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Pacific Stock Assessment Review Committee (PSARC) Annual Report for 1987

M. Stocker, R. Harbo, B. Riddell, J. Schweigert,
and A. Tyler (editors)

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June 1988

Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 1988

Fisheries and Oceans   Pêches et Océans

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Canadian Manuscript Report of Fisheries and Aquatic Sciences

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Canadian Manuscript Report of

Fisheries and Aquatic Sciences No. 1988

June 1988

PACIFIC STOCK ASSESSMENT REVIEW COMMITTEE

(PSARC)

ANNUAL REPORT FOR 1987

by

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Cat. No. Fs 97-4/1988E ISSN 0706-6473

Correct citation for this publication:

Stocker, M., R. Harbo, B. Riddell, J. Schweigert, and A. Tyler [editors]. 1988. Pacific Stock Assessment Review Committee (PSARC) Annual Report for 1987. Can. MS Rep. Fish. Aquat. Sci. 1988: 125 p.

Chairman's Report for 1987

This is the second Annual Report of PSARC, summarizing the third year of operation of the committee providing biological advice on the status of Pacific fisheries resources. In 1987 PSARC established a complete annual meeting schedule that included salmon related activities. 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 1987 33 Working Papers were prepared, providing the basis for biological advice for Pacific fisheries resources. The resulting five Advisory Documents are contained in this report.

Steering Committee review of the 1987 PSARC Shellfish, Herring and Groundfish Subcommittee Reports took place on September 11th, 1987. PSARC presented the respective Advisory Documents to the regional Fisheries Resource Management Executive Committee (FRMEC) on September 21st, 1987. The approved biological advice was used by Fisheries Managers to prepare fishing plans for the region.

The Salmon Subcommittee Report on Chinook was reviewed by the Steering Committee on November 11th, 1987. The resulting Advisory Document was submitted to FRMEC on November 9th, 1987. The approved document provided useful input to the November meetings of the Pacific Salmon Commission.

My term of office as Chairman of PSARC has been extended by FRMEC for a further year. There were however some changes in the composition of the Steering Committee in 1987. In June D. Radford replaced D. Barrett as the representative of the Program Planning and Economics Branch. In September, Dr. D. McKone became the Headquarter's representative replacing Dr. F. Bernard. In November, Dr. N. Bourne took over the Chair of the Shellfish Subcommittee from Mr. Harbo whose term of office has been completed. PSARC extends its thanks to these outgoing members for their invaluable contributions.

This document is the result of a process. It presents the efforts of the stock assessment community in the Pacific Region. The principal contributors are those authors listed in the PSARC Working Paper Index for 1987. Numerous other members of DFO staff played key roles in producing this document. I want to take the opportunity to thank all those who contributed so much to make 1987 a successful year of operation of PSARC. I am particularly grateful to my colleagues on the Steering Committee, and the members of the FRMEC for their continued support. The efficient and helpful secretarial help provided by Placements Vancouver Island is also much appreciated.

Max Stocker
Chairman

Rapport du président pour 1987

Il s'agit du deuxième rapport annuel du Comité scientifique consultatif de la recherche dans le Pacifique, résumant la troisième année d'opération du Comité qui formule des recommandations d'ordre biologique sur l'état des ressources halieutiques du Pacifique. En 1987, le Comité a établi un calendrier annuel complet de réunions qui englobait des activités associées au saumon. Cette mesure a permis au Comité de formuler des recommandations d'ordre biologique en fonction d'un échéancier compatible avec le processus décisionnel et consultatif régional, avant les activités de pêche prévues.

En 1987, 33 documents de travail qui ont été préparés ont servi de base aux recommandations d'ordre biologique formulées en ce qui concerne les ressources halieutiques du Pacifique. Le présent rapport renferme les cinq documents consultatifs qui en ont découlé.

Le comité directeur a procédé, le 11 septembre 1987, à la revue des rapports du sous-comité des mollusques et crustacés, du hareng et du poisson de fond. Le Comité scientifique consultatif de la recherche dans le Pacifique a présenté les documents consultatifs respectifs au comité exécutif régional de gestion des ressources halieutiques (CEGRH) le 21 septembre 1987. Les gestionnaires des pêches se sont inspirés des recommandations biologiques approuvées pour préparer les plans de pêche pour la région.

Le rapport du sous-comité du saumon sur le saumon quinnat a été revu par le comité directeur le 11 novembre 1987. Le document consultatif qui en a découlé a été présenté au CEGRH le 9 novembre 1987. Le document approuvé a permis de fournir des données utiles à la Commission du saumon du Pacifique lors de ses réunions de novembre.

La durée de mon mandat comme président du Comité scientifique consultatif de la recherche dans le Pacifique a été prolongée d'une autre année par le CEGRH. Il y a eu toutefois des modifications à la composition du comité directeur en 1987. En juin, D. Radford a remplacé D. Barrett en qualité de représentant de la Direction de l'économie et de la planification des programmes. M. D. McKone est devenu, en septembre, le représentant de l'administration centrale, pour remplacer M. F. Bernard. En novembre, M. N. Bourne a remplacé au poste de président du sous-comité des mollusques et crustacés M. Harbo dont le mandat était terminé. Le Comité tient à remercier tous ces membres sortants de leur précieuse contribution.

Le présent document est le fruit d'un processus. Il présente les efforts déployés par la communauté responsable de l'évaluation des stocks dans la région du Pacifique. Les principaux contributeurs sont les auteurs énumérés dans le répertoire des documents de travail du Comité pour 1987. Nombre de membres du personnel du MPO ont joué un rôle clé dans le cadre de la production du présent document. Je souhaite profiter de l'occasion pour remercier tous ceux qui, par leur contribution, ont permis en 1987, d'assurer le succès des opérations du Comité. Je suis particulièrement reconnaissant envers mes collègues du comité directeur et les membres du CEGRH de leur soutien suivi. Nous avons également beaucoup apprécié les services de secrétariat fournis par Placements Vancouver Island.

Max Stocker
Président

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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, and formulates and evaluates methodologies employed to establish management plans and to assess local fisheries. 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 Resource 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 Resource Management Executive Committee of sound and appropriate methods for fisheries management in the Region.

3. PSARC shall provide scientific and technical advice to the Resource Management Executive Committee - Pacific on matters relating to fishing statistics, sampling of catches, information needs for stock assessments, 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 so 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 consistency of biological advice with long-term Pacific fisheries management objectives.

The Steering Committee

Composition

The Steering Committee includes 16 members as follows:

1 Chairman
1 F.R.B Section Head from Salmon, or delegate
3 F.R.B Section Heads from Marine Fish (Groundfish, Herring, and Shellfish), or delegate
5 Subcommittee Chairmen
1 Past-Chairman
1 Head, Biological Services, Fisheries Branch
1 Chief, Resource Allocation and Industry Liaison, Fisheries Branch
1 Delegate from Regional Planning and Economics Branch
1 Delegate from S.E.P.
1 Delegate from Ottawa

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 Resource 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 meetings 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 for planning the year's activities. 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 be submitted to the Resource Management Executive Committee.

After Advisory Documents are approved for release by the Resource Management Executive Committee, they are distributed to the management working groups, 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 Division Chiefs 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 citation guidelines of documents so received.

Subcommittee Chairmen can communicate directly with scientific staff if this communication is restricted to matters that are for information purposes and do not have program repercussions. Items relating to program implementation and requests for assistance are to be referred to Directors for approval prior to direct communication with the departmental stock assessment community.

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 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 Subcommittee

The PSARC Salmon Subcommittee is to provide biological advice consistent with (1) sound conservation principles, and (2) optimization of production, through PSARC on the management of all salmon 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 stocks and to predict the effects of alternative management measures on potential yields;
- preparing biological advisory reports on salmon 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 Subcommittee's mandate;
- reviewing stock assessment-related research programs on salmon, 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;
- reviewing research requirements for salmon resource management, and recommending initiation of such programs as may be required to PSARC.

PSARC Herring Subcommittee

The PSARC Herring Subcommittee is to provide biological advice consistent with (1) sound conservation principles, and (2) optimization of production, through PSARC on the management of all herring 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 herring stocks and to predict the effects of alternative management measures on potential yields;
- preparing biological advisory reports on herring 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 Subcommittee's mandate;
- reviewing stock assessment related research programs on herring, 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 herring;
- reviewing research requirements for herring resource management, and recommending initiation of such programs as may be required to PSARC.

PSARC Groundfish Subcommittee

The PSARC Groundfish Subcommittee is to provide biological advice consistent with (1) sound conservation principles, and (2) optimization of production, through PSARC on the management of all 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 groundfish stocks and to predict the effects of alternative management measures on potential yields;
- preparing biological advisory reports on 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 Subcommittee's mandate;
- reviewing stock assessment related research programs on 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 groundfish;
- reviewing research requirements for groundfish resource management, and recommending initiation of such programs as may be required to PSARC.

PSARC Shellfish Subcommittee

The PSARC Shellfish Subcommittee is to provide biological advice consistent with (1) sound conservation principles, and (2) optimization of production, through PSARC on the management of all shellfish 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 shellfish stocks and to predict the effects of alternative management measures on potential yields;
- preparing biological advisory reports on shellfish 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 Subcommittee's mandate;
- reviewing stock assessment related research programs on shellfish 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 shellfish;
- reviewing research requirements for shellfish resource management, and recommending initiation of such programs as may be required to 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 priorities, and recommending work priorities to the Computer Services Division, and review policies, procedures, and schedules to ensure they meet Regional priorities and integrate with PSARC;
- developing an integrated stock assessment data system, and reviewing stock assessment-related E.D.P. work plans and assign priorities; and
- 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 conclusions.

PSARC STEERING COMMITTEE

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List of Meetings, 1987

1. PSARC Stock Assessment Data System Subcommittee - May 7, 1987 - Pacific Biological Station, Nanaimo, B.C.
2. PSARC Steering Committee Meeting - May 20, 1987 - Coast Bastion Inn, Nanaimo, B.C.
3. PSARC Stock Assessment Data System Subcommittee - June 22, 1987 - Pacific Biological Station, Nanaimo, B.C.
4. PSARC Salmon Subcommittee Meeting - July 3, 1987 - 1090 West Pender Street, Vancouver, B.C.
5. PSARC Stock Assessment Data System Subcommittee - August 13, 1987 - 1090 West Pender, Vancouver, B.C.
6. PSARC Shellfish Subcommittee Meeting - August 31-September 1, 1987 - Inn at Cowichan Bay, B.C.
7. PSARC Groundfish Subcommittee Meeting - September 2-3, 1987 - Pacific Biological Station, Nanaimo, B.C.
8. PSARC Herring Subcommittee Meeting - September 9-10, 1987 - Island Hall, Parksville, B.C.
9. PSARC Steering Committee Meeting - September 11, 1987 - Coast Bastion Inn, Nanaimo, B.C.
10. PSARC Salmon Subcommittee Meeting - October 26-27, 1987 - DFO Headquarters, Vancouver, B.C.
11. PSARC Steering Committee Meeting - November 6, 1987 - Coast Bastion Inn, Nanaimo, B.C.
12. PSARC Stock Assessment Data System Subcommittee - December 15, 1987 - Pacific Biological Station, Nanaimo, B.C.

PSARC Working Paper Index for 1987

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H87-3:30	Herring stock estimates from diving surveys of spawn for the lower east coast of the Queen Charlotte Islands in 1987.	C. W. Haegele J. F. Schweigert
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H87-6:8	The potential and limitations of hydroacoustics biomass estimates for Pacific herring in offshore locations.	D. E. Hay R. Kieser P. B. McCarter
H87-7:8	Offshore herring distribution, length composition and recruitment forecast for lower west coast of Vancouver Island stock, August, 1987.	D. M. Ware R. Tanasichuk
H87-8:12	An evaluation of an improved method for forecasting spawn timing for B. C. herring.	R. Tanasichuk D. M. Ware

2. Groundfish

G87-1:304	Groundfish stock assessments for the west coast of Canada in 1987 and yield options for the 1988 fishery.	J. Fargo M. Saunders A.V. Tyler [eds.]

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I87-5:5	North coast geoduck fishery and processing at sea	S. Farlinger
I87-6:23	Abalone resurvey in the southeast Queen Charlotte Islands, June 1987	W. Carolsfield S. Farlinger B. C. Kingzett N. A. Sloan G. Thomas
I87-7:8	Abalone	S. Farlinger N. Sloan
I87-8:3	Horse clams	R. Harbo
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I87-17:1	Crab fisheries - Dungeness, king and tanner crabs	G. Jamieson
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I87-19:1	Squid-inshore	G. Jamieson
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I87-21:4	Plankton-euphausiids	J. Fulton

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S87-3:48	Unaccounted for sources of fishing associated mortalities of chinook salmon in B.C. salmon fisheries (1977-1986)	B. Riddell

Section II

Advisory Documents

Pacific Stock Assessment
Review Committee

PSARC Advisory Document 87-1

BIOLOGICAL ADVICE ON THE MANAGEMENT OF

BRITISH COLUMBIA HERRING FOR 1988

As its meeting on September 11, 1987, PSARC reviewed the Herring Subcommittee Report as contained in this document.

The Subcommittee met at the Island Hall in Parksville during September 9-10, 1987 to derive a consensus on the status of herring stocks. The list of working papers (Appendix 1) and participants (Appendix 2) are attached. The primary objectives for the meeting were:

1. Reach a consensus regarding the status of stocks relative to the 1987/88 fishing season.

2. Review the stock assessment source documents prepared by staff of the herring section and make recommendations regarding 1987/88 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.

The following 9 criteria were evaluated for each stock in order to make recommendations regarding stock status and potential catch levels:

1. Age structured model analysis:

    a) Hay's Spawn Index.
    b) Stock trends estimated by model.
    c) Forecast stock size age 4 and older.
    d) Forecast 3-year old recruits.

2. Escapement model analysis:

    a) Stock trends estimated by model.
    b) Forecast stock size age 4 and older.
    c) Forecast 3-year old recruits.

