocks (Table 11.1). Historically, estimates of the catch by stock relied mainly on differences in the frequency distribution of circuli counts in the first freshwater and spring scale growth zones. The allocation of catch to stock was done by graphically comparing the distributions of circuli counts in samples from the fishery with known distributions in samples from the spawning grounds. Since mid-1980s, allocations have been based on additional scale characters and using more robust classification models (i.e. Cook and Lord 1978). Assumptions about run timing dictate the choice of stocks to include in baseline samples. In this analysis apriori assumptions about run timing are explicitly avoided to assess the utility of scale characters. Estimates of stock composition were made using Fournier et al.'s (1984) maximum likelihood mixture model.

11.2 DATA USED

Frequency distributions of scale circuli counts in the first freshwater and plus growth zones made by the IPSFC were used to estimate accuracy and precision for eight years of data between 1971 and 1985. For comparison, a seven character baseline comprised of the two circuli counts and five additional scale characters based on width measurements were estimated for two of the eight years. The two years for which the additional characters were measured were selected because they represent a relatively good year of stock separation (1980) and a relatively poor year (1981) based on similarity dendograms. (for examples, see Figures 11.1 and 11.2).

11.3 ANALYSIS

Two simulation tests were performed to evaluate accuracy and precision at different levels of stock groupings. In the first test, known mixtures of 100% Adams sockeye (n=200) were generated and the rates of misallocation were evaluated at different levels of stock grouping. These simulations were done to see how, in a specific situation, Adams sockeye are misallocated among the other stocks in the baseline in a good (1980) and bad year (1981). In reality, the true composition in a mixture sample from a commercial fishery is not known. In the second test, simulations were performed on mixtures of known composition containing random combinations of the selected stocks. For each stock, mixtures of known composition are randomly selected from the range of all possible proportions between 0 and 1. These simulations were done to assess the general level of accuracy and precision expected for all the major stocks over the range of possible stock proportions.

Table 11.1. Major stocks and years of data used to assess the accuracy and precision in stock composition estimates of Fraser River sockeye. The 'X's denote years when sampling occurred.

	Year							
Stock	71	72	74	75	78	80	81	85
E. Stuart	x	x	x	x	x	x	x	x
L. Stuart		x	x	x	x		x	x
Stellako	x	x	x	x	x	x	x	x
Horsefly			x		x		x	x
Chilko R.	x	x	x	x	x	x	x	x
Birkenhead	x	x	x	x	x	x	x	x
Lower Adams	x	x	x	x	x	x	x	
Weaver	x	x	x	x	x	x	x	x

11.4 RESULTS

For the rather simple simulation experiment using mixtures of 100% Adams sockeye, better estimates were obtained from the seven character baseline that with baselines of only the two circuli counts (Fig. 11.3 and Fig. 11.4). However, at the unit stock level (Adams complex only), there was a large negative bias for both sets of baseline data. These ranged from 23% in 1980 and 29% in 1981 for the two character baseline and 20% and 24%, respectively, for the seven character baseline. As stocks are grouped together the accuracy and precision improve. However, this results in the creation of potential problem clusters that cannot be separated on the basis of scale characters alone.

For the randomized simulation experiment, there is considerable variability in the *potential* bias among stocks and among years for both the two and seven character baselines (Fig. 11.5 and Fig. 11.6). For the two character baseline, the mean bias for all stocks and years combined was -19.6% at the unit stock level and -16.4% for stock groupings that preserve the integrity of the major stocks. The high rate of misallocation implies that the scale circuli counts have a high degree of similarity among stocks. Generally, the precision of the estimates is positively correlated with accuracy. Stocks with low accuracy (high bias) are associated with low precision. Accuracy and precision improved considerably when based on the seven characters baseline for the two years that scale widths were measured (1980 and 1981). The mean bias for 1980 was -9.5% based on circuli counts and -6.9% based on the larger number of characters. Precision increased by more than 50%. For 1981 the bias declined from a mean of -25.8% to -13.2%, respectively. Precision improved by 49%.

For the seven character baseline samples for 1980 and 1981, little improvement is gained by grouping similar stocks together at a level that maintains the separation of the major stocks (Fig. 11.7). This is because most major stocks

already have a relatively high degree of dissimilarity. Grouping beyond the unit stock level is not possible without including one or more major stock and hence creating a problem cluster.

11.5 CONCLUSION

The scale characters used in this analysis resulted in negative biases in the estimated stock composition. The bias is particularly apparent using only circuli counts. Despite the additional information in the scale width measurements, the estimates of stock composition can still be strongly biased. Because scale growth patterns change annually, depending on the prevailing rearing environment, there will always be good and bad years of stock separation. It's clear that without additional information, accurate and precise stock composition estimates are not possible in some years even with a large number of scale characters.

11.6 REVIEWERS' COMMENTS

This issue was first addressed in 1989 (Working Paper S89-22). In the evaluation, data from 1981 only were used. At that time the Sub-committee recommended that examination of other years of data be continued but as an independent assessment. As such members of the PSC's staff have not reviewed and commented on the current paper.

This paper continues addressing an important issue concerning how well stocks of Fraser River sockeye can be identified by scale pattern analyses alone. Scale pattern analyses are used to allocate catch to stocks and the results of these analyses directly influence the management of fisheries, assessments of stock productivity and exploitation rates. Only very recently has the Department begun to evaluate how accurate the allocations of catches are and how errors may influence interpretations about stock dynamics.

Three reviewers agreed that the estimates of stock composition by the use of scale characteristics only can be strongly biased. These reviewers acknowledged that improved estimates were obtained by using increased number of scale characteristics and by grouping various stocks. However, accuracy was improved, but at the expense of resolution. The reviewers presented several items of consideration which can be addressed by the author.

One reviewer concluded that the simulation study was well designed and executed and the conclusions appear incontrovertible. The author demonstrated that very poor estimates occur frequently and that the results presented in Working Paper 89-22 were not unusual nor as a result of atypical stock mixtures. Scale pattern analysis alone frequently cannot provide acceptable estimates. These conclusions raise serious questions about the adequacy of existing methods for estimating stock compositions and harvest rates on individual Fraser River sockeye stocks. This has important implications for the management, stock assessment and rebuilding of stocks and thus warrant careful attention.

11.7 SUB-COMMITTEE ADVICE

In view of the serious implications raised by this paper, the Sub-committee recommends that improvements are needed in the procedure used to allocate Fraser sockeye catches by stock. The Sub-committee recommends:

1. That a working group, consisting of appropriate PSC and DFO staff, be established to develop a consolidated approach to this problem. This working group would:
    a) Identify the levels of accuracy, precision and stock resolution required for management and assessment of stock productivity, and the evaluation of rebuilding options. This is to be developed in consultation with the Fraser River Sockeye Task Group.
    b) To improve existing capabilities, develop a rigorous procedure for incorporating stock specific run timing information and explore the possibilities of developing rigorous statistical procedures for utilizing additional information provided by trends in estimates from sequential catch estimates.
    c) Explore the possibilities of developing rigorous statistical procedures for utilizing additional information provided by trends in estimates from sequential catch samples.
    d) Prepare a Working Paper with respect to progress on the above items for presentation to the Sub-committee in the spring of 1991.

12. ASSESSMENT OF CHILKO LAKE SOCKEYE (Working Paper S90-10)

12.1 INTRODUCTION

This report addresses the potential of assessing the effects of lake fertilization on juvenile sockeye production can be detected in Chilko Lake. The International Pacific Salmon Fishery Commission collected extensive data to monitor sockeye production in Chilko Lake since the 1930s. It is now the only lake in the Fraser River watershed where smolt size and abundance are measured annually. The data used in this analysis are the estimates of adult escapement and the size and abundance of juvenile sockeye for brood years 1950-85 (Table 12.1).

12.2 TESTING FOR DENSITY DEPENDENT EFFECTS

For lake fertilization to increase juvenile sockeye production, density dependent survival and/or growth is a necessary prerequisite. After all, fertilization will not increase fish production if environmental or spawning ground limitations control abundance. To test for density dependent effects, the relationship between several indices of sockeye production are compared to the survival and size of smolts for a 34 year time series. The potential egg deposition (PED) in Chilko River, the main spawning grounds for Chilko Lake was negatively correlated with smolt mean length (Fig. 12.1). PED was shown to be positively correlated to fry and smolt density (Fig.12.2 and Fig. 12.3) and is

assumed to index stocking density. The relationship between PED and smolt length is consistent with a hyperbolic model that relates food ration size to population density. A linear regression using $\log_e$ transformed data resulted in a statistically significant relationship ($p=0.02$). However, there was a large amount of unexplained residual noise in the relationship and only 17% of the variation in smolt length is explained by PED. There is no evidence that stocking density affects in-lake survival.

Goodlad et al. (1974) suggested juvenile sockeye growth in Chilko Lake was positively correlated with lake temperature. In the present analysis, the mean May-September temperatures at Chilko River was positively correlated to smolt mean length ($p=0.035$) (Fig. 12.4). However, temperature only accounted for 13% of the variation in length. There was no evidence that temperature affects in-lake survival. However, there was a positive correlation between temperature and the proportion of smolt that go to sea at age 1 compared to age 2. This suggested that at higher temperatures more juveniles attain a size sufficient to smolt at age 1.

12.3 MONITORING THE EFFECTS OF LAKE FERTILIZATION

In order to evaluate the effect of lake fertilization, the question to be answered is 'What increase in juvenile survival and/or growth must occur to detect possible effects of lake fertilization?' The necessary increase from a statistical point of view is dependent on the number of new data points (i.e. future measurements of survival and growth) and on the observed change in survival and growth. For example, for a single new observation, the statistical uncertainty is much greater than for several new observations. The one-tailed 75% 80% and 90% upper confidence intervals were computed using only PED and then using PED and temperature to predict smolt mean length. There is little difference between the upper confidence intervals for each of the regressions. This is not surprising since neither expanatory variable expains much of the variation in mean length. To be statistically significant at the 90% level, smolt mean length must be greater than 89 mm compared to the historic geometric mean of 82 mm.

There was no evidence that egg-to-smolt survival is affected by density or temperature. If survival is assumed to be a normally distributed random variable, then survivals must increase by more than 73% from the geometric mean of 4% to be significant at the 90% level. However, tests for normality were not statistically significant.

12.4 DISCUSSION

Although both PED and temperature were shown to have an effect on juvenile production, the high residual error implied an extremely low level of predictability. It may be possible to find another explanatory variable to explain more of the variance in smolt length. If so, the proportional increase in juvenile production needed to be statistically significant would be reduced to detect the effects of lake fertilization. The significance of outliers on the various relationships explored in this analysis were not investigated. For

example, mean smolt length in 1962 was greater that expected. If it turns out that the removal of such outliers from the regression is justified, the uncertainty would be less than reported.

The potential effects of a south-end lake population in Chilko Lake on juvenile production was ignored in this analysis. The quality of data attributable to this population is questionable. Only recently have rigorous attempts been made to estimate spawning escapements for this population. Henderson and Cass (MS, in preparation) show that smolts from the north-end spawning population are larger than from the south-end population. For the three years of data analyzed by Cass and Henderson, the contribution of the southern population to smolt samples from Chilko Lake was shown to be negligible. Nevertheless, the proportion of smolts from each spawning population can be separated with a high degree of accuracy using a maximum likelihood mixture model approach as done by Henderson and Cass. One could analyze the north-end population separately. If the south-end population continues to increase, as recent escapement data seems to suggest (Cass 1989), then the confounding effects resulting from mixed stock problems could be an issue when measuring responses to lake fertilization.

12.5 CONCLUSION

The ability to measure the effects of lake fertilization on juvenile production is complicated by a high level of unexplained residual error in the indices of juvenile production. The analysis present here could be taken further by searching for other explanatory variables or for measures of juvenile productivity. As well increases in escapements beyond recent levels concurrent with lake fertilization, as might occur if stock rebuilding plans are adopted, will confound efforts to monitor changes due to lake fertilization alone. A simulation study would be useful to understand how uncertainty changes with increases in the number of future observations and with increments of production.

12.6 REVIEWER COMMENTS

Both reviewers note that considering the available data, it will be very difficult to detect a fertilization effect on juvenile sockeye productivity if it is not a profound response.

Both reviewers suggest that the data support a linear, rather than a curvilinear response in the smolt vs potential egg deposition (PED), as suggested by the author. As well, they agree that the temperature response of juvenile production accounts for little of the variability, thus other factors may be important (and unmeasured). Other data should be sought for analysis, if they are available.

The ability to assess fertilization responses will be confounded by the proposed rebuilding scenario of the Fraser River Sockeye Task Force. It will be necessary to coordinate this factor into the evaluation if both proceed. The Sub-committee feels that the small size of Chilko lake sockeye smolts, relative to other Fraser sockeye stocks, indicates that food and/or temperature are limiting. The Sub-committee agreed that the analysis suggests it will be difficult to measure any changes due to fertilization.

12.7 SUB-COMMITTEE ADVICE

To measure the effects of lake fertilization (given the inherant noise demonstrated by the existing data) a profound productivity response, a consistent response or monitoring over several years will be required. It was also noted that the data presented does not support the hypothesis that smolt production from Chilko Lake is food limited. The situation in Chilko Lake may be simular to Hugh-Smith Lake in Alaska. Koenings and Burkett (1987) reported that smolt size did not increase following lake fertilization in spite of an increase in zoo plankton. It was concluded that Hugh-Smith Lake was limited by density independant factors (eg. temperature limitation). Given the information presented in Working Paper S90-10 it is equivical that smolt production in Chilko Lake is density dependant.

The Sub-committee recommends:

1) That other data not available to the Sub-committee needs to be reviewed to support fertilization of Chilko Lake. This data may be available in PSC files or in LEP files.

Table 12.1. A summary of data collected for Chilko Lake sockeye by brood year. Estimates of potential egg deposition and number of fry are for Chilko River.

Brood Year	Potential Egg Deposition (x10e6)	No. Age 1 Smolts (x10e6)	No. Age 2 Smolts (x10e6)	Mean Length Age 1 Smolts (mm)	No. fry (x10e6)	Mean May-Sep Chilko R. Temperature (c)
1949	88.58	3.15	0.05	-	-	-
1950	20.18	1.17	-	-	-	-
1951	176.66	11.51	0.41	-	-	-
1952	714.43	24.49	1.03	81.72	-	9.82
1953	282.00	7.69	0.25	72.88	-	8.22
1954	62.08	2.85	0.59	81.07	-	9.01
1955	206.57	9.16	0.51	86.86	21.66	9.72
1956	1021.28	28.24	0.92	81.90	54.78	9.69
1957	221.46	9.46	0.17	84.44	19.34	11.76
1958	192.35	6.90	1.08	75.87	26.01	8.91
1959	656.71	32.17	2.52	73.83	48.46	9.88
1960	686.87	33.78	1.45	74.57	59.55	10.38
1961	44.45	1.59	0.11	85.12	4.96	9.70
1962	125.11	8.81	0.05	100.64	16.13	9.78
1963	166.10	9.27	0.69	76.95	44.15	8.55
1964	377.55	23.67	1.80	73.06	53.00	10.22
1965	61.27	2.35	0.28	79.09	5.75	8.26
1966	343.69	17.36	0.30	85.50	23.93	11.18
1967	249.32	9.15	0.36	84.12	14.29	9.61
1968	530.64	31.54	0.47	84.36	-	10.13
1969	73.62	3.59	0.11	92.85	-	10.48
1970	162.10	3.83	0.77	79.34	-	9.35
1971	281.18	5.67	0.71	83.75	-	9.19
1972	1005.45	20.01	1.54	78.46	-	9.45
1973	97.89	4.17	0.13	84.99	-	9.93
1974	223.57	7.06	0.17	85.80	-	10.12
1975	321.57	13.01	1.76	77.37	-	9.04
1976	630.72	25.41	0.29	88.66	-	10.83
1977	58.43	2.61	0.00	95.27	-	11.65
1978	246.94	18.14	0.20	80.90	-	10.94
1979	395.12	20.72	0.23	84.11	-	9.30
1980	810.31	31.98	0.31	80.28	-	10.89
1981	59.21	1.67	0.11	83.01	-	10.64
1982	404.66	13.40	0.40	83.04	-	10.08
1983	455.82	14.23	2.25	74.99	-	10.39
1984	647.50	6.50	0.67	74.49	-	10.47
1985	112.47	1.91	0.19	82.52	-	9.36

WORKSHOPS

13. REPORT FROM A PSARC WORKSHOP: REVIEW AND EVALUATION OF THE WCVI TROLL FISHERY MANAGEMENT MODEL (Working Paper S90-16)

13.1 INTRODUCTION

The purpose of this workshop was to review and evaluate the WCVI troll fishery management model with reference to : 1) its past uses and applications; and 2) its potential use for stock specific analysis in both WCVI and the Strait of Georgia as well as other troll fisheries. Of particular concern for the WCVI and North Coast fisheries are the need to analyze adjustments to fishing time and area for the effects on specific stocks. While there is need to assess stock specific effects in both of these fisheries, only the WCVI currently has a simulation model of its troll fishery.

For the Strait of Georgia, analytical needs focus on evaluating the effects of management actions on sport and troll fisheries with reference to specific stocks of both chinook and coho. This need is emphasized by current problems with Lower Strait of Georgia chinook stocks and Strait of Georgia coho stocks. While the WCVI model forms the structual basis for the new Strait of Georgia model, only the WCVI model has been documented. It is believed, however, that a review of the components of the WCVI model as documented will provide a partial description of the Strait of Georgia version for the purpose of this review.

All of the available model documentation is provided in a primary technical report (English et al. 1987). This document was distributed to all workshop participants and was the basis of discussion and review.

13.2 RESULTS

This workshop served a number of useful purposes besides a review of the WCVI troll model. Firstly, the hook and line models were developed without input from Science Branch and in this workshop the majority of the Departmental staff reviewing the model were from Science Branch. The interchange of ideas was beneficial and will strengthen the utility of the models. Secondly, the need for a new modelling group composed of Fisheries and Science Branch staff was identified.

Another useful outcome of the workshop was the independent perspective provided by Drs. J.R. Sibert and D.A. Fournier of Otter Software. The need for a coast-wide and integrated modelling approach to chinook and coho primarily, but also to sockeye and pink was evident. Specific models may not have to be coast-wide but they must be compatible between areas with linkages developed.

It is difficult to provide an in-depth review of a complex multi-species management model like the WCVI troll fishery during a two day workshop. During the course of the review and the resulting discussions it was felt that the WCVI model provide a reasonable approximation of the dynamics of the fishery simulated. However there were several recommendations for improvement including

methods to address the stock dynamics. It was agreed that the Hook & Line models should conform where possible to assumptions and parameters used in the P.S.C. chinook rebuilding model. Further work is required on how parameters are estimated and recommendations are made to accomplish this. Recommendations provided by the independent review of Sibert and Fournier are incorporated in the following recommendations.

Finally, tools like simulation models are required to simulate the dynamics of in-season management. The first steps of development have been accomplished. However, in the next stage of model development parameter estimates need to be refined and a more detailed understanding regarding the behaviour of interacting model components needs to be pursued.

13.3 SUB-COMMITTEE ADVICE

Working paper S90-16 represents a report from the workshop that PSARC conviened in response to the Director General's request to review the utility of the WCVI model to evaluate management options with respect to South Coast coho and WCVI chinook fisheries. This report is presented in a different context than the other working papers in that the peer review has taken place as part of the workshop. The Sub-committee generally accepted the recommendations from the workshop. The Sub-committee notes that the terms of reference, to the workshop, were not completely fulfilled. The task was too large in that the time permitted allowed only the WCVI model to be addressed.

The Sub-committee recommends:

1) That more effort be allocated to review the model and to accomplish the next stage of development.

2) That a regional modelling group be established to accomplish the next stage of development. These activities would include development of models for the North Coast and Strait of Georgia fisheries and consideration of completely rewriting the WCVI model. In regard to the next stage of development, particular attention should be given to;

   a) Stock groupings to conform to the Pacific Salmon Commission (PSC) rebuilding model and the (PSC) Coho Technical Committee stock aggregations.

   b) Determine temporal distribution of stocks of concern in fisheries to evaluate if and when stock specific management action can be applied.

   c) To allow for fish movement among models the required linkages be developed.

   d) The lack of an abundance predictor in the fisheries for chinook and coho hinders the utility of these models. Forecasting methods should be developed.

e) Methods to deal directly with daily and seasonal sport bag limits should be incorporated particularly for model simulation in the Strait of Georgia fisheries.

f) The algorithm for calculation of shaker deaths to conform to that used in the Chinook Rebuilding Model.

g) Improve the data input to the effort switching feature by an effort switching in multi-species model evaluation of historical log book program data.

h) Develop a more empirical methodology to model small area closures.

3) That the existing WCVI troll fishery model be continued in use to its original intent of fishery differences in modelling management actions and projected catches under those action scenarios. This model could be improved by incorporating items for the recommendation immediately above.

QUALITY OF SPAWNING ESCAPEMENT DATA

STATEMENT OF THE PROBLEM

The Sub-committee has concluded, based on some of the papers presented this year and comments made to it in the past, that the Department is in a crisis situation concerning the collection of accurate salmon escapement data of known precision in this Region. The Sub-committee believes that the present methods of obtaining these data will not stand up to scrutiny and will not meet the needs of future stock assessments, either domestically or internationally.

BACKGROUND

Spawning escapements have been estimated by Fisheries Officers and their staff for a large number of B.C. salmon populations since the early part of this century. At the same time, other staff, notably the former IPSFC, the former FRB, other Fisheries Branch SEP and Biological Sciences Branch staff have collected more rigourous escapement data for stocks deemed to be of sufficient importance. Since 1951, single point estimates or a range of estimates have been reported in a standard format and are currently available on a computerized data base. Recent refinements to the system include the reporting of some of the supporting data which underlie the final escapement estimate: for example, the clarity of the water, the enumeration method, the time of the survey relative to the spawning timing, and the number of fish observed by species.

In spite of the apparent rigour with which the Fishery Officers' escapement estimates are reported, the accuracy is uncertain and the estimates are considered to be poor for many species and systems. Nevertheless, these escapement estimates are routinely used for stock assessment and fishery management purposes where faulty conclusions and decisions can mean considerable

economic and social disruption, as well as potential stock conservation problems. During the current Sub-Committee meeting, assessments on the Kitimat Arm, west coast of Vancouver Island (WCVI) and Harrison River chinook stocks all acknowledged the poor quality of the Fishery Officer escapement data, but then proceeded to use it (Kitimat Arm), adjust it for relative reliability (WCVI) or discard it entirely (Harrison River). This pattern of apology or compensation for poor data quality is common on many stocks throughout the Pacific Region.

As the need for rigourous, defensible stock assessments grows domestically and internationally, there will be an even greater reliance placed upon collecting reliable escapement data. The Sub-committee does not believe that the present quality of the data will support these assessments in most instances. While the demand for higher quality data increases, we are also faced with shrinking resources to carry out existing enumeration programs. This has meant a curtailment, reduction or inconsistency in the enumeration effort on many systems at the discretion of local fishery management staff.

Furthermore, the Sub-committee is concerned that the resources that are still available are not being put to the best use possible. Working Paper S90-11 recommends upgrading escapement data quality in enhanced systems to improve SEP and stock assessments. Firstly, the Sub-committee believes that the stocks to be enumerated need to be priorized, both for enhanced and unenhanced stocks, keeping in mind stock assessment, fishery management, SEP and habitat protection requirements. Then, the enumeration survey methods for the priorized streams and species need to be upgraded and standardized. Considering the importance of the data, the large numbers of staff currently involved in their collection and the investment by the Department in research on assessment methods, the Sub-committee is confident that improvements are possible, even within exisiting resources.

SUB-COMMITTEE ADVICE

The Sub-committee recommends: 1) the formation of a small Assessment Priorities Working Group (3 or 4 people) to prepare a working paper for the fall/90 PSARC Salmon Sub-committee meeting describing alternative approaches and time-tables for achieving the following:

a) definition of "priority" or "important" stocks for fishery management, stock assessment, SEP assessment and habitat protection purposes;

b) upgrading and standardizing the collection of assessment data (escapement, coded wire tag recoveries etc.) for these priority stocks.

While the working group could recommend approaches requiring additional resources, their focus should be on those that improve the effectiveness of existing assessment programs within existing Pacific Region resources.

(note: A variation of this approach to improving assessment data quality was suggested by the RMEC in 1988. Other priorities have delayed the response to that suggestion. However, the Sub-committee now considers this issue to be of the highest, long term importance.)

FORECASTS FOR 1990 AND FISHERY IMPACTS

The Salmon Sub-committee was advised of forecasts for 11 major salmon stocks returning in 1990. The forecast methods for each of these stocks have been previously reviewed by the Sub-committee. This information is summarized as follows:

SUMMARY TABLE: Summary of 1990 Forecasts

Species	Stock	Escapement Goal	Expected No. of Spawners	1990 Forecast Return	Expected or Allowable Catch	Absolute(b) Forecast Variability (Years)	Basis for Assessment Data(a)			
							Catch Data	No. of Spawners	Escapement Goal	Forecast Procedures
Sockeye	Fraser River: (1986 cycle)	7,500,000	5,230,000	16,500,000	11,270,000	22% (7)	C1,&C2	M/R and Visual	S/R and Policy	Reg. Models and Juv. Production
	Barkley Sound	400,000	-	342,000	-	4% (3)	C1	Quant. Cnt.	Juv. Model	Reg. Model (SSM)
	Smith Inlet	200,000	200,000	625,000	425,000	42% (6)	C2	Quant. Cnt.	Policy	Ave. R/S
	Rivers Inlet	400,000+	460,000	750,000	290,000	73% (5)	C1	V & I	Policy and Scheduled Harvest rate	Ave. R/S but reduced by 55%
	Skeena River	900,000	1,000,000	2,100,000	1,100,000	45% (10)	C2	Quant. Cnt.	S/R	Ave. R/S & T/S
	Nass.	200,000	200,000	426,000	226,000	51% (6)	C2	Visual	S/R	Ave. R/S
Pink	Skeena	1,000,000	1,000,000	2,200,000	1,200,000	52% (9)	C2	Visual	Historic Spawners	Ave. R/S
	Southern B.C. Even Year	3,111,000	3,183,000	4,692,000	2,462,000	67% (10)	CR	Visual	Historic Spawners	Ave. R/S
Chums	Central B.C. Bella Coola	267,000	230,000	890,000	660,000	101% (6)	C2	Visual	Spawning Area	Ave. R/S
	Southern B.C. John. St. - Fraser	2,759,000	-	2,835,000	-	37% (21)	CR	Visual	Spawning Area	Ave. R/S
Chinook	Southern B.C. Big Qualicum Hatchery(c)	3,800 females	6,800 adults 3,600 females	N/A	N/A	N/A (2)	C1 & M/R	Quant. Cnt.	Enhancement Goal	Reg. Models

N/A indicated not available
Footnotes on following page

Summary table (contd).

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 electric 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 brood year escapement.
Policy = decision to set escapements levels for measurement of changes in production.

4. Forecasts of return abundance estimated via:

Ave R/S = brood year escapement * average adult return per spawner observed historically * expected age composition in catch (forecast may be altered du to qualitative assessment of environment 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 brood year.
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. Deviations are calculated as forecasted return minus the observed return divided by the observed return.
c) Values in numbers of total adults (male + female), escapement goal base on 19 million eggs required and 5,000 eggs/female.
d) Fraser River Sockeye Task Force goal.

Forecasts presented indicate good returns and fishing in 1990 for Fraser River sockeye, Skeena River sockeye and Southern B.C. pinks, Skeena River pinks and Bella Coola chums. Moderate to weak returns are indicated for the other stocks.

Sockeye returns to the Fraser are expected to be similar to the large returns in 1986. Approximately 73% of the total will be late timed stocks such as the Adams, Lower Shuswap, Birkenhead and Weaver. Poor returns are expected for the early timed stocks of Early Stuart.

Sockeye returns to the Skeena are expected to be moderate and similar to the returns in 1989. This return will be dominated by enhanced fish. Surplus enhanced stocks will be for the spawning grounds. Beginning in early August increased fishing restrictions will be required to provide for depressed early timed Skeena coho stocks.

Sockeye returns to Barkley Sound are not expected to meet escapement objectives.

Pink returns for Johnstone Strait and Strait of Georgia stocks are expected to be well above average as a result of good brood year escapements. The Johnstone Strait interception fishery and the Area 12 Mainland Inlet fishery will be the primary fisheries.

Pink returns to the Skeena River are expected to be less than average as a result of poor brood year escapements. The early timed stocks are expected to be very weak. Conservation may be required in late July to early August.

Chum returns to the Johnstone Strait Fraser River area are not expected to provide fisheries in Johnstone Strait. Terminal area harvesting is expected in the Qualicum, Fraser River and Cowichan areas.

Returns of enhanced chinook to the Big Qualicum hatchery are expected to be dominated by a strong 1986 brood year. This should provide an adequate number of females in 1990.

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LIST OF FIGURES (CONT'D)

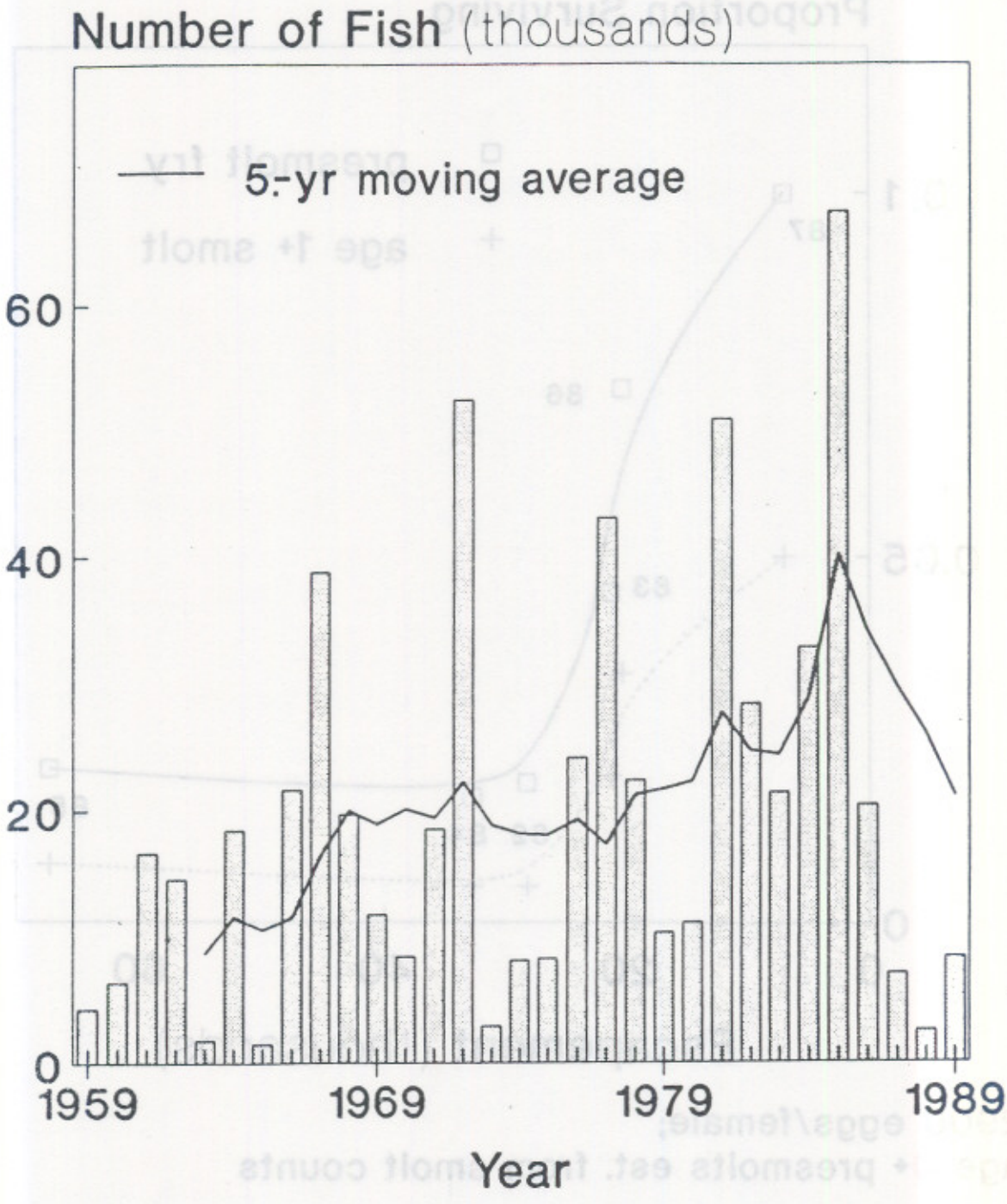
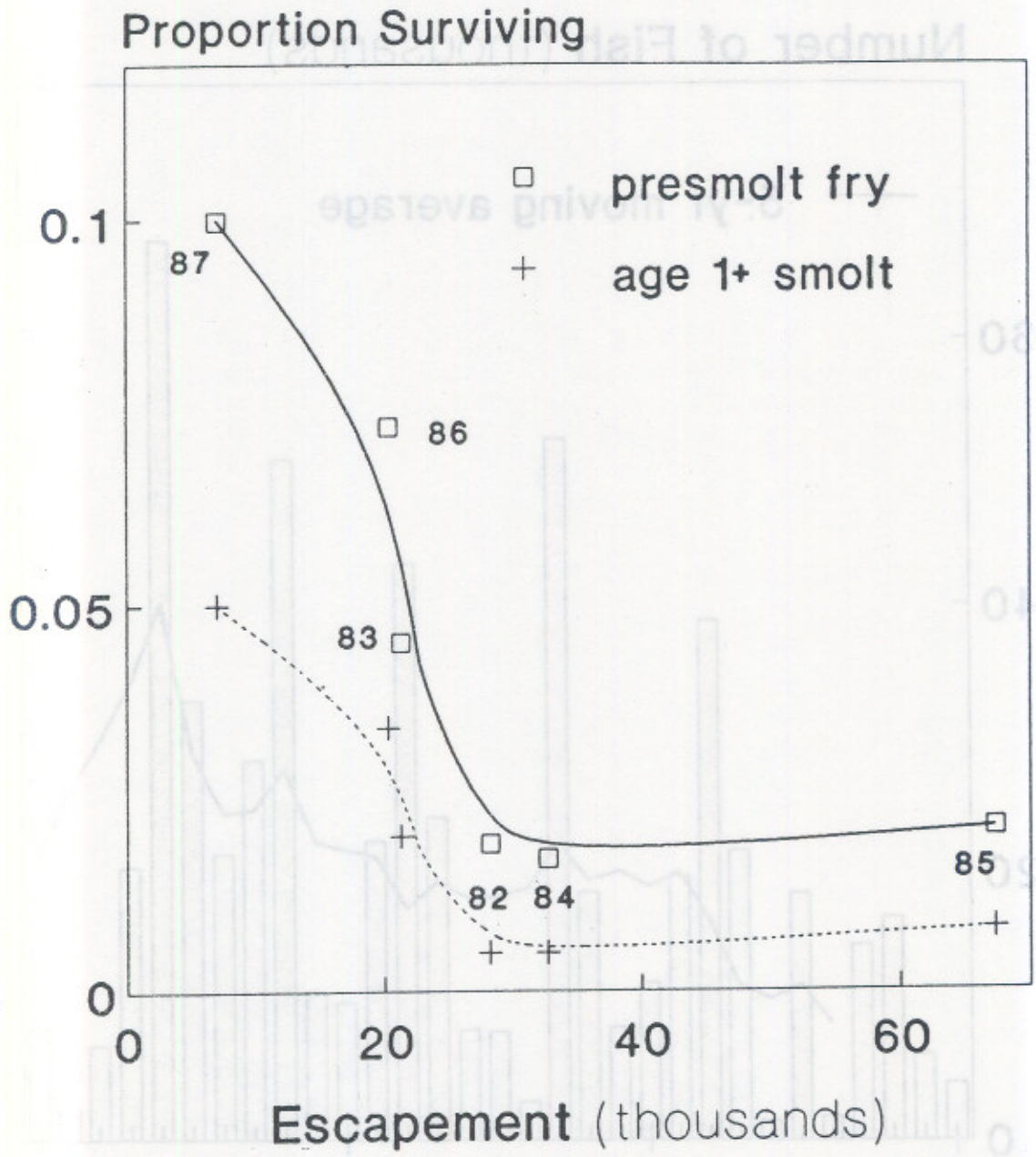

Number of Fish (thousands)
5-yr moving average
60
40
20
0
1959
1969
1979
1989
Year

FIGURE 3.1



2900 eggs/female;
age 0+ presmolts est. from smolt counts

FIGURE 3.2

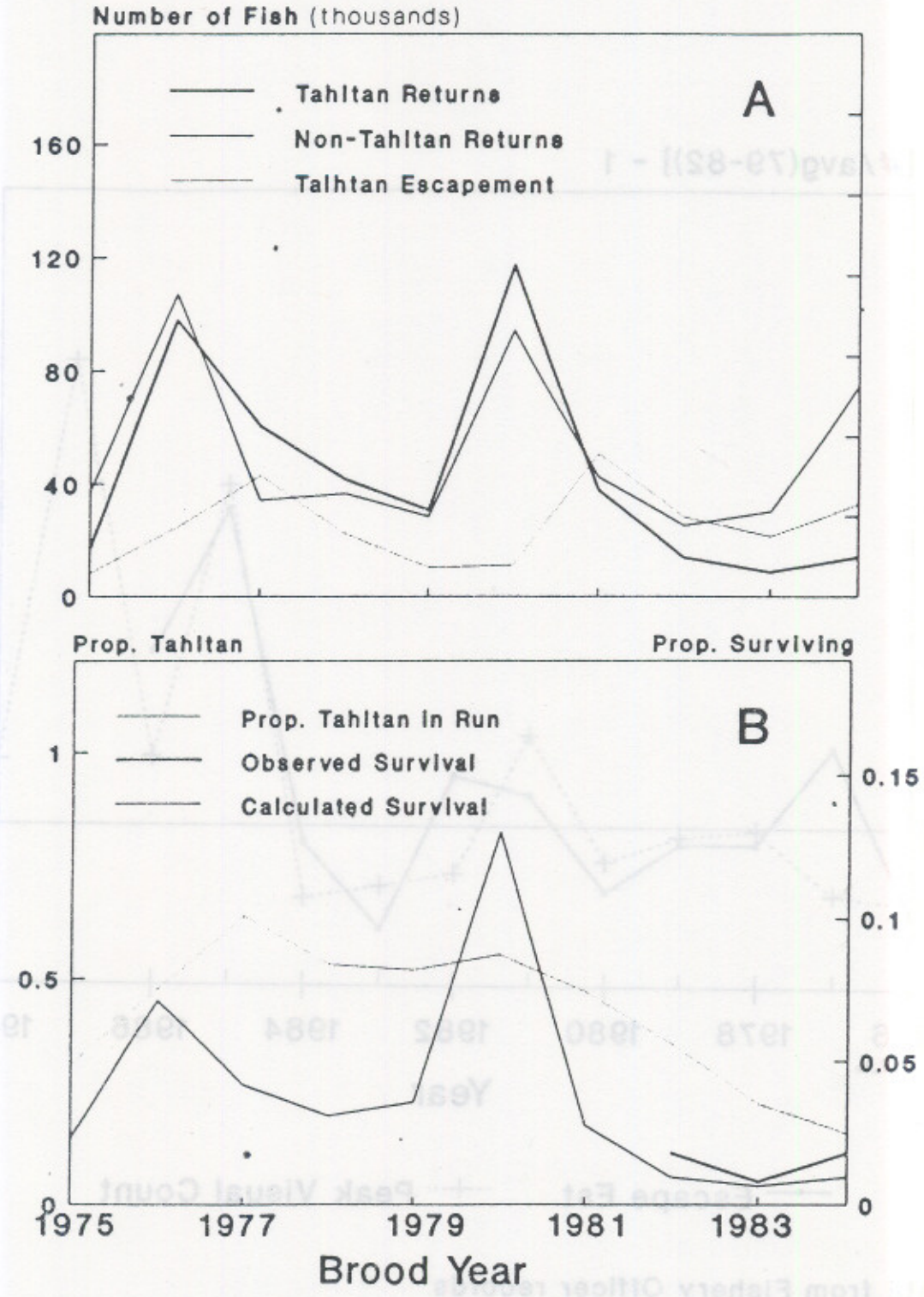
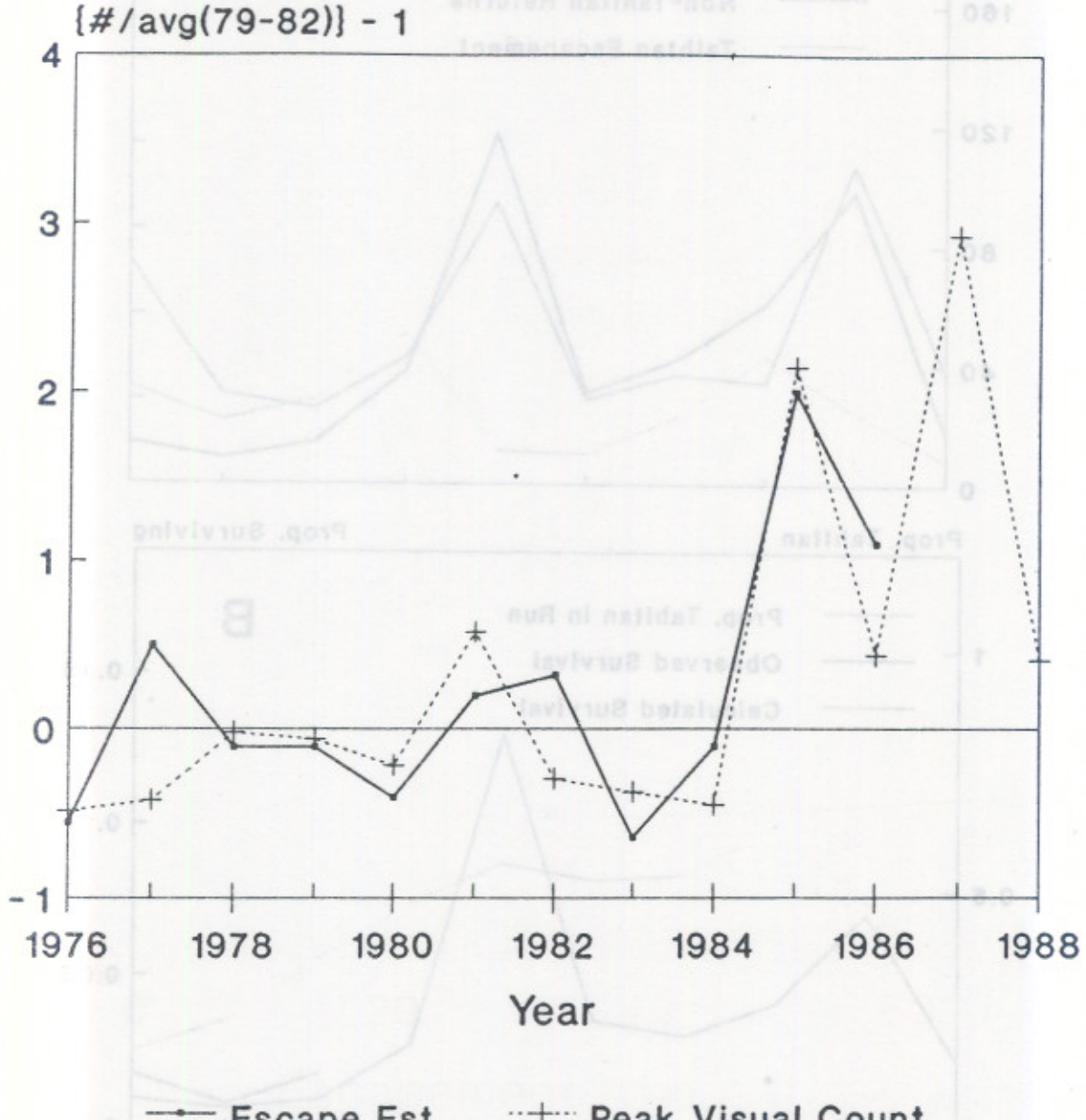

Number of Fish (thousands)
Tahltan Returns
Non-Tahltan Returns
Tahltan Escapement
A
160
120
80
40
0
Prop. Tahltan
Prop. Surviving
Prop. Tahltan in Run
Observed Survival
Calculated Survival
B
1
0.5
0
0.15
0.1
0.05
0
1975
1977
1979
1981
1983
Brood Year

FIGURE 3.3



All data from Fishery Officer records

FIGURE 4.1

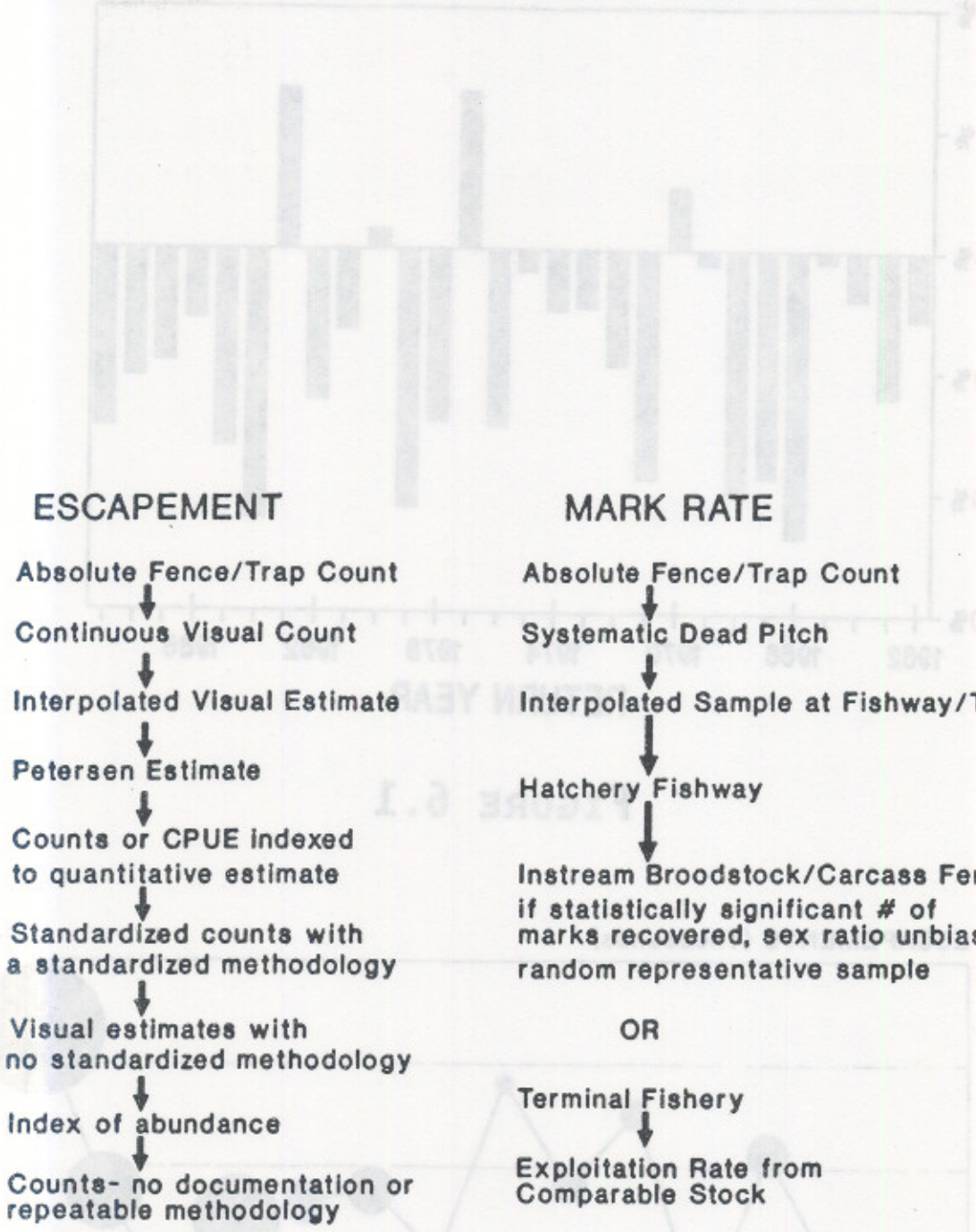

ESCAPEMENT
Absolute Fence/Trap Count
Continuous Visual Count
Interpolated Visual Estimate
Petersen Estimate
Counts or CPUE indexed to quantitative estimate
Standardized counts with a standardized methodology
Visual estimates with no standardized methodology
Index of abundance
Counts- no documentation or repeatable methodology
MARK RATE
Absolute Fence/Trap Count
Systematic Dead Pitch
Interpolated Sample at Fishway/Trap
Hatchery Fishway
Instream Broodstock/Carcass Fence
if statistically significant # of marks recovered, sex ratio unbiased random representative sample
OR
Terminal Fishery
Exploitation Rate from Comparable Stock

FIGURE 5.1

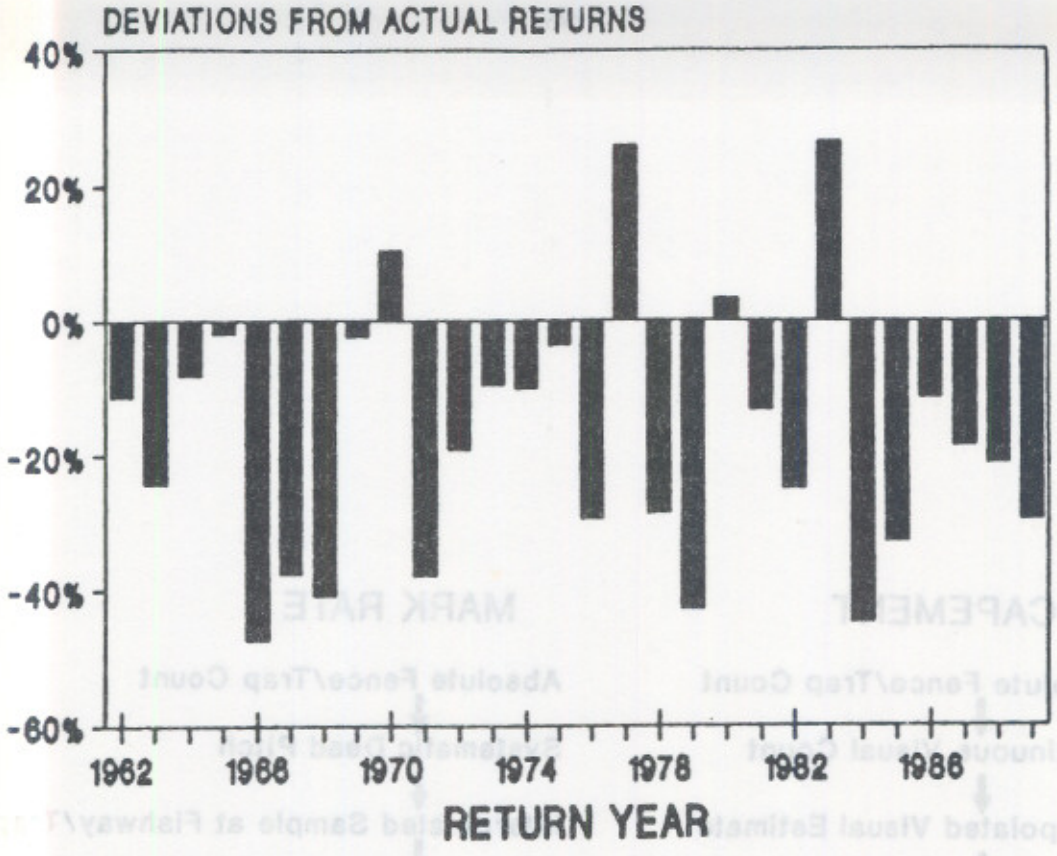


FIGURE 6.1

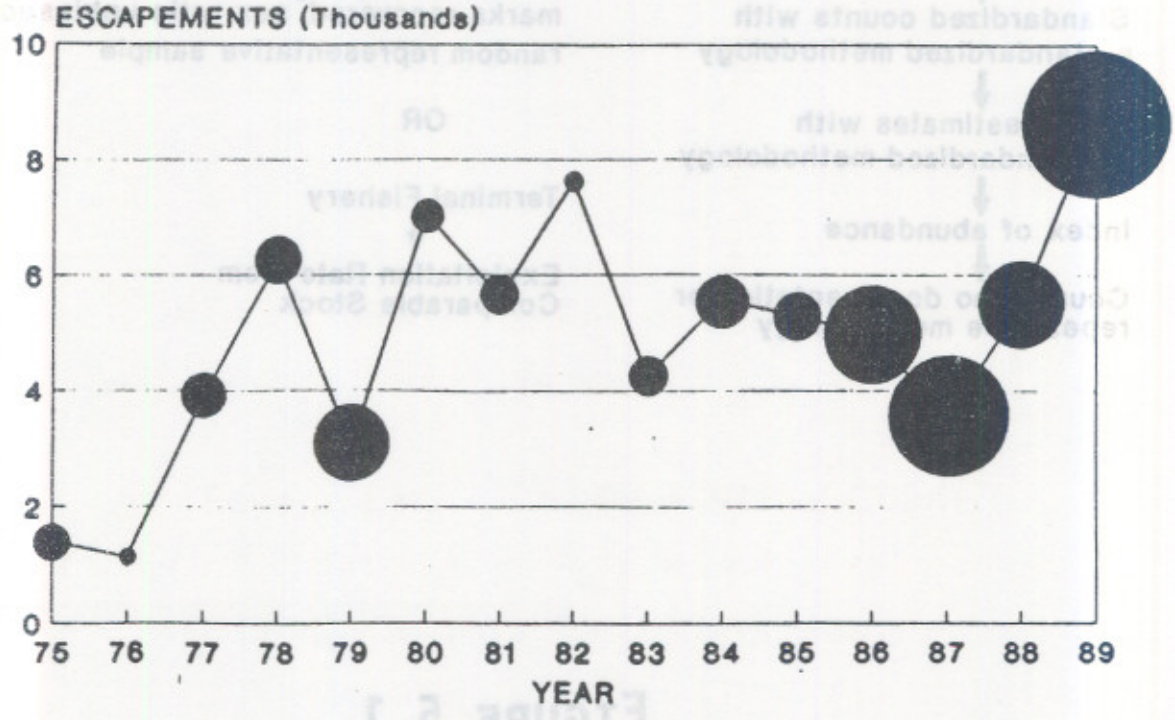


FIGURE 7.1

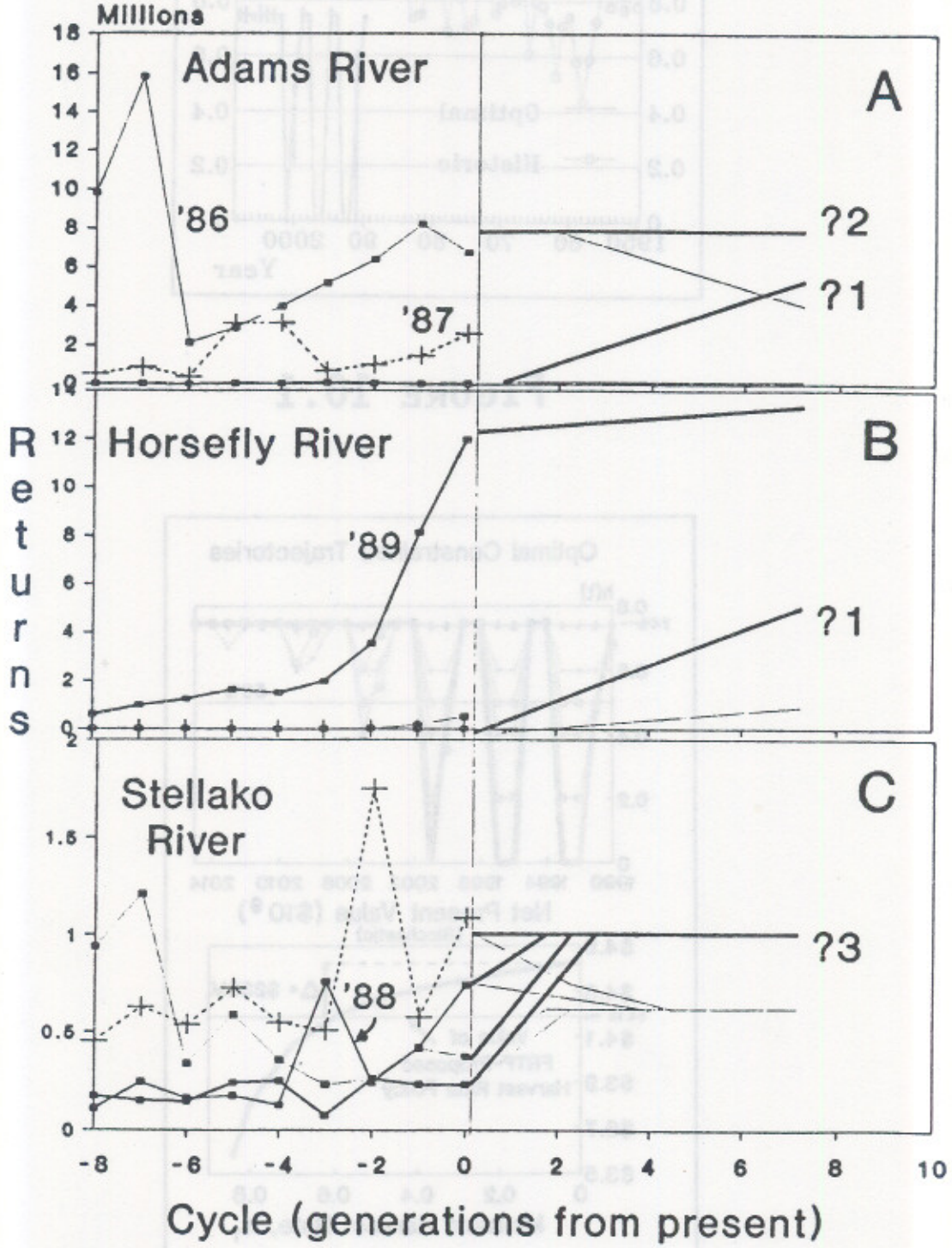

Millions
Adams River
A
'86
'87
?2
?1
Horsefly River
B
'89
?1
Returns
Stellako River
C
'88
?3
Cycle (generations from present)