3. Forecasts of recruiting year class strength.

4. Forecast weighted run size.

5. Sounding surveys.

6. CUTOFF level.

7. Diving surveys.

8. Charter skipper comments.

9. Ancillary information for specific stocks.

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

Biological and Management Objectives

British Columbia herring are currently managed by a fixed harvest rate policy in conjunction with a CUTOFF level of 25 percent of the long-term equilibrium biomass. To ensure conservation of the stocks 20 percent of the forecast biomass of each of seven recognized distinct stocks is harvested annually unless the run falls below the CUTOFF level in which instance 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 catch records date back to 1888, reliable records of place, date, and quantity caught are available only since 1950. There was a fishery for the dry salted market in the Orient from 1904-1934. Up to 85,000 tonnes were taken in a given year. A reduction fishery, mainly by purse seining followed (1935-1967). Fish were taken during their inshore spawning migrations from November to March. Very large catches of over 200,000 tonnes annually in the early 1960s followed by a series of poor recruitments led to the collapse of the reduction fishery, with a closure in 1968. Cessation of the intensive reduction fishery resulted in a gradual recovery of stocks. The roe herring fishery began in 1971. Herring are now caught on or near the spawning grounds by both gillnets and purse seines. Roe herring landings have averaged 29,000 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 1978) and quotas (since 1983) in thousands of tonnes are shown below:

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Queen Charlotte Islands										
Roe Catch	12.5	8.7	3.4	6.4	5.3	8.1	5.0	6.3	3.6	1.7
Roe Quota						*	4.6	5.0	3.8	1.4
Prince Rupert District										
Roe Catch	5.1	2.5	2.7	1.4	0.1**	0	3.5	6.5	8.3	5.6
Roe Quota							4.0	5.0	6.4	5.4
Central Coast										
Roe Catch	14.0	0	0.5	2.6	6.3	5.6	7.2	5.2	3.3	3.2
Roe Quota						*	6.6	4.1	2.3	3.4
Strait of Georgia										
Roe Catch	11.5	6.8	3.3	7.1	8.9	16.4	10.2	6.2	0.2	9.1
Roe Quota						11.7	11.6	4.7	0	8.1
West Coast Vancouver Island										
Roe Catch	20.0	19.3	4.5	8.8	6.1	8.7	6.7	0.2**	0.2	15.6
Roe Quota						4.5	4.5	0	0	9.4
Total Coast										
Roe Catch	63.1	37.3	14.4	26.3	26.5	38.8	32.6	24.4	15.6	35.2
Roe Quota						28.0	31.3	18.8	12.5	27.7

*North of Cape Caution the quota for 1983 was 11.8.

**Charter boat removals.

Age Composition

Queen Charlotte Islands

The seine catch in 1987 was dominated by 5 and 6 year-old herring, that is the 1982 (24%) and 1981 (38%) year-classes. There was also a residual contribution of the strong 1977 year-class (6%), which are now 10 year-olds.

Prince Rupert District

The seine catch in 1987 was dominated by 3 and 6 year-old fish. The 1981 year-class contributed 30 percent to the catch while a reasonably good 1984 year-class contributed 39 percent to the total.

Central Coast

The seine catch in 1987 was dominated by 5 year-old herring (32%) of the 1982 year-class. The 1983 and 1984 year-classes contributed 15 percent and 23 percent respectively, while the aged 1977 year-class still accounted for 6% of the total seine catch.

Strait of Georgia

North - The charter and fishery samples consisted primarily of 3 to 5 year-old herring. The 1983 year-class (40%) was predominant, followed by the 1984 (31%) and 1982 (17%) year-classes.

South - The catch and charter samples showed an even distribution of 2 to 4 year-old fish. The 1984 year-class (36%) was most abundant, followed closely by the 1985 (28%) as 2 year-olds and the 1983 (28%) as 4 year-old herring.

West Coast Vancouver Island

South - The samples from the 1987 fishery and charter program contained an even distribution of 2 to 5 year-olds with the 1983 year-class (36%) being most prevalent. The 1982 and 1984 year-classes accounted for 16 and 19% of the catch. The high proportion of age 2 fish (15%) in the samples may be indicative of a strong 1985 year class.

North - The 1987 charter samples for this area indicate a dominant 1982 year-class with 5-year olds comprising 36% of the sampled fish. The 1983 and 1984 year-classes were represented equally in the samples (23%) while the 1985 year class is showing very strong at age 2 (14%).

Stock Status in 1987

Herring abundance along the British Columbia coast decreased slightly in 1987. This decrease resulted from below average recruitment to all areas except the Prince Rupert District.

North Coast Stocks

The Queen Charlotte Islands and Central Coast stocks have been declining since the early 1980s as the extraordinarily large 1977 year-class moved through the fisheries. Both stocks had reached historically high levels during this period. However the decline has been less severe in the Central Coast stock. There has been no significant recruitment to the Queen Charlotte Islands stock since 1980, except for the 1981 year-class which is now supporting the fishery. The year classes recruiting at age 3 in both 1986 and 1987 are among the poorest on record. The 1987 weighted spawning biomass of 15,100 tonnes is down slightly from the previous year, although estimates from the escapement model alone indicate an increase in spawn. This discrepancy in the stock trend between the two assessment methods may result from the comprehensive dive survey, which was conducted in this area for the first time in 1987, providing a more accurate estimate of spawning area. In addition, there is concern that the 1986 spawn survey may have been incomplete.

The rate of decline in the Central Coast stock has been halted by an average recruitment in the 1982 year-class. The 1987 spawning stock biomass was estimated at 24,000 tonnes, down marginally from the previous year. This stock remains well above the CUTOFF level but its trend will require special attention over the next few years.

The stock in the Prince Rupert District continues to remain near historically high levels. The estimated spawning biomass for 1987 is 40,400 tonnes, a level it has maintained over the past four years. The 1981 and 1984 year-classes which recruited to the fishery in 1984 and 1987, were well above average levels and should maintain the abundance of this stock for a few more years.

South Coast Stocks

The four herring stocks which can support roe fisheries on the South Coast all declined steadily from 1981 to 1985 due to a series of years of below average recruitment. A combination of fisheries closures and above average recruitment in 1986 caused a sharp increase in spawning levels. The estimated spawning biomass for the northern and southern Strait of Georgia stocks in 1987 was 32,300 and 9,700 tonnes respectively, for a total of 42,000 tonnes. Slightly below average recruitment in 1987 caused a drop in stock sizes relative to 1986 levels.

The spawning stock biomass on the West Coast of Vancouver Island followed a similar pattern although the increase in 1986 was less dramatic. The 1987 spawning biomass estimates of 21,100 tonnes in the south and 15,500 tonnes in the north are down from 1986 levels as a result of below average recruitments and large catches, particularly in the southern stock. The spawning stock estimates from the two assessment models track each other very well since 1982, the first year of dive spawn surveys, for the southern west coast of Vancouver Island stock. However, recent spawning trends for the northern stock are very different for the two models. Dive surveys have been conducted on most of the major spawns in this area since 1984 so we feel the escapement model estimates of spawning biomass are the most accurate.

The dynamic nature of herring stocks is a direct result of recruitment variability. It is very difficult to estimate recruitment accurately because of the many biological and environmental factors that appear to be involved. To this end, research projects on La Perouse Bank and in Georgia Strait are investigating the effects of some of these factors on recruitment.

Recruitment Forecasting and Prognoses for 1988

The CUTOFF levels are established at one-forth of the estimated unfished equilibrium biomass. For the seven areas on the coast, the following CUTOFF levels were established:

Queen Charlotte Islands	13,100 tonnes
Prince Rupert District	8,900 tonnes
Central Coast	11,100 tonnes
Strait of Georgia - north	14,600 tonnes
Strait of Georgia - south	6,200 tonnes
W. C. Vancouver Is. - south	15,400 tonnes
W. C. Vancouver Is. - north	6,000 tonnes

The forecasts of recruitment, the corresponding 1988 runs, and recommended catches ('000 tonnes) are shown below:

Area	Recruitment	1988 Run	Recommended Catch
Queen Charlotte Islands	poor-average	12.13	0
Prince Rupert District	average-good	43.75	8.75
Central Coast	average	23.80	4.76
Strait of Georgia			
North	average	36.30	7.26
South	average	10.35	2.07
West Coast Vancouver Island			
South	average	23.00	4.60
North	average	16.56	3.31
Total Coast		165.89	30.75

For the Queen Charlotte Islands the forecast stock size is 12,130 tonnes with poor-average recruitment. While the stock - environment - recruitment model forecast was for average recruitment in 1988, the committee felt that given the downward stock trend and the estimates of poor recruitments in the last 3 years, this forecast may be overly optimistic. Therefore, the committee recommended to adopt a forecast midway between poor and average recruitment. The forecast stock biomass under this assumption is below the CUTOFF of 13,100 tonnes. Therefore, there is no identifiable surplus production available in this stock assessment region. Detailed evaluation of the 9 criteria for the Queen Charlotte Islands is presented in Appendix 3.

This stock was flagged last year because of concern about stock abundance and a comprehensive dive survey completed to ensure complete and accurate spawn assessment. We therefore feel confident about the escapement biomass estimate for 1987.

For the Prince Rupert District, assuming average-good recruitment, a pre-fishery stock size of 43,750 tonnes is forecast. This yields a recommended catch of 8,750 tonnes. The forecast run to the central coast, based on a predicted average recruitment, is 23,800 tonnes. As this stock is still well above the CUTOFF level, a 20% harvest rate yields a recommended catch of 4,760 tonnes.

Forecasts using time-series analysis predict average recruitment in 1988 for all south coast herring stocks. This, combined with reasonable estimates of returning adults, means that all southern stocks are predicted to be well above CUTOFF levels in 1988. The forecast runs for the Strait of Georgia are 36,300 tonnes for the northern stock and 10,350 tonnes for the southern stock. These stock predictions yield recommended catches of 7,260 tonnes and 2,070 tonnes for the northern and southern stocks, respectively. The forecast for the southern west coast of Vancouver Island is 23,000 tonnes with a recommended catch of 4,600 tonnes. For the northern west coast the forecast stock size is 16,560 tonnes yielding a recommended catch of 3,310 tonnes.

Fisheries Issues

Currently stock assessments and forecasts are conducted only for the 7 major migratory stocks. In addition there are numerous minor herring stocks on the British Columbia coast for which there is only limited spawn assessment, catch, and biological information. Therefore it is not possible to do accurate assessments and forecasts for these stocks. There are currently fisheries on some of these minor stocks, for example, Johnstone Strait bait fisheries, and there is increasing pressure to conduct roe fisheries on other minor stocks. To provide for future management of these stocks it is important to begin the collection of baseline data on the age structure and spawn depositions.

Recruitment estimates for the southern Strait of Georgia stock indicates a long term decline. In addition, there has been a decrease in the number of locations where spawn deposition has occured in this area. It has been suggested that habitat degradation may be responsible for these declines. With the additional pressure anticipated from a number of aquaculture facilities research should be initiated to address habitat issues.

Reviewers Comments and Research Recommendations

The herring stock assessments for 1987 and forecasts for the 1987/88 fishing season are conceptually sound. This year's analyses show a number of improvements over the 1986 assessments, particularly the inclusion of variance estimates for the forecasts. It is encouraging to see the forecasts from the escapement and age-structured models agree more closely this year as compared with last year's assessments. Further stock identification research was recommended.

To improve on the current assessment procedure PSARC makes the following research recommendations:

1. For both modelling approaches used for herring stock assessment, confidence intervals of model parameters and estimated biomass should be calculated.

2. To enhance forecasting of recruiting herring stock sizes surveys of the relative abundance of juveniles should be continued.

3. Continuation of studies on herring recruitment mechanisms to determine major factors determining year-class strength.

4. Some concern was expressed that there may have been a degradation of herring spawning and rearing habitat in the southern Strait of Georgia, and a subsequent decline in the ability of that area to produce herring recruits. A research program should be designed to evaluate if there is a problem.

A follow up of last year's recommendations for stock assessment related activities is appended (Appendix 4). Subcommittee recommendations for stock assessment related activities for this year are appended (Appendix 5).

Appendix 1. 1987 PSARC Herring Subcommittee working papers.

Number:Pages	Title	Authors
H87-1:41	Summary of 1987 herring stock assessments and forecasts for 1988.	V. Haist J. Schweigert
H87-2:5	Forecasting Pacific herring (*Clupea harengus pallasi*) year-class strength.	M. Stocker
H87-3:30	Herring stock estimates from diving surveys of spawn for the lower east coast of the Queen Charlotte Islands in 1987.	C. W. Haegele J. F. Schweigert
H87-4:18	Herring stock estimates from diving surveys of spawn for the south coast of British Columbia in 1987.	C. W. Haegele J. F. Schweigert
H87-5:17	A review and overview of the geographical distribution and migrations of herring stocks in B. C. with implications for management.	D. E. Hay C. W. Haegele
H87-6:8	The potential and limitations of hydroacoustics biomass estimates for Pacific herring in offshore locations.	D. E. Hay R. Kieser P. B. McCarter
H87-7:8	Offshore herring distribution, length composition and recruitment forecast for lower west coast of Vancouver Island stock, August, 1987.	D. M. Ware R. Tanasichuk
H87-8:12	An evaluation of an improved method for forecasting spawn timing for B. C. herring.	R. Tanasichuk D. M. Ware

Appendix 2. List of participants.

Name	Association
W. D. McKone	Fisheries and Biological Sciences HQ, Ottawa
Doug Hay	Herring Research, Pacific Biological Station
Ron Tanasichuk	Herring Research, Pacific Biological Station
Lyle Freeman	Fisheries OPS, Port Alberni
Tom Russell	P.T. Assn., Port Hardy
George Vardy	Department of Fisheries and Oceans, District #5
Carl Haegele	Herring Research, Pacific Biological Station
Trevor Fields	Department of Fisheries and Oceans, District #3
Dennis Chalmers	Department of Fisheries and Oceans, Southcoast
Jack Broome	Department of Fisheries and Oceans, Nanaimo
Susan Farlinger	Department of Fisheries and Oceans, Prince Rupert
Chris Wood	Salmon Section, Pacific Biological Station
Lorena Rosenfeld	Pacific Biological Station, Nanaimo
Vivian Haist	Pacific Biological Station, Nanaimo
Jake Schweigert	Pacific Biological Station, Nanaimo
Chris Dragseth	Department of Fisheries and Oceans, District #8
John Lewis	Department of Fisheries and Oceans, District #9
William Procopation	U.F.A.W.U., Vancouver
John Brajcich	Fishing Vessel Owners, Association of B. C.
Bob Armstrong	Department of Fisheries and Oceans, Nanaimo
John Greenlee	Department of Fisheries and Oceans, Central Coast
Lloyd Webb	Department of Fisheries and Oceans, Vancouver
Dan Ware	Department of Fisheries and Oceans, Nanaimo
Max Stocker	Department of Fisheries and Oceans, Nanaimo
Ed Safarik	Ocean Fisheries.