FIGURE 8.1

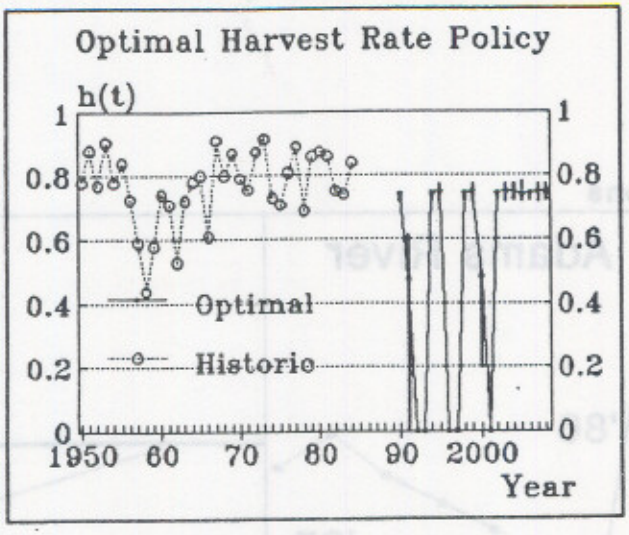


FIGURE 10.1

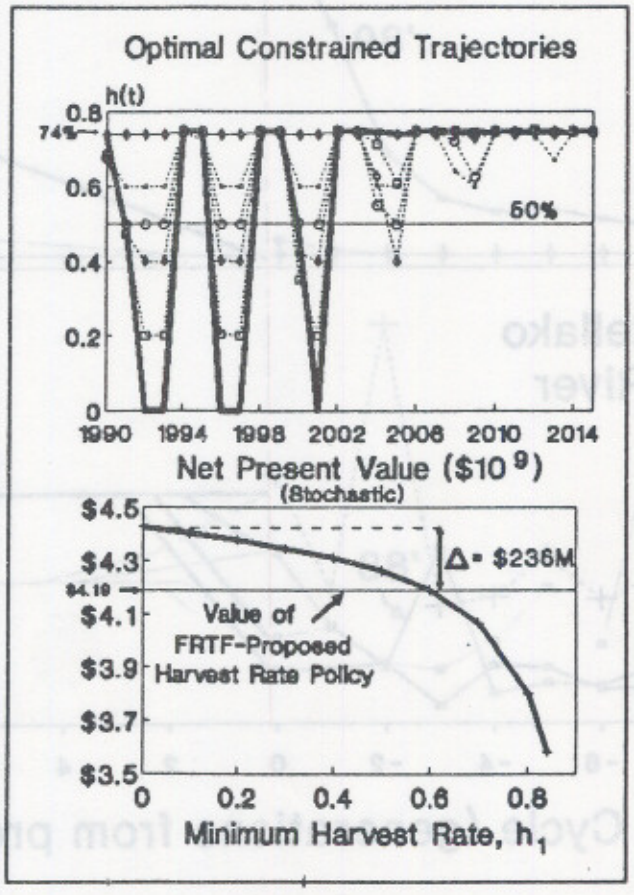


FIGURE 10.2

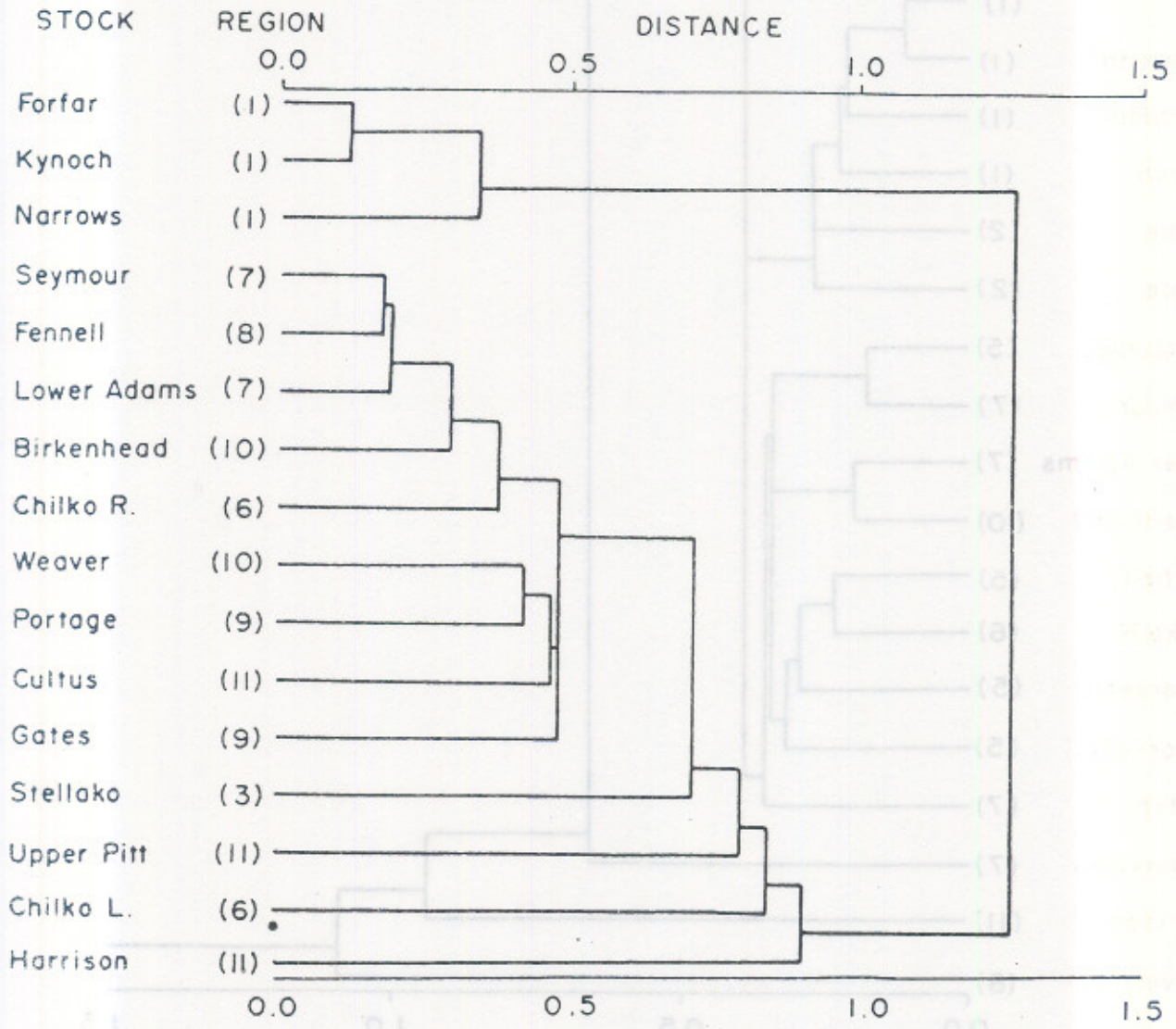

STOCK
REGION
DISTANCE
0.0
0.5
1.0
1.5
Forfar (1)
Kynoch (1)
Narrows (1)
Seymour (7)
Fennell (8)
Lower Adams (7)
Birkenhead (10)
Chilko R. (6)
Weaver (10)
Portage (9)
Cultus (11)
Gates (9)
Stellako (3)
Upper Pitt (11)
Chilko L. (6)
Harrison (11)
0.0
0.5
1.0
1.5

FIGURE 11.1

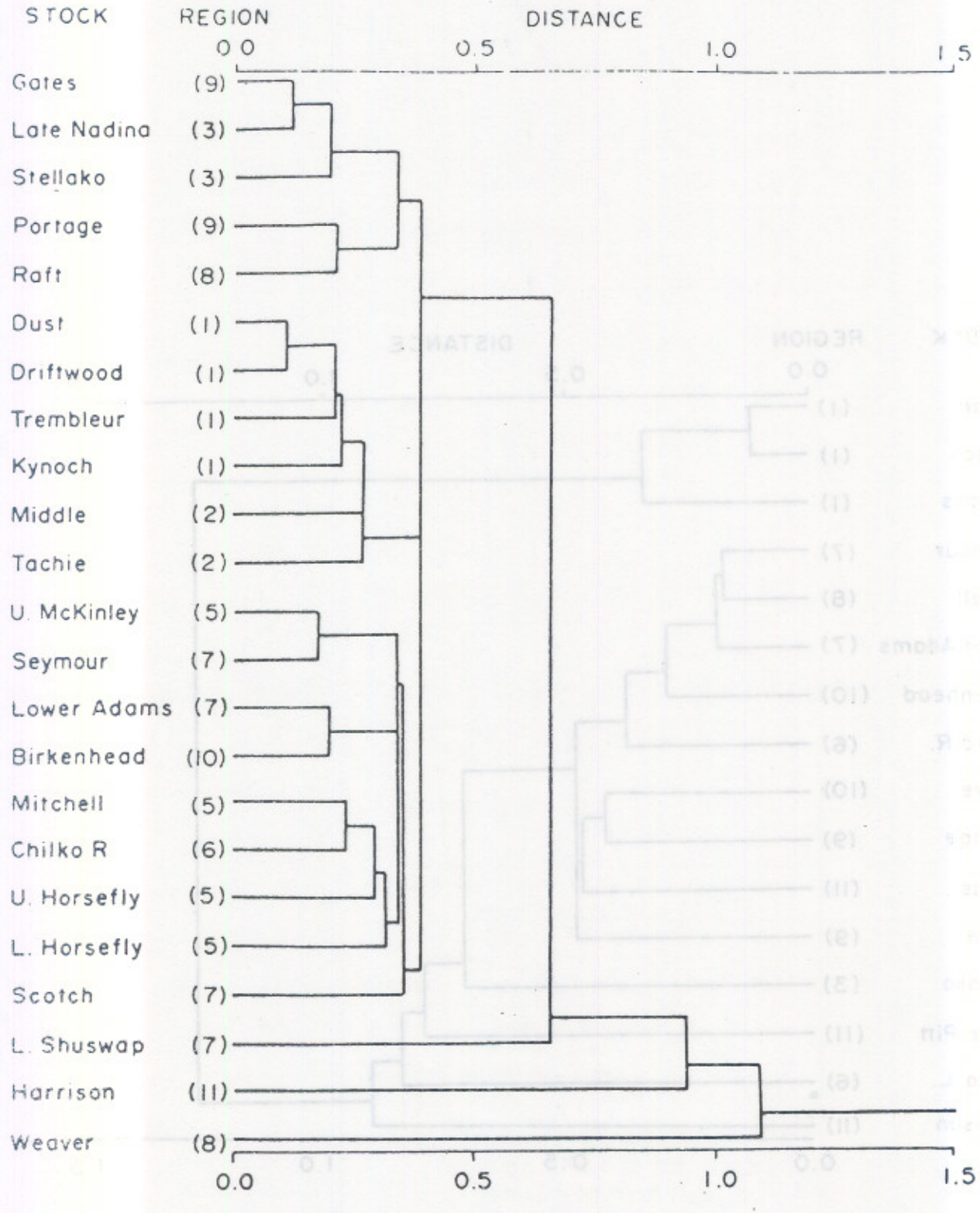

STOCK
REGION
DISTANCE
0.0
0.5
1.0
1.5
Gates (9)
Late Nadina (3)
Stellako (3)
Portage (9)
Raft (8)
Dust (1)
Driftwood (1)
Trembleur (1)
Kynoch (1)
Middle (2)
Tachie (2)
U. McKinley (5)
Seymour (7)
Lower Adams (7)
Birkenhead (10)
Mitchell (5)
Chilko R (6)
U. Horsefly (5)
L. Horsefly (5)
Scotch (7)
L. Shuswap (7)
Harrison (11)
Weaver (8)
0.0
0.5
1.0
1.5

FIGURE 11.2

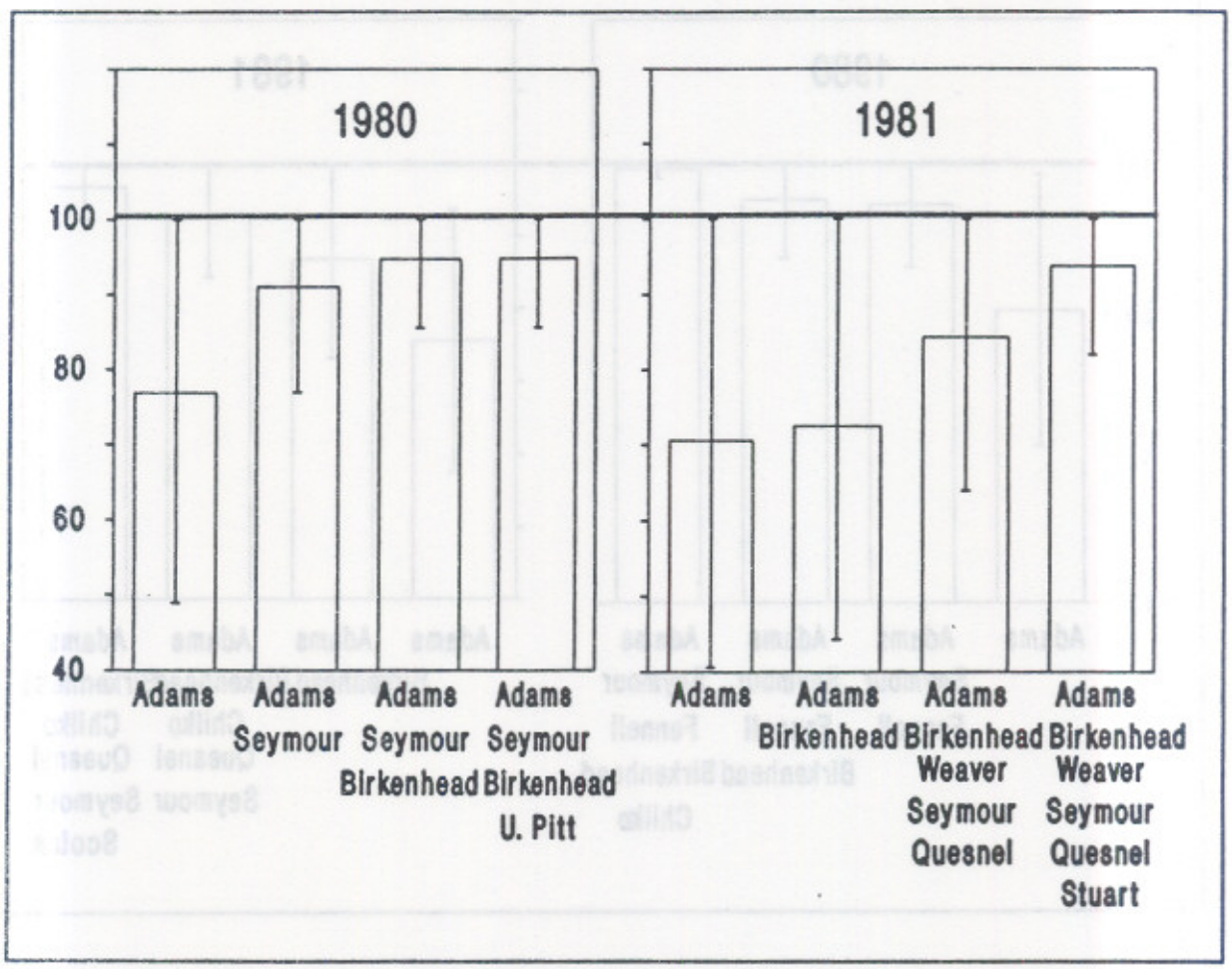

1980
1981
100
80
60
40
Adams
Adams Seymour
Adams Seymour Birkenhead
Adams Seymour Birkenhead U. Pitt
Adams
Adams Birkenhead
Adams Birkenhead Weaver Seymour Quesnel
Adams Birkenhead Weaver Seymour Quesnel Stuart

FIGURE 11.3

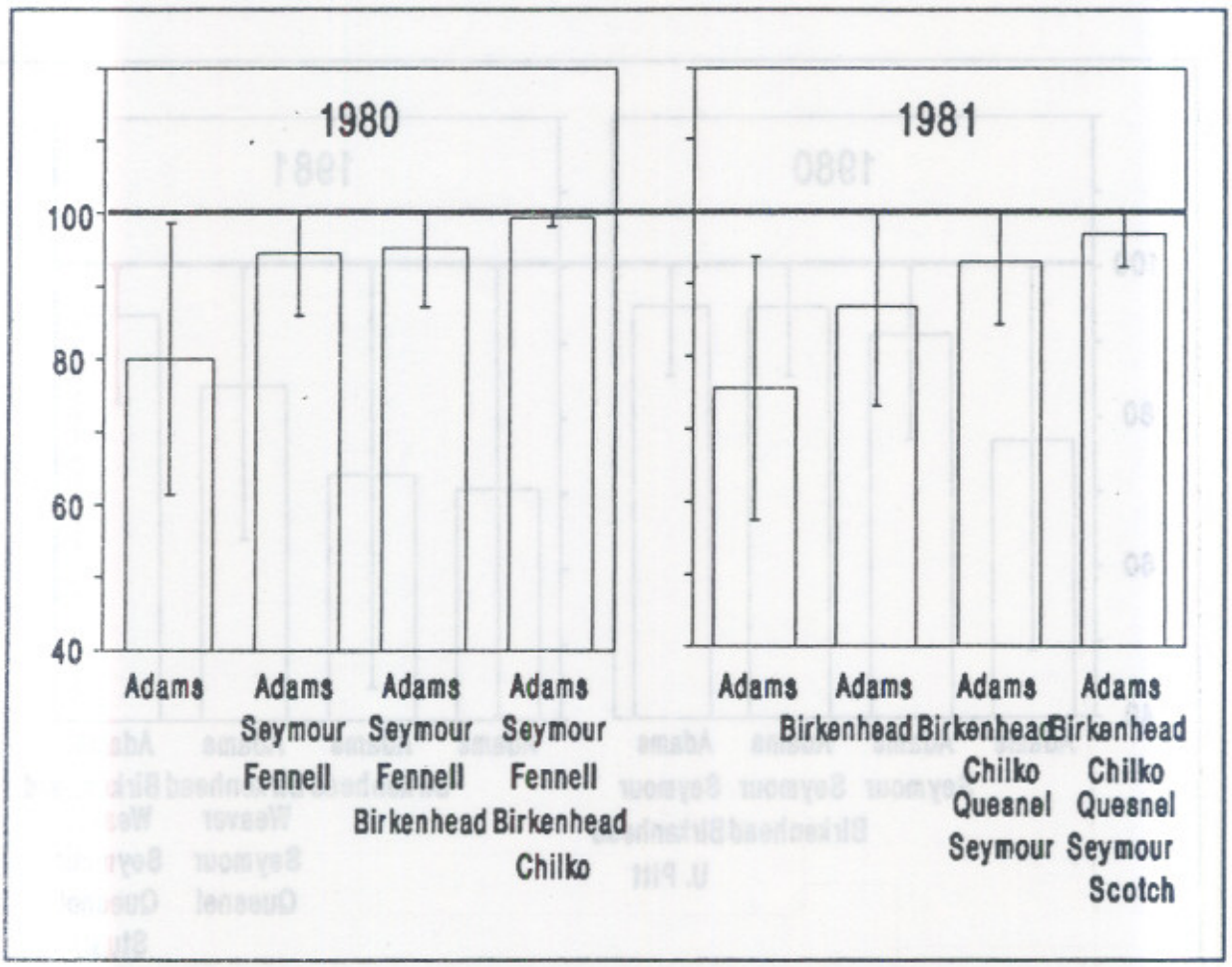

1980
1981
100
80
60
40
Adams
Adams Seymour Fennell
Adams Seymour Fennell Birkenhead
Adams Seymour Fennell Birkenhead Chilko
Adams
Adams Birkenhead
Adams Birkenhead Chilko Quesnel Seymour
Adams Birkenhead Chilko Quesnel Seymour Scotch

FIGURE 11.4

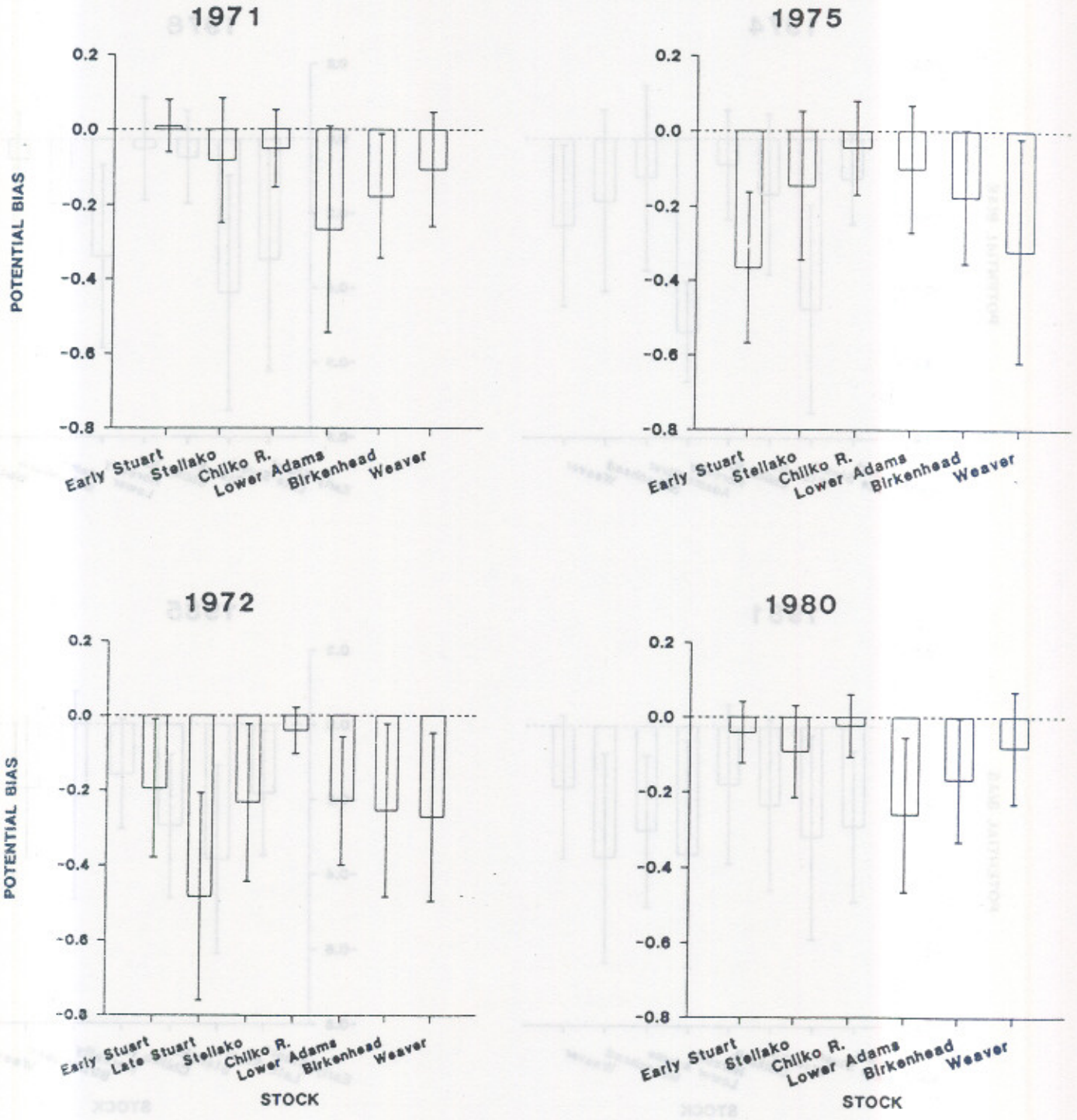

1971
1975
1972
1980
POTENTIAL BIAS
0.2
0.0
-0.2
-0.4
-0.6
-0.8
Early Stuart
Late Stuart
Stellako
Chilko R.
Lower Adams
Birkenhead
Weaver
STOCK

FIGURE 11.5

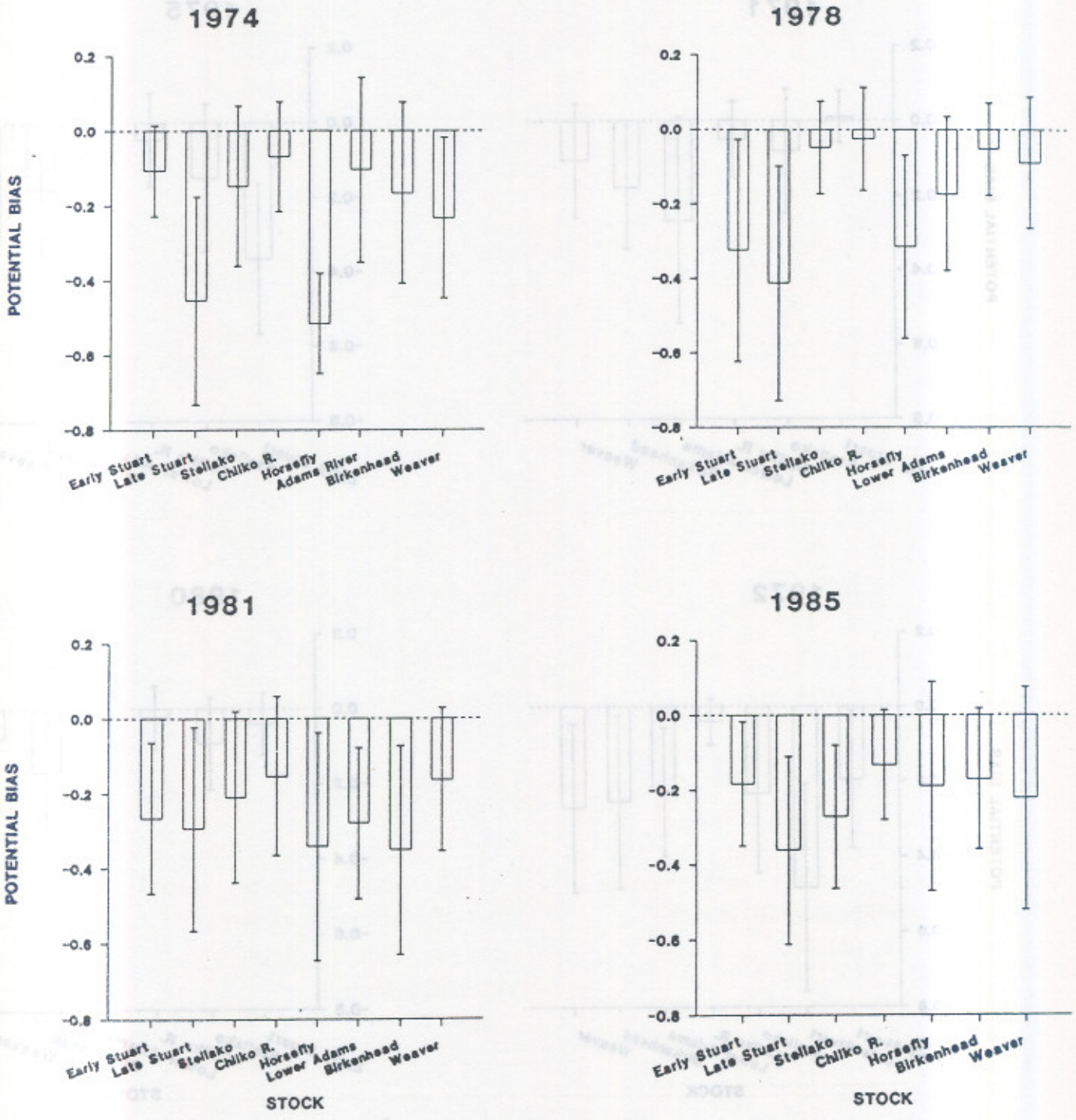


FIGURE 11.5 continued

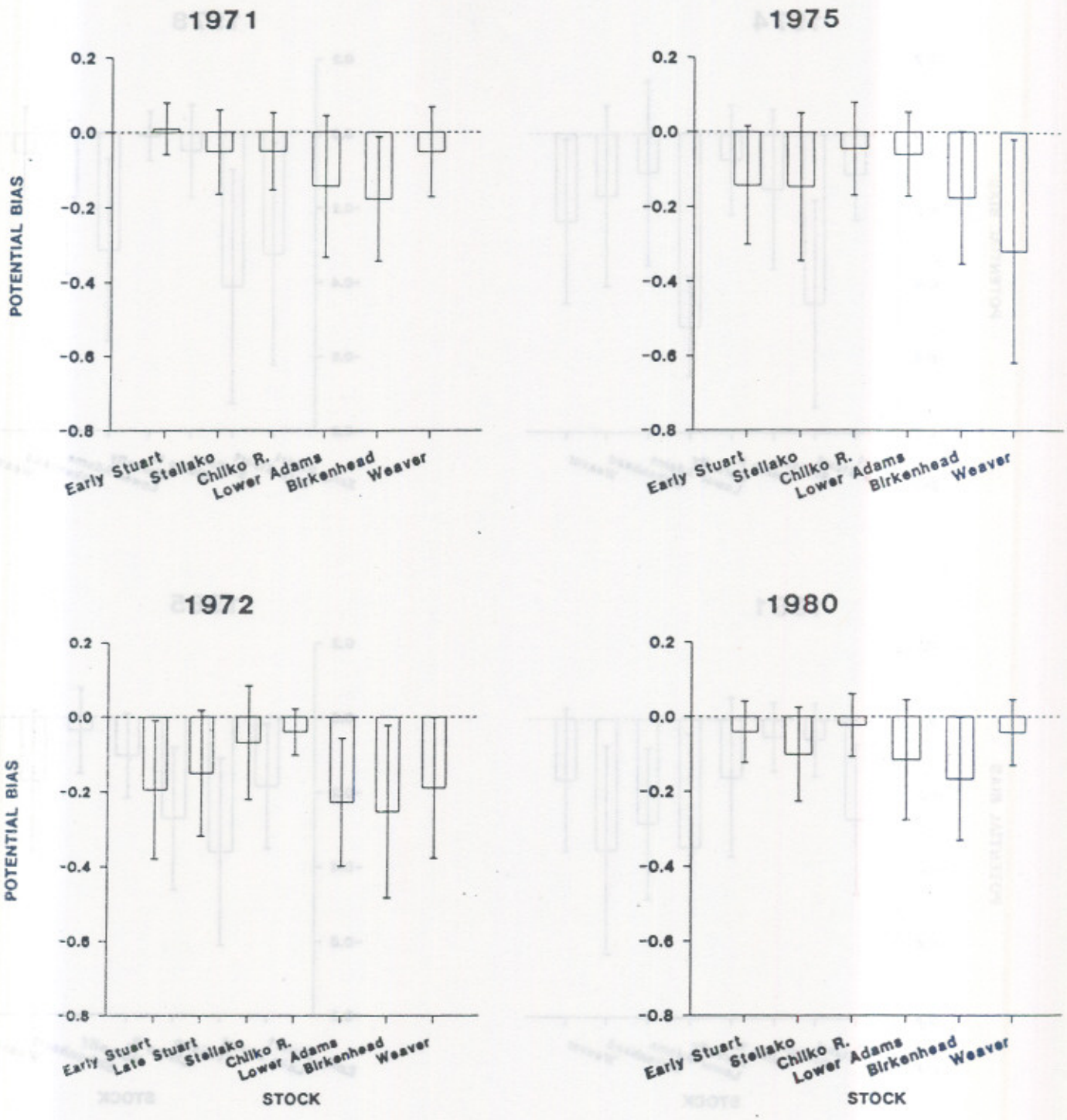

1971
1975
1972
1980
POTENTIAL BIAS
0.2
0.0
-0.2
-0.4
-0.6
-0.8
Early Stuart
Late Stuart
Stellako
Chilko R.
Lower Adams
Birkenhead
Weaver
STOCK

FIGURE 11.6.