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

Criteria	Status
1. Age structured model analysis.	
a) Hay's Spawn Index.	1987 index double the 1986 index.
b) Stock trends estimated by model.	Continuous downward trend since 1982. 1987 estimate down 25% from 1986.
c) Forecast stock size age 4 and older.	12,200 t.
d) Forecast 3-year old recruits.	Poor - 900 t; average 2,800 t.
2. Escapement model analysis.	
a) Stock trends estimate by model.	1987 estimate up 56% from 1986. However, concern expressed that the 1986 spawn surveys may have been incomplete. Ignoring the 1986 spawn assessment this stock has declined steadily since 1981.
b) Forecast stock size age 4 and older.	8,800 t.
c) Forecast 3-year old recruits.	Poor - 600 t; average 2,220 t.
3. Forecasts of recruiting year class strength.	Ricker environment model forecast is for average recruitment of 3 year olds in 1988.
4. Forecast weighted run size.	11,250 t assuming poor recruitment 13,000 t assuming average recruitment.
5. Sounding surveys.	Maximum in-season hydroacoustic estimate was 10,000 t, down from 17,000 t estimate for 1986. Note, however, there is an inverse relationship between hydroacoustic stock estimates and the subsequent estimate of standard square meters of spawn.
6. CUTOFF level.	13,100 t.

Appendix 3 (cont'd).

Criteria	Status
7. Diving surveys.	Dive survey estimated 12,284 t (8,751 - 15,807, 95% confidence limits). In addition, an estimated 3,106 t of spawn was estimated from surface surveys alone. (Note: these estimates include Cumshewa stocks. The spawn survey estimate for the Queen Charlotte Islands stock assessment region alone is 13,963)
8. Charter skipper comments.	Charter skipper from Area 2E was not at meeting for comments.
9. Ancillary information for specific stocks.	N/A.

Appendix 4. Stock assessment related activities recommended in 1986 and action taken in 1987.

Recommendations	Action
1. Note that the Queen Charlotte Islands is an area of concern.	Action recommended in this report.
2. a) The comprehensive dive survey (PBS/FOB) be continued with the Queen Charlotte Islands the designated area for 1987 spawn survey.	Completed.
b) For the survey to go ahead, a commitment of five fishery officers is required (e.g., one per district, on the basis that each district will ultimately be on the receiving end of this project) for the period April 1 - 21.	Completed.
3. Synoptic surveys (fishery officers with SCUBA equipment) should be done on major south coast spawns to provide continuity with existing data.	Approximately 50% of west coast Vancouver Island spawns and 90% of Strait of Georgia spawns were surveyed by Fisheries and Oceans dive teams.
4. The stock assessment group at P.B.S. should continue work on harvest rates.	Not done.
5. Vital Spawning Area document (Doug Hay) requires review and comment by field staff for September 17.	Done. Will be published later this fiscal year.
6. Charter vessels should be made available for spawn survey in areas which are otherwise unaccessible.	Charter vessel used for Fishery Officer dive spawn survey in northern west coast of Vancouver Island. Worked out well.
7. Continue work to standardize sounding equipment (by soliciting funds for contracts or into presently planned F.R.B. surveys).	Additional standard bottom sites identified.
8. Spawn Committee should continue to meet in January and June, reporting to Stock Assessment Committee.	Only one meeting was held in 1987 as this was adequate to address all issues.

Appendix 4 (cont'd).

Recommendations	Action
9. Continue tagging to identify in-season herring movement; consult with processors about tag recovery system.	No funds were available this year.
10. Continue to provide the Stock Assessment document in a timely fashion; although it presses the researchers for time, it allows sufficient time for the management and licensing process.	1987 document was circulated 2 weeks prior to PSARC Subcommittee meeting.
11. Continue fall and winter echo-sounding program in the Strait of Georgia.	Is continuing on annual basis.
12. Initiate a joint F.R.B./F.O.B. juvenile herring survey of Georgia Strait to determine the possibility of developing a recruitment index (this goes hand in hand with the offshore program in progress).	Small program initiated by B.S.B. Fisheries Branch did not receive funds to support this program.

Appendix 5. Recommendations for stock assessment related activities.

1. A regionally funded diving spawn survey be initiated for all areas. Fishery Officer Diving Surveys should be continued for all south coast areas and initiated at least in the Queen Charlotte Islands in 1988. Some egg samples should be collected wherever possible.

2. Publish report on historical herring spawning locations and distribution.

3. The Herring Stock Assessment Group reevaluate CUTOFF levels and continue investigation of harvest rates.

4. Working Group to review charter boat coverage in all areas. Some problem areas identified - Johnstone Strait, 2W, upper west coast Vancouver Island.

5. Continue work on the standardization of sounding methods: develop standard bottom for an area in the north.

6. Working Group to identify areas in which to continue short-term tagging to identify in-season movement.

7. Continuation of fall and winter echo-sounding and hydroacoustic assessments for Georgia Strait and the north coast, respectively.

8. Continuation of Juvenile Herring Survey of Georgia Strait to develop an index of recruitment and recommend involvement of Fisheries Branch in this survey.

9. Research be initiated to investigate habitat degradation in southern Georgia Strait, and identify possible effects of spawning ground degradation on recruitment.

10. Stock identification is an integral part of stock assessment and management. Therefore the acquisition of coded wire tagging equipment should be pursued and a study design developed.

11. Working Group to obtain clarification of net pen guidelines with respect to herring.

12. Produce stock status document for distribution to industry.

13. Herring Working Group to evaluate implications of confidence intervals ("range" concept) for stock status assessment.

Pacific Stock Assessment
Review Committee

PSARC Advisory Document 87-2

BIOLOGICAL ADVICE ON MANAGEMENT OF BRITISH COLUMBIA GROUNDFISH FOR 1988

At its meeting on September 11, 1987 PSARC reviewed the Groundfish Subcommittee Report as contained in this document.

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

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

LIST OF ASSESSMENTS

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

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

MANAGEMENT POLICY

While management policy is not set by the stock assessment process, a statement on policy as it exists should help to provide the setting to understand the assessments. Policy is set by the managers in consultation with representatives from industry. The analyses conducted by assessment biologists address items of policy, and specific problems brought forward by management and industry. For example, earlier this year managers suggested that it would be valuable for biologists to present assessment information on the red-striped rockfish, Sebastes proriger. As a result, the slope rockfish sub-document contains this information.

The overriding objective of the management approach is to achieve a 12-month trawl fishery. An annual quota is usually set if a stock is considered to be under sufficient fishery pressure to warrant concern. The managers and industry representatives then set quarterly sub-quotas and trip limits so that fishing opportunities are available through most of the calendar year.

In setting the annual catch quota, biologists are first concerned with maintaining a sufficient spawning stock to permit at least reproductive replacement of the capacity to produce. The ultimate goal for this high-volume, commercial fishery is to maximize potential catch in the long term, while taking into account natural long-term trends and year-to-year variation in natural production. When the data to derive these estimates are lacking, quotas are calculated that are least likely to cause, by their removal, a diminshed potential for production in the near future. Partly because of the uncertainty in the estimates, managers are usually given a range of yield options, as defined below.

YIELD OPTIONS

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

(i) Zero yield

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

(ii) Rebuilding yield

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

(iii) Sustainable yield

This option provides some opportunity to maintain stocks at existing levels. In many ways this is the least certain of the options available since it entrains many assumptions about the behaviour of stocks in response to fishing and biological processes. This option should be taken to mean that the probabilities of either decline or increase in yield (biomass) are approximately equal. The term "sustainable" should be understood in its broad sense, i.e., that the stock will oscillate around the expected level as a result of oscillation in recruitment, rather than be maintained at a fixed level. The amplitude and frequency of these oscillations may vary considerably among and within stocks at different levels of biomass. In the simplest terms, this is our best estimate of the highest yield at existing stock levels.

(iv) Conservative (low risk)-sustainable

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

(v) (High) Risk-sustainable yield

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

(vi) Non-sustainable yield

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

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

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

(vii) Unlimited yield

Few conditions would call for consideration of this option. Depletion of stocks and elimination of fisheries when harvests are uncontrolled are well documented throughout the world. However, this option might be considered: for experimental purposes; for stock eradication (in the case of competing species); or for economic returns where the loss of a particular stock does not outweigh the chaotic effects that lowered yield would create in the industry.

(viii) Other measures

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

MAJOR FISHERY CONCERNS

Major fishery concerns in the past year relate to the rockfishes. There is a disagreement between fishermen and biologists regarding the size of the standing stocks. The trawler captains believe that the stocks will support more catch than the annual quotas allow. Biologists have pointed out that the stocks are so slow-growing, that a large biomass is necessary in order to maintain the existing catch. The Groundfish Staff have met with the Deep Sea Trawlers Association (DSTA) several times in the past year in order to reach an understanding. In turn, the DSTA has developed a proposal for experimental management of the stocks. An interesting part of this proposal is an annual trawl survey funded by DSTA, and conducted jointly with DFO. The objective is to reduce the uncertainty in the stock estimates so that less risk is associated with increasing the annual quota and catch in some areas on a trial basis.

There is a high potential risk of increasing the catch in this manner. The species are very slow-growing and the populations have a slow turn-over rate. For example, individuals are 8 - 15 years old before they spawn for the first time. If a quota is set too high on a trial basis for 5 - 6 years, and overfishing occurs, it will take 25 to 30 years to repair the stock.

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, rock sole	Low
English sole, Dover sole, arrowtooth flounder	Average to high
Sablefish	Average to high
Pacific hake	High
Spiny dogfish	Average to high
Walleye pollock	Low to average
Slope rockfish	Low to average
Shelf rockfish	Average
Inshore rockfish	Low to average

The recommendations for west coast groundfish for 1987 are summarized below:

Area	Species	Management options
4B	Lingcod	1. Add time to winter fishing closure Nov. 15 - Apr. 15. 2. Introduce minimum size limit of 58 cm for sport-caught lingcod to protect young.
3C	Lingcod	1. Sustainable: 1400 t 10,000 lb trip quota, limit after 75% of quota taken. 2. Risk-sustainable: no quota, self regulation.
3D, 5A, 5B, 5C, 5D, 5E	Lingcod	No options proposed.
4B	Pacific cod	No options proposed.
3C/3D	Pacific cod	Close Amphitrite Bank Jan. 1 - Mar. 31 and safety margin to all trawling.
5A/5B	Pacific cod	No options proposed.
5C/5D	Pacific cod	No quota proposed. Stock increasing rapidly.
5E	Pacific cod	No options proposed.
Coastwide	Petrale sole	1. Sustainable: trip limit 25,000 lb.
4B	Flatfish	No options proposed.
3C/D	Flatfish	No options proposed.

Area	Species	Management options
5A	Rock sole	1. Sustainable: 100 t (30,000 lb trip limit).
5B	Rock sole	1. Conservative sustainable: 250 t, 30,000 lb trip limit. 2. Risk sustainable: 400 t, no trip limit.
5C	Rock sole	1. Conservative-sustainable: 100 t, 30,000 lb trip limit. 3. Risk-sustainable: 400 t, no trip limit.
5D	Rock sole	1. Conservative sustainable: 100 t, 30,000 lb. trip limit. 2. Risk-sustainable: 400 t, no trip limit.
5C/D	English sole	1. Conservative sustainable: 400 t. 2. Risk-sustainable: 600 t.
	Arrowtooth flounder	1. Sustainable: 5,000 t.
5C/5D/5E	Dover sole	1. Conservative sustainable: 800 t quota, 20,000 lb/trip permitted after 75% of the quota is reached. 2. Risk-sustainable: 1,000 t quota 20,000 lb/trip permitted after 75% of the quota is reached.
Coastwide	Sablefish	1. Conservative-sustainable: 2,700 t quota. 2. Risk-sustainable: 4,100 t quota.
4B, not including MSA 19, 20	Pacific hake	1. Conservative-sustainable: 8,000 - 11,000 t quota. 2. Risk-sustainable: 11,000 - 16,000 t quota.

Area	Species	Management options
3C	Pacific hake	Yield options to be presented at a later date when all current biological information is collated in the joint Canada - U.S. assessment algorithm.
Coastwide (not including 4B)	Dogfish	1. Pulse fishing: variable annual quota until non-nuisance abundance reached. 2. Conservative-sustainable: 15,000 t. 3. Risk-sustainable: 25,000 t.
4B, not including MSA 12, 19, 20.	Dogfish	1. Pulse fishing: variable annual quota, see text. 2. Conservative-sustainable: 2,000 t annual quota. 3. Risk-sustainable: 3,000 t annual quota.
4B	Walleye pollock	1. Conservative-sustainable: 2,500 t quota. 2. 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.
5E	Walleye pollock	Options not proposed.
Coastwide	Yellowtail rockfish	Conservative-sustainable: 1,000 t. Risk-sustainable: 4,000 t.

Area	Species	Management options
3C	Silvergray rockfish	Conservative-sustainable: 25 t Risk-sustainable: 200 t
3D	Silvergray rockfish	Conservative-sustainable: 250 t Risk-sustainable: 350 t
5A/5B	Silvergray rockfish	Conservative-sustainable: 700 t Risk-sustainable: 1,000 t
5C/5D	Silvergray rockfish	Conservative-sustainable: 400 t Risk-sustainable: 1,000 t
5E-S	Silvergray rockfish	Conservative-sustainable: 100 t Risk-sustainable: 250 t
5E-N	Silvergray rockfish	Conservative-sustainable: 100 t Risk-sustainable: 150 t
3C	Canary rockfish	Conservative-sustainable: 200 t Risk-sustainable: 400 t
3D	Canary rockfish	Conservative-sustainable: 500 t Risk-sustainable: 600 t
5A/5B	Canary rockfish	Conservative-sustainable: 350 t Risk-sustainable: 500 t
5C/5D	Canary rockfish	Conservative-sustainable: Unknown Risk-sustainable: 500 t
5E-N/S	Canary rockfish	Conservative-sustainable: Unknown Risk-sustainable: 500 t
3C	Pacific ocean perch	1. Rebuilding: 0 t 2. Conservative-sustainable: 100 t 3. Risk-sustainable: 200 t

Area	Species	Management options	
3C	Redstripe rockfish	Conservative-sustainable: Risk-sustainable:	200 t 1,000 t
3D	Pacific ocean perch	Conservative-sustainable: Risk-sustainable:	200 t 600 t
3D/5A	Yellowmouth	Conservative-sustainable: Risk-sustainable:	250 t 750 t
3D/5A	Redstripe	Conservative-sustainable: Risk-sustainable:	350 t 900 t
5A/5B	Pacific ocean perch	Conservative-rebuilding: Conservative-sustainable: Risk-sustainable:	400 t 700 t 1,000 t
5C/5D	Pacific ocean perch	Conservative-sustainable: Risk-sustainable:	1,900 t 3,000 t
5C/5D	Yellowmouth	Conservative-sustainable: Risk-sustainable:	160 t 500 t
5C/5D	Redstripe	Conservative-sustainable: Risk-sustainable:	350 t 570 t
5E-S	Pacific ocean perch	Conservative-sustainable: Sustainable:	400 t 700 t
5E-S	Yellowmouth	Conservative-sustainable: Risk-sustainable:	400 t 700 t
5E-S	Rougheye	Conservative-sustainable: Risk-sustainable:	200 t 300 t

Area	Species	Management options	
5E-S	Grouped slope rockfish	January-June	
		Conservative-sustainable:	300 t
		Risk-sustainable:	600 t
		September-December	
		Conservative-sustainable:	600 t
		Risk-sustainable:	1,100 t
5E-S	Redstripe	Conservative-sustainable:	100 t
		Risk-sustainable:	200 t
5E-N	Pacific ocean perch	Conservative-sustainable:	150 t
		Risk-sustainable:	200 t
5E-N	Yellowmouth	Conservative-sustainable:	350 t
		Risk-sustainable:	500 t
5E-N	Rougheye	Conservative-sustainable:	50 t
		Risk-sustainable:	100 t
5E-N	Redstripe	Conservative-sustainable:	500 t
		Risk-sustainable:	700 t
4B-MSA-12	Copper/ Quillback	Conservative-sustainable:	75 t
		Risk-sustainable:	150 t
4B-MSA-13	Copper/ Quillback	Conservative-sustainable:	50 t
		Risk-sustainable:	100 t
4B-MSA-14-20, 28,29	Copper/ Quillback	Conservative-sustainable:	150 t
		Risk-sustainable:	200 t

LINGCOD - AREA 4B

Yield Options

The analysis suggests that current yield levels cannot be sustained, especially in statistical areas 13 and 17. Three management strategies are suggested to reduce yield and protect lingcod at vulnerable stages in their life history.

1. Minor area closures during a greater portion of the year should help to rebuild local stocks because mature lingcod are sedentary and fish nesting on a particular reef system are probably the chief source of recruitment to that reef.

2. An extension of the winter closure period would help to further protect nesting lingcod while they are especially vulnerable to fishing, and would also serve to reduce overall fishing effort. Lingcod have been observed to guard their nests as late as early June. Thus, extending the closed period beyond the currently enforced date of April 14 may provide further protection to spawning fish and improve recruitment.

3. A size limit on the sports fishery may also be prudent in order to reduce overall effort in this fishery. At present, there is no strong evidence to indicate that landings of immature lingcod adversely affect spawning stocks. However, it should be noted that lingcod stocks have declined during the same period that sports fishery landings have increased, and that over 60% of female lingcod taken in the sports fishery are immature. A size limit on the sports fishery would increase the number of fish surviving to maturity provided fish released after capture survive. A minimum size limit may have two desirable effects--it may increase the number of fish surviving to maturity and increase the yield--per recruit to the sports fishery. A 58 cm limit is suggested for consistency with the commercial regulation.

LINGCOD - AREA 3C

Condition of the Stock

The LPUE data suggest that the present fishery is having little or no effect on the stock. The tagging data demonstrate that the exploitation rate is high. The stock is likely maintained by immigration from non-trawlable areas.

Yield Options

Conservative sustainable 1,400 t.

PACIFIC COD - AREA 3C

Condition of the Stock

The abundance index for Pacific cod off the west coast of Vancouver Island, calculated from the LPUE for Big Bank during April - September indicates a small increase in abundance. The index is 37 kg/h for 1986 compared to 13 kg/h for 1985. Data for 1987 indicate it may be continuing to improve. LPUE for April - June 1987 is 284 kg/h, due in large part to the 1985 year class. While an improving trend is indicated, the 1986 LPUE of 37 kg/h is still only at 15% of the average level during 1970 - 79 and the increased LPUE in 1987 is largely due to the 1985 year class which has not yet had opportunity to spawn and contribute to rebuilding the stock.

Yield Options

Until the stock has rebuild toward historic levels, protection of the stock during spawning is warranted. We suggest that Amphitrite Bank, and a safe margin around it, be closed to all trawling during January, February, and March, 1988. This suggestion was implemented in both the 1986 and 1987 management plans. The closure is to protect cod when they are particularly vulnerable as they concentrate for spawning. The alternative of continuing the fishery on spawning fish could possibly prevent re-building of the stock.

PACIFIC COD - AREA 5C/5D

Condition of the Stock

The abundance index for Pacific cod in Hecate Strait, calculated from the LPUE from Horseshoe and Two Peaks - Butterworth during April - September indicates an increase in abundance. The index is 557 kg/h for 1986 compared to 151 kg/h for 1985. Data for 1987 indicate a further improvement. LPUE for April-June 1987 is 1,149 kg/h, due largely to the 1985 year class. The 1986 LPUE is 79% of the long-term (1956-85 level and the 1987 LPUE is 168% of the long-term level, the highest value since 1966.

Yield Options

Alternative recommendations last year were (1) 900 t, conservative quota; (2) 1800 t, sustainable quota; or (3) no quota (risk sustainable) on the basis that the fishery is self-regulating. With the large increase in LPUE in 1987 due to the 1985 year class, after an extended period of low abundance, we feel there is further evidence that the fishery is still self-regulating and that Pacific cod stocks have the capacity to recover quickly under favourable environmental conditions. We therefore are suggesting no quota for the 1988 fishing year.

PETRALE SOLE - COASTWIDE

Condition of the Stock

All indications are that petrale sole stocks off the west coast of Vancouver Island are at low levels of abundance with recruitment also at low levels. Warm water temperatures (8-9°C) at time of spawning, which are favourable to petrale sole year-class production were prevalent in the early 1980s but have not, as yet, resulted in a significant increase in recruitment for petrale sole stocks off the west coast of Vancouver Island. The reason for this could be that a minimum size spawning stock is necessary for successful yearclass production even under favourable environmental conditions, and the current stock size of petrale sole may be below this level. Signs of increasing recruitment as a result of favourable ocean temperatures should have been noticed by the 1986 fishery because age of recruitment for petrale sole is 4 years.

Yield Options

A 44,000 lb trip limit regulation for petrale sole from January 1 - March 31 is in effect, coastwide. The January-March period corresponds to the spawning time for petrale sole, a period when these stocks are particularly vulnerable to exploitation. This regulation is the result of a request by industry aimed at reducing a target fishery on petrale sole while stocks are depressed. For the last three years, no landings of petrale sole have exceeded 25,000 lb.

1. Conservative sustainable option: Analysis shows that petrale sole stocks are depressed compared to 1950s and 1960s levels and that recruitment could be impaired. A target fishery for petrale sole should be discouraged with stocks at low levels. A trip limit of 25,000 lb should be adequate to allow fishermen to retain incidental catches of petrale sole.

ROCKSOLE - AREA 5A

Condition of the Stock

On the basis of trends in LPUE, the Area 5A rock sole stock is considered to be at average to low levels of abundance with recruitment at low levels, although length frequency samples, used for monitoring recruitment, were not obtained in 1986. Average yield for the stock with similar LPUE levels in the past (1972-78) was approximately 100 t.

Yield Options

Sustainable yield option: A yield of 100 t is considered to be sustainable for the current stock level and low recruitment mode. The 30,000 lb trip limit regulation is consistent with this option.

ROCK SOLE - AREA 5B

Condition of the Stock

On the basis of LPUE trends, the Area 5B stock is considered to be at a stable level of abundance since the early 1970s. The average yield over this time period has been approximately 250 t. An increase in recruitment could possibly double that figure over the next few years.

Yield Options

Conservative sustainable yield option: A yield of 250 t is considered to be sustainable for the Area 5B stock. The 30,000 lb trip limit currently in effect for Queen Charlotte Sound is consistent with this option.

Risk sustainable yield option: Yields of 400 t could be sustained with a significant increase in recruitment. Free fishing should be permitted to take advantage of this. As a caveat to this option, no trend in recruitment has yet been demonstrated. Only one year's observation is used to describe a possible increase in recruitment (increase in percentage of smaller size fish). This phenomenon could also be due to sample bias or error.

ROCK SOLE - AREA 5C

Condition of the Stock

The Area 5C rock sole stock is considered to be at low levels, with recruitment currently at low levels. This is based on trends in LPUE and length frequency anomalies.

Yield Options

Sustainable yield option -- The sustainable yield as indicated by trend in LPUE from 1980-86 is between 100 - 400 t for the Area 5C stock. A yield of 100 t would constitute a low risk for the stock while a yield of 400 t would constitute a high risk. A trip limit of 30,000 lb is consistent with a non-directed fishery for this stock and is consistent with the sustainable yield option.

Non-sustainable option -- A 400 t quota would allow a directed fishery for rock sole to take place in Area 5C. This option may not be consistent with sustainable yield for this stock at the present time due to the low recruitment mode.

ROCK SOLE - AREA 5D

Condition of the Stock

The rock sole stock in Area 5D is considered to be at low levels on the basis of trends in LPUE. The recruitment mode for the stock has also been at low levels since the early 1980s according to length frequency and ageing data, but increases in recruitment may occur over the next 2 or 3 years according to length frequency samples obtained from the 1987 fishery.

Yield Options

Managers have indicated, in the past, that rock and English soles do not have management priority within the Hecate Strait region. Consequently, quota overruns have occurred for both of these species with the unregulated directed fishery for Pacific cod (most productive species in the region). The current trip limit regulation for rock sole is aimed at discouraging a target fishery on the species while abundance/recruitment is low. The trip limit allows for retention of incidental catches of rock sole in the Pacific cod and Arrowtooth flounder fisheries. When recruitment/abundance increases, the trip limit level can be adjusted to be consistent with a sustainable yield for the stock at a new abundance level, permitting a directed fishery.

Conservative sustainable yield option -- As indicated by trends in LPUE from both models over the last five years, the sustainable yield for the Area 5D stock is 100 t. The 30,000 lb trip limit is consistent with this option.

Risk sustainable yield option -- Removals of 400 - 500 t in 1980-81 did not result in a reduction of LPUE as indicated by the multiplicative model but information from length frequency data indicates that recruitment during the late 1970s was fairly high and thus the stock size in 1980-81 was higher than the stock size at present. Consequently, removals of as much as 400 t would constitute a significantly greater risk of overfishing to the stock at this time.

ENGLISH SOLE - AREA 5D

Condition of the Stock

On the basis of trends in LPUE in recent years, the Area 5D English sole stock is considered to be at average to low levels.

Length frequency data indicates a low recruitment mode for the stock and signs of juvenescence, common to an overfishing situation.

Yield Options

Conservative sustainable yield option -- Yields of 400 t will decrease the probability of fishing up observed over the past five years. As a caveat here, the increasing Pacific cod fishery in Hecate Strait will negate a trip limit regulation for English sole at the present time by simply increasing discards while a catch quota for English sole is certain to negatively impact Pacific cod production if enforced.

Risk sustainable yield option -- With the current low recruitment mode, 600 t yields can probably be sustained. These figures are based on LPUE trends from 1982-86 from both effort standardization models. However, biological data indicates some signs of over-fishing with yields of 400 - 600 t over the last five years.

DOVER SOLE - AREA 5C/5D/5E

Condition of the Stock

The LPUE time series indicates that the 5CDE Dover sole stock is presently stable, with no observable effects of overfishing. The length frequency data also indicates no sign of overfishing. MSY estimated from effort and LPUE using Gulland's method is 861 t, while optimum effort level is estimated at 1,779 hours.

Yield Options

Conservative sustainable option -- The analysis above indicates that 800 t yields are sustainable for the Area 5CDE Dover sole stock. However, the rising trend in LPUE with removals of 800 t over the last several years indicates that the maximum sustainable yield may be higher than 800 t.

Risk sustainable option -- With 1,793 hours of effort in 1986 (close to F_{opt}), a yield of over 1,000 t was achieved. This indicates that the actual MSY for this stock may be closer to 1,000 t. However, landings in excess of 1,000 t have occurred in only one the last ten years and, at the present time, no prediction can be made regarding the response of the stock to a harvest of this level.

ARROWTOOTH FLOUNDER - AREA 5C/5D

Condition of the Stock

The information from landing statistics and biological data such as length frequencies for the species are too scant to reveal trends in abundance and size composition. Yield simulations indicate that the maximum sustainable yield for the species is considerably higher than current removals (including estimates of discards).

Yield Options

Sustainable yield option -- At the present time, catches of 5,000 - 6,000 t are estimated to be sustainable on the basis of yield simulations for the population.

Non-sustainable yield option -- Yields greater than 6,000 t do not appear to be sustainable according to yield simulations performed.

SABLEFISH - COASTWIDE

Yield Options and Condition of Stock

Yields were calculated using a F_{opt} of .205. The assumption here is that the management goal is to optimize the yield per recruit. Using this strategy strong year classes such as the 1977 are exploited more heavily with catches remaining high for several years. In the past, strong year classes have been approximately ten years apart. Although there is every indication that moderate to strong year classes have occurred since 1977 (e.g., 1978, 1979, 1980), it is possible that persistently poor recruitment could occur again as it did in the early to mid-1970s. Should this happen sustainable yields would drop to levels below those in place now. If industry is willing to accept the lows with the highs then the current strategy is acceptable. An alternative is developing a strategy that responds to incoming strong year classes but maintains a level of biomass that supports at the very least, some minimum yield required by industry for five to ten years in the event of poor recruitment.

Risk in the yield options below is a function of the uncertainty regarding mortality and recruitment. There exists a strong possibility that the high-risk or non-sustainable levels may interfere with the future yield for the fishery. As discussed above, work is currently underway to refine the estimates of mortality and predict the level of recruitment.

Yield option		Yield (t)
Sustainable - low risk	-	3500
Sustainable - high risk	-	4200
Non-sustainable	-	>4200

PACIFIC HAKE - AREA 4B, NOT INCLUDING MSA 19, 20

Condition of the Stock

A general forward simulation model was adapted for Pacific hake and was used to investigate constant catch and variable effort management scenarios. The model indicates that over the long term yields of up to 8,000 t, 11,000 t, and 16,000 for rates of M of 0.16, 0.23, and 0.29, respectively are sustainable assuming low recruitment.