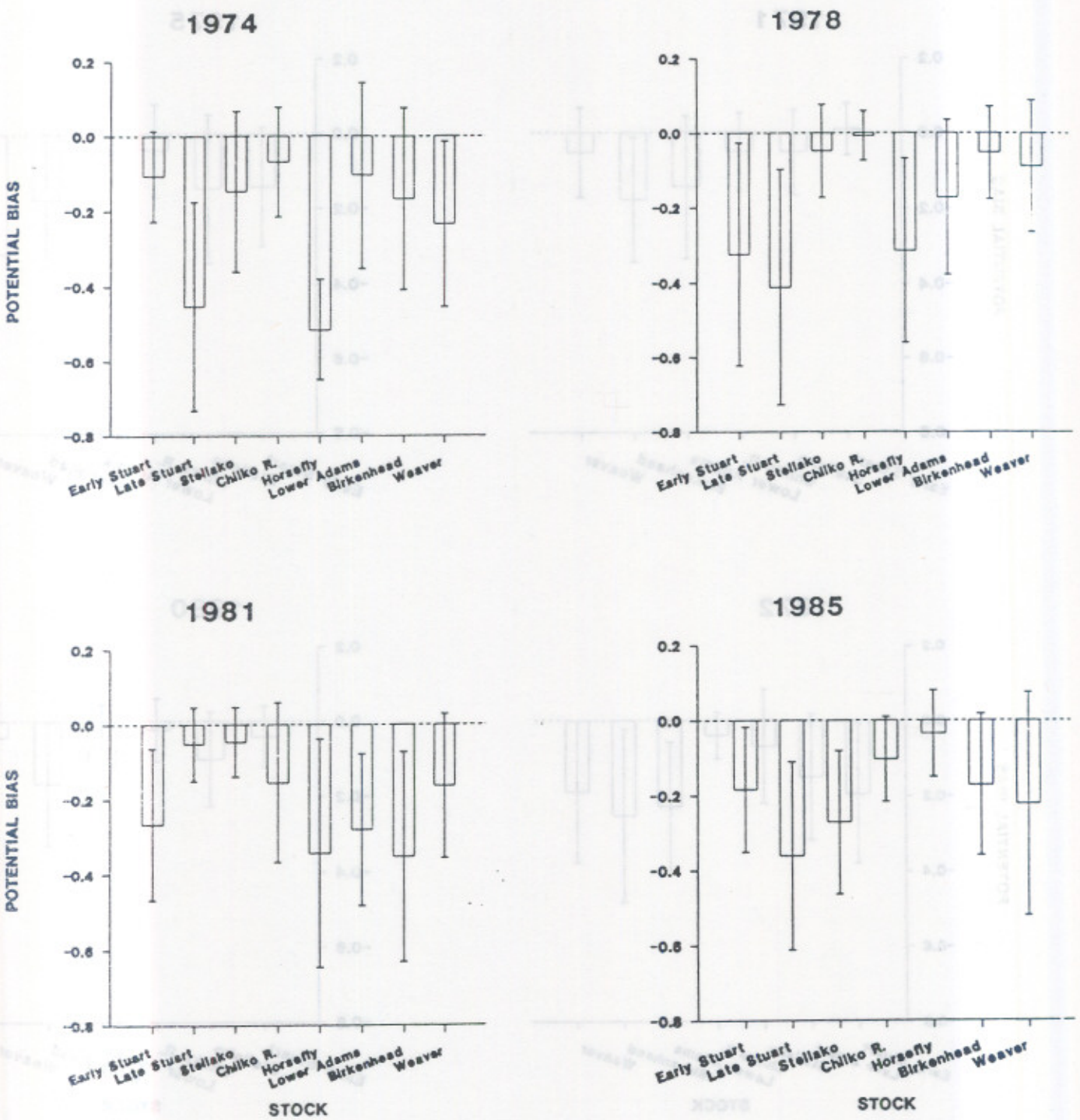


FIGURE 11.6 continued

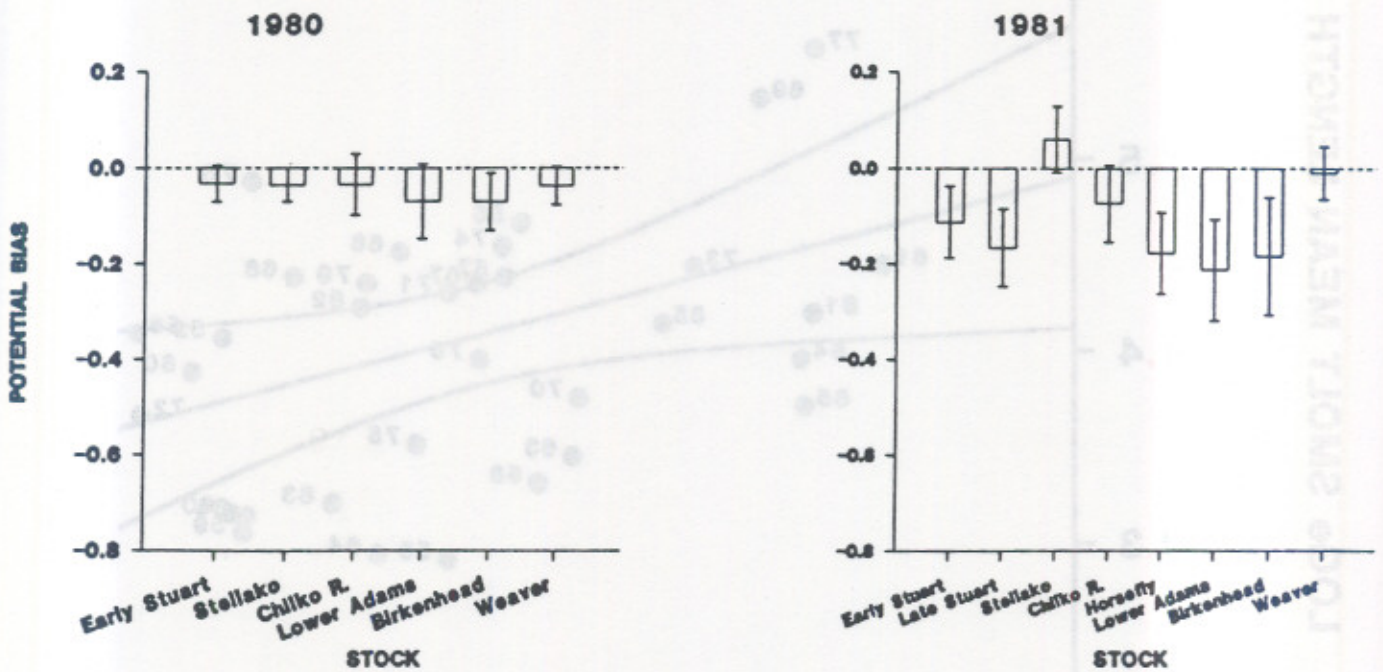

1980
1981
POTENTIAL BIAS
0.2
0.0
-0.2
-0.4
-0.6
-0.8
Early Stuart
Stellako
Chilko R.
Lower Adams
Birkenhead
Weaver
Early Stuart
Late Stuart
Stellako
Chilko R.
Horsefly
Lower Adams
Birkenhead
Weaver
STOCK
STOCK

FIGURE 11.7

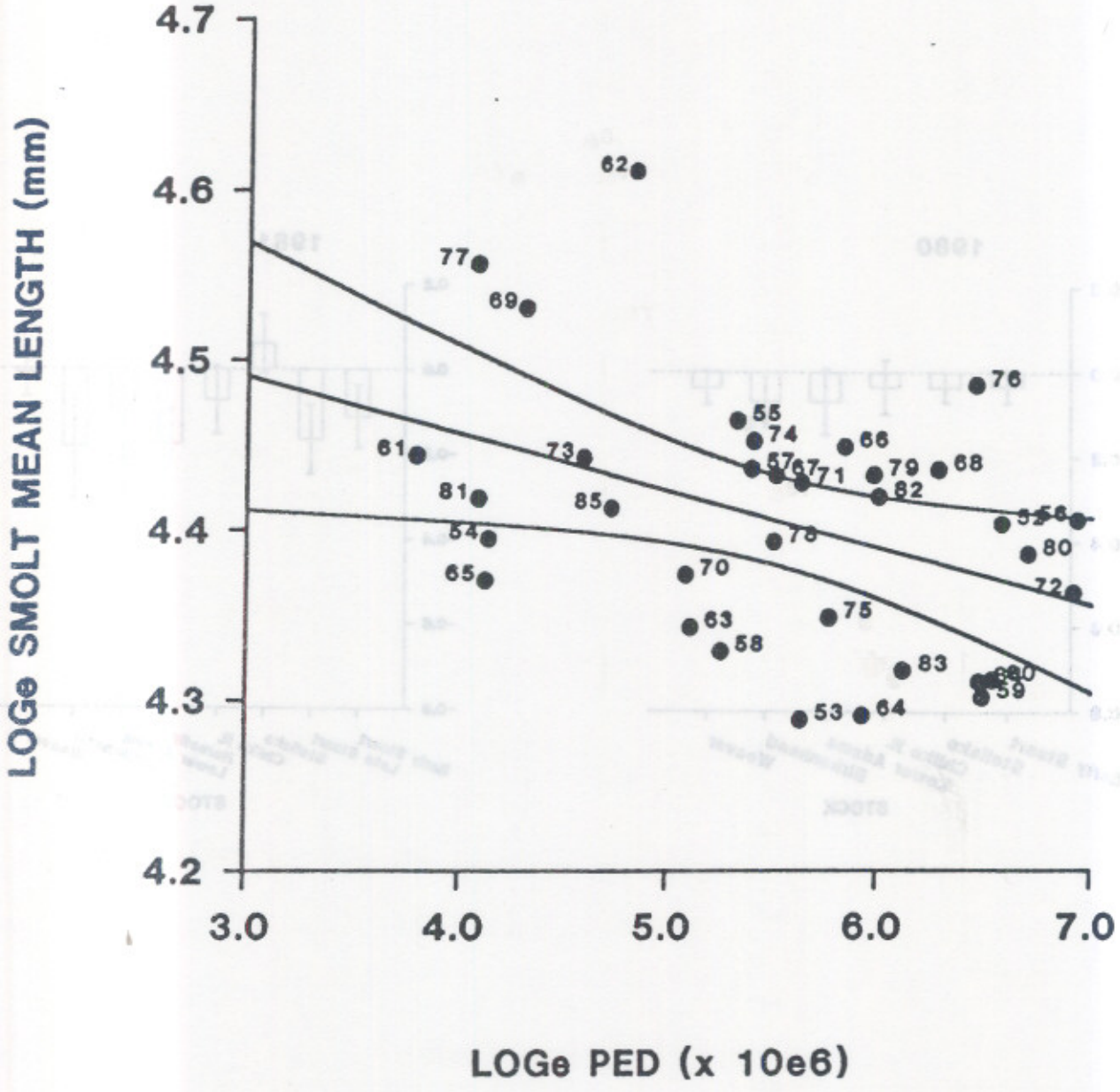

LOGe SMOLT MEAN LENGTH (mm)
4.7
4.6
4.5
4.4
4.3
4.2
3.0
4.0
5.0
6.0
7.0
LOGe PED (x 10e6)
62
77
69
76
55
74
66
61
73
57
67
71
79
68
81
85
82
54
78
80
65
70
72
63
75
58
83
59
53
64

FIGURE 12.1

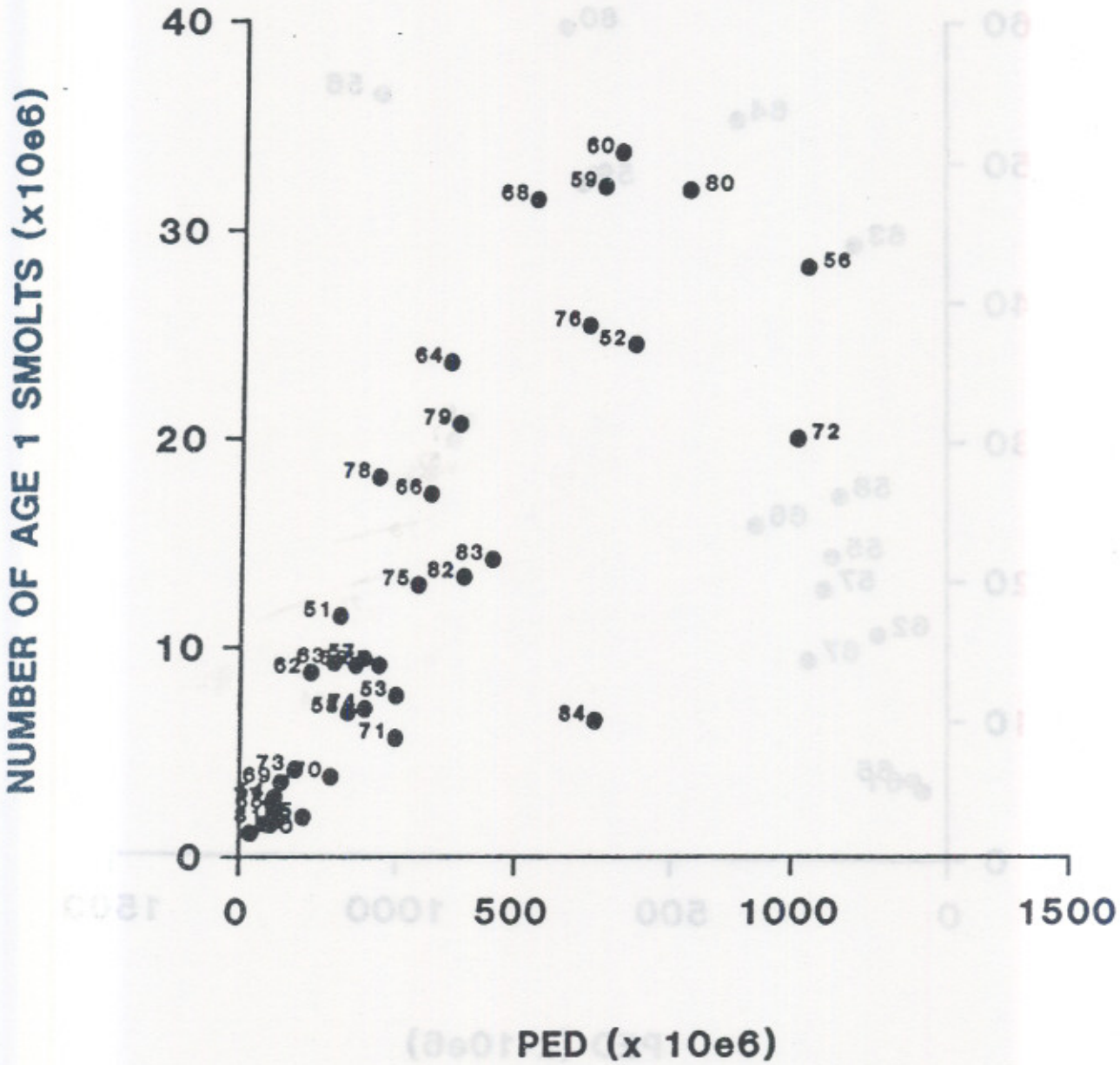

NUMBER OF AGE 1 SMOLTS (x10e6)
40
30
20
10
0
0
500
1000
1500
PED (x 10e6)
60
59
68
80
56
76
52
64
79
72
78
66
83
75
82
51
62
53
84
71
73
69

FIGURE 12.2

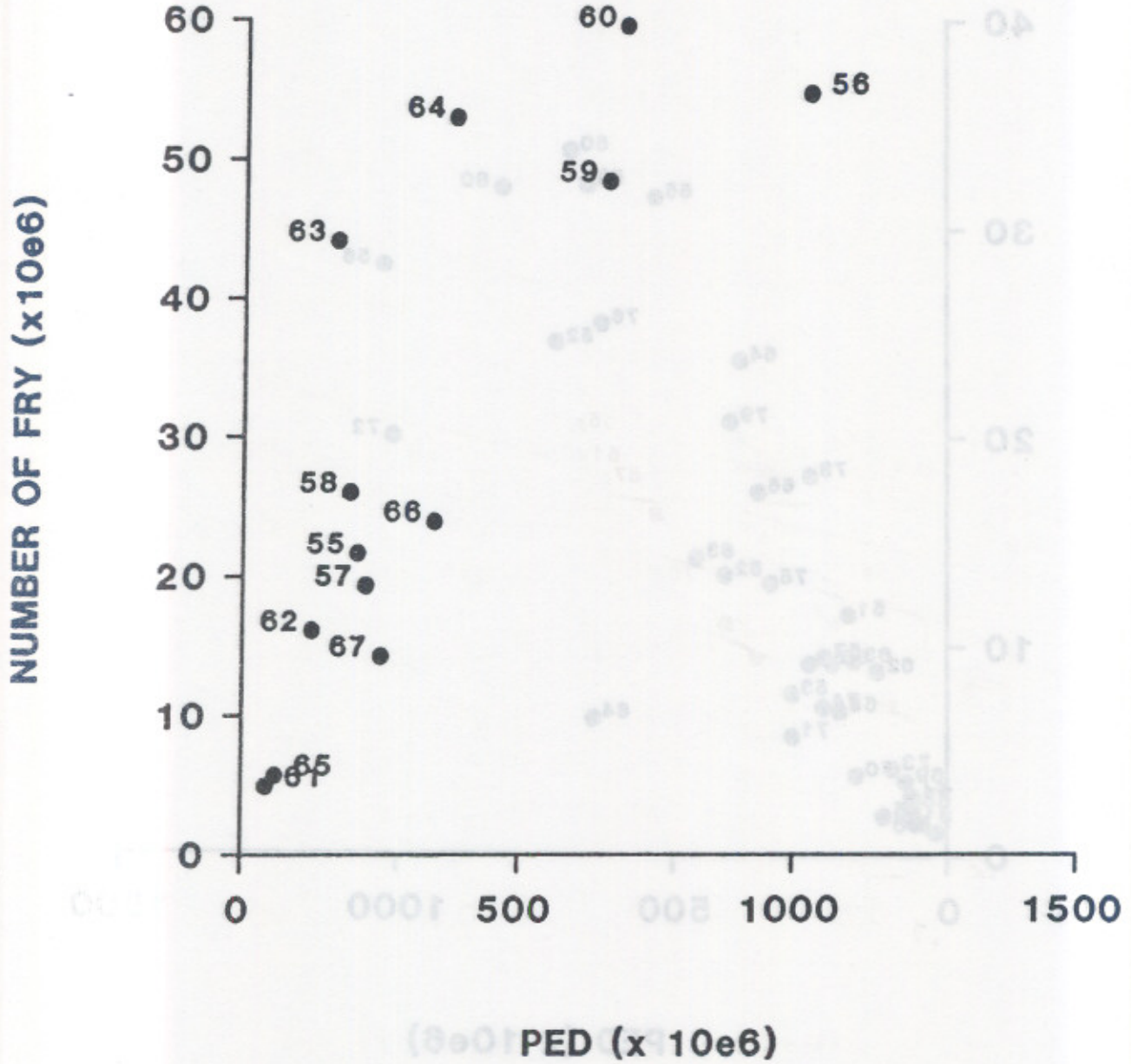

NUMBER OF FRY (x10e6)
PED (x 10e6)
0
10
20
30
40
50
60
0
500
1000
1500
60
56
64
59
63
58
66
55
57
62
67
65

FIGURE 12.3

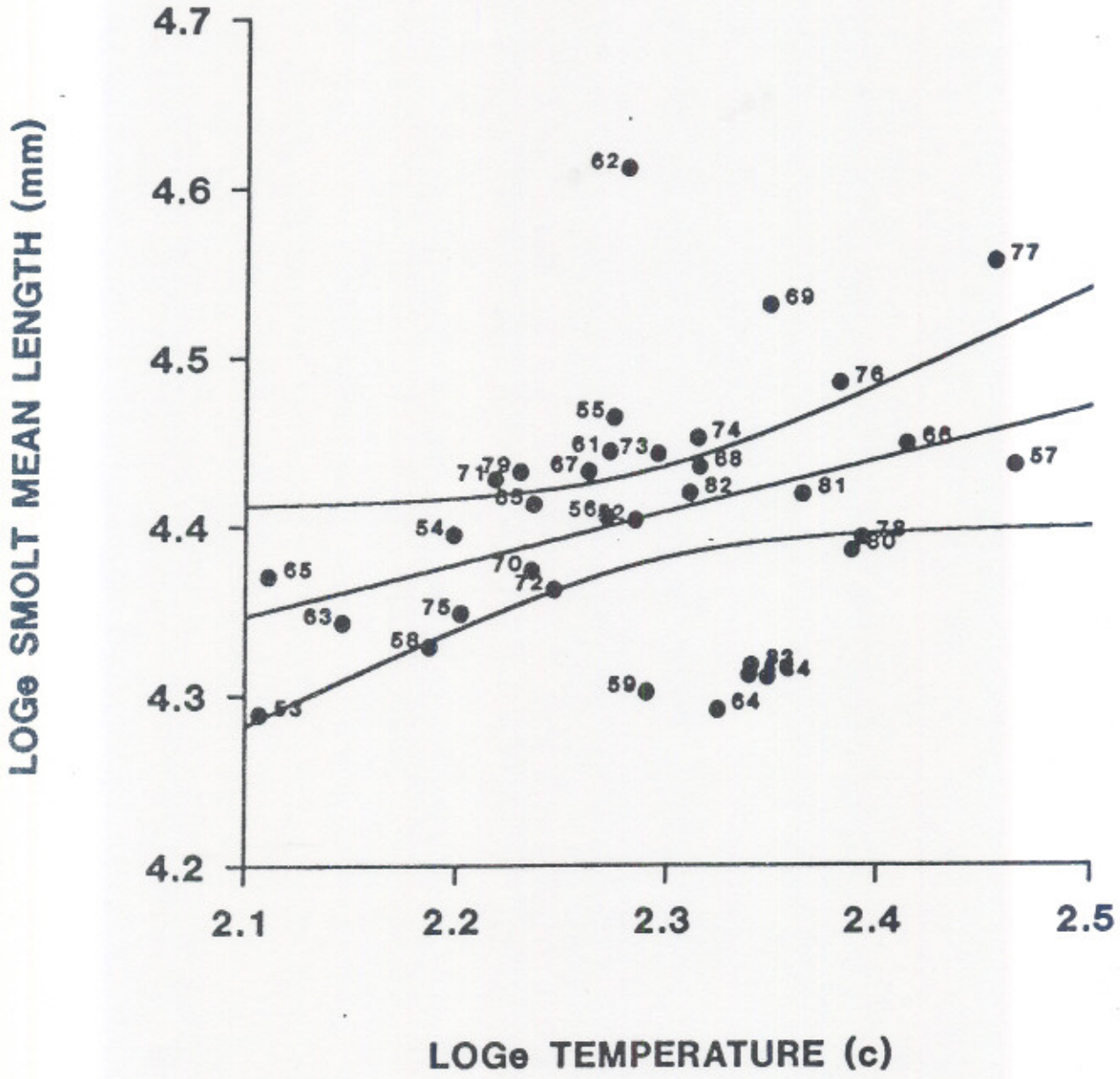

LOGe SMOLT MEAN LENGTH (mm)
4.7
4.6
4.5
4.4
4.3
4.2
2.1
2.2
2.3
2.4
2.5
LOGe TEMPERATURE (c)

FIGURE 12.4

APPENDIX 1. LIST OF PARTICIPANTS FOR THE SALMON SUB-COMMITTEE, APRIL 23-27, 1990.

MEMBERS: (*indicates not present)

D. Anderson - Chairman
T. Beacham
R. Harrison
R. Kadowaki
K. McGivney
D. Meerburg
D. Peacock
T. Perry
B. Riddell*
D. Schutz
P. Starr
C. Wood

AUTHORS:

D. Bailey
A. Cass
A. Gould
L. HopWo
K. Hyatt
L. Jantz
M. Joyce
C. McConnell
K. McGivney
P. Ryall
N. Schubert
T. Shardlow
B. Snyder
B. Spilsted
P. Starr
D. Welch
I. Winther
C. Wood
W. Saito

REVIEWERS: (*indicates not present to present review)

S. Argue
T. Beacham
A. Cass
R. Harrison
M. Henderson*
L. HopWo
K. Hyatt
J. Irvine
R. Kadowaki
C. MacKinnon
C. Wood
S. McKinnell
D. Peacock
K. Pitre
D. Radford*
B. Riddell*
W. Saito
R. Semple
P. Starr
G. Steer
D. Welch
C. West

OBSERVERS:

S. Farlinger (Chairman, PSARC)
G. Berezay
D. Blackburn
L. Collicutt
D. Harding
L. Lapi
W. Luedke
D. Nagtegaal

APPENDIX 2. WORKING PAPERS PRESENTED TO THE SALMON SUB-COMMITTEE, APRIL 23 TO 27, 1990, NANAIMO, B.C.

Paper Number	Title	Authors
S90-1	Chairman's Report. for the 1989 Salmon Sub-committee.	D. Anderson B. Riddell
S90-3	Assessment of Kitimat Arm Chinook Stocks.	D. Peacock B. Snyder
S90-5	Fraser Sockeye Forecasting Methodologies.	W. Saito G. Smith
S90-6	Experimental Rebuilding of Off-Year Cycles in Selected Fraser River Sockeye Stocks: Further Recommendations from the Cyclic Dominance Working Group.	C. Wood
S90-7	Stock Status of Stikine Sockeye.	C. Wood S. Johnston
S90-8	Fraser River Sockeye Interim Escapement Goals.	K. McGivney W. Saito R. Harrison
S90-9	Assessment of Stock Identification Capabilities for Fraser sockeye.	A. Cass
S90-10	Assessment of Chilko Sockeye.	A. Cass
S90-11	Framework for Estimating Escapement of Naturally Spawning Mark Returns Produced by SEP Facilities.	D. Bailey C. Cross K. Pitre K. West D. Plotnikoff
S90-13	Update Assessment of Harrison River Chinook Salmon.	P. Starr N. Schubert
S90-15	Status of W.C.V.I. Natural Spawning Chinook Populations with a Proposed Method for Evaluating the Reliability of Escapement Counts.	T. Shardlow C. McConnell
S90-16	Report From a P.S.A.R.C. Workshop on Status and Useability of Hook & Line Computer Simulation Models in British Columbia.	T. Shardlow (Chairman) P. Ryall

Paper Number	Title	Authors
S90-19	Stock Status and 1990 Forecasts of Barkley Sound Sockeye.	K. Hyatt S. Heizer
S90-20	Performance of 1989 Forecast, 1990 Forecast and Fishery Impacts; Smith Inlet Sockeye	R. Goruk I. Winther
S90-21	Performance of 1989 Forecast, 1990 Forecast and Fishery Impacts; Rivers Inlet Sockeye.	R. Goruk
S90-22	Performance of 1989 Forecast, 1990 Forecast and Fishery Impacts; Skeena River Sockeye.	L. Jantz M. Henderson
S90-23	Performance of 1989 Forecast, 1990 Forecast and Fishery Impacts; Nass River Sockeye.	L. Jantz M. Henderson
S90-24	Performance of 1989 Forecast, 1990 Forecast and Fishery Impacts; Fraser Sockeye.	W. Saito
S90-25	Evaluation of the 1989 Return and the 1990 Forecast and Fishery Impacts; Johnstone Strait - Fraser River Chum.	A. Gould M. Joyce L. HopWo
S90-28	Performance of 1989 Forecast, 1990 Forecastand Fishery Impacts; Bella Coola Chum.	R. Goruk
S90-29	Performance of 1989 Forecast, 1990 Forecast and Estimation of Population Statistics; Big Qualicum Chinook.	P. Starr
S90-30	Evaluation of 1988 Returns, 1990 Forecast and Fishery Impacts; Johnstone St. - St. of Georgia Pink.	A. Gould L. HopWo
S90-31	Performance of 1988 Forecast, 1990 Forecast and Fishery Impacts; Skeena River Pink.	L. Jantz
S90-33	Optimal Harvest Rate Policies for Rebuilding the Adams Sockeye.	D. Welch

CONTENTS

1. STEERING COMMITTEE REPORT. The PSARC Steering Committee met to review the Shellfish Subcommittee Report September 13, 1990 at the Coast Bastion Inn, Nanaimo. The subcommittee report was reviewed and the following recommendations particularly noted.

1) Abalone stocks are at a level estimated to be 4% of prefishery biomass. Closure of abalone fisheries is recommended. This follows the 1989 PSARC recommendation to do a resurvey to confirm stock levels. The survey is complete and low stock levels are widely recognized. Abalone occur from the lower intertidal zone to at least 100 m in depth, with greatest concentrations from 0 tide to 5 m in depth.

2) The Subcommittee recommendation to consider euphausiid fisheries was discussed at length. The Steering Committee wishes to note concern about fisheries on "forage" species, which are low in the food chain. Effects of fishing would be very difficult to detect.

2. SHELLFISH SUBCOMMITTEE REPORT.

INTRODUCTION

This report is a summary of advice and recommendations resulting from the PSARC Shellfish Subcommittee, held August 28, 29, 1990 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 in the 1980s but declined slightly in 1988 and 1989 compared to the previous year (Table 1). Declines in landings occurred in geoduck and sea

cucumber and reflects changes in management. A decline in manila clam landings of 20% in 1989 from 1988 is followed by a continued decrease in 1990. It is likely that landings for this species reflects annual recruitment to the fishery. 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 eighteen hundred intertidal harvesters. Shellfish are of considerable importance in the recreational fishery and it is estimated that 37,000 people participate in this fishery.

The landed value of invertebrate fisheries was about $46 million (including oysters, $5.2 million) in 1989, an increase over the previous year (Table 2). This increase was due primarily to a significant increase in the price paid for sea cucumbers and geoducks. Intertidal clams, prawns and geoducks accounted for almost 75% of the total landed value of invertebrates in 1989 (Fig 2).

Recommendations from this subcommittee in 1989 formed the basis of 1990 fishing plan and a similar situation will pertain for formation of the 1991 fishing plan and planning for research work for 1991. Considerable work has been accomplished and initiated but important work has not been initiated due to lack of resources. As a result, many recommendations this year are the same as in the past and are still regarded as high priority.

The subcommittee particularly wishes to note the following:

i) The survey and all data reviewed show a continued widespread decline in abalone stocks; these results led to the recommendation to close abalone fisheries.

ii)The need for support for harvest log programs is reiterated. These supply the only reliable source of information for many of these fisheries. Support has been eroded rather than increased.

iii)Basic work required to support management for the red sea urchin fishery and the sea cucumber fishery is still required.

MANAGEMENT POLICY

Substantial changes to management have been made from 1989 to the present including licence limitation and area licensing. Management policies have been outlined below.

MAJOR FISHERIES

Dungeness Crab Fisheries: Entry will be limited in 1991.

- 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 limited in 1990.

- 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 will be limited in 1991.

- 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 will be limited in 1991.

- 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 licence.

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

Sea Cucumber: Entry will be limited in 1991.

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

Shrimp Trawl: This is a limited entry fishery.

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

MINOR OR DEVELOPING FISHERIES

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

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

Specific fishing limitations have been set for euphausiids (quotas) and for scallops (size limits).

Euphausiids - Plankton: A conservative quota (500 t) has been set for inshore waters (Strait of Georgia and adjacent waters). Recommendations are made here to expand opportunities for exploratory fisheries.

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

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. Change in escape port size and number (2 ports at 110mm). 2. Excessive proportions of undersize crab in Fraser RIver sport fishery should be investigated.
Prawn	1. No change in advice to management. 2. Continue experimental management in study areas. 3. Continue mandatory harvest log program. 4. Continue annual coastwide closure.
INTERTIDAL	
Intertidal clams	1. No change in advice to management. 2. Research in progress to examine effects of digging on juvenile clams. 3. Surveys suggest stocks are available to initiate exploratory fisheries in the Central Coast. 4. Research into clam farming techniques is required.
DIVE	
Geoduck	1. Conservative levels of harvest should be used. 2. Rotational fisheries should be maintained to reduce local overharvesting and to minimize effect of fishing on recruitment. 3. Estimates of numbers of geoduck per square meter and bed area used to calculate the quotas need to be substantiated. 4. Fished beds should be examined for effects of fishing on recruitment.

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

Major Fishery	Biological Advice and Information
Red Sea Urchin	1. No change in advice to management. 2. Continue harvest log system. 3. Continue and expand research to obtain biological information required to manage resource (size limit and other).
Abalone	1. Close the abalone fishery. 2. Closure to extend to all user groups. 3. Rehabilitation/enhancement options should be developed. 4. Surveys should continue and expand into other areas to monitor recovery.
Sea cucumber	1. No change in advice to management. 2. Continue harvest log program. 3. Expand research to provide basic biological data.
NET	
Shrimp trawl	1. Delay area 124 opening until August to maximize yield per recruit 2. A study to examine biological basis for fluctuations in offshore shrimp stocks should be initiated using existing data. 3. A survey should be conducted in 1991 to test previous survey techniques. 4. A review of inshore fisheries is required to develop a management plan for these fisheries.

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 for tanner crab. 2. Maintain harvest logbook program.
NET	
Squid inshore	1. Continue harvest logbook program
Euphausiids	1. Exploratory fisheries could be considered. Biological monitoring should be required as a condition of licence. 2. Effort should be dispersed throughout fishing areas.
DIVE	
Scallops	1. Continue harvest logbook program 2. Monitor trawl catches.
Horse clams	1. A size limit is inappropriate for this species. 2. Catches should be monitored to detect changes in mean size in harvest. 3. Research is required to evaluate rotational fishery strategy. 4. Continue harvest logbook program.
Octopus	1. Continue harvest logbook program.
Purple sea urchin	1. A cautious approach to purple urchin management should be adopted. Any experimental permits issued should be closely monitored and areas rotated.

SUMMARY OF BIOLOGICAL ADVICE FOR MANAGEMENT OF MINOR INVERTEBRATE FISHERIES IN 1990 CONT'D

Minor Fishery	Biological Advice
INTERTIDAL	
Gooseneck barnacle	1. Continue harvest logbook program.
	2. Resurvey study sites for recruitment
Mussels	1. Minor fishery. Monitor landings.

POSITION PAPERS AND RECOMMENDATIONS

Dungeness Crab (I90-1)

Dungeness crab traps containing various escape port sizes and frequencies and with either 2 or 4 entrance mouth triggers were tested to evaluate trap selectivity. Eighty experimental traps were fished during each of 2, 2-week periods in 1989 in the Tofino area. In each trap one of five escape port diameters was used: 100, 106, 108, 110, and 112 mm; in combination with the two port and trigger frequencies. In addition, 10 double wired traps with no escape ports were fished as controls. During the study a total of 2000 male and 1188 female crab were captured and sampled. The catch rate of sublegal sized crab (<165 mm carapace width) was considerably reduced with increasing ring size. There was little difference in retention of legal sized crab between the 108 and 110 mm ring sizes but catch rate decreased significantly with a 112 mm ring. Having 1 or 2 ports or 2 or 4 triggers had little effect on trap selectivity.

The escape port size of 100 mm presently in Canadian regulation has no biological basis. Adjacent American states all require 2 escape ports of at least 108 mm diameter, although the biological data supporting a regulation indicated a 114 mm ring was most optimal. Evidence from this study supports increasing escape port size to 110 mm in Canadian regulation.

Reviewers Comments

Two reviews of this paper are available.

Two reviewers expressed the view that the study had merit and the paper was generally well written. The reviewers agreed that the results of the study substantiated the recommended increase in escape port size.

Subcommittee Recommendations

1. Commercial crab trap escape port regulations should be modified to include two ports per trap, each of 110 mm diameter. A second escape port is recommended to allow for escapement when one port is blocked by debris.

Development of Clam Farming Policy (I90-2)

There has been a significant change in the harvest of intertidal clams in the past twenty years. Until the mid 1970's the main species harvested was the butter clam, Saxidomus giganteus. Since then steamer clams, littleneck, Protothaca staminea and manila, Tapes philippinarum, have been the main species harvested and since the mid 1980's manila clams have comprised over 75% of intertidal clam landings. The increase in manila clam landings was the result of strong markets and an abundance of labour. As a result many beaches in the south coast district have been dug several times in a year and there has been a tendency to harvest manila clams in restricted areas. Landings of manila clams have decreased in the last two years because accumulated stock has been removed and now the industry must rely mainly on incoming single year classes.

The decline in abundance and landings of manila clams has prompted people in industry to consider the possibility of clam farming to augment harvest of the wild resource. This attitude is due not only to strong markets but also to the success of clam farming operations in other places, particularly the State of Washington. Many west coast bivalve hatcheries are now producing juvenile manila clams so seed is readily available.

Present DFO policy only permits calm farming operations in areas where there is no history of commercial, recreational or native clam harvest. This policy will have to be changed if clam farming is to be encouraged in British Columbia.

The advantages and disadvantages of culture over wild harvest are well known. The main problem for regulatory agencies will be to insure that people are actually farming an area and not simply

treating it as a private clam beach. Six criteria are presented that can be used either singly or in combination to assure that clam farming is actually being undertaken.

Short and long term clam farming policies are suggested for DFO. The short term policy would last for a period of 5-10 years and would permit clam farming on all existing oyster leases, on intertidal areas fronting Indian reserves and in the north coast district. Results of clam farming would be monitored closely in the short term period to determine the viability of such operations. If clam farming was successful, then the long term policy could be introduced in which beaches would be taken out of the common property resource (up to 25% in any area) and assigned to people for clam farming operations.

Intertidal Clam Survey (I90-3)

A survey to assess intertidal clam stocks in eight areas in the north coast district (Areas 4-7) was undertaken from June 20-27, 1990. Beaches selected for survey extended from Kitkatla Inlet in the north (Area 4) to two areas in Area 6 and to several beaches in the Bella Bella area (area 7). Estimates of abundance and growth were determined for butter clams, Saxidomus giganteus, littleneck clams, Protothaca staminea, and manila clams, Tapes philippinarum. The area of the clam bearing part of the beach and substrate type was determined. Additional sampling was undertaken to determine the northward distribution of manila clams and to assess if commercially harvestable quantities of this species exist in the north coast district.

Butter and littleneck clams were found in all areas suveyed. Density of butter clams ranged from 0-204 per square meter for legal sized clams (63 mm shell length and larger) and 1-292 for sublegal sized clams. At most sites sublegal sized butter clams comprised at least half the catch indicating that consistent recruitment has occurred in recent years. Growth was similar in most areas, the legal size was attained in 7-8 years.

Littleneck clams were the most abundant bivalve sampled during the survey. Density of legal (38 mm shell length and larger) and sublegal sized littleneck clams ranged from 0-224 and 0-436 per square meter respectively. Sublegal sized clams were abundant at most sampling sites indicating that consistent recruitment has occurred in recent years. Growth was similar at most sampling locations, the legal size was generally attained in 3.5-4 years.

Manila clams were not found in abundance north of Milbanke Sound, the farthest north specimen was at Hird Point in Mathieson Channel (Area 6). South of Milbanke Sound density of legal (38 mm shell length and larger) and sublegal sized manila clams ranged from 14-170 and 3-168 per square meter respectively. In other

plots dug specifically to assess numbers of manila clams, density ranged from 0-248 per square meter. There were large accumulations of manila clam shell on many beaches in area 7 indicating there have been substantial populations of manila clams in this area for at least the past ten years. On many beaches there was a preponderance of larger sized manila clams indicating that recruitment has not been consistent in recent years. Growth was similar in most areas, the legal size was generally attained in 3.5 years.

Commercially harvestable quantities of all three species, butter, littleneck and manila, exist in the north coast district.

Reviewers Comments

One review of this paper is available.

The reviewer noted the importance of this survey due to the lack of historic information since these areas are not readily accessible. It was suggested that the annuli on stunted clams be measured so that the growth at older ages may not be overestimated. When inconsistent recruitment is discussed, a measure of "normal" or "inconsistent" recruitment should be provided.

Subcommittee Recommendations

The subcommittee did not accept recommendations for further surveys to determine abundance.

1. An exploratory fishery for clams should be encouraged in the Central Coast based on availability of clams subject the required public health surveys (PSP and water quality).

<u>Euphausiid fishery review regarding potential expansion concerns (I90-4)</u>

Recent interest from industry in expanding quotas for the B.C. euphausiid fishery has resulted in this review of 1)history of euphausiid fishing to date, 2) knowledge of the biology of the species involved, and 3) concerns about the impact of possible expansion on the dynamics of other commercial species. Research recommendations to improve our understanding of euphausiid biology and its importance ot other species are suggested. To permit collection of additional biological data, exploratory quotas on an area basis are recommended. Quota levels should be pre-emptive, conservative and should be set so as to have minimal impact on the dynamics of other species.

Reviewers Comments

One review of this paper is available

The reviewer found this paper to be in general, a very thorough and clearly written review of the subject. He had no major reservations about its contents and agrees with most of the points of necessary future research. He agreed that the authors have been properly cautious, but perhaps could have emphasized to an even greater degree the difficulty of getting clear-cut results from this kind of work in the short-to-medium-term. The reviewer provided the author with a number of detailed comments.

Subcommittee recommendations

The Subcommittee did not approve quotas suggested in the paper, and put the following recommendations forward:

1) Exploratory fisheries for euphausiids should be considered on a coastwide basis with restrictive ceilings on catch. Biological monitoring should be required as a condition of licence as determined by research and management biologists.
2) Fishery effort should be dispersed throughout the areas to maximize information.

Results of the 1990 shrimp survey (I90-5)

This report summarizes results of the area-swept trawl survey off the west coast of Vancouver Island during a shrimp biomass survey in the spring of 1990. This survey is one in a continuing series conducted during the same time period each year to assess abundance and distribution of the pink shrimp, Pandalus jordani. Detailed catch records and resulting evaluations of biomass and year-class strength are presented. A comparison with previous surveys to the same area is shown. Biomass estimate was ≈2665 metric tonnes in areas of density > 1 metric tonnes. This is about 76% of the 1989 abundance. In terms of age class distribution it shows a 15% increase of 3+ animals, a 39% decline in 2+ animals and a 82% decline in 1+ animals (N.B. 1+ indices are very suspect as the animals are not fully recruited to the fishing gear). Yield per recruit analysis from the previous report suggests maximum yield occurs in late summer.

Reviewers Comments

One review of this paper is available.

The reviewer states that the paper presents a clear and concise picture of the status of the smooth pink stock off the west

coast of Vancouver Island. This is part of an ongoing study that has included similar surveys in almost every year since 1973. As a result of this long series of data we now have a good understanding of the dynamics of this shrimp population and some of the factors that affect its abundance.

The reviewer recommends that this survey be continued in 1991. As well, the results should be communicated to MAF who provide assistance to small plants dependent on this fishery.

Subcommittee recommendations

1) Area 124 offshore shrimp fishery opening should be delayed until August 1991 to maximize yield per recruit. Exploration and utilization of other stocks should be encouraged.

2) A study should be initiated to explore the biological basis for fluctuations on offshore shrimp stocks using existing Canadian and US data bases.

3) A repeat trawl survey with gear mensuration should be done to verify assumptions of catchability and gear behaviour. This survey should be done in 1991 to take advantage of shrimp abundances.

Climatic change and the intertidal influences (I90-6)

This paper provides initial data on the possible impacts climatic change may have on the growth, recruitment, and survival of intertidal invertebrate species. Plausible relationships were investigated between mean annual air and sea surface temperatures and 1) annual indices of geoduck growth in Ladysmith Harbour, B.C. 2) the magnitude of oyster spawning in Ladysmith Harbour, and 3) winter mortalities in manila clams in the Georgia Strait.

Trends in geoduck growth appear to be linked with low frequency shifts in mean annual temperature. A general warming period of about 0.5°C around 1920 was coincident with a 9 % increase in annual growth. For the range of temperatures examined, there is a positive relationship between temperature and growth.

Oyster spawning success was linked to mean sea surface temperature. Significant spawning events were coincident with relatively high mean sea surface temperatures during the period June 1 to August 31. The time series of mean sea surface temperature during this summer period exhibited strong shifts in variance over time. The reason(s) for this behaviour is(are) unknown. Mean summer sea surface temperatures have increased steadily since 1980.

Hourly dry-bulb air temperatures and calculated tidal heights for the period 1960 to 1989 were used to determine winter exposure factors (degree hours) for manila clams in the southern portion of the Strait of Georgia. The maximum exposure factor was -73.2 °C•h recorded in 1968. Exposures greater than -40 °C•h, which appears sufficient to induce significant mortalities, were recorded in 10 of the 30 years examined.

These investigations indicate that anticipated climate change will have a significant impact on the growth, recruitment, and survival of intertidal invertebrate species. Further research to document and quantify connections between the various biotic and abiotic factors is planned. In particular, the relationship between temperature and both growth and mortality will be investigated because of the increased interest in clam culture.

One review of this paper is available.

The reviewer noted that this paper does not fall into the category of stock assessment per se and should probably be classed as a supporting document and need not be sent out for an in depth review. He agrees with the need to expand research into the importance of temperature and salinity variability on growth and survival of bivalves in general. The reviewer did not agree with the statement that one would expect changes in relative abundance and not the disappearance or introduction of different species resulting from physical and or biological influences on species. Full support was indicated for the recommendations of the paper.

Subcommittee recommendations

1) Plausible links between environmental variation and bivalve growth should be investigated. Samples should be taken before and after any predicted extreme climactic event.

Review of Geoduck Quotas (I90-7)

The commercial fishery for geoduck clams began in British Columbia in 1976. Annual quotas were first set in 1979, at an arbitrary 8,000,000 lb. (3628 tonnes) for the coast. The quotas decreased over the period, 1981 to 1985, due to uncertainties in the stock size. Quotas have increased to 8,800,000 lb. (3391 t) in 1990, based on an evaluation of logbook data. The commercial fishery has landed approximately 95.6 million lb. (43,346 t) over the period 1976 to 1989.

There is a great uncertainty as to the stock size of subtidal geoduck clams. Initial dive surveys were not intended for stock assessment. No attempts of stock assessment on a large scale have been undertaken other than from logbook data supplied by the fishermen.

Harvest rates recommended in 1979 were from 2 to 5% of virgin biomass, but in 1980 yield options of 1.5% were used. Recommended yields were revised down to 0.75 to 2% of the original biomass in 1981. The yield options are useful only if there are reliable stock estimates.

The recommended 1991 quota for the south coast is 5,280,000 lb. (2395 t). At a harvest rate of 1%, to support this quota over 16,611 ha an average density of 1.35 geoducks/square metre would be required. Quotas for individual areas were set based based on historical levels of harvest. For the south coast a range of stock estimates and quota options that could be applied to this fishery is presented. Present quotas fall within this range.The ranges are great due to the large range of possible geoduck densities over large areas.

For the north coast, the recommended 1991 quota is 3,520,000 lb. (1597t) based on geoduck bed area identified from harvest logs for Areas 1 to 10. Quotas have been calculated at 1% harvest rates, at densities of geoducks at 3.5 or 5 clams/square metre, over the 1989 estimated area of 3734 ha in the north coast.

It is recommended that quotas continue to be based on logbook data and that other assessments are required before quota derivations are significantly changed.

Reviewers Comments

One review of this paper is available.

The reviewer was impressed with the completeness of the document regarding history and management of the geoduck fishery. He made the following specific comments:

1. The management approach may not be as conservative as supposed, since habitat area and density parameters are poorly resolved.

2. There is a possibility that the geoduck fishery is sustained by harvest of new beds within major areas leading to the possibility of fishery collapse when all beds are harvested.

3. A more complete discussion of biological parameters should be provided. As well, research should be focused on recruitment since the present management approach is only appropriate if recruitment is consistent.

4. A computerized GIS should be employed to document fishing locations and calculate bed size.

5. The policy of applying quota to unfished areas could lead to over-capitalization of the fishery in the event stocks are small.

Subcommittee Recommendations

1. Conservative levels of harvest should be used until research has been undertaken on the distribution and abundance of geoduck clams.

2. The effect of fishing on recruitment should be determined. In the interim the current three year rotational fishery should be maintained and additional "sub-rotations" be derived, so that geoduck beds are fished only once every six or nine years.

3. Additional information is required on geoduck densities in each management area. A program of surveys should be considered, surveying one or more areas per year.

4. There are uncertainties in the area measurements for many of the geoduck beds. Some field surveys are required to determine the extent of the geoduck beds. Fishermen, knowledgeable of stocks in an area should be interviewed to determine their estimate of the extent of the beds. The GIS system is suggested.

Review of the Biological Basis for Management of the B.C. Abalone Fishery (I90-8)

Quotas for the abalone fishery were originally set in 1979 and based on an estimate of annual production (115 t.). Since that time quotas have been reduced with the following rationale:

1. continuing decrease in stock size as measured by surveys in two major fishing areas.
2. concern that assumptions in the original analysis were unmet
3. recruitment estimated at less than replacement levels even before the fishery might have had an effect. Since 1985 the quota has remained at the same level (47 t.) as surveys in the mid 1980's showed no further decline. Resurveys done in 1989 and 1990 show further decline, although it is widely accepted that the survey methodology may not measure changes at the present low densities of abalone. Other information examined includes port sampling data, catch per unit effort and literature from studies on this and other abalone stocks. All indications are that abalone abundance continues to decline. Recruitment (as measured in surveys) also continues at levels less than that required to produce the densities in the 1970's.

It is not known if recruitment overfishing has caused the decline; however, the stock will be even more vulnerable to overfishing at low stock sizes such as have been reported here. The high value of abalone and its accessability support a high, but undetermined level of landings in excess of the quota. If the amount of these landings is larger than the quota, then any reduction in allowable catch other than closure would be fruitless.

With the total landed value of the legal fishery at one million dollars annually, the cost of dealing with illegal fishing and the risks associated with continued fishing may not be reasonable. Surveys to monitor abundance of abalone should continue regardless of the management action taken. Research into the relationship between recruitment and adult abundance is required to elucidate the effect of harvest on these stocks.

Reviewers Comments

A good review is provided. A discussion of results from closed areas should be included. Enhancement may be required to rebuild the stock. This could take the form of transplant or outplanting programs. Fishermen could lease/enhance allocated areas.

Subcommittee Recommendations

see recommendation under I90-9 for both papers

Abalone Resurvey in the Queen Charlotte Islands 1990 (I90-9)

Abalone stocks at 69 standard sites on the east coast of the Queen Charlotte Islands (area 2E) were resurveyed in 1990 and the results compared to previous surveys. Present abalone abundance in area 2E is similar to that observed in 1984, remaining at 20% of levels in 1978-79. Mean densities of total, legal (>100 mm), and pre-recruit (94-101 mm) sized abalone were significantly less in 1990 than in 1987, while there was no change in new recruit density. There was an increase in the number of zero sites and decrease in number of sites containing legal abalone between the two years. The present mean density of legal sized abalone ($0.1/m^2$) is far below estimated prefishery levels ($2.5/m^2$). Densities in sites open and closed to commercial fishing were of similar magnitude in 1990.

The failure of abalone abundance in area 2E to return to initial levels may be attributed to a variety of causes. It is possible that large removals by the commercial fishery in the late 1970's (and by other undocumented sources) may be a contributing factor.

Reviewers Comments

One review of this paper is available.

The reviewer suggested that it should be stated that no attempt has been made to determine stock recruitment relationships for northern abalone. He felt that the recommendations were too guarded, and also that the sport fishery must be closed if the commercial fishery is to be closed to ensure a reduction in poaching and overall harvest.

Subcommittee Recommendations

1. The abalone fisheries should be closed. The abalone stock has continued to decline to a level estimated to be less than 20% of 1978-79 biomass and approximately 4% of estimated prefishery biomass (1976). Evidence for the decline includes.
   i. Surveys conducted in 1978, 79, 83, 84, 85, 87, 89, 90 show significantly decreasing indices of abundance for legal sized, recruit and prerecruit abalone.
   ii. There is a long term downward trend in catch rate.
   A coastwide quota was introduced in 1979 at 227 t and was continually reduced to 47 t in 1985 as surveys and review suggested stocks could not sustain these quota levels. It has remained as 47 t to the present. Surveys conducted in 1989 and 1990 indicated a further decline. Regardless of the cause of the decline, abalone are even more vulnerable to recruitment overfishing at these low stock sizes.

2. The closure should extend to all user groups. Surveys show that legal, recruit and prerecruit abalone abundance have declined in areas open only to recreational and native food fishing to the same level as in areas open to commercial fishing.

3. Rehabilitation and enhancement options should be developed. Studies from other fisheries suggest that closures in themselves are not necessarily sufficient for rehabilitation if some critical density of reproductive adults is not available. Options include transplanting, outplanting or experimental leases in some form.

4. Surveys to monitor abundance should continue and be actively expanded into other coast areas. When there is evidence of stock recovery, consideration will be given to reopening the fishery. Because abalone grow slowly and do not recruit to the fishery until they are 7-10 years, it is anticipated the closure would be in effect for a minimum of 5 years.

Horse Clams (I90-10)

Size at maturity occurs at about 68 mm SL or at age of 3 years when I. nuttallii looses its redigging ability if disturbed. Few individuals <100 mm SL are caught in commercial fisheries; most horse clams are >150 mm SL (average 173 SL). A commercially desirable horse clam takes about 12 years to reach about 173 mm SL in Lemmens Inlet. Rotational closures of 3 years are probably not sufficiently long to provide protection to the stocks. Spawning period is in the summer.

Reviewers Comments

One review of this paper is available

The reviewer stated that the paper was straightforward and the analysis appropriate for interpreting growth and maturity of horse clams. It was suggested that larger sample sizes would increase the accuracy of analysis and that size frequencies be included in the document. Also, the management implications of this study should be discussed further.

Recommendations

1. A minimum size limit regulation would not be useful at this time since horse clams >70 mm SL would not be able to rebury themselves and survive predation.

Purple Sea Urchins (I90-11)

Size frequency samples indicate low recruitment of subtidal S. purpuratus on the southwestern coast of Vancouver Island. Purple sea urchins are difficult to collect since they occur in high wave action areas. Although S. purpuratus can occur in dense populations (>100m^2) their distribution is irregular and gonadal quality may not be consistent. Based on published literature, purple sea urchins from the intertidal are shown to have slow growth rates (large individuals can be over 50 years old), are mature by >40 mm test diameter, reproduce annually with large gonads during fall-winter and have low and sporadic recruitment and larval settlement. A great deal more information is required on the biology, distribution and abundance of subtidal S. purpuratus in British Columbia.

Reviewers Comments

One review of this paper is available.

The reviewer has indicated that the paper lacks a detailed description of the methods in which the density and size frequency data was collected. He also stated that the mean densities and/or the percentage of pre-recruits at the various sample locations should be described. The reviewer questioned whether the paper should mention the possibility of grow out sites for purple sea urchins.

Recommendations

1) A cautious approach to purple urchin management should be adopted. Any experimental permits issued should be closely monitored and areas rotated. As well, fishing should be restricted to the October to December period when gonad condition is optimum.

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.