Forward projections were run with the numbers of age for 1979 from VPA results at different levels of M. Catches from 1979 to 1987 were included and numbers recruiting at age 2 were taken from the VPA up to 1986. Beyond 1986 recruitment was assumed to be constant and runs using low, average and high recruitment from the VPA were conducted. Biomass has been increasing from 1979 to 1983 and has decreased slightly through to 1987. The biomass in 1981 ranges from 80 to 160 thousand t which compares favorably with fishery independent biomass estimates of 85-130 thousand t and 40 - 150 thousand t. The biomass in 1987 is estimated to be between 98 and 130 thousand t.

Yield Options

Yield options are proposed under two management options, constant and variable yield. The yield options under constant yield are levels that should be sustainable over the long run working to the goal of providing a steady fishery. Under the variable catch option the goal is to maximize the yield per recruit. Yields available will likely vary considerably from year to year.

The risk associated with the harvest ranges is a function of the sensitivity of the entire analysis to the rate of natural mortality (M). In the case of variable catch the risk, in addition to M, is a function the inability to predict the numbers recruiting at age 2 in 1988.

Constant yield	- Low risk sustainable	- 8,000 - 11,000 t
	- High risk sustainable	- 11,000 - 16,000 t
Variable yield	- High risk sustainable	- 16,000 - 24,000 t

DOGFISH - COASTWIDE

Condition of the Stock

The model of Wood et al. has been updated with catches to 1985. The predicted pulse in abundance set in motion by the 1940s liver fishery is levelling out from the downward trend in abundance. At current harvest levels of less than 2,500 t, the marketable biomass of dogfish is predicted to continue increasing over the next two decades. The estimated biomass coastwide at the present time is approximately 280,000 t. Assuming that one-half to two-thirds of the stock resides off the coast of Canada, the biomass of fish in the Canadian zone is between 150,000 - 200,000 t.

Yield Options

Yield option 1: Unlimited yield
Yield option 2: Pulse fishing
Yield option 3: Sustained yield - low risk - 15,000 t
Yield option 4: Sustained yield - high risk - 25,000 t

The risk involved is based on ranges of compensatory mortality and starting stock sizes used to determine the sustainable yields. All options refer to coastwide (including U.S.) removals and no provision has been made for adjusting Canadian catches in the event of increased U.S. landings.

DOGFISH - AREA 4B, NOT INCLUDING MSA 19, 20

Condition of the Stock

The model of Wood et al. has been updated to include 1986 catches. The model predicts that the marketable biomass is increasing and that at current harvest levels abundance should continue to increase over the next few years. Current biomass levels are in the order of 60,000 t.

Trends in relative abundance as indicated by LPUE continue to differ between longline and trawl data. The trawl LPUE decreased in 1986 while longline LPUE increased. It is questionable whether these time series accurately reflect actual changes in abundance considering the low level of trip log coverage, the difficulty in estimating the actual numbers of hooks deployed (effort) and the schooling nature of this species.

Yield Options

Yield option 1: Unlimited yield
Yield option 2: Pulse fishing
Yield option 3: Sustained yield - low risk - 2,000 t
Yield option 4: Sustained yield - high risk - 3,000 t

The removals in yield option 3 and 4 refer to the Strait of Georgia only.

WALLEYE POLLOCK - AREA 4B

Condition of the Stock

The size composition data indicate little change from the previous years. Model size continues to range from 40 - 43 cm. Presumably the stock has remained in stable condition.

There have been no new analyses conducted and the 1988 assessment is based on Gulland's equation where MSY = a(M)(Bo).

Yield Options

Yield options for 1988 may be chosen from:

Yield option 1: Conservative level of 2,500 t.
Yield option 2: High risk level of 5,400 t.

WALLEYE POLLOCK - AREAS 5C/5D

Condition of the Stock

Size composition of the 1986 landings indicate that larger fish were landed as compared to last year. The model sizes increased approximately 3 cm to 55 - 57 cm.

Yield Options

The yield option for 1988 remains unchanged from the previous assessment. The catch is currently limited to weak market demand.

Yield option 1: unrestricted yield.

PACIFIC OCEAN PERCH - AREA 3C

Yield Options

The S. alutus stock off southwest Vancouver Island remains in poor condition. Equilibrium yield estimates range from approximately 70 - 200 t. The upper end of this range is probably not sustainable in view of the poor recruitment expected over the next 5 - 8 y. Rehabilitation of this stock cannot be expected within the next decade, even with very low fishing mortality. Perhaps of greatest concern is the possibility of complete recruitment failure for the stock. Unfortunately, we have little information upon which to base recruitment estimates at low stock levels. Collapse and continued depression of rockfish fisheries in other areas should, however, be borne in mind when developing management strategies.

REDSTRIPE ROCKFISH - AREA 3C

Yield Options

The sustainable yield for S. proriger in Area 3C is estimated to range from 200 - 1000 t. In the absence of detailed analysis, but recognizing the biological affiliation of the species and rockfish exploitation histories, it might be prudent to maintain yield at $\leq$500 t for a period sufficient to evaluate its suitability (approximately 5 y).

PACIFIC OCEAN PERCH - AREA 3D

Yield Options

The catch history of S. alutus in Area 3D suggests that the historical fishery, although it has been brief, has been able to sustain removals of approximately 250 t/y. The upper limit of sustainability is unknown, however, some guidance may be obtained from the progression of other rockfish fisheries wherein estimated levels of long-term sustainable production ranged from 1 - 5% of virgin biomass. Maximumn long-term yield has been estimated as approximately 2% of unexploited biomass.

The intense S. alutus fisheries of the mid-1960s found no significant quantities of fish in Area 3D, hence the virgin biomass must have been considerably less than those of either Queen Charlotte Sound (approximately 80,000 t) or southwest Vancouver Island (approximately 68,000 t). If the biomass was in the 10,000 - 30,000 t range, then long-term sustainable yield might be approximately 200 - 600 t.

REDSTRIPE ROCKFISH - AREAS 3D/5A

Yield Options

The yield options for S. proriger in Area 3D/5A are based on published work relating initial yields from fisheries to their ultimate long-term yields. Francis estimates these latter yields seldom exceed 200 - 300% of initial yields. The average yield from the first six years of the fishery was approximately 350 t and this may be used as a lower estimate of sustainable yield. The upper limited would then be estimated at approximately 900 t (i.e., 250% of 350 t). Stability of quotas over the next 3 - 5 y may assist in the evaluation of their validity.

YELLOWMOUTH ROCKFISH - AREAS 3D/5A

Yield Options

The stock of S. reedi in the 3D/5A areas has apparently sustained removals of approximately 200-250 t/y by the domestic fishery. The previous catch history by foreign vessels is less certain due to species designation problems. While the upper limit of sustainable yield is unknown. At this time it might be prudent to approach the expansion of this fishery in a staged manner. Experience in other rockfish fisheries suggests that yields in excess of 200 - 300% of the initial yields (i.e., prior to the typical exponential increase in catches) from a fishery are seldom sustainable. Accordingly, the estimated upper limit for the sustainable yield option from this stock is approximately 400 - 750 t.

PACIFIC OCEAN PERCH - AREA 5A/5B

Yield Options

As with all rockfish stocks, the dynamics of the Goose Is. Gully stock of S. alutus are relatively slow and rehabilitative management actions of even large measure have little impact over the short term. Previous work has shown that, with the exception of complete closure, there are relatively small differences in the periods of rehabilitation between F=0.0-0.05. While there may be uncertainty about the exact level of stock biomass in 1987, the values of F associated with long term maximum yield are relatively well determined (F is approximately 0.06). Present stock biomass is estimated to be in the range of 8,000 - 13,000 t, suggested by the simulations using the 1985 and 1977 age compositions (N[j]), respectively. Yields from these biomasses are dependent on the choice of management policy and have been outlined in previous assessments. For example only, yields at F=0.06 would range, including the contribution of the Mitchell's Gully component of the stock, from approximately 700 - 1,000 t. If management considers maximum available yield to be a desirable management goal then a winter fishery, with its female bias, would reduce available yield relative to an unbiased summer fishery.

PACIFIC OCEAN PERCH - AREA 5C/5D

Yield Options

One assessment suggests no change in the yield options for the Moresby Gully S. alutus stock over those identified in the previous assessment. These options were based on a biomass estimate from a trawl survey (which will generally tend to underestimate rockfish biomass), although for that survey the bias will be less than for traditional surveys, for the reasons noted above. The yield estimates may, on that basis, be conservative. In opposition to this conjecture is the downward trend of catch rates in recent years. Previous rockfish studies have shown that major shifts in catch rates such as these can indicate substantial changes in biomass. One approach to the solution of this problem may be to maintain present yields from this stock to determine if catch rate changes persist (which will indicate stock declines), or to reduce yield in an effort to reverse this trend. If changes in yield are considered, they should be as fixed steps for approximately 5 y periods, which will permit sufficient opportunity for their evaluation.

A recent internal review of the Moresby Gully S. alutus assessment has suggested that yields may be underestimated. The review noted the general unreliability of trawl survey biomass estimates and identified a higher level of sustainable yield (3,000 t), that might be approached on an experimental basis, for a minimum of five years. Accordingly, the upper limit of sustainable yield is set as 3,000 t.

REDSTRIPE ROCKFISH - AREAS 5C/5D

Yield Options

The long-term average harvest from this stock (approximately 160 t) is assumed to be a lower limit of sustainable yield. There is little to guide the determination of an upper estimate; we will use the same criterion as in Section 9.5.1.3, i.e., 200 - 300% of initial harvests represents a non-sustainable level. The upper limit is therefore estimated to be 500 t.

PACIFIC OCEAN PERCH - AREA 5E(S)

Yield Options

Some of the estimators of stock biomass for the Area 5E(S) *S. alutus* stock suggest that the 600 t yield presently used should be sustainable, if not actually conservative. Opposing this conclusion is the steady decline of qualified LPUE for the fishery and the length frequency distribution, arguing that this yield exceeds sustainable levels. Resolution of the paradox might best be achieved through maintenance of existing yields for an additional 2 - 3 y, to provide an opportunity for LPUE to reflect their suitability. Continued decline or the absence of variation will suggest that approximately 600 t in an inappropriate level. Size frequency changes will also need to be closely monitored.

YELLOWMOUTH ROCKFISH - AREA 5E(S)

Yield Options

Yield options for the *S. reedi* stock in Area 5E(S) remain approximately the same as in 1987, although the range of values reflects the uncertainty associated with this assessment. Sustainable yield is estimated to range from 400 - 700 t.

ROUGHEYE ROCKFISH - AREA 5E(S)

Yield Options

The estimated yield options for the *S. aleutianus* stock in Area 5E(S) reflect the uncertainty of our assessment, although the generally low level of available yield from the area is recognized. Sustainable yield is estimated to range from 200 - 300 t.

REDSTRIPE ROCKFISH - AREA 5E(S)

Yield Options

If the decline in LPUE for recent landing (approximately 700 t/y) of S. proriger from Area 5E(S) is representative of stock condition, then it is unlikely this level is sustainable. Cluster analysis of landings from this area suggests that the normal catch ratio of S. proriger to S. alutus is approximately 0.217. Based on the yield options identified for S. alutus, the estimated level of sustainable yield for S. proriger is in the 80 - 150 t range. These figures may be conservative if the landing patterns, upon which the catch ratio is based, do not accurately reflect the catch of S. proriger. There has been no evidence of such market limitations in recent years, although they may have been operative in the late 1970s.

SLOPE ROCKFISH - AREA 5E(N)

Yield Options

Yields of S. alutus in the order of 2,000 t/y appear to have generated total mortality rates in the 0.6 - 0.7 range. If these figures are correct, then sustainable yields (Z is approximately 0.10) should be in the range of 140 - 170 t. The upper limits of sustainability are unlikely to be more than twice this figure, and may be less if stock biomass has been reduced below levels giving rise to observed mortality rates. Similar calculations were applied to the average yield of 300 t/y for S. aleutianus. Yield options for S. reedi and S. proriger are simply guideline figures based on Francis' observations concerning the relationship between initial and long-term yields. Hence, sustainable yields are estimated to be approximately 350 - 500 t and 500 - 700 t, respectively. A cautionary note concerning the potential yield from these two species should be added. Both species were recorded by observers in catches by Japanese trawlers during 1977. The exact exploitation history for these species is therefore uncertain and yields identified here as those of initial fisheries may overestimate long-term yield, when used in this fashion. Characteristics of these two species in this area bear careful scrutiny in the future.

YELLOWTAIL ROCKFISH - COASTWIDE

Condition of the Stock

While analysis of the Canadian stock is hampered by a lack of age composition and survey data, this is not the case for U.S. assessments of yellowtail rockfish. Their stock delineation uses the INPFC divisions of the "Vancouver" area, which covers Areas 3C and 3D of the B.C. coast and the northern two-thirds of the Washington coast and the "Columbia" area which includes the remaining southern portion of Washington and the northern two-thirds of the Oregon coast.

The most recent U.S. assessment states that yellowtail stocks from both areas have been declining over the previous 19 years (1967-1985) with some stabilization over the last three years. Biomasses were estimated to be 5,421 - 6,150 t for the Vancouver area and 20,284 - 21,231 t in the Columbia area. The recommended catch ranges were 854 - 1,333 t and 2,227 - 3,154 t for the Vancouver and Columbia areas respectively, with the former range being set below the equilibrium yield in order to promote stock reconstruction.

Canadian fish tend to be larger but the mean size in Canadian bottom trawl landings also declined 2 - 3 cm over the same period. Unlike the U.S. situation this response occurred during a period of limited landings. The U.S. catches may have had an impact on abundance in the Canadian zone or, the annual catches in Canadian waters of 2,000 - 7,500 t in the 1969-78 period removed many of the older (larger) fish resulting in reduced mean size in the 1981 - 1986 bottom trawl samples and reduced abundance as evident from the low catches during this period. Mean size may have decreased temporarily as incoming recruiting represented an increasing proportion of the stock. In obvious contradiction however, was the successful midwater fishery of late 1986 off the central coast of Vancouver Island which appeared to concentrate on older males (76% males). As mentioned earlier, a similar fishery by Polish trawlers occurred in 1975 but the fishery did not seem able to sustain itself for a second year as the Polish catch rates declined by 59% in 1976.

The mean yield of 2,085 t for 1967-85 has not produced consistent signs of overfishing. An apparent reduction in availability between 1981 and 1985 as indicated by low catches, and the trend towards smaller mean size in bottom-trawl catches, conflicts with the observation of high catch rates and larger mean size in the recent midwater fishery off central Vancouver Island. The 2,085 t mean yield remains a minimum estimate of sustainable yield.