Table 1. Landings of invertebrates in tonnes in British Columbia, 1981-1989

	1981	1982	1983	1984	1985	1986	1987	1988	1989
INTERTIDAL CLAMS									
Razor	30	68	31	101	90	142	142	155	117
Butter	120	103	77	131	252	159	69	83	42
Manila	317	597	1049	1677	1914	1894	3608	3833	2728
Nat. Ln.	179	241	325	295	192	285	373	288	428
Mixed	161	155	280	409	478	369	87	27	159
TOTAL INTERTIDAL C	807	1164	1762	2613	2926	2849	4279	4386	3474
GEODUCK	2704	3135	2636	3483	5370	5006	5734	4553	4087
HORSE CLAM	57	321	21	7	6	96	355	328	115
SHRIMP	581	415	411	408	678	768	2644	2211	2211
PRAWN	358	274	331	381	514	550	620	708	894
CRAB	1317	1002	960	1155	1165	1321	1631	1406	1406
ABALONE	85	54	56	58	42	52	49	48	49
OCTOPUS			37	25	34	53	130	205	205
SEA URCHIN									
RED			982	1764	1815	2067	2223	1951	2645
GREEN								434	570
SEA CUCUMBER				95	346	786	1722	1930	1101
SCALLOP		8	11	18	53	68	66	66	77
PLANKTON	19	0	47	103	131	166	130	249	380
SQUID			71	14	111	79	86	8	70
MUSSELS			tr	1	tr	2	2	3	4
GOOSENECK BARNACLES						2	32	18	34
TOTAL TONNES	5909	6373	7325	10125	13191	13865	19703	18070	16752

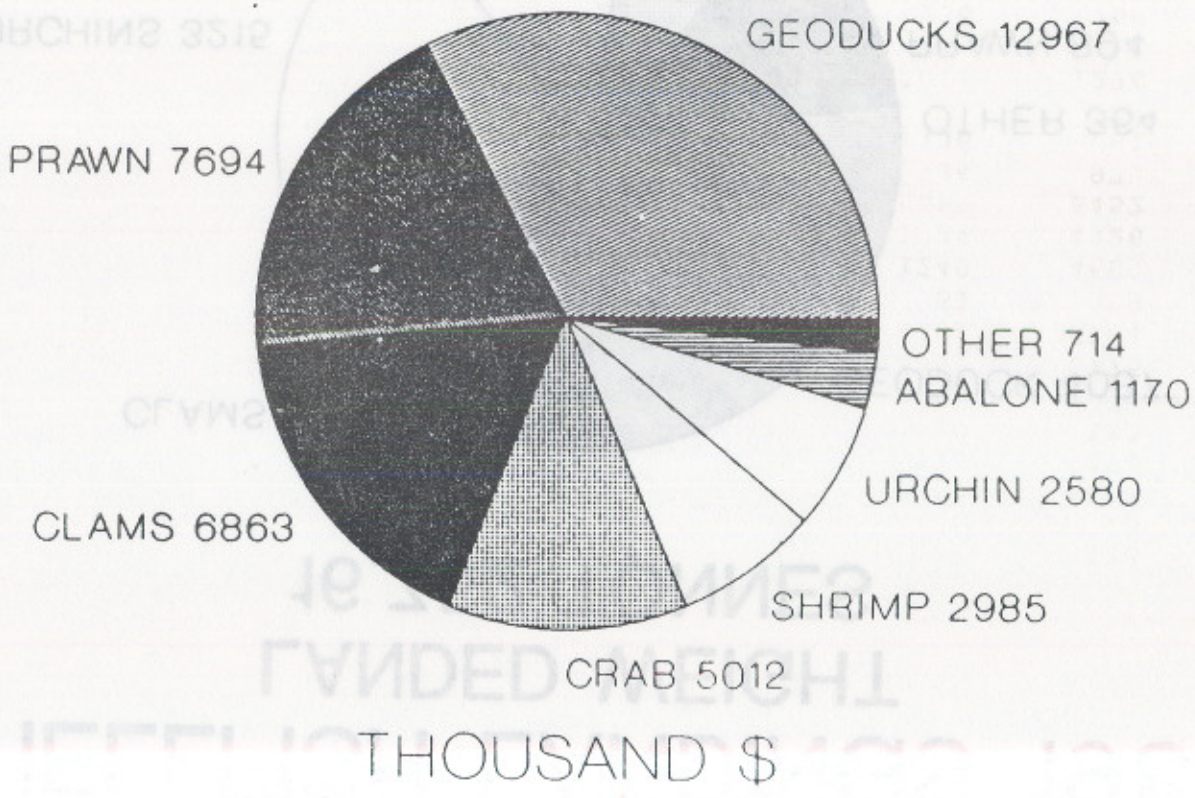
Table 2. Landings in thousands of dollars of invertebrates in British Columbia, 1981-1989

	1981	1982	1983	1984	1985	1986	1987	1988	1989
INTERTIDAL CLAMS									
RAZOR	24	55	24	123	95	127	126	137	124
BUTTER	42	36	33	55	138	75	40	40	44
MANILA	323	611	1043	1813	2278	2762	6003	7023	5919
NAT. LN	195	263	329	311	202	327	474	357	580
MIXED	175	169	293	455	575	510	132	36	196
TOTAL INTERTIDAL C	759	1134	1722	2757	3288	3801	6775	7593	6863
GEODUCK	2434	2814	1818	2937	4777	4294	6184	9762	12967
HORSE CLAMS	42	235	12	5	6	63	309	300	144
SHRIMP	912	652	1095	1022	1180	1240	4609	2802	2985
PRAWN	2019	1545	2154	2464	3379	3734	4326	5724	7694
CRAB	3556	2703	3320	4558	4719	5661	6452	5555	5012
ABALONE	721	457	464	530	442	734	973	1076	1170
OCTOPUS			80	56	82	136	381	629	655
SEA URCHIN									
RED			358	712	763	1011	1276	1108	1627
GREEN								569	953
SEA CUCUMBER				22	94	236	768	961	998
SCALLOP		17	45	56	139	212	244	285	321
PLANKTON	6	0	19	42	89	113	102	192	223
SQUID			95	17	184	127	132	113	94
MUSSELS		tr	tr	tr	0	tr	tr	tr	tr
GOOSENECK BARNACLES						5	221	478	397
TOTAL VALUE	10449	9557	11182	15178	19142	21367	32752	36578	41150

SHELLFISH LANDINGS 1989

LANDED VALUE

$ 40 MILLION

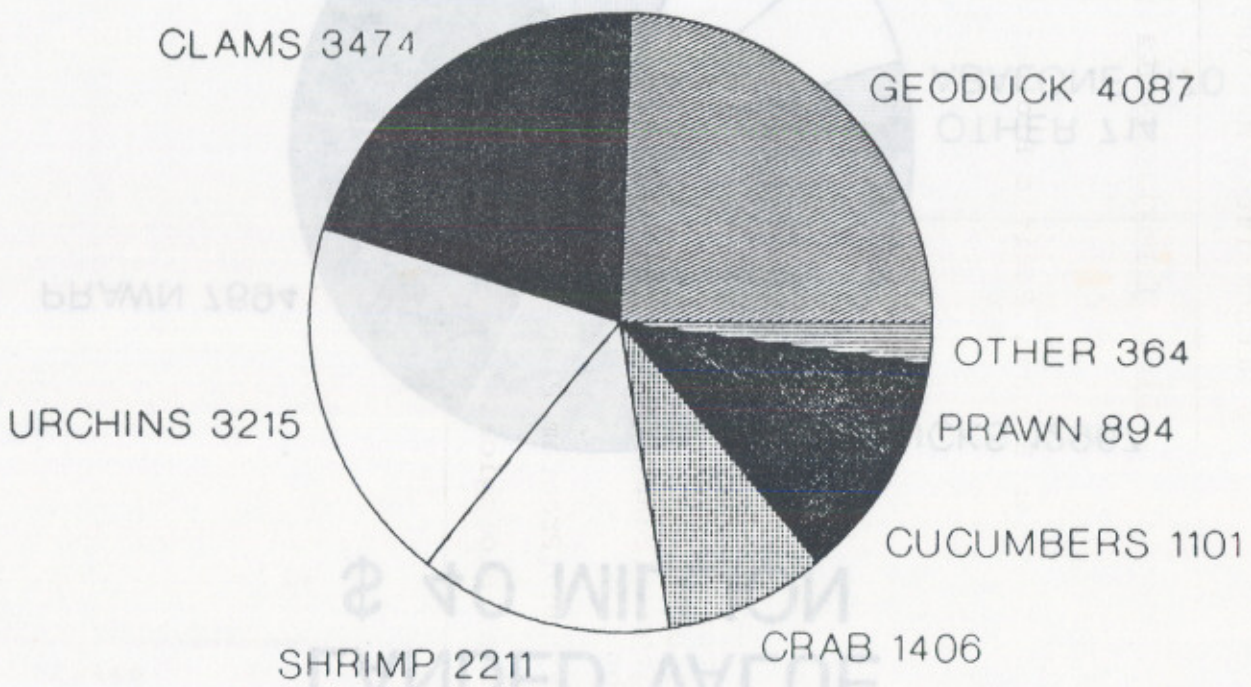


saleslip data (data incomplete)

SHELLFISH LANDINGS 1989

LANDED WEIGHT

16,752 TONNES



saleslip data (data incomplete)

Appendix 1. Participants

1990 PSARC-Invertebrate Subcommittee Meeting

List of participants

August 28-29, 1990

Biological Sciences Branch, Pacific Biological Station

Neil Bourne
Jim Boutillier
Alan Campbell
Glen Jamieson
Don Noakes

Fisheries Branch

Lynn Yamanaka
Steve Heizer
Frances Dickson
Sue Farlinger (PSARC chairman)
Rick Harbo
Kerry Hobbs
Marilyn Joyce
Scottie Roxburgh
Greg Thomas (Subcommittee chairman)

Sheila Fagnan (Program Planning)

Doug McKone, Biological Sciences Directorate, Ottawa

Appendix 2. List of position papers and fisheries updates submitted to 1990 PSARC Shellfish (Invertebrate) Subcommittee

Number	Title	Authors
	POSITION PAPERS	
I90-2	Development of a Clam Farming Policy for the Pacific Region of DFO	N. Bourne F. Dickson
I90-3	A preliminary report of an intertidal clam survey in the north coast district - 1990	N. Bourne G. Cawdell
I90-4	Euphausiid fishery review regarding potential expansion concerns	G. Jamieson
I90-5	Results of the 1990 shrimp survey	J. Boutillier
I90-6	Climatic change and the intertidal: Physical and biological influences on species composition, abundance and recruitment patterns	D. Noakes G. Jamieson
I90-7	A review of Geoduck quotas and their derivation	S. Farlinger R. Harbo K. Hobbs
I90-8	Review of the Biological Basis for Management of the British Columbia Abalone Fishery	S. Farlinger
I90-9	Abalone resurvey in the southeast Queen Charlotte Islands in 1990	G. Thomas S. Farlinger
I90-10	Growth and size at maturity of the Horseclam Tresus nutallii (Conrad) in southern British Columbia	A. Campbell N. Bourne W. Carolsfeld
I90-11	Size structure of Purple Sea Urchins, Strongylocentrotus purpuratus, in southern British Columbia	A. Campbell

Appendix 2 (cont'd)

FISHERIES UPDATES

Molluscs

Intertidal clams	N. Bourne
Geoducks	R. Harbo G. Thomas
Horse Clams	R. Harbo
Oysters	N. Bourne
Scallops	R. Harbo
Octopus	R. Harbo
Squid	R. Harbo

Crustaceans

Crab	G. Jamieson
Prawn	B. Adkins
Plankton	J. Fulton
Gooseneck barnacles	R. Harbo

Echinoderms

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

Pacific Stock Assessment Review Committee **PSARC Advisory Document 90-3**

CONTENTS

1. STEERING COMMITTEE REPORT

The PSARC Steering Committee met September 13, at the Coast Bastion Inn, Nanaimo to review the Subcommittee report. The Steering Committee makes the following particular recommendations in addition to support of Subcommittee recommendations:

1) A problem is identified in which stock assessments for individual species are used for coastwide management, resulting in overfishing of the most accessible stocks. A management objectives document is required to explore and establish congruent management and stock assessment.
2) With the recommendation for lingcod closure in the Strait of Georgia, the Steering Committee recommends that specific advice for stocks in area 12 and 13 be provided. A review of strategies for managing lingcod is solicited before implementation of the coastwide size limit.
3) The overfishing of inshore rockfish is of concern. Data should be split out by area and by species (type) and more information collected.

2. GROUNDFISH SUBCOMMITTEE REPORT

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 catch-at-age 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--R. P. Foucher and A. V. Tyler
Flatfish--J. Fargo
Sablefish--M. W. Saunders and G. A. McFarlane
Pacific hake--M. W. Saunders
Dogfish--B. L. Thomson, M. W. Saunders and M. S. Smith
Walleye pollock--G. D. Workman and M. W. Saunders
Slope rockfish--L. J. Richards
Shelf rockfish--R. D. Stanley
Inshore rockfish--C. M. Hand and L. J. Richards
Pacific hagfish--C. M. Neville and R. J. Beamish

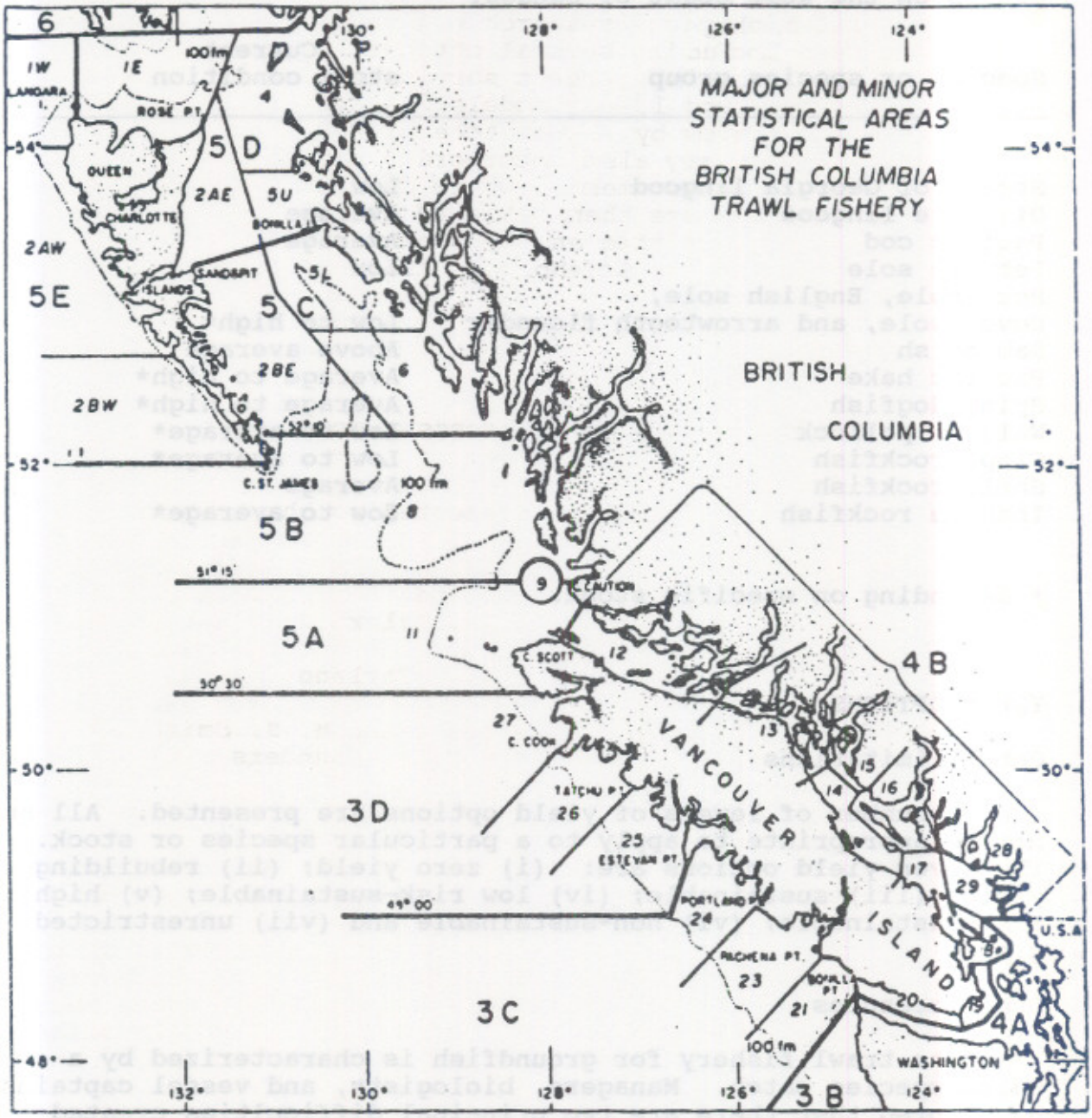


Fig. 1. International (Pacific Marine Fisheries Commission) Major and Minor Statistical Areas along the British Columbia coast.

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	Average
Petrale sole	Low
Rock sole, English sole, Dover sole, and arrowtooth flounder	Low 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*

* depending on specific stock.

YIELD OPTIONS

Catch limitations

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.

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 high risk-sustainable options if

at all possible. 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 is 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.

MAJOR FISHERY CONCERNS

Groundfish research staff have met, over the past four years, 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. Joint surveys between the Deep Sea Trawlers Association and Groundfish Section Staff have been postponed until funding mechanisms are worked out.

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 most 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 not sustainable due to quota over-runs. Biologists are concerned about the quota overruns that have occurred annually in all statistical areas except Moresby Gully, and believe that the Pacific ocean perch resource is being eroded. The quota overruns extend to westcoast Vancouver Island, canary and silvergray rockfish and yellowmouth rockfish in Queen Charlotte Sound. The persistent quota overruns will soon cause a decrease in yield potential in these stocks (See Appendix Table 3).

An additional problem which hampers effective stock management is a lack of formal objectives from a stock perspective and the stock complex as a whole. This results in confusion as to the appropriate management protocols which need to be adopted when dealing with the mixed-species nature of the

groundfish fishery, and the often opposing results of alternative actions. More effort is required in the development of stock-by-stock objectives and integration of these objectives into an overall groundfish stock management plan. The long-term economic tradeoffs of fisheries on short-lived, highly dynamic vs. long-lived, stable species require analysis. The biological assessments produced by this Branch will form only one part of such an analysis. We are increasingly concerned that the biological and economic penalties arising from the lack of a more integrated stock oriented management plan may be large, and result in overall decreases in stock yields. By highlighting these concerns we hope to stimulate the process of developing an improved system.

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. It is recommended that the size limit be applied coast-wide for both sport and commercial species. Stocks were determined to be at extremely low levels in the Strait of Georgia portion of the Vancouver Area and a complete closure to all gear types was recommended. In the remainder of the Charlotte-Vancouver Region, stocks were determined to be at moderate-high levels, with yields ranging from 2700-4600 t in 1990.

Pacific cod

The very strong 1985 year class of Pacific cod is passing out of the fishery, leading to a general decline in abundance from previously high levels. CPUE figures suggest that stocks are now at about average levels of abundance in Hecate Strait (459 kg/h in 1989 and 397 kg/h for the second quarter of 1990). They are lower than average in Queen Charlotte Sound (97 kg/h in 1989) and in the Strait of Georgia (265 kg/h in 1989). The age-structured model developed last year for use with Hecate Strait stocks predicts a potential yield for 1990 of 3248 t and for 1991 of 2777 t. Indications from observer samples and discards from the commercial fishery are that there is a strong 1989 year class developing which will start contributing to the fishery early in 1991. No catch limitations have been suggested for Pacific cod stocks in 1991 because of the projected strong recruitment and continued moderate fishing effort directed at them.

Flatfish

Flatfish stocks were assessed in 1990 on the basis of surplus production analysis of standardized landing statistics, trends in CPUE, yield per recruit analysis, and a length-based simulation model. Petrale sole stocks were determined to be at low levels, rock sole stocks at average to high levels, and English sole and Dover sole stocks at low to high levels. Landing statistics for all rock sole stocks were standardized using a multiplicative model accounting for effects of vessel horsepower on CPUE. Recruitment of the strong 1985 rock sole year-class continued in 1989 for stocks in all Areas except Area 5C. Sustainable yield estimates for rock sole stocks in all Areas except 5C have increased over last year. In Area 5C, estimates of the sustainable level have decreased because the 1985 year-class does not appear to be as strong as it is in other areas. A recruitment increase was also observed for Hecate Strait. English sole in 1989 and yields up to 1000 t may be sustainable in 1991. Area 3CD Dover sole were determined to be overexploited based on estimates of fishing mortality from a new length simulation model. Estimates of sustainable yield have been lowered accordingly. The upper limit of sustainable yield for Area 5CDE Dover sole has been increased by 25% from last year based on estimates of fishing mortality for the stock using a new length simulation model.

Sablefish

Coastwide standardized CPUE values increased from 21.2 kg/trap in 1988 to 22.6 kg/trap in 1989. Biological studies indicate that the change in age frequencies in the fishery may be an artifact of changing effort patterns. 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 1991.

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 11,000 t may be sustainable. Assessment information for the offshore stock is not yet available.

Dogfish

The stock assessment for spiny dogfish in both offshore and Strait of Georgia waters remains unchanged from last year. Current harvest rates are below the level of low risk for a sustainable fishery for both areas. As such, the estimated biomasses of 380,000 tonnes (offshore) and 60,000 tonnes (Strait of Georgia) are expected to increase.

Walleye pollock

The 1989 pollock catch in the Canadian domestic fishery decreased from 1112 t in 1988 to 509 t in 1988. The 1988 incidental joint-venture and foreign catch decreased to 907 t from 252 t in 1988. The Strait of Georgia 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. Quota recommendations are unchanged.

Shelf rockfish

Stock assessments are presented for seven offshore shelf rockfish fisheries. Quota recommendations are unchanged for the southern and central coast fisheries for canary rockfish. They remain 400-600 and 350-500 t respectively. Recommendations for the southern and northern (Hecate Strait) silvergray rockfish are also unchanged at 400-600. The recommendation for the central coast (Queen Charlotte Sound) fishery for silvergray rockfish is lowered from 700-850 to 200-700. The wide range is a result of recently aged material which indicates significant overfishing in

contrast with historical catch rates which are reasonably stable after a sustained harvest of approximately 700 t/yr for over 20 years.

The yield recommendation for the yellowtail rockfish stock of Queen Charlotte Sound is down slightly from last year's range of 1400-3600 to 1400-3000. The change is a result of changes in the method of analysis. We continue to recommend an experimental yield range of 500-1000 t for the central west coast of Vancouver Island stock.

The yellowtail rockfish fishery off the southwest coast of Vancouver Island appears to exploit a biomass that is shared with the U.S. fishery in northern Washington. We present a yield range for this transboundary stock of 1000-2000 t. The WDF biologists recommends an "Acceptable Biological Catch" of 2000 t. The biology of the species does not appear to pertain to the allocation issue.

Inshore rockfish

The escalation of the line fishery for inshore rockfish in the Vancouver-Charlotte Region has continued. 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 505-1665 t in 1990.

Hagfish

The experimental hagfish fishery is new in B.C. and information on the life history and population parameters of hagfish is sparse. Catch statistics were summarized for the fishing period (October 1988 June 1990) and decreases in CPUE documented. It is recommended that the fishery remain classified as experimental until more information on their biology is known. Also, although expansion of the fishery into areas other than 23-27 and 123 is acceptable, limits on effort within each area should be maintained.

YIELD OPTION SUMMARY TABLE

*Change from last year.

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

Area	Species	Management options
4B Areas 13-20 20, 28, 29	Lingcod*	Total closure of sport and commercial fisheries.
Area 12	Lingcod*	1. Winter closure Nov. 15-Apr. 30. 2. Size limit of 65 cm.
3C	Lingcod*	1. Winter closure Nov. 15-Apr. 30. 2. Sustainable: 2000 t 3. Size limit of 65 cm.
3D	Lingcod*	1. Winter closure Nov. 15-Apr. 30. 2. Size limit of 65 cm. 3. Sustainable: 600 t.
5A/B	Lingcod*	1. Size limit of 65 cm for commercial fishery. 2. Sustainable: 2000 t
5C/D/E	Lingcod	1. Winter closure Nov.15- Apr. 30. 2. Size limit of 65 cm.
4B	Pacific cod	No options proposed.
3C/3D	Pacific cod	Open fishing due to average abundance and moderate fishing effort.

Area	Species	Management Options
5A/5B	Pacific cod	No options proposed.
5C/5D	Pacific cod*	Open fishing due to strong recruitment, average abundance and moderate fishing effort.
5E	Pacific cod	No options proposed.
Coastwide	Petrale sole	1. Sustainable: trip limit 44,000 lb.
4B	Flatfish	No options proposed.
3C/D	Dover sole*	Low risk sustainable: 500 t. Sustainable: 750 t. High risk sustainable: 1000 t.
5A	Rock sole*	1. Low risk sustainable: 250 t (with 30,000 lb trip limit). 2. Sustainable: 375 t. 3. High risk sustainable: 500 t.
5B	Rock sole*	1. Low risk-sustainable: 250 t with a 30,000 lb trip limit. 2. Sustainable: 425 t, 30,000 lb trip limit. 3. High risk-sustainable: 600 T.
5C	Rock sole*	1. Low risk-sustainable: 100 t. 2. Sustainable: 250 t, 3. High risk-sustainable: 400 t. with a 30,000 lb trip limit.

Area	Species	Management options
5D	Rock sole*	1. Low risk-sustainable: 800 t, 30,000 lb trip limit 2. Sustainable: 900 t, trip limits as in 1. 3. High risk-sustainable: 1000 t.
5C/D	English sole*	1. Low risk-sustainable:700t. 2. Sustainable: 850 t 3. High risk-sustainable: 1000 t.
5C/5D/5E	Dover sole	1. Low risk-sustainable: 800t quota, 20,000 lb/trip permitted after 75% of the quota is reached. 2. Sustainable: 1000 T. trip limit as above. 3. High risk-sustainable: 1,200 t quota trip limit as above.
Coastwide	Sablefish	1. Low risk-sustainable: 2,900 t quota. 2. Sustainable: 4,000 t. 3. High risk-sustainable: 5,000 t quota.
4B, except MSA 19, 20	Pacific hake	1. Low risk-sustainable: 8,000 t. 2. Sustainable: 11,000 t. 3. High risk-sustainable: 14,000 t.
3C	Pacific hake	Yield options to be announced at a later date when all current biological information is collated in the joint Canada-U.S. assessment algorithm.

Area	Species	Management options
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.
5C/5D	Walleye pollock	Open fishing option proposed.

Area	Species	Management
5E	Walleye pollock	Options not proposed.
3B-3C* *Combined U.S. & CDN. quota	Yellowtail rockfish*	Low risk sustainable 1000 High risk sustainable 2000
3D	Yellowtail rockfish	Low risk sustainable 500 High risk sustainable 1000
5A/5B	Yellowtail rockfish	Low risk sustainable: 1400 t High risk sustainable: 3000 t.
3C/3D	Silvergray rockfish	Low risk-sustainable: 400 t. High risk-sustainable: 600 t.
5A/5B	Silvergray rockfish*	Low risk sustainable 200 t High risk-sustainable: 700 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. No trip limit should apply
3C/3D	Canary rockfish	Low risk-sustainable: 400 t High risk-sustainable: 600 t

Area	Species	Management options
5A/5B	Canary rockfish	Low risk-sustainable: 350 t 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
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

Area	Species	Management options
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
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 12-20, 28, 29	Yelloweye	Sustainable:50 t Includes sport fishery
4B 12-20, 28, 29	Grouped line rockfish, except yelloweye	Sustainable:400t Includes sport fishery

Area	Species	Management options
11, 21-27, 121-127, 111	Grouped line rockfish*	Sustainable:400t Includes sport fishery
6-10, 106-110	Grouped line rockfish*	Sustainable:200t Includes sport fishery
3-5, 103-105	Grouped line rockfish*	Sustainable:100t Includes sport fishery
1,2,101,102,130, 142	Grouped line rockfish*	Sustainable:300t Includes sport fishery

REVIEWER ASSIGNMENTS FOR GROUNDFISH STOCK ASSESSMENTS

Title	Authors	Reviewers
Lingcod	Richards, Hand	Leaman, McFarlane
Pacific cod	Foucher, Tyler	Leaman, Saunders
Flatfish	Fargo	Hand, Noakes
Sablefish	Saunders, McFarlane	Stanley, Fargo
Dogfish	Thomson, Saunders	Tyler, Richards
Walleye pollock	Saunders, Workman	Stanley, Tyler
Pacific hake	Saunders	Hand, Fargo
Slope rockfish	Richards	Tyler, Fargo
Shelf rockfish	Stanley	Saunders, Richards
Inshore rockfish	Richards, Hand	Thomson, Starr
Hagfish	Neville, Beamish	Thomson, Tyler

PARTICIPANTS AT THE GROUNDFISH SUBCOMMITTEE MEETING
August 30, 31, 1990

A. Tyler, Chairman
D. Adams
G. Beuchler
J. Fargo
S. Farlinger
C. Hand
R. Harbo
B. Leaman
D. McKone
G. McFarlane
C. Neville
D. Noakes
M. Saunders
R. Stanley
P. Starr
G. Thomas
B. Thomson
L. Richards
N. Venables
G. Workman
L. Yamanaka

Appendix 1.

Table 1. Total Canadian landings* (t) of groundfish by species, taken from all areas of the Pacific coast, 1979-89.

Species	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1979-88	1989*
English sole	1,069	1,244	1,500	559	532	812	692	452	755	879	849	1,043
Rock sole	1,874	1,843	1,059	745	660	525	430	454	887	1,960	1,045	2,076
Petrale sole	282	222	290	367	439	417	336	416	445	790	392	954
Dover sole	861	1,273	1,245	914	871	1,140	963	1,167	633	1,281	1,036	2,130
Rex sole	203	145	190	74	49	219	205	87	83	145	140	135
Starry flounder	296	118	198	168	66	170	66	54	65	110	131	125
Turbot	1,826	1,448	946	525	323	369	764	895	1,193	375	866	689
Other flatfish	59	57	183	220	199	141	161	215	232	147	161	53
Pacific cod	9,554	8,703	6,708	4,810	4,505	3,465	2,342	3,650	13,917	11,015	6,867	9,168
Lingcod	2,098	2,151	2,467	4,162	3,755	3,688	5,668	3,827	3,591	3,462	3,487	3,930
Sablefish	2,031	3,793	3,888	3,976	4,414	3,855	4,275	4,668	4,719	5,770	4,139	5,843
Pollock	3,387	2,201	1,251	924	1,070	880	1,895	577	1,270	1,111	1,449	442
Hake	818	686	5,691	2,826	3,122	4,680	6,855	6,802	13,275	6,854	4,985	8,788
Ocean perch	2,819	5,290	5,183	5,983	5,655	6,698	6,869	5,914	6,335	6,929	5,680	6,834
Other rockfish	5,962	4,476	4,857	5,893	7,824	8,512	11,789	19,840	18,177	20,399	10,525	18,447
Misc. species	215	383	266	141	156	175	192	245	344	353	239	171
Hagfish	-	-	-	-	-	-	-	-	-	66	-	471
Dogfish	4,757	4,547	1,151	3,875	3,274	2,510	2,815	3,289	3,881	5,483	3,550	2,788
Animal food	214	191	42	65	94	161	389	255	188	130	165	126
Reduction	248	528	382	458	321	244	214	175	218	581	327	342
Total	38,485	39,139	37,337	35,877	36,537	38,589	45,160	52,182	70,120	67,840	46,039	62,787

* Does not include catches from joint-venture or foreign fisheries, see Table 2.
* Preliminary data.