While similar to other rockfishes, with respect to longevity and growth, yellowtail rockfish appear to be more mobile and, perhaps as a consequence, much more variable in availability. Yield options for this species, more than for other rockfishes, should be perceived as long-term averages. This is consistent with the management of the last few years during which regulations have not limited the harvest. When the population apparently became more available to midwater trawl gear in late 1986, the mangers allowed a large harvest in lieu of the minimal Canadian landings from 1980 to 1985.

A guideline annual yield option is still required however, as a target for mean yield. Managers may also wish to implement a ceiling annual harvest level to prevent excessive fishing during years of increased availability.

Yield Options

We suggest that a yield option equal to the mean yield (2,085 t) does not represent a major risk and that the yield could be increased unless sizes and catch rates continue to decline over the short-term. The yield option must account for the expected catches of yellowtail rockfish in the 1988 offshore hake fishery.

If managers wish a yield in excess of the long-term average, the previous Polish midwater fishery and the U.S. assessments provide insight into what might be considered excessive. Polish catch rates were reduced by 50% after a one year total harvest (Polish and domestic) of 7,512 t. The U.S. fisheries to the south are showing consistent signs of overfishing after only 10 years of a combined mean yield of approximately 8,000 t. United States biologists now estimate that the maximum sustained yield of the two stock <u>combined</u> lies between 1,000 and 4,000 t, at optimal levels.

It seems unlikely, given the Polish fishery results, the U.S. assessments, and the declining mean size in the Canadian bottom-trawl catches, that the B.C. coast could sustain more than the U.S. estimate of maximum MSY from the Washington, Oregon, and southern B.C. coasts combined. A yield of 4,000 t sets an upper limit to what might be expected from this stock.

The low-risk option would be 1,000 t, significantly below the mean yield owing to concern over declining size in bottom-trawl catches, a possibly large by-catch in the offshore hake fishery, and the possibility that the stock is continuous with the declining stock in U.S. waters. The suggested yield range is 1,000 - 4,000 t.

SILVERGRAY ROCKFISH - AREA 3C

Yield Options

Given, that there has never been significant landings of silvergray rockfish for over 20 years in spite of major groundfish fisheries on these grounds and the relatively small size in the available samples, it seems unlikely there is a major under-exploited resource of silvergray rockfish in this area. The sustainable yield is probably greater than the mean yield of 25 t/y but may be less than the 225 t captured in 1986. The suggested yield rage is 25 - 200 t.

CANARY ROCKFISH - AREA 3C

Yield Options

The long-term mean yield of 215 t remains a minimum estimate of sustainable yield and can be considered the low-risk option. One is referred to the comments in Section 10.0. regarding the choice of a yield option if overfishing is not evident.

The absence of significant landings of Canary rockfish for 20 years in spite of heavy groundfish exploitation on these grounds strongly suggests that there has never been a biomass capable of supporting an annual harvest of 500 - 600 t such as has been observed in more northern stocks. The long-term sustainable yield therefore probably lies within the range of 200 - 400 t.

Combined Silvergray and Canary Rockfish Yield Option (Area 3C)

The applicability of assemblage management is dependent on what managers choose as the yield option for each stock. If the options are not dissimilar the managers may wish to simply add the two options. We suggest that the combined option be less than the sum of the two in case one of the species becomes especially available during the 1988 fishing year. This would be particularly important if managers choose yield options significantly in excess of mean historical yields. This principle applies to all applications of assemblage management.

SILVERGRAY ROCKFISH - AREA 3D

Condition of the Stock

Partial recruitment parameters can vary among stocks and over time, but the aged samples from Nootka and the length frequency samples for both years for the whole area provide a consistent picture of a population which has undergone significant exploitation. The most likely explanation for the young age composition is that the traditional yield of 200+ t/y, augmented by four recent years of a 600 t/y harvest, has had a major impact on this stock.

The alternative explanation is that the older fish are still numerous but are swamped numerically in the samples by very successful recent year-classes. This requires the coincidence that the charters happened to take place 15 years following a 5 - 10 year period of very high recruitment, the first period of high recruitment in 50 - 60 years. Massive incoming recruitment should also lead to rising catch rates, however qualified catch rates remain relatively stable and low for a rockfish fishery (0.37 - 0.53 t/hr). Nominal rates are declining.

Yield Options

The charter vessel observations support the premise that the sustainable yield for this stock may not be any larger than what the stock has traditionally produced. On this basis anything sigificantly greater than 250 t can be considered to be a high risk quota.

On the other hand, managers may wish to consider maintaining a high yield for two or more years in order to use this stock as a test for the management of this species. If 250 t is the sustainable yield for this fishery it implies a biomass in 1984, prior to the increase in harvest, of 5,000 t. The 4-year summed harvest of 676 t/y would then have reduced the biomass to 3,400 t. A further reduction of 1,000 t, by allowing high yields for two years, should be detectable in the age composition by repeating the sampling charter in 1989. If at that time no changes are detected, then the sustainable yield will be assumed to be in excess of 250 t, and possibly as high as 650 t.

The suggested sustainable yield range is 250 - 350 t.

CANARY ROCKFISH - AREA 3D

Yield Options

The declining catches and catch rates argue against a sustainable yield option in excess of the mean yield of 500 t. Managers may wish to consider a more conservative option. While the declining catches and more

We know of no analytic technique for identifying a high-risk option from the available information but in light of the declining catch rates and landings, yields more than 25% greater than the long-term mean would seem excessive. The suggested harvest range is 500 - 600 t.

Combined Yield Options - Silvergray and Canary Rockfish (Area 3D)

The separate options for the two species determines whether assemblage management is appropriate. Landings over the last four years indicate a 50:50 split between the two species. As long as the desired yield options correspond to this ratio then a combined quota is appropriate. If managers wish to curtail landings of one of the species, a combined yield options might still be effective but may require use of specific trip limits as was employed for Moresby Gully silvergray rockfish in 1987.

SILVERGRAY ROCKFISH - AREA 5A/5B

Yield Options

Although a source for concern, one recent sample of small fish is not conclusive evidence for overfishing. The mean yield remains the minimum estimate of sustainable yield. Managers may wish to increase the harvest pressure on this stock but it would seem unlikely that this resource could match Pacific ocean perch in productivity so it would be extremely surprising if it could sustain harvests in excess of 1,000 t (see Section 9.5.3). The historical absence of major yields and the small size in the 1986 sample argue against a sustainable harvest much in excess of the historical yield. A suggested harvest range is 700 - 1,000 t.

CANARY ROCKFISH - AREA 5A/5B

Yield Options

Landings continue to decline within the constraint of a coastwide combined yield option for both species of rockfish. While it is obvious that catches in some stocks must decline if others increase within a combined option, it still implies that there is not a vast unexploited biomass when fishing pressure and success shifts so readily to other stocks. While we can assume that the mean yield of 364 t is a minimum estimate of the sustainable yield, there is no evidence to suggest that this yield can be significantly increased. The low-risk option is the long-term mean yield of 364 t. Managers may wish to increase harvest pressure a modest amount. We suggest a harvest range of 350 - 500 t for consideration.

Combined Yield Option - Silvergray and Canary Rockfish

A combined yield option for silverygray and canary rockfish is suggested for Q. C. Sd. It can be the sum of the individual yield options if the two options chosen by managers follow the historical landings proportion of 2 to 1 silvergray to canary rockfish.

SILVERGRAY ROCKFISH 5C/5D

Yield Options

The recommended sustainable yield option was raised from 300 to 600 t in 1983, prior to any effective quota restrictions under the assumptions that a significant biomass might be present. We suggested that the option be maintained at that level for 3 - 5 years. Based on 1985 and 1986 catch rates and stock composition, the stock is not exhibiting significant signs of overfishing. Apparently the fishery since 1979, with a mean yield of 396 t, has not yet had a significant impact. A yield option of 400 t can now be considered a minimum estimate of the sustainable yield. Managers may wish to maintain the current option of 600 t or even increase it for another trial period. The area productivity study would suggest that a yield of more than 1,000 t is not likely. The suggested harvest range is 400 - 1,000 t.

YELLOWTAIL ROCKFISH - AREA 5C/5D

Yellowtail rockfish landings continue to be minor in Hecate Strait with 96 t landed in 1986. Significant landings (150 - 600 t) last occurred during the pollock fishery in Dixon Entrance between 1976 and 1979. There is no analytical means for identifying yield options, managers may wish to consider a ceiling yield option as they chose for the 1987 fishing year.

CANARY ROCKFISH - AREA 5C/5D

Canary rockfish catches from Hecate Strait continue to be low as only 63 t were landed in 1986. Managers may wish to choose a ceiling yield option as they have in the past.

SILVERGRAY ROCKFISH - AREA 5E

Yield Options

No analytic assessments are possible for these two stocks. Suggested ranges are 100 - 250 t for the southern stock and 100 - 150 for the northern stock with the suggestion that no constraints be placed on the latter fishery until conclusion of the experimental fishery for Pacific ocean perch.

YELLOWTAIL AND CANARY ROCKFISH - AREA 5E

The fishery for these two species off the west coast of the Queen Charlotte Islands remains insignificant. No yellowtail landings and only 110 t of Canary rockfish were reported to have come from these grounds in 1986. Managers may wish to continue with guideline quotas as in past years.

INSHORE ROCKFISH

Condition of the Stock

Quillback rockfish stocks in Area 12 appear to be in good condition. The weight distribution of quillback rockfish in the Area 12 commercial samples is probably typical of a relatively unexploited stock. Although there was a decrease in mean weight between 1986-87, it is not clear whether this represents a decrease in mean weight of the stock or a market preference for smaller fish. Significant differences in mean fish size may occur among samples from different localities, seasons and depths. The small mean weight from the 1985 Area 12 sample is an anomaly and is indicative of the possible among-sample variance. Based on one 1986 sample aged to date, the mean age is 26 yr with a range in age of 5 - 60 yr.

In contrast to the Area 12 stocks, quillback rockfish stocks in Area 13 appear to be in relatively poor condition. There are two main types of evidence for a decline in size of quillback rockfish stocks in Area 13. First, based on the fishery data, landings, LPUE, and the number of vessels that reported landings in Area 13 have all declined over the past two-three years, in spite of increases in other areas. Second, there is a trend of decreasing mean fish weight, range of weight and modal weight for quillback rockfish landed in Area 13 between 1984-87. Model weight decreased from 0.9 kg in 1984 to 0.3 kg in 1987, with weight at first recruitment to the fishery of 0.2 kg. As weight at 50% maturity is about 0.4 kg, and as fish as large as 0.9 kg may be immature, a high proportion of immature fish are landed by the fishery. The mean age from a 1984 and a 1986 sample from Area 13 and a 1986 sample from Area 17 was 18 yr with a range of 4 - 55 yr.

Yield Options

	Statistical area		
	12	13	14-20,28,29
Yield option 1. conservative	75 t	50 t	150 t
Yield option 2. risk sustainable	100 t	75 t	200 t
Yield option 3. non-sustainable	>150 t	100 t	no limit

Yield options apply to all species except yelloweye, and were derived from historical all-species rockfish landings.

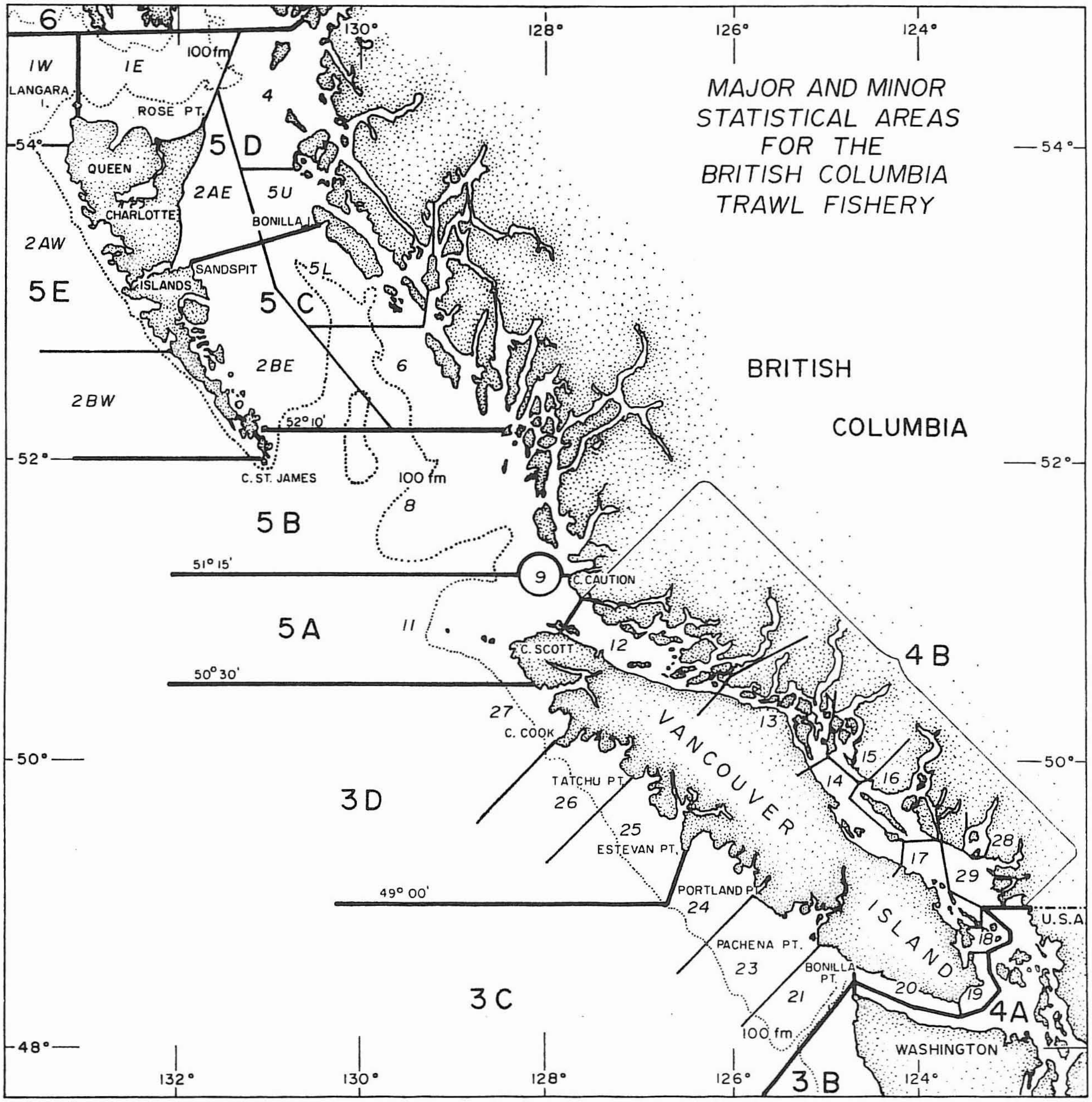

Fig. 1. International (Pacific Marine Fisheries Commission) Major and Minor Statistical Areas along the British Columbia coast.