Appendix 1.
Table 2. Joint-venture and foreign catches* (t) of groundfish from International Area 3C -- southwest coast of Vancouver Island in 1989.

Nation and species	Joint-venture	National	Supplemental	Total
Poland				
Pacific hake	26,252	16,862	1,392	44,506
Walleye pollock	413	3	2	418
Pacific ocean perch	6	117	12	135
Other rockfish	113	808	115	1,036
Other species	1	-	-	1
USSR				
Pacific hake	26,870	12,738	585	40,193
Walleye pollock	338	3	tr.	341
Pacific ocean perch	1	67	tr.	68
Other rockfish	113	82	13	207
Other species	tr.	-	-	0
Japan				
Pacific hake	12,980	-	-	12,980
Walleye pollock	11	-	-	11
Pacific ocean perch	-	-	-	0
Other rockfish	20	-	-	20
Other species	-	-	-	0
Total				
Pacific hake	66,102	29,600	1,977	97,679
Walleye pollock	762	6	2	771
Pacific ocean perch	7	185	12	204
Other rockfish	246	890	127	1,263
Other species	1	0	tr.	1

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

Table 3. History of stock management - slope rockfishes. Note that figures reflect designated management units, in terms of areas and species aggregates. Does not include catches for non-quota species or areas.

STOCK		YEAR AND QUOTAS (t) 1978	1979	1980	1981	1982	1983	1984	1985	1986(C)	1987	1988	1989(C)
Southwest Vanc. Is.													
alutus	Recommended	0	50	600	500	500	500	150-500	0-500	0-500	0-200	100-200	100-200
	Adopted	0	50	600	500	500	500	500	300	C	100	150	C 150
	Catch		125	430	547	508	752	551	243	242	542	308	279
Northwest Vanc. Is.													
alutus	Recommended	n/a	n/a	n/a	n/a	250	250	250	250-500	250-500	250-500	200-600	200-600
	Adopted					250	250	250	350	C	350	400	C 400
	Catch		3				86	193	313	1046	451	492	994
NWVIs/QCSd													
reedi	Recommended	n/a	100	100	250	250	200-500	200-500	200-500	200-500	250-750	250-750	250-750
	Adopted					250	250	250	350	C	350	375	C 500
	Catch	17	10	28	5	228	628	458	717	1208	1170	575	984
Queen Charlotte Sd.													
alutus	Recommended	2000	2000	2000	1500	1000	1100-2000	1100-2000	1050-1800	1050-1800	600-1150	700-1000	700-1000
	Adopted	2000	2000	2000	1500	1000	1250	1050	1200	C	850	850	C 850
	Catch	1240	1431	1531	1481	856	1874	1318	1540	1831	1646	1186	1173
Moresby Gully													
alutus+	Recommended	n/a	n/a	n/a	1800	2000	2000-2800	2000-2800	1900-2800	1900-2800	1900-2800	2160-3500	2160-3500
reedi	Adopted				1800	2000	2250	2250	2250	C	2250	3250	C 3350
	Catch				2217	3626	2422	2393	2199	729	2027	3432	1682
Queen Charlotte Is. (S)													
alutus+	Recommended	1500	1400	1400	1400	1400	900-2500	900-2500	900-2200	900-2200	900-2200	900-1700	900-1500
reedi+	Adopted	1500	1400	1400	1400	1400	1400	1400	1400	C	1400	1400	C 1250
aleut.	Catch	3518	1420	1398	1532	1309	1498	1383	1482	1475	1408	1410	1050
Langara - Dixon Ent.													
alutus+	Recommended	0	10	400	200	200	F	F	F	F	F	200-270	200-270
aleut.	Adopted	0	10	400	200	200	F	F	F	F	F	F	F
	Catch		241	87	207	411	419	2413	2404	3159	1310	1556	2061
Coastwide incl. Langara	Adopted	3500	3460	4400	5400	5600	5900	5700	5850	5000	5300	6425	6500
	Catch	4775	3230	3474	5989	6938	7679	8709	8898	9690	8554	8959	8223

C = Coastwide quota
F = Free fishing experiment

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1. STEERING COMMITTEE REPORT. The PSARC Steering Committee reviewed the Herring Subcommittee Report on September 13, 1990 at the Coast Bastion Inn, Nanaimo. Quota recommendations were approved and concern about support for spawn surveys noted.

The recommendation was made to explore alternative methods to ensure that spawn surveys are done.

2. SUBCOMMITTEE REPORT. The Subcommittee met at the Inn at Westminster Quay in New Westminster during September 5-6, 1990 to derive a consensus on the status of herring stocks in 1990 and expectations for 1991. The list of working papers (Appendix 1), participants (Appendix 2), criteria used to evaluate stocks in each assessment area (Appendix 3) and Subcommittee recommendations (Appendix 4) are attached.

The Subcommittee particulary wishes to highlight their recommendation that a higher Regional priority is required to ensure complete and comprehensive herring spawn surveys coastwide. These surveys are fundamental to the assessment and quota determination process and require commitment and support at the Regional level to ensure consistent survey coverage and optimal use of this resource.

There were three fisheries issues identified by the Subcommittee:

1. For the west coast of the Queen Charlotte Islands the Subcommittee recommended a quota based on 10% of the previous seasons spawning biomass, consistent with the method used to determine the 1990 quota. Because we haven't the information based to determine minimum spawning requirements, the Subcommittee also recommends a policy of not fishing more than 50% of the biomass sounded in any location.

2. In the Prince Rupert District spawnings in Kitkatla Inlet may be near historic low levels. The committee recommends that when developing fishing plans for this area consideration be given to these recent spawn trends.

3. In the Northern West Coast Vancouver Island stock assessment region every effort should be made to catch the assigned quota within the assessment region rather than in the southern assessment region. There is concern that if all the fish are caught in the south these stocks could approach the CUTOFF level in 1991 and therefore impact on future fisheries.

The primary objectives for the meeting were:

1. Reach a consensus regarding the status of stocks relative to the 1990/1991 fishing season.

2. Review the stock assessment source documents prepared by staff of the herring section and make recommendations regarding the potential 1990/91 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 4).

The following 8 criteria were evaluated for each stock in order to make recommendations regarding stock status and potential catch levels (Appendix 3):

1. SPAWN AND STOCK TRENDS - Age-structured Model
   - Escapement Model
   - Spawn Indices

2. RECRUITMENT TRENDS - Age-structured Model
   - Escapement Model

3. RECRUITMENT FORECASTS

4. FORECAST WEIGHTED RUN SIZE

5. SOUNDING SURVEYS - In-Season
   - Winter

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 estimated unfished average biomass. To ensure conservation of the stocks 20 percent of the forecast biomass to each of seven recognized stock assessment regions 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), where fish were taken during their inshore spawning migrations from October to February. Very large catches (200,000 tonnes annually), in the early 1960s followed by a series of poor recruitments, led to the collapse of the reduction fishery and subsequent closure in 1968. Cessation of the intensive reduction fishery resulted in a gradual recovery of stocks. The roe herring fishery began in 1971. Herring are now caught on or near the spawning grounds by both gillnets and purse seines. Roe herring landings have averaged 32,180 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 1983 (for 1990 data are hailed; catches and quotas are in thousands of tonnes):

	1983	1984	1985	1986	1987	1988	1989	1990
Queen Charlotte Islands								
Roe Catch	8.1	5.0	6.3	3.6	2.0	0.3[a]	1.5	8.6
Roe Quota	*	4.6	5.0	3.8	1.4	0.0	0.9	5.5
Prince Rupert District								
Roe Catch	0.0	3.5	6.5	8.3	6.1	7.9	8.5	4.1
Roe Quota	*	4.0	5.0	6.4	5.4	7.5	7.3	3.5
Central Coast								
Roe Catch	5.6	7.2	5.2	3.3	3.6	4.5	9.4	8.0
Roe Quota	*	6.6	4.1	2.3	3.4	3.7	7.8	7.4
Strait of Georgia								
Roe Catch	16.4	10.2	6.2	0.2[a]	9.1	7.5	8.4	7.5
Roe Quota	11.7	11.6	4.7	0.0	8.1	6.4	7.4	7.1
W. Coast Vancouver Is.								
Roe Catch	8.7	6.7	0.2[a]	0.2[a]	15.9	9.7	13.3	9.4
Roe Quota	4.5	4.5	0.0	0.0	9.4	8.1	10.3	7.2
Total Coast								
Roe Catch	38.8	32.6	24.4	15.6	36.7	29.9	41.7	37.6
Roe Quota	28.0	31.3	18.8	12.5	27.7	25.8	33.7	30.7

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

Stock Status in 1990

Herring abundance along the B.C. coast increased slightly in 1990. The estimated spawning biomass for the seven assessment regions is 180,500 tonnes, a 5% increase over 1989 spawn levels. The 1985 year class remains predominant in the northern assessment regions while a strong 1987 year class recruited to the Strait of Georgia assessment regions. The following discussion of stock trends and 1990 spawning biomass is based on the weighted escapement estimates of both assessment methods. Spawn trends are shown in Figures 1 and 2, and other assessment criteria are listed in Appendix Table 3.

The assessment regions used for the 1990 stock assessments are the same as those used in 1989. For the Queen Charlotte Islands, the assessment region had been expanded in 1989 to include the inlets and bays from Cumshewa Inlet in the north to Louscoone Inlet in the south. The Prince Rupert District stock assessment region includes all of Statistical Areas 3 to 5. The Central Coast assessment region encompasses Area 7, Kitasu Bay in

Area 6, and Kwakshua Channel in Area 8. In the south coast both the Strait of Georgia and the west coast of Vancouver Island are separated into two stock assessment regions. The boundary between the northern and southern Strait of Georgia assessment regions is at Dodds Narrows. The southern west coast Vancouver Island assessment region comprises Areas 23 and 24 while the northern region was revised in 1989 to include only Area 25.

North Coast Stocks

Spawning stocks in the Queen Charlotte Islands decreased slightly in 1990; the estimated biomass of 24,000 tonnes represents a 14% decrease from 1989 spawn levels. Five year olds (1985 year class) comprised 60% of the stock and 4 year olds (1986 year class) 18% of the stock. The 1985 year class is estimated to be double the long term average and the 1986 year class is estimated as average.

The two assessment models produce substantially different estimates of stock size for the Prince Rupert District. The age-structured model estimates of abundance are consistently higher then those from the escapement model, and the two models have shown divergent trends during the past two years. Age-structured model estimates suggest this stock has increased to historically high levels over the past two years whereas escapement model estimates suggest a substantial stock decline over the past two years (Fig. 1). The most likely reason for this difference is biased stock abundance estimates from the age-structured model analysis as a result of a long-term trend in size-at-age. The parameterization of gillnet selectivity in the model is as an age-dependant event. However, gillnet selectivity appears to be size-dependent, therefore, as size-at-age has decreased the relative selectivity of gillnets for younger fish (ie. 4-6 year olds) has also decreased. This could lead to overestimation of stock size for this model. As a result, the age-structured model stock estimates are not used for this years assessment of herring abundance in the Prince Rupert District. The escapement model estimate of 19,400 tonnes of spawners in 1990 represents a 50% increase in stock size over the 1989 level. However, this apparent increase is also anomalous, implying that the abundance of repeat spawners in 1990 was greater than the spawning escapement in 1989.

The 1990 weighted spawning biomass estimate for the central coast stock is 40,600 tonnes, a 7% decrease from 1989. However, the stock remains near historically high levels. The 1985 year-class was particularly dominant in this region; 5 year olds comprised 73% of the stock. This cohort is one of the largest over the 1951-1990 time period.

South Coast Stocks

Spawning biomass in the Strait of Georgia increased 27% in 1990. The weighted spawning biomass estimate was 62,200 tonnes, with 47,700 tonnes spawning in the northern area and 14,500 tonnes spawning in the southern area. The 1987 year-class, which recruited to the fishery as 3-yr olds in 1990, is dominant in both assessment regions. This year class comprised 56% of the northern stock and 59% of the southern stock.

The spawning biomass for the southern west coast of Vancouver Island stock decreased 22% from 1989 to 24,100 tonnes. The 1985 year class remains dominant in this stock with 5-yr olds comprising 48% of the sampled fish, while 3-yr olds from the 1987 year class account for another 27% of the stock. The spawning escapement in the northern area increased 43% from 1989 to 10,200 tonnes. The 1985 year class comprised 39% of the stock while the 1987 year class accounted for 28% of the stock.

Recruitment Forecasting and Prognoses for 1991

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 forecast 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. Generally, the expectation used for the forecast year is average, unless there is additional information to forecast recruitment.

Recruitments are added to expected repeat 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 (in thousands of tonnes) have been established:

	CUTOFF
Queen Charlotte Islands[a]	11,700
Prince Rupert District	12,100
Central Coast	10,600
Strait of Georgia	22,100
Northern west coast Vancouver Is.	5,200
Southern west coast Vancouver Is.[a]	15,100

[a] The CUTOFF levels for the Queen Charlotte Islands and the northern west coast of Vancouver Island have been recalculated to reflect the revised assessment regions.

The recruitment assumption, the corresponding 1991 runs, and the recommended catches (in thousands of tonnes) are shown below (also see Appendix 3):

Stock Assessment Region	Recruitment	1991 Forecast	Recommended Catch
Queen Charlotte Islands	average	23,200	4,640
Prince Rupert District	average	19,400	3,880
Central Coast	average	38,200	7,640
Strait of Georgia			
Northern region	average	53,700	10,740
Southern region	average	16,100	3,220
West Coast Vancouver Is.			
Southern region	poor-avg.	23,850	4,770
Northern region	average	10,000	2,000
Total Coast		184,450	36,890

The forecast stock size for the Queen Charlotte Islands stock assessment region is 23,200 tonnes with an assumption of average recruitment. The recommended catch for this region is 4,640 tonnes.

For the Prince Rupert District there is a continuing concern, as identified in the 1989 assessment, because of the uncertainty about recent stock trends and current spawning biomass. The Subcommittee recommended that only the escapement model be used to forecast 1991 stock abundance for this assessment region. Assuming average recruitment, the stock forecast is 19,400 tonnes for a recommended catch of 3,880 tonnes.

For both the central coast and Strait of Georgia herring stocks an assumption of average recruitment was adopted for 1991. The forecast pre-fishery biomass for the central coast is 38,200 tonnes for a recommended catch of 7,640 tonnes. The forecasts for the northern and southern Strait of Georgia assessment regions are 53,700 tonnes and 16,100 tonnes respectively. This yields catch recommendations of 10,740 and 3,220 tonnes for a combined Strait of Georgia allowable catch of 13,960 tonnes.

For the southern west coast of Vancouver Island assessment region the La Perouse herring survey suggested a below average recruitment of three year olds for 1991. The Subcommittee

adopted a recruitment forecast midway between poor and average for a stock forecast of 23,850 tonnes. This yields a recommended catch of 4,770 tonnes.

There was substantial discussion generated during the Subcommittee meeting regarding the southern west coast of Vancouver Island stock assessment because the Hesquiat Harbour herring spawn had not been surveyed in 1990 as support staff were engaged in conducting fisheries. This spawn appears to have been considerable; the fishery patrolman responsible for the area has suggested that it was the largest one he has seen in the 30 years he has covered the area. However, there is no reasonable way to estimate the biomass for this spawn so all the Subcommittee could do was to recognize that potential catch for this area in 1991 was reduced as a result of the incomplete spawn survey coverage.

Stocks on the northern west coast of Vancouver Island appear to have increased in 1990, and an average recruitment forecast was adopted for 1991. The forecast stock biomass is 10,000 tonnes for a recommended catch of 2,000 tonnes.

In addition to the stock assessments and quota recommendations for the seven major herring assessment regions the Subcommittee discussed fishery options for the "minor" stocks on the west coast of the Queen Charlotte Islands. Because there is not a consistent time series of data for this area it is not possible to forecast stock abundance. In 1989 the Subcommittee recommended that a quota of 10% of the previous seasons spawn abundance be established for this area. This was the basis for the 1990 fishery. The Subcommittee recommends that this policy (ie. 10% of previous seasons spawn abundance) be continued for these minor stocks. Based on the 1990 spawning stock estimate of 10,460 tonnes this yields a 1046 tonne quota for the west coast of the Queen Charlotte Islands. In addition, recognizing that the various inlets on the west coast of the Charlottes may support separate and distinct stocks, the Subcommittee also recommends that no more than 50% of the sounded biomass estimated for a location be taken by the fishery in 1991.

Summary of Reviewed Working Papers

H90-1. Stock assessment for British Columbia herring in 1990 and forecasts of the potential the potential catch in 1991.
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 1991. No significant changes were made to either model for the current assessment. Results of egg counts for 1990 from the Prince Rupert District were substantially lower than model predictions and if accurate would suggest a precipitous decline in this stock. Age structure model estimates for this area were higher than last year but are felt to be biased. Modifications to the age-

structure model to incorporate size selectivity appear required to rectify the discrepancies in stock forecasts for this stock. Stock forecasts for all other areas by the two assessment models are consistent and indicate healthy levels coastwide with the exception of an apparent downturn on the southern west coast of Vancouver Island.

Summary of reviewer comments:

The reviewer had no comments on the specific yield recommendations. He suggested that the sampling protocol for determining proportions at age be evaluated with a view to possible bias to overestimation of older age classes. He also felt that an evaluation of forecast accuracy through some form of hindcasting would be worthwhile as well as some other indicators of model performance. The discrepancy between egg counts from spawn samples and model predictions was noted, and the suggestion made that this should be further investigated. The reviewer commented that the stock assessment provides a thorough and innovative use of assessment methodology in a form useable by managers.

Additional information was presented to the Subcommittee as summarized:

Summary: Results of In-season Tagging in 1990

There were 96,671 floy tags applied coastwide during the 1990 pre-fishery charter program in the seven major stock assessment regions and in one minor region (WC QCI). There were 1,385 tags recovered inseason and the recovery rate averaged 1.4% coastwide, ranging from 0.6%-3.4% between areas. Most tags were recovered from the districts in which they were tagged however there was evidence of movement between areas. In the north coast 5 tags from the upper WC-QCI tagging were recovered in the central coast; 7 tags from Prince Rupert tagging were recovered in Area 2E, and 7 were recovered in the central coast; 12 tags from the central coast tagging were recovered in area 2E, and 11 were recovered in Prince Rupert. In the south coast 14 tags from the Strait of Georgia were recovered from the WCVI and 9 were recovered from the central coast; 13 tags from WCVI tagging were recovered in the Strait of Georgia, and 12 were recovered in the central coast. An additional 81 tags from tagging in 1988 and 1989 were also recovered.

Summary: Distribution of herring larvae in the Strait of Georgia

Larval herring distribution in the Strait of Georgia was assessed by 403 oblique plankton hauls taken between April 10-20 1989, approximately 2-3 weeks after hatching. Larval herring densities were estimated by comparing larval numbers by volume filtered. Larvae were found throughout most of the Strait of Georgia, however, the vast majority were caught along a SE line from Cape Lazo to Kulleet Bay and a NW line from Grief Point to Cortes Island. Maximum densities reached 94 larvae/cubic meter near Bowser. Plankton densities, larval lengths and other fish larval distributions were also examined to see if rates and directions of larvae dispersal could be determined. The nearly continuous distribution of herring larvae has implications for stock structure which were discussed.

Summary: Climate Forcing of Pacific Herring recruitment and growth in southern British Columbia.

Over the last 50 yrs. much of the variability in ocean climate and herring recruitment has occurred at two dominant periods centred around 5 and 16 yrs. Herring growth has also exhibited a dominant 5 and 18 yr. periodicity. A recent analysis of a number of relevant time series suggests that interannual variations in oceanic conditions off the west coast of Vancouver Island affect the survival of herring, and their principle predator, Pacific Hake, which also exhibits a marked 16 yr. oscillation in abundance. Thus the dynamics of the herring stock are modulated by a combination of climate and predator forcing. Much of the interannual variation in herring growth is centred around the 5 year (moderate ENSO period) and 16 year (strong ENSO period) ocean climate oscillations, and the recruitment oscillation.

Summary: Offshore herring distribution and recruitment forecast for the lower west coast Vancouver Island, August 1990

A bottom and mid-water trawl survey of the herring, hake and groundfish stocks off the lower west coast Vancouver Island was conducted between August 15-21, 1990. The survey covered 6000 sq. km. of the continental shelf from the U.S.-Canada border, north to 49 degrees latitude, and seaward to the 200 m isobath. Fishing operations were conducted in the major fishing subareas. Eleven bottom and 18 mid-water tows were made to determine the diet, length composition and age composition of the dominant fish species in the area. This trawl survey has been conducted for the

last 6 yrs. as part of the La Perouse Research Project. A principle objective of this project is to clarify how interannual changes in oceanic conditions, and in the distribution and abundance of offshore predators affect herring year-class strength and production. Based on the 1990 survey a below average recruitment of 3 year old fish is forecast for the southern west coast of Vancouver Island assessment region in 1991.

Summary: Hydroacoustic survey - Strait of Georgia

The present sounding program has been in place for 9 years with a good correlation with spawn estimates until 1990, when the relative sounding estimate was much lower then the estimated spawning biomass. Following are a few possible reasons for the discrepancy:

1. The timing of the inshore migration via Juan De Fuca Strait and movement within the Strait of Georgia was different, thus the distribution during the key sounding periods was abnormal. For example,the movement into the southern Strait occurred over two time periods (normal Oct. to Dec. and Feb.) and because the second wave was substantial the echo sounding results and relative abundance index was affected.
2. The Northern component immigrating via Discovery Pass was larger than normal.

The above observations are supported by the tagging recovery results and inseason sounding estimates. The same vessel and hydroacoustic equipment was used and the same personnel were involved in the echo sounder interpretation.

Summary: Growth and size-at-age in B.C. Herring

Size-at-age and growth of lower west coast Vancouver Island herring are functions of biomass and sea temperatures late in the growing season when growth is most rapid. Biomass affects on size-at-age 3 and 4 appear strongest during the first year of life.

Combinations of the two assessment model biomass estimates, and the estimates themselves were used to determine if the single model estimate or the one based on a combination of the two describes size-at-age variations well. Presumably, the most effective predictor of size-at-age reflects stock biomass. For LWCVI herring, a 50:50 weighting of the escapement and age-structure biomass estimates explained size-at-age variations most effectively.

The analysis of growth rate-biomass relationships can examine interactions between stocks after assuming competition for food among stocks. The biomass measure which most accurately described the variation in growth rate was LWCVI and Strait of Georgia biomasses from the escapement model summed.

Summary: Egg survival in Pacific Herring Spawns

To estimate egg loss in Pacific herring spawns in southern British Columbia, herring spawn was sampled for egg loss throughout the incubation period (1990 was the last year of a two year study). Bird and invertebrate egg predators were identified and enumerated. Egg loss was greater in shallow than deep water and at sites where birds were congregated. Egg loss over the 14 day incubation period was as high as 85% on *Sargassum* sp. in shallow water and almost negligible on red algae in deep water. Decreases in egg density on vegetation were accompanied by decreases in observations of egg layers and percent cover of the vegetation. There were up to 61,000 birds, mostly gulls and diving ducks, in the Lambert Channel study area and they were estimated to have consumed 5% of the spawn. Bottom-dwelling invertebrates, chiefly crabs, starfish, and snails, were estimated to have consumed a further 5% of the spawn.

Summary: Juvenile Herring Recruitment in Georgia Strait

A study of juvenile herring recruitment was initiated in 1990. The objectives of the study are:

- determine the distribution of juvenile herring in relation to their food supply and the growth of herring in relation to the abundance of the food supply.
- determine the trophic relationship between plankton, juvenile herring, and other fishes.
- determine the feasibility of hydroacoustics to estimate juvenile herring abundance.

Activities to date have been:

- Fish and plankton collections were made at five sites in eastern Georgia Strait in early June, July, and August. Seine sets and bongo tows were made nearshore and 1, 2, 3 and 4 km offshore. Juvenile herring were most abundant within 2 km of shore and they frequently occurred with juvenile salmon, dogfish, and jellyfish, and occasionally other fish species (eg. midshipmen, hake, older herring).
- A hydroacoustic survey with 38 and 120 khz transducers, along with fish and plankton collections, is scheduled for early October.

Summary: Evaluation of the impact of salmon netpens on herring and juvenile salmon

Field and laboratory tests examined effects of salmon netpens on herring and juvenile salmon. Herring eggs were incubated at 3 different farms. Egg survival was high at all farms but varied slightly between farms. Differences were related more to naturally occurring oxygen levels than netpen wastes. In laboratory tests herring eggs were exposed to netpen wastes. Survival of young eggs (< 3days) declined at waste levels exceeding 4 g/L(dry wt.). In general, waste levels required to impair egg survival were much higher than those found around

netpens. To investigate predation, live salmon were purchased from netpens and stomach contents analyzed. Of 1750 stomachs examined from 9 farms over 3 months, only 10 (0.6%) contained any fish, all juvenile herring and no salmon. Juvenile herring, salmonids and other species were abundant at all sites. About 40% of stomachs contained other wild feed - mainly planktonic invertebrates from netpen webbing 'fouling' communities. These results indicate that predation by netpen salmon on wild fish is not a concern in the study area.

Appendix 1. 1990 PSARC Herring Subcommittee working papers.

Number	Title	Authors
H90-1	Stock Assessments for British Columbia herring in 1990 and forecasts of the potential catch in 1991	V. Haist J. Schweigert

Appendix 2. List of Participants

Name	Association
Dennis Chalmers (Chairman)	Department of Fisheries and Oceans, Nanaimo
Doug McKone	Biological Sciences Directorate, HQ, Ottawa
Doug Hay	Pacific Biological Station, Nanaimo
Ron Tanasichuk	Pacific Biological Station, Nanaimo
Carl Haegele	Pacific Biological Station, Nanaimo
Lyle Freeman	Department of Fisheries and Ocean, Nanaimo
Susan Farlinger	Department of Fisheries and Ocean, 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	Pacific Biological Station, Nanaimo
Bruce McCarter	Pacific Biological Station, Nanaimo
Chuck Fort	Pacific Biological Station, Nanaimo
Ed Safarick	Fisheries Council, Vancouver
Jim Steward	Department of Fisheries and Oceans, Prince Rupert
John Radosevic	U.F.A.W.U., Vancouver
Bruce Turris	Department of Fisheries and Oceans, Vancouver

Appendix 2. List of Participants Cont'd.

Name	Association
Chris Ashton	Fishing Vessel Owners Association
Joe Chambers	Department of Fisheries and Oceans, Port Hardy
Gus Jacobson	Pacific Gillneters Association, Richmond
Greg Thomas	Department of Fisheries and Oceans, Prince Rupert

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

	Criteria	Status
1.	Spawn and Stock Trends	
	a) Age-structured Model	Slight decrease from 1989.
	b) Escapement Model	Slight increase.
	c) Spawn Indices	Slight decrease from 1989.
2.	Recruitment Trends	
	a) Age-structured Model	1985 strong, 1986 + 1987 below average.
	b) Escapement Model	Same as above.
3.	Recruitment Forecast	N/A.
4.	Forecast Weighted Run Size	23,200 t assuming average recruitment.
5.	Sounding Surveys	
	a) Hydroacoustics (winter)	N/A.
	b) In Season	Above average but lower than 1989 (18,000 t).
6.	CUTOFF	11,700 t.
7.	Charter Skipper Comments	Stocks look good.
8.	Additional Information	N/A.

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

	Criteria	Status
1.	Spawn and Stock Trends	
	a) Age-structured Model	Slight increase from 1989.
	b) Escapement Model	As above.
	c) Spawn Indices	As above.
2.	Recruitment Trends	
	a) Age-structured Model	N/A.
	b) Escapement Model	Past two years were below average.
3.	Recruitment Forecast	N/A.
4.	Forecast Weighted Run Size	19,400 t.
5.	Sounding Surveys	
	a) Hydroacoustics (winter)	N/A.
	b) In Season	Decline in stocks, different distribution
6.	CUTOFF	12,100 t.
7.	Charter Skipper Comments	No indication of stock trend.
8.	Additional Information	Egg counts to validate escapement model suggests estimate may be biased high. Age structure model estimates seriously biased. Weighting of ASM:ESM of 0:100 adopted.

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

Criteria		Status
1.	Spawn and Stock Trends	
	a) Age-structured Model	Slight decrease from 1989.
	b) Escapement Model	Similar to 1989.
	c) Spawn Indices	Similar to 1989.
2.	Recruitment Trends	
	a) Age-structured Model	1985 year-class strong, 1986 and 1987 poor.
	b) Escapement Model	Same as above.
3.	Recruitment Forecast	N/A.
4.	Forecast Weighted Run Size	38,200 t.
5.	Sounding Surveys	
	a) Hydroacoustics (winter)	N/A.
	b) In Season	Record high soundings.
6.	CUTOFF	10,600 t.
7.	Charter Skipper Comments	Stocks look good, slight decrease from 1989.
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-structured Model	Substantial increase in 1990.
b) Escapement Model	Slight decrease from 1989.
c) Spawn Indices	Same as above.
2. Recruitment Trends	
a) Age-structured Model	1985 and 1987 year-class above average, 1986 poor.
b) Escapement Model	Same as above.
3. Recruitment Forecast	N/A.
4. Forecast Weighted Run Size	53,700 t assuming average recruitment.
5. Sounding Surveys	
a) Hydroacoustics (winter)	Down slightly from 1989.
b) In Season	Up slightly from 1989.
6. CUTOFF	22,100 t for entire Gulf.
7. Charter Skipper Comments	Stocks in good shape, 47,000 t.
8. Additional Information	N/A

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-structured Model	Substantial increase in 1990.
	b) Escapement Model	Same as above.
	c) Spawn Indices	Same as above.
2.	Recruitment Trends	
	a) Age-structured Model	1987 year-class above average, 1986 poor.
	b) Escapement Model	Same as above.
3.	Recruitment Forecast	N/A.
4.	Forecast Weighted Run Size	16,100 t assuming average recruitment.
5.	Sounding Surveys	
	a) Hydroacoustics (winter)	
	b) In Season	See N. Gulf.
6.	CUTOFF	22,100 t for entire Gulf.
7.	Charter Skipper Comments	Lots of fish, 10-15,000 t.
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-structured Model	Indicates slight decrease in stocks in 1990.
b) Escapement Model	Same as above.
c) Spawn Indices	Slight decrease from 1989.
2. Recruitment Trends	
a) Age-structured Model	Strong 1985 year-class, below average 1986 and 1987.
b) Escapement Model	Same as above.
3. Recruitment Forecast	Offshore survey - below average.
4. Forecast Weighted Run Size	23,850 t assuming poor-average recruitment.
5. Sounding Surveys	
a) Hydroacoustics (winter)	N/A.
b) In Season	Soundings in Area 23 down slightly.
6. CUTOFF	15,100 t.
7. Charter Skipper Comments	N/A.
8. Additional Information	Major spawning in Hesquiat Harbour not surveyed.

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-structured Model	Similar to 1989 level.
	b) Escapement Model	Substantial increase from 1989 levels.
	c) Spawn Indices	Same as above (Spawn index double; total length tripled).
2.	Recruitment Trends	
	a) Age-structured Model	Above average 1985 year-class, below average 1986 and 1987.
	b) Escapement Model	Same as above.
3.	Recruitment Forecast	N/A.
4.	Forecast Weighted Run Size	10,000 t assuming average recruitment.
5.	Sounding Surveys	
	a) Hydroacoustics (winter)	N/A.
	b) In Season	Down from 1989 but poor coverage in Nootka.
6.	CUTOFF	5,200 t (Revised to reflect new stock concept.)
7.	Charter Skipper Comments	Poor stocks but left the area early.
8.	Additional Information	N/A.

Appendix 4. Recommendations for stock assessment and related activities

1. Spawn surveys require consistent support. Stock assessments and quotas are based on spawn surveys. There is potential for significant dollar loss to users due to inconsistent surveys. For example: major spawnings in Hesquiat Harbour, Knights Inlet and Wakeman Sound were not surveyed in 1990; additionally numerous minor spawns are not surveyed regularly. Inadequate spawn surveys reduce management flexibility.

Recommended Action:

1. A Regional commitment to organizing and funding the herring spawn assessment program (similar to the Regional charter program).

2. Reporting system for herring spawn survey data to be reviewed by the Spawn Assessment Committee.

2. The age-structured model should be revised to parameterize gillnet selectivity as a size-selective, rather than age-selective process. This may alleviate uncertainty with respect to stock trends and current status in the Prince Rupert District.

3. PSARC to review the biological basis for the Strait of Georgia herring stock assessment regions.

Recommended Action:

Papers are to be presented at the PSARC meeting in 1991 relating to this topic:

- Nuclear DNA analysis; J. Schweigert

- Review of in-season and reduction tag recovery information; C. Haegele and B. Armstrong

- Larval distribution; D. Hay and B. McCarter

- Distribution and timing of spawn; D. Hay

- Size-at-age; R. Tanasichuk

4. Continue to support recruitment forecasting studies (eg. La Perouse project, Strait of Georgia project, North Coast hydroacoustic survey)

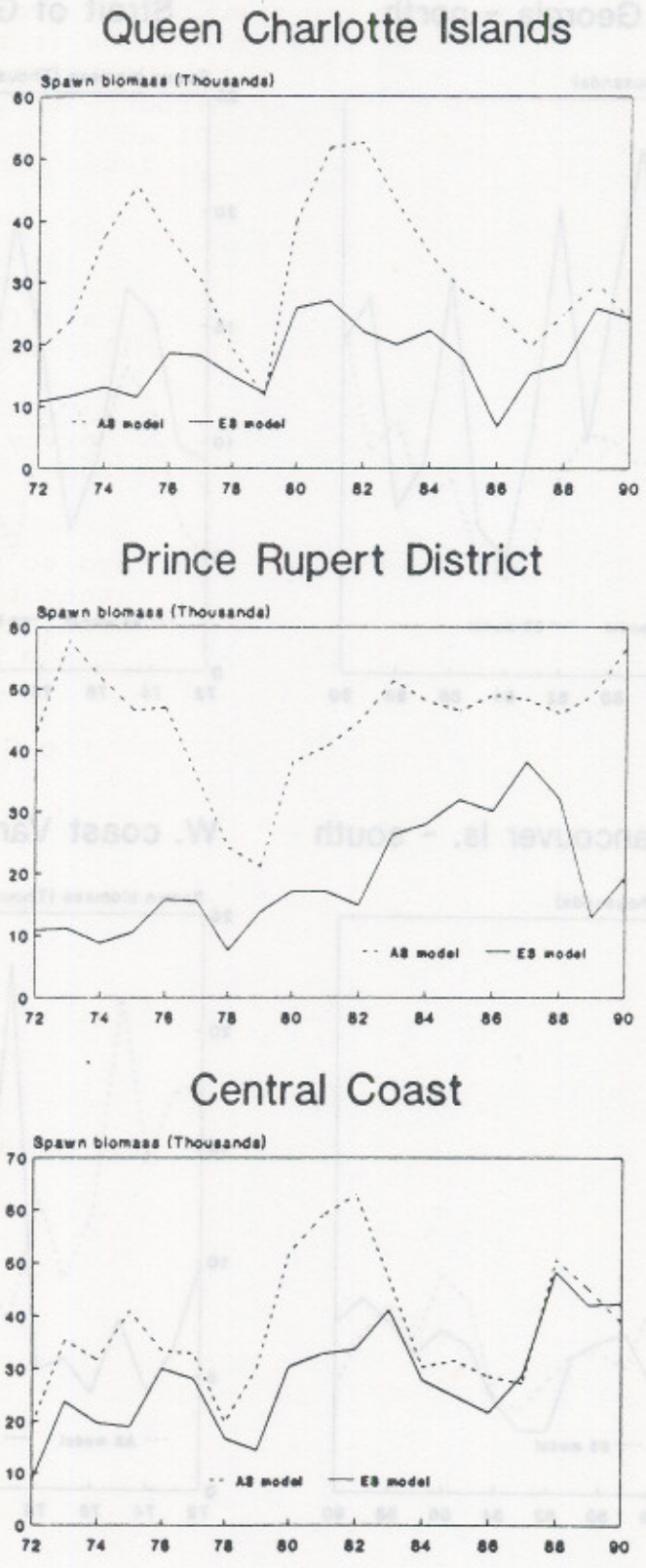

Fig. 1 Estimates of spawning biomass (1972-90) from age-structured model and escapement model analysis for northern B.C. herring stock assessment regions.

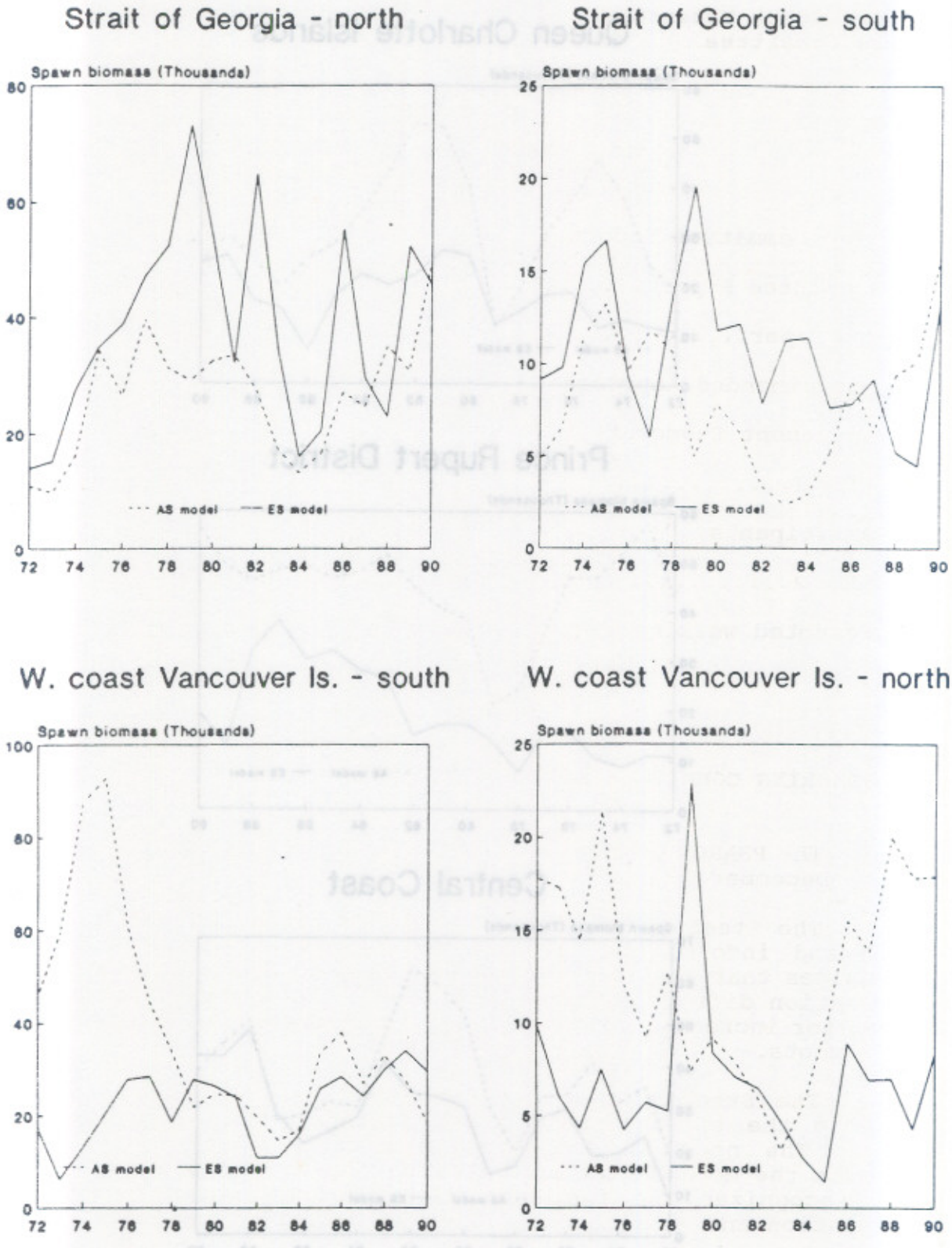

Fig. 2 Estimates of spawning biomass (1972-90) from age-structured model and escapement model analysis for northern B.C. herring stock assessment regions.

CONTENTS

1) STEERING COMMITTEE REPORT

The PSARC Steering Committee met to review the sub-committee report December 10, 1990 at Nanaimo.

The Steering Committee notes the progressive reduction of money and information coverage of salmon escapement data. It recognizes that the importance of escapement and stream visitation information differs between streams and stocks, and that there is a need for increased accountability in Departmental information and assessments.

The Steering Committee endorses the proposed program to evaluate the effectiveness and efficiency of salmon escapement data. The need to set priorities on species/streams and to evaluate the methods for each application is clear. The Committee also recognizes the need for close communication between data correlation and analysis staff in the different branches. It is

noted that existing work such as operational framework and key stream information needs to be incorporated. Further evaluation of the methods used is an essential part of the proposal.

To accomplish these objectives, the Steering Committee recommends an enhanced version of option 1 and 3 with local area committees reporting through a central coordinating person or unit. The inclusion of standardized training for Fishery Officers in the Regional training program is strongly supported.

2) SALMON SUB-COMMITTEE REPORT

The Salmon Sub-committee of the Pacific Stock Assessment Review Committee met November 14, 1990 at the Sheraton Landmark Hotel in Vancouver, B.C. The objectives for this meeting were:

1) to review the working papers presented for the purpose of advising on technical issues for salmon management including those expected in the 1990-91 Pacific Salmon Commission negotiations;

2) to develop consensus on advice and recommendations from these papers;

3) to conduct routine Sub-committee business.

Six papers were scheduled for this meeting. Of these, two papers were presented to the Sub-committee. The other four papers (concerning escapement requirements for Fraser River coho, WCVI chinook stock status, terminal area catch exclusions for north coast chinook, and the distribution of chinook and chum in the upper Yukon River) were not complete in time for presentation to the Sub-committee. These papers will be reconsidered for the Spring meeting.

Of the two papers presented to and considered by the Sub-committee, only one is included in this report. The second paper concerning hooking mortality rates for chinook and coho salmon is not included. The author of this paper was not able to attend the Sub-committee meeting. Alternate arrangements for presentation were made. In retrospect, further discussion and clarification will be needed to develop consensus on advice and recommendations regarding this working paper.

Discussion took place regarding the interaction between the Data and Systems Sub-committee and the Salmon Sub-committee. It was agreed that data and systems concerns would be identified by the Salmon Sub-committee and forwarded to the Data Sub-committee.

Requirements and assignments for the meeting in the spring of 1991 will be addressed in the near future.

WORKING PAPER

A Recommended Approach to Improving Salmon Spawning Escapement Enumeration (PSARC Working Paper S90-36 by Assessment Priorities Working Group of the PSARC Salmon Sub-committee).

The reviewers were L. Ottmann (in consultation with K. Harper), and L. Lapi.

SUMMARY

INTRODUCTION

This working paper addresses the recommendations made in the April, 1990 PSARC Salmon Sub-committee report concerning the urgent need to improve the quality and consistency of salmon escapement data in the Pacific Region of DFO. The specific recommendation called for the preparation of a working paper by a small group for the fall/1990 PSARC Salmon Sub-committee meeting which described alternative approaches and time-tables for achieving the following:

i) definition of "priority" or "important" stocks for fishery management, stock assessment, SEP assessment and Habitat protection purposes; and

ii) upgrading and standardizing the collection of assessment data (escapement, coded wire tag recoveries, etc.) for these priority stocks.

In addition, it was stipulated that "while the working group could recommend approaches requiring additional resources, their focus should be on those that improve the effectiveness of existing assessment programs within existing Pacific Region resources."

BACKGROUND

Scientifically rigorous population estimates are made on only a handful of important stocks. The remainder are surveyed by Fishery Officers using a variety of visual methods. There are currently no departmental standards for Fishery Officer estimates of spawning escapement. The methods used to collect observational

information and make escapement estimates are almost always left to the discretion of sub-District Fishery Officers. Methods used may vary between sub-Districts, streams, Fishery Officers and years, and are, at best, poorly documented.

The streams surveyed for salmon escapement can also change form year to year. Resource limitations and changing priorities at the local level may result in reductions in the number of streams surveyed or a re-allocation of resources to a different species or stock. A discontinuous escapement record of unknown accuracy and precision is a serious shortcoming in stock assessment. Biologists are forced to devise band-aid measures to overcome the deficiencies when using escapement data for analyses of escapement trends and stock and recruitment. It can also lead to incorrect or misleading uses of the data, especially when the derivation of the data is unknown.

Where escapement monitoring has been treated as an integral part of the salmon management program, increased production and improved fisheries management has resulted. The management of Fraser River sockeye, formerly carried out by the International Pacific Salmon Fisheries Commission, is as dependant upon accurate spawning escapement estimates as it is upon effective in-season management tools. Considerable priority and resources are allocated to this function, but the long term benefits in fisheries management, enhancement and habitat planning make this a wise investment. The same can be said for the annual investment in monitoring a high proportion of the Skeena River sockeye run through the Babine River fence. The Babine sockeye run has grown from near extinction in the early 1950's to very high levels in recent years as the result of spawning channel enhancement and the careful control of harvest afforded by the counting fence and an associated river-mouth test fishery.

ESTABLISHMENT OF REGIONAL ESCAPEMENT MONITORING PROCEDURES

Regardless of the production and harvest management systems used, spawning escapement data collected for stock assessment purposes should be known accuracy and precision and comparable from one year to the next. At a minimum, the escapement data must serve as a defensible index of the true escapement level.

More detailed data will need to be collected, particularly in streams where coded wire tag recovery data are being used to scale ocean catches or to estimate ocean exploitation rates. Accurate escapement data to the whole stream must be known to some level of precision.

To meet these requirements the following Regional procedures need to be applied to all systems and all species:

1. Stocks and/or streams for escapement enumeration should be selected based on their importance to fishery management, stock assessment, SEP assessment and habitat protection;

2. Based on the above selections, the stocks/streams should be priorized in order of importance; Regional criteria on which to base the priorization of stocks should be established; these priorities will determine the type and intensity of assessments, depending on budget limitations;

3. Selected stocks/streams will be surveyed annually using a pre-defined method and schedule;

4. Survey methods must produce estimates of known accuracy and precision and be fully documented;

5. A validation system (species ID, verify counts) may need to be instituted for some streams; and,

6. For some stocks/streams, it may be necessary to collect biological information along with the escapement counts (this would include age composition information, sex ratios, and tag incidence, as well as insuring that there are sufficient resources to process and analyze the data).

7. The final estimate of escapement for each system could be done by Fisheries Officers, by Fisheries Branch management biology staff, by Science Branch assessment staff or by Enhancement Branch staff. In any of these cases, the methods used to make the estimate need to be fully documented and reported to PSARC.

IMPLEMENTATION OPTION #1:

In this option, the responsibility for developing a plan to implement the above Regional procedures would be addressed at a local level (Fisheries Branch Districts or Divisions) with regional coordination. Local Escapement Monitoring Committees (LEMC) would be formed with the following suggested membership in order to involve all branches with an interest in good quality escapement enumeration:

1. local management biologist(s), -Fishery Coordinator
   -Sr. Biologist
2. sub-District Fishery Officers,
3. enhancement personnel, both local and regional,
4. local habitat biologist(s), and
5. a BSB stock assessment biologist

Carrying out the plan chosen by the LEMC would remain the responsibility of individual Branches, depending on fund allocations and the priorities identified by the LEMC. This means that the Branches will enumerate the streams in the agreed order of priority until available funding is exhausted.

Regional coordination would be required to ensure that the regional procedures were being applied in a consistent manner. A system of Sub-committees dealing with data are being proposed through the Information Management Committee (chaired by D. Griggs). One of the proposed Sub-committees would deal with escapement data and could be made up of the chairs of each of the LEMC's.

Although this option is designed to make optimal use of existing PY's and escapement monitoring dollars, it would require a significant adjustment of staff priorities and the procedures they use to make escapement estimates. To maximize the effectiveness of this approach, escapement monitoring should be the first priority of at least one individual in each LEMC.

Variant on Option #1:

The LEMC could be given more authority by assigning resources to it through the workplan process and making it directly responsible for the implementation of the Regional procedures.

IMPLEMENTATION OPTION #2:

Fisheries Branch could implement the Regional procedures independently of other Branches as it currently has the responsibility (and most of the funding) of providing escapement estimates for the Region.

Variant on Option #2:

Fisheries Branch could directly assign PY's (either regionally or in each Division) to oversee the application of the Regional procedures within the Branch. Alternatively, such an assignment could work directly with the LEMC's proposed in Option 1.

IMPLEMENTATION OPTION #3:

A more elaborate option would involve the creation of a Regional Assessment Unit (RAU) which could unify stock assessment efforts in the Region and be responsible for implementation of the Regional procedures.

REPORTING REQUIREMENTS (applicable to all options):

An absolutely essential aspect of any proposed escapement enumeration system is the proper reporting of all accumulated data. In particular, this means capturing the information collected from each stream visit, regardless of enumeration method. Currently, a form is being used in the Region to capture such data and a data entry system is being developed to process the data contained in this form. Regardless of which of the above options is chosen, this form should be updated to accommodate any new requirements which may result from proposals advanced by the implementation of the new Regional procedures. As well, system development for individual stream visits should be continued. Once the form is standardized and accepted, the use of this form should become mandatory for every stream visit and a data retrieval process to capture the resulting data should be implemented.

Finally, all escapement data should be stored on, and retrievable from, a central computer data base. Resources need to be explicitly allocated to this function if regional needs for this data are to be effectively met.

TRAINING:

An important deficiency in the Region's effort towards escapement enumeration is the lack of an organized training system to ensure that there is a standardization between individuals doing the work. It is suggested that such a training program be developed as a part of the implementation of this new system of escapement enumeration.

REVIEWERS' COMMENTS:

Both reviewers felt that the paper presented good ideas on the approaches needed to improve the quality of salmon escapement enumerations, including more emphasis on training for escapement enumerators (skills, techniques, analysis and importance), timely and consistent documentation of plans and results, and establishment of regional escapement monitoring standards (procedures) that recognize the needs and importance of different interest groups (fisheries management, stock assessment, enhancement, protection and habitat) and their involvement in standards development.

One reviewer made two suggestions that he felt should be considered in developing the implementation process aimed at improving escapement enumerations:

- Ensure that the regional escapement monitoring standards (procedures), the enumeration training course and implementation process are all developed from the bottom up within the organization. The process should

begin by officers/hatchery staff, etc. discussing, documenting, and finalizing enumeration requirements, methods, and procedures with the biologist at the division level, who will be using the data.

This consultation will provide the field input into the regional enumeration standards (procedures) and the basis for what should or should not be taught as sound enumeration practices. Divisional recommendations would then be combined to form a Regional perspective.

- Choose implementation options that will produce the desired results while minimizing resources required for administration/review processes and put those funds back into obtaining field data.

One reviewer felt that training should be mandatory for all staff involved in stock enumeration. Both reviewers expressed great concern about insufficient and insecure funding and resources for escapement enumeration because of changing Divisional and Regional priorities and implied that a new process for allocating resources should be considered.

SUB-COMMITTEE ADVICE

The Sub-committee generally agreed with the reviewers' comments and focused most of its effort on the next steps towards achieving the desired goal of improving escapement enumeration in the Region namely, the implementation process by which this objective can be accomplished, where to start, what area and species to include and how.

The Sub-committee felt that adoption of implementation Option #1 would be the most effective means of accomplishing the desired goal. Option #1 sees the formation of Local Escapement Monitoring Committees (LEMC's) with responsibility for planning and reporting the escapement enumerations conducted by individual Branches. In other words, individual branches would be responsible for implementing the LEMC plans in the agreed order of priority until available funds are exhausted. Next to the status quo, this option would be the least disruptive organizationally, would not likely involve the need for significant increases in existing resources and clearly defines accountability for planning, implementation and documentation of results that can be reviewed by PSARC.

The choice and priorization of species, stocks and streams for improving escapement enumeration depends on such things as historical escapements, the objectives of different interest groups (fish management, stock assessment, habitat, etc.) countability of fish, stream access and stock specific catch (species ID). Much of this information is currently available and criteria have been

developed, e.g. Fraser River Chinook and Coho, for selecting and priorizing stocks and streams for escapement enumeration. The Salmon Escapement Database System (SEDS) contains current and historical salmon escapement records for numerous systems surveyed by Fisheries Officers. The Sub-committee felt that the SEDS database together with a review of existing selection and priorization criteria could provide a kick-start in developing implementation Option #1. A mail-out questionnaire to all Districts and Sub-districts requesting such information as the numbers of streams and stocks being enumerated, their importance, countability and reliability needs to be developed and distributed to further refine the above-mentioned process. A questionnaire used for the Strait of Georgia should be reviewed and revised if necessary.

The Sub-committee recommends that:

1) In the Fraser River and the Strait of Georgia, where some preliminary data exist a pilot project choosing and priorizing streams and stocks for escapement enumeration using a species and a limited geographic area that would be most beneficial to current Regional initiatives, and that a progress report be presented at the Spring 1991 meeting of PSARC.

2) That a questionnaire be developed and mailed out to all remaining Districts and Sub-districts for completion by Fisheries Officers, the purpose of which would be to "flesh out" the importance, practicality and magnitude of escapement enumeration for stocks and streams in their area.

APPENDIX 1. PARTICIPANTS SALMON SUB-COMMITTEE

Members

D. Anderson, Chairman
B. Riddell
T. Beacham
C. Wood (afternoon only)
T. Perry, Working Paper rapporteur
R. Semple (alternate for D. Schutz), Working Paper rapporteur
G. Berezay
R. Harrison
P. Starr
D. Peacock
R. Kadowaki
D. Meerburg

Reviewers:

P. Ryall
V. Palermo (not present)
L. Lapi
L. Ottmann

Observers:

D. Radford (Chairman, DSSC)
S. Farlinger (Chairman, PSARC)

APPENDIX 2. LIST OF WORKING PAPERS

PAPER NO.	TITLE	AUTHOR(S)
S90-35	Hooking mortality rates for sport-caught chinook and coho salmon.	T. Gjernes
S90-36	A recommended approach to improving salmon spawning escapement enumeration.	R. Kadowaki P. Starr G. Berezay

1) STEERING COMMITTEE REPORT

The PSARC Steering Committee met December 10, 1990 at Nanaimo to review the Sub-committee report. The Sub-committee recommendation was endorsed; that is, to support the development of a Regional commitment to the dive survey as part of the 1991/92 workplans.

2) SUB-COMMITTEE REPORT

The PSARC Data and Systems Sub-committee met on November 2, 1990. At that meeting, the sub-committee reviewed a paper that made some specific recommendations for spawn data requirements for herring stock assessments, including: a requirement for a Regionally supported coastwide spawn survey; increased Fisheries Branch responsibility for data quality, both in collection and verification; and the need for adequately trained Fisheries Branch staff to participate in the data collection. A second paper dealing with escapement data requirements for salmon stock assessments was discussed, but was deferred to the Salmon Sub-committee for review.

Spawn Data Requirements for Herring Stock Assessment (Working Paper D90-1)

Spawn data are an essential component of both methods of pre-season forecasting herring abundance. There are two basic methods of estimating spawn abundance. These are surface surveys and dive surveys. Of the two, the dive survey has the potential to provide more accurate and consistent estimates of egg deposition. Problems that have arisen to reduce the reliability of the data include a lack of a regional commitment to spawn surveys. This lack of commitment results in spawn surveys being secondary to actual fishery management. It may also contribute to a reduction in surface surveys for minor spawns. Because the time demands of the dive surveys are so much greater, there is a potential for overlooking the minor spawns. Other problems that are related to herring spawn data include: the validity of making comparisons between historical surface survey data and dive survey data; and, data management, including reporting, validation and data entry. The working paper made the following recommendations:

1) Complete coastwide spawn survey coverage should be a top priority in order to create a pool of fully equipped divers to ensure that spawn data is collected independent of other time and resource constraints. The author noted that Fisheries Branch was recently asked to prepare an action plan to respond to this issue.

2) Increased responsibility for data on behalf of Fisheries Branch in order to allow the Herring Section of BSB to complete the herring stock assessments and forecasts in a timely manner and to proceed with other developmental duties.

3) Trained Fisheries Branch personnel to participate in all surveys to avoid the data consistency and interpretation problems that arise when surveys are not conducted according to survey guidelines.

There were two reviews of this paper. The first reviewer made a number of comments aimed at improving the clarity of the paper. He also made several suggestions for improving the methodology. These include: the development of an optimum mix of surface surveys and dive surveys to ensure best coverage of spawn; an evaluation of the effects of lack of spawn data in the forecasting process; and, the inclusion of dive survey duties to the PASs for Fishery Officers.

The second reviewer also had some suggestions for improving the clarity of the paper. In particular, it was noted that herring management, particularly the area licensing system, is highly dependant on pre-season stock forecasts, and that this point was critical in understanding the importance of spawn data and the overall forecasting procedure. This reviewer also made some methodological suggestions. These included: a method for improving data quality by having the Fisheries Branch biologists act as responsibility centres for supervision and collection and, subsequently, editing and checking of all survey data; and, the use of charter vessels paid in fish to support the dive survey and improve coverage.

Sub-committee Recommendations:

The sub-committee agreed with the recommendations, and noted that the Senior Executive has requested (20 September, 1990) that Fisheries Branch take action on a regional commitment to the Fishery Officer dive surveys. Because it appears progress is being made, the sub-committee chose not to forward all the recommendations of this paper, but rather, to support the

initiative to develop a Regional commitment to the dive survey, and to recommend that it be developed and implemented in the forthcoming (1991/92) workplan process.

List of Participants:

Margaret Birch	Jim Bjerring	Rick Stanley
Don Noakes	Carol Cross	Lorena Hamer
Don Radford	Alex Fiteni	Louis Lapi
Paul Starr		

Reviewers:

Bruce Leaman
Sue Farlinger

List of working papers:

D90-1: Spawn data requirements for herring stock assessment L. Hamer.