Appendix 1: Participants at the Groundfish Subcommittee Meeting, September 2-3, 1987

A. Tyler, Chairman

T. Beacham

G. Beuchler

J. Fargo

S. Farlinger

R. Foucher

C. Hand

R. Harbo

R. Kadowaki

B. Leaman

D. McKone

G. McFarlane

M. Saunders

W. Shaw

R. Stanley

M. Stocker

L. Richards

Appendix 2. Reviewers for groundfish stock assessments.

Subject	Authors	Reviewers
Lingcod	L. Richards	M. Saunders, A. Tyler
Pacific cod	R. Foucher, A. Tyler	J. Fargo, D. Noakes
Flatfish	J. Fargo	T. Beacham[a], L. Richards, C. Hand
Sablefish	M. W. Saunders, W. Shaw G. A. McFarlane	R. Foucher, R. Stanley
Pacific hake	M. W. Saunders, W. Shaw A. Babcock-Hollowed	R. Stanley, L. Richards
Dogfish Walleye pollock	M. W. Saunders W. Shaw	J. Fargo, B. Leaman
Slope rockfish	B. Leaman	M. Saunders, S. McFarlane
Shelf rockfish	R. Stanley	D. Noakes, R. Kadowaki[a]
Inshore rockfish	L. Richards	B. Leaman, R. Foucher

Appendix 3. Recommendations.

It was recommended that a study be conducted of inshore lingcod stocks on the west coast of Vancouver Island. If necessary Barkley Sound can be chosen as the study area. The purpose would be to determine the following:

- Stock size or the relative strength of the stock.
- Whether the inshore stock is separate from the offshore one. If not, whether there appears to be consistent recruitment from offshore areas.
- Whether there is any biological evidence to suggest that the winter closure (November 15 - April 15) is either working or, if it is even necessary.

Pacific Stock Assessment
Review Committee

PSARC Advisory Document 87-3

BIOLOGICAL ADVICE ON MANAGEMENT OF BRITISH COLUMBIA SHELLFISH (INVERTEBRATES)

PSARC reviewed the Shellfish (Invertebrate) Subcommittee Report as contained in this document.

This report is a summary of advice and recommendations from meetings of the PSARC Shellfish Subcommittee, held August 31 - September 1,1987. A list of the participants is given in Appendix 1. A list of the 21 working papers submitted is shown in Appendix 2. Presentations were made by the Shellfish Section, Pacific Biological Station, Biological Sciences Branch and by biologists from the North and South Coast divisions of the Fisheries Branch. Representatives from DFO, Ottawa and the Province of British Columbia, Ministry of Agriculture and Fisheries, participated as well.

Shellfish fisheries (Table 1) have grown rapidly in the past five years, with participation by over 500 vessels and in excess of two thousand intertidal harvesters, many of which rely on shellfish fisheries for a major portion of their income. Shellfish are also increasing in interest and value to the recreational fishery and estimates of 37,000 sport fishermen have been made.

The landed value of shellfish fisheries exceeded $20 million in 1986, double that of 1982 (Table 2), and shows some promise for further increases. Table 2 ranks the species according to total landings (tonnes) and total landed value.

The PSARC Shellfish Subcommittee expressed concern that adequate research and management support are not being allocated for invertebrate fisheries. With the rapid growth of existing fisheries and many new fisheries, little is known about the biology, stock abundance and stock distribution for invertebrates.

Recommendations from this subcommittee in 1986 formed the basis of 1987 fishing plans. Appendix 3 details actions that resulted from recommendations made from this subcommittee in 1986 for management and research programs. 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.

Appendix 4 presents the results of a priorization exercise undertaken by the Regional Shellfish Working Group and the PSARC Shellfish Subcommittee.

MANAGEMENT POLICY

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

MAJOR FISHERIES

Crab Fisheries: Entry is not limited.

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

Prawn Trap Fisheries: Entry is not limited.

- In season monitoring is carried out to allow a minimum escapement of the spawning cohort of prawns within a management area.
- Trap escapement modifications are proposed to maximize the economic yield and reduce handling mortality of prerecruits.
- Study areas are in place to examine alternative management options.

Intertidal Clams: Entry is open to anyone with a personal commercial fishing licence. Support vessels are not licenced.

- Minimum size limits allow clams to spawn at least twice before being taken in the fishery (maximize yield per recruit analyses proposed).
- Some beaches are closed seasonally to reduce mortality of sublegal clams from repeated harvesting or due to high risk of paralytic shellfish poison (PSP).
- The north coast is closed to harvesting, with the exception of razor clams, due to high risk of PSP.

Geoduck: This ia a limited entry fishery with 55 vessels licences.

- Management by maximum sustained yield proposed at annual exploitation levels of 0.75 to 2% of the original biomass.
- Quotas are set to limit the growth of the fishery until more is known about recruitment and biomass.
- Quotas and seasons have been adjusted to provide a year-round supply.
- P licences have been issued in the north coast, where shore-based processing is not available.

Sea Urchin: Entry not limited.

- Area and subarea quotas have been set to limit growth of the fishery while biological data is obtained.

- Quotas for some areas (17, 18, and 19) 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.
- P licences have been issued for the north coast.

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

- A single, coastwide quota was originally set, based on sustained yield (from preliminary estimates of the original biomass and turnover rates). Quotas have been reduced and maintained at low levels, based on surveys of relative abundance and recruitment as compared to earlier surveys.
- The current size limit is intended to allow abalone to spawn two to three times before being taken in the fishery.

Sea Cucumber: Entry is not limited.

- Arbitrary quotas have been set for three regions of the coast (500 tonnes for each) to limit growth of this fishery until further biological data is obtained on growth, age and recruitment.

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

- There are several species and stocks of shrimps exploited. Generally, the stocks are managed as inshore and offshore.
- It may be possible to manage inshore stocks on a sustained yield basis. Biological data is being collected by a mandatory logbook program, but to date there have not been any restrictions on the fishery.
- Conservative quotas have been set for the offshore stocks on the assumption that there may be a stock-recruitment relationship and a sustained yield is possible. Offshore stocks have shown high fluctuations in abundance. Further research is required to determine the optimal size or age to harvest in periods of peak abundance.

Offshore Squid: This in an exploratory fishery, undertaken in cooperation with Japanese vessels. Special licences have been issued to Canadian vessels for exploratory fishing.

MINOR OR DEVELOPING FISHERIES

Most of the minor or developing fisheries are currently regarded as underutilized. Their growth has been limited because of the lack of markets.

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

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

<u>Euphausiids</u> - <u>Plankton</u>: A conservative quota (500 tonnes) has been set for inshore waters (Strait of Georgia and adjacent waters). The quota is based on a harvest rate of 0.1% of the estimated standing stock of euphaussids in the Strait of Georgia. Exploitation at this low level should not impact on the stock.

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

MAJOR FISHERY CONCERNS (1987)

There were several specific fishery concerns in 1987. For many of the species little is known about their stock abundance and recruitment. The abalone fishery has continued at low levels. The geoduck fishery has grown an for the first time all the quotas were taken in the north coast. The market demand was strong for sea urchins and sea cucumbers and the growth of these fisheries has been limited by arbitrary quotas.

1. There is concern over the mammal bycatch in the offshore driftnet squid fishery. Further exploratory fishing was undertaken in the summer of 1987

2. There was considerable discussion with industry regarding the implementation of trap escapement modifications for the release of small prawns.

3. Closures for soft shell crab were implemented in the Fraser River estuary and at Tofino. Concerns were expressed about the increase in effort and the number of traps.

4. Processors and fishermen question the minimum size limit for sea urchins and have requested it be either reduced or eliminated.

5. Arbitrary quotas were set for the sea cucumber fishery, resulting in early closures in the south coast.

6. Offshore shrimp stocks are at the highest level of abundance since the 1970s and could support an increase of fishing effort in 1987 and 1988. Management options should be considered in the event of a rapid increase in effort and landings. Further surveys and studies are recommended to achieve the optimal harvest of this stock that undergoes high fluctuations in abundance.

7. Conflicts between commercial and recreational clam diggers and commercial diggers and property owners occurred on several occasions during the past year. Many communities are requesting recreational reserves, where commercial fishing would be prohibited. One of the most serious conflicts was at Savary Island (Area 15) which is the most important manila clam beach in the Province. Savary Island is important to the commercial clam industry and it is felt that with closer monitoring in the area, most of the conflicts can be avoided.

SUMMARY OF ADVICE FOR SHELLFISH (INVERTEBRATE) FISHERIES IN 1988

Section 1 discusses the fisheries of major importance in 1988, those with the greatest landings and highest values as shown in Table 2. These include crab and prawn trap fisheries, intertidal clams, diving fisheries for geoduck, sea urchin, abalone and sea cucumber. The offshore shrimp trawl fishery is expected to be strong in 1987 and 1988.

Other species support only minor fisheries at this time, and are discussed in Section 2. This includes plankton, minor crab species, inshore squid, scallops, horse clams, octopus, goose barnacles, and mussels.

SECTION 1 - MAJOR SHELLFISH (INVERTEBRATE FISHERIES)

TRAP FISHERIES
- CRAB (I87-16, 17)
- PRAWN (I87-13, 14, 15)

INTERTIDAL FISHERIES
- INTERTIDAL CLAMS (I87-1)

DIVING FISHERIES
- GEODUCK (I87-4, 5)
- SEA URCHIN (I87-9)
- ABALONE (I87-6, 7)
- SEA CUCUMBER (I87-10)

NET FISHERIES
- SHRIMP TRAWL - OFFSHORE AND INSHORE (I87-18)
- OFFSHORE SQUID (<u>OMMASTREPHES</u>) (DRIFT GILLNET) (I87-20)

SECTION 2 - MINOR OR DEVELOPING SHELLFISH (INVERTEBRATE FISHERIES)

TRAP FISHERIES
- TANNER, KING AND GALATHEID CRABS (I87-17)
- (SHRIMP BY TRAP - NO RECOMMENDATIONS FOR 1987/88)

NET FISHERIES
- SQUID (INSHORE) (I87-19)
- PLANKTON - EUPHAUSIIDS (I87-21)

DIVING FISHERIES
- SCALLOPS (I87-11)
- HORSE CLAMS (I87-8)
- OCTOPUS (I87-12)

INTERTIDAL FISHERIES
- GOOSENECK BARNACLES (I87-2)
- MUSSELS (I87-3)

SUMMARY OF BIOLOGICAL ADVICE FOR MANAGEMENT OF MAJOR INVERTEBRATE FISHERIES IN 1988

Major Fisheries	Biological Advice
TRAP	
Dungeness crab	1. No advice. Research in progress
Prawn	1. Trap escapement modifications, specified to maximize yield per recruit.
	2. Continue study areas and mandatory logbooks.
INTERTIDAL	
Intertidal clams	1. Assessments in progress - to monitor stock and recruitment. Study areas proposed.
	2. Rigorous enforcement of minimum size limits.
DIVING	
Geoducks	1. Assessment of harvest log data suggests decline in shallow stocks. Review current levels of harvest. Continue harvest log program.
Sea urchins	1. No stock assessment. Restriction of effort by quotas or other means is recommended. Continue harvest log program.
	2. Attempt experimental management in the north.
Abalone	1. Survey of Area 2E suggests stock has stabilized at low level. Maintain quotas at current low level.
	2. Enforce minimum size limit.
	3. Continue harvest logs.
Sea cucumber	1. No stock assessment. Effort should be limited until further biological data is obtained. Continue harvest logs.

SUMMARY OF BIOLOGICAL ADVICE FOR MANAGEMENT OF MAJOR INVERTEBRATE FISHERIES IN 1988 (cont'd)

Major Fisheries	Biological Advice
NET	
Shrimp trawl	1. Large increase in biomass projected for 1987/88.
	2. Closely monitor stock and fishing on west coast of Vancouver Island. Review quota options.
	3. Continue mandatory harvest logbook program.
Offshore squid	1. Potential for growth in this fishery.
	2. Carry out additional test fishing with improved scientific opportunities to evaluate how bycatch can be reduced.

SUMMARY OF BIOLOGICAL ADVICE FOR MANAGEMENT OF MINOR INVERTEBRATE FISHERIES IN 1988

Major Fisheries	Biological Advice
TRAP	
Tanner, king, and galatheid	1. No stock assessment.
	2. New species codes for sales slips to aid in assessment of catch trends.
Shrimp by trap	1. Continue monitoring of landings and effort (Sooke). TAC not evaluated.
NET	
Squid inshore	1. No advice. Underutilized. Continue harvest logs.
Plankton	1. No stock assessment.
	2. High potential for growth. Monitor for catch and effort. Limit effort by a quota of 500 t for Strait of Georgia.
DIVING	
Scallops	1. Assessment recommended reductions of the minimum size limit for pink and spiny scallops. Continue harvest logs.
Horse clams	1. No stock assessment. Monitor landings, species composition of catch. Continue harvest logs.
	2. Evaluate habitat - occurrence in areas of vegetation supporting herring spawn.
Octopus	1. No stock assessment. Underutilized. Continue harvest logs. Allow experimental fishing with different gear types.
INTERTIDAL	
Gooseneck barnacles (new fishery)	1. No stock assessment. Monitor landings, continue harvest logs.
Mussels	1. No advice. Minor fishery, continue harvest logs.

SECTION 1 - MAJOR SHELLFISH (INVERTEBRATE FISHERIES)

TRAP FISHERIES

DUNGENESS CRAB (I87-17)

Overall landings in 1986 are 11% greater than that of 1985 with the greatest increase in landings being on the west coast of Vancouver Island. Significant increases also occurred in the Queen Charlotte Islands and around Victoria, while landings at the mouth of the Fraser River decreased. Regional fluctuations in landings represent expected variability in annual recruitment, since overall crab price remains high and all known concentrations of crab are heavily exploited. There were 389 vessels that reported landings of crab in 1986.

Two presentations on crab discussed current ongoing research programs. In general terms, factors affecting larval settlement magnitude by geographic location on the west coast of Vancouver Island, management implications of the current minimum legal size limit, and the locations of female crab brooding areas are proposed to have continued high research priority. Research in progress may lead to direct management recommendations in future years.

Recommendations

1. Further research should be carried out at Tofino, to continue studies in progress. Research programs are proposed to be initiated in the Fraser River estuary.

PRAWN TRAP FISHERY (I87-13, 14, 15)

The British Columbia shrimp trap fishery began in the early 1900s. The fishery targeted mainly on prawns (*Pandalus platyceros*) with incidental catches of humpback (*P. hypsinotus*) and pink shrimp (*P. borealis*).

Of the six commercial pandalid shrimp species in British Columbia waters, prawns are the largest, with a maximum reported size of 254 mm total length (Butler 1970).

Traditionally, the prawn fishery was limited to south coast areas with the first substantial landings from the north coast occurring in 1979.

Participation in this fishery requires a Z licence for shrimp trap fishing. In 1986, 551 licences were issued but only 205 vessels reported landings. This is a five-fold increase over the number of vessels reporting landings in this same fishery in 1976. The best estimated catch for 1986 was 543 t, a seven-fold increase over the 71 t reported in 1976.

Comparisons of the logbook and sales slip data bases indicates that up to 25% of the catch has gone unreported in the published sales slip catch statistics prior to 1983.

In-Season Management

Prior to 1979, there was no management program in place for prawns. With the rapid expansion of the fishery in 1979, a management system was developed which allowed for a minimum escapement of the spawning cohort of prawns within a management area. An index is obtained by monitoring the age by length frequency analysis and sex composition of the commercial catch-per-trap. This establishes an index of spawners which is then compared to a criterion of minimum spawner escapement established from study areas in Knight and Kingcome inlets which were monitored from 1973 to 1982. If the spawner index in the commercial catch falls below the monthly criteria, the area is closed until the egg-bearing period is over, usually the following April.

In 1983, the prawn fishery came under the Z licence category and, as a condition of the licence, participating fishermen are required to keep a detailed log of their catch and effort.

Winter Closures - South Coast

Starting in 1984, a winter closure of prawn fishing was implemented by managers for all south coast areas during the period January to March inclusive. The closure was in response to low spawner indices and an inability to adequately monitor these fisheries at this time of year. This south coast closure caused shifts of fishing effort (but not increases in landings) into more remote northern areas where it was difficult to monitor the fishery.

Minimum Size Limit and Trap Escape Studies

A minimum size limit of 30 mm carapace length was adopted in 1985. The regulation has since been varied so that it is not now in effect and other options are under study. To simplify enforcement, it was recommended at industry meetings in early 1986 that trap modification be developed which insured escapement of sublegal prawns. Research programs have been directed to test various types of traps and final results are summarized in the recommendation section.

Benefits From Increasing Age At First Capture of Prawns

At the request of industry at several public meetings held since 1983, the Department was asked to institute trap escapement modifications to allow for escape of sub-legal prawns; the intent is to increase the first age of capture from 12 to 24 months. Fishermen indicated that trap escape modifications were preferable to enforcing a size limit as it would both eliminate the need to sort prawns and reduce subsequent mortality to undersized prawns being returned to the water.

The British Columbia prawn industry currently operates without gear restrictions, type or number of traps. By increasing the age and size of first capture of prawns from one to two years, it is estimated that the total weight yield will increase by 4%, and the dollar value by 25%, resulting from the harvest of higher quality prawns. This was based on the differential prices paid for small, medium, and large prawns. The size of prawns at 2 years at first capture would be approximately 18 g; 25 prawns per pound, 56 prawns per kg; 106 mm or 4.2 inches total length (from the back of the orbit of the eye to the tip of the tail) or 72 mm or 3 inches tail measurement.

Research studies in 1985 and 1986 found that catches of small prawns (less than 2 years old) could be reduced, while maintaining the catch of the larger prawns. These experiments were carried out with web covered, wire mesh, and solid-side traps. Shorter sorting times and fewer bycatches were other benefits found.

Mortalities of sublegal prawns, due to handling and release, should be reduced by "savings gear" or mesh size restrictions. Both Alaska and Washington currently have mesh size restrictions for traps.

Biological Sampling

In 1985, studies were initiated in six experimental prawn fishing areas. Three study areas; Salmon-Sechelt inlets (Area 16), Alberni Inlet (Area 23) and Howe Sound (Area 28) are located on the south coast, and three, Rivers - Moses Inlets (Area 9), Gardner Canal (Area 6), and Work Channel (Area 3), are located on the north coast. The purpose of establishing these areas is to build a data set using logbooks and regular, standardized sampling practices which allows estimation of fishery impacts on various population parameters such as total, natural, and fishing mortalities; growth rates of the total population and of individuals within a year-class; and the relationship of density to growth, survival, catch ability, and availability.

To meet the objectives of the experimental area program, an experimental manipulation of the Howe Sound prawn fishery was carried out and evaluated for 1986. This led to a split season in 1987.

Recommendations

1. Various alternate management scenarios should be developed and evaluated using biological data collected from experimental prawn fishing areas. With an anticipated lower prawn population for the 1987 fishery, it is

again proposed to have two openings: the first being in July (after the animals go through a rapid spring and summer growth period) and the second in December to take advantage of the Christmas market).

2. The usefulness of the logbook data base, in conjunction with the biological sample data base, should be continued to be evaluated for stock assessment purposes. Biological sampling procedures should be standardized for all fisheries staff gathering biological information on prawn stocks.

3. For independent checks on logbook and sales slip data quality, we need to develop a standard format for data to be submitted from the biological monitoring program.

4. Recommended trap escapement modifications are:

   a) Web or Soft Mesh Traps are to be covered with a single layer of mesh measuring a minimum of 1.5 inches (38.1 mm). All mesh used in the trap, including the tunnels must conform to this minimum size. We recommend that the mesh be placed on the trap in such a manner that a round peg measuring 3/4 inch (19 mm) in diameter will readily pass through an opening in the mesh without stretching or altering the shape of the opening.

   b) Solid Sided Traps. These traps have either (a) Tunnel entrances which are to be constructed in such a manner that a 3/4 inch (19 mm) square peg will readily pass through an opening in the material without stretching or altering the shape of the opening. Plastic webbing is available. If web mesh is used, we recommend 1 3/4 inch (44.5 mm) mesh size, cut in 4 pieces and sewn to maintain the square openings.
   OR (b) 4 slots; 16 mm (5.8 inch) wide for the entire length of the trap, at the top and bottom of each side. (We do not recommend this modification--losses of legal catches will occur if the opening warps.)

   c) Wire or Hard Mesh Traps (a) With four opposing tunnels; the tunnels are to be constructed of a rigid square mesh material having a minimum dimension that will allow the passage of a 7/8 inch (22.2 mm) square peg without altering the shape of the opening. The lower side of each tunnel must extend to the bottom edge of the trap and must be at least one-half the width of the trap side.
   OR (b) Without 4 opposing tunnels the bottom and two opposing sides are to be constructed of a square mesh material that will allow (after dip coating) the passage of a 3/4 inch (19 mm) square peg without altering the shape of the opening.

INTERTIDAL FISHERIES

INTERTIDAL CLAMS (I87-1)

Total landings of intertidal clams, butter (*Saxidomus giganteus*), littleneck (*Protothaca staminea*), manila (*Tapes philippinarum*), and razor (*Siliqua patula*), decreased slightly (2.6%) in 1986 compared to the previous year but the value increased 13.8% to $3.74 million. Except for razor clams, virtually all landings were from the south coast district.

As in the past four years, the main species landed was manila clams. Landings declined slightly in 1986 (1.1%) compared to the previous year, but the value increased 19.4% to $2.72 million. Landings of manila clams have tended to level off between 1,700-1, 900 t in the last three years.

Landings of littlenecks increased 48% over the previous year to 285 t (Fig. 1) and the value increased 61% to $325,475. (Landings of littleneck and manila clams were slightly higher because most of the mixed clam landings are a mixture of these two species.)

Butter clam landings declined 37% to 159 t with a value of $60,177. For many years butter clams were the dominant and most valuable species landed in the commercial fishery, but high production costs apparently make it uneconomic to process this species.

Razor clam landings were all from statistical Area 1 increased 57% to 142 t with a value of $127,094. The main reason for increased razor clam landings was that part of the catch was processed for human consumption rather than used entirely for crab bait.

Fishery

Although there are a few other minor regulations controlling clam harvest, it is believed that size limits are the only practical method to manage intertidal clam resources in British Columbia.

Area 23 remained closed to commercial clam harvesting because of conservation problems.

In Area 24, most beaches were opened to commercial clam digging beginning November 1. Beginning in December some beaches are closed to avoid incidental mortality to juvenile clams on heavily harvested beaches.

Clam Farming

Minor attempts to farm manila clams continued, mainly in Areas 23 and 24. Clam farming can involve making improvements to the beach, protecting juvenile clams or planting seed that is purchased from the United States. Problems associated with clam farming are under review.

The problem of clams on oyster leases, whether wild clams or farmed clams, is under review and is being discussed with Provincial authorities. The aim is to reach a policy that will encourage development of oyster and clam farming but not seriously interfere with the commercial wild harvest of clams.

Study Areas - Intertidal Clams

A clam "atlas" of beaches in the south coast division, for each management area, was prepared in 1986. The charts form a working document, with limited distribution.

Areas to study clam populations, assess recruitment and determine the affects of fisheries on clam populations have been established at Nanoose, Gabriola Bar (Area 17), Savary Island (Area 15), Seal Island (Area 14), Clayoquot Sound (Area 24), Mary Basin (Area 25), and Metlakatla Bar (Area 4). Two other study areas should be located in the Alert Bay area (Area 12) and the Gulf Islands region (Area 18). In the past year, sampling was done at Nanoose, Gabriola Bar, Savary Island, Clayoquot Sound, and Metlakatla Bar. It is proposed to increase sampling in these study areas in the next year.

Recommendations (Intertidal Clams)

1. Management of commercial clam harvesting should continue to be by strict enforcement of existing size limits.

2. Work in study areas should be increased to provide further biological information for management of the resource.

3. If razor clam landings continue to increase, a resurvey of the population in Area 1 should be considered. (The last survey was in 1969.)

4. Resurvey populations of butter clams--considering current low levels of harvest, we might expect increases in populations. (Low priority at this time.)

DIVING FISHERIES

GEODUCK CLAM (I87-4 & 5)

The geoduck fishery has been well documented in terms of landings and fishing effort. However, little is known about stock size and recruitment. There are 55 limited entry licences to harvest geoducks and horse clams by diving.

The 1987 Management Plan reserved quotas and delayed openings in areas to maintain a year round supply of geoducks for the live market. Higher prices are received for live product and managers attempted to maximize the value at the request of industry. An association representing boats involved in supplying geoducks for live markets was formed in 1987 and has requested input into the 1988 fishing plan.

Trends in the 1986 and 1987 fisheries were harvesting at deeper depths and increased effort in the north coast. Additional P licences were issued in 1986 and 1987 to harvest and process geoducks in the north coast. There was some shore-based processing carried out in the north coast in 1987 and further interest that has prompted a further review of the P licence policy.

Area Landings

Landings decreased in 1986 over 1985, since no large exploratory fisheries took place. In 1986 the north coast landings increased to 1682 t (35% of total landings). In 1987, for the first time, all area quotas were taken in the north coast.

The fishery slowed considerably in November and December, 1986, but there were opportunities to fish and supply live markets to the end of the year.

Stock Estimates and Quotas

Fishing Area Estimates

Estimates of fishing grounds (ha) have been made from harvest log data; the fishing areas were measured planimetrically from nautical charts.

Quota options are calculated by multiplying (area - ha) X (Density - tonnes of geoducks per ha) X (% sustainable yield) and have a wide range of values. Quotas should be kept within 0.75 to 2% of the virgin biomass in order to maintain a sustainable yield and a population of 50% of the original biomass.

Area quotas are calculated from fishing areas identified in the harvest logs and various estimates of densities as determined from survey data and reports of densities from fishermen.

Depth of Harvesting Geoducks

Geoducks are found intertidally to depths of 111 m (Jamieson et al. 1984). Since 1982 there has been a trend of increased harvesting at depths 41 to 50 feet and 50 to 60 feet.

CPUE Trends - Vessel and Divers

There has been a slight decline in CPUE in 1986 in the south coast for vessels and divers. Daily vessel landings increased in 1986 in the north coast (Fig. 1) but individual diver CPUE decreased.

Recommendations (Many of the recommendations for 1988 are the same for 1987.)

1. Quota options should be reviewed. There are trends of declining CPUE and harvesting at greater depths.

2. Survey techniques and stock assessment require more resources than are presently available. At least three study areas should be established to investigate stock abundance and to monitor recruitment after harvest.

3. A survey for geoducks at Hesquiat Harbour should be undertaken in cooperation with the herring spawn dive assessments to assess if harvesting geoducks would be harmful to marine vegetation.

4. A new standard logbook for all diver fisheries has been proposed. This should be issued for the 1988/89 season if possible.

5. The extent of deep water stocks should be investigated.

6. An assessment of recruitment on harvested grounds (areas to be identified by industry) should be carried out.

7. The development of hatchery techniques should be monitored and trial seedings of juvenile geoducks should be considered.

RED SEA URCHIN FISHERY (I87-9)

The fishery for red sea urchins increased in 1986, with total landings of 2073 t for a landed value of approximately $900,000. Removal of sea urchins (tonnes) ranked third, following geoducks and intertidal clams.

Growth of the fishery has been limited by seasons and area quotas imposed in the south coast. This limitation has been based on fears of local over harvesting that could lead to recruitment failure. With the rapid increase in the number of vessels participating, the increase in landings and the apparent strong market demand, it was felt that some ceiling was necessary to maintain stocks, habitats, and parental adults.

The north coast has been open without limits of quotas or a season but the logistics of harvesting and processing has prevented any significant fishery in the northern areas. Approximately 12 t were recorded for Area 10 in 1986. The south coast quotas do not meet the market demand for Canadian sea urchin roe and higher prices will no doubt lead to an expansion of the fishery on the west coast of Vancouver Island and the north.

Area Quotas, 1987 - 1988

The quotas for 17, 18, and 19 were based on published survey data but other quotas were arbitrary limits set by management biologists.

Closed Areas

In 1987 a number of areas were closed under conditions of the Z licence. These closures were reviewed by a subcommittee of the Pacific Region Shellfish Working Group and further discussion is required before they are included into the 1988 licence conditions and fishing plan.

There is concern expressed by Native Indian bands on the west coast that areas traditionally harvested for food fish are being over explioted.

Catch Per Unit Effort Data

No further work has been done to analyze logbook data for areas that have been heavily exploited. Reports from fishermen of stock size, product quality and recruitment are mixed so that no apparent trend is available.

No obvious declines of vessel and diver CPUE are noted.

An important trend has been the increase in the number of fishing vessels from 46 in 1985 to 67 in 1986 (Table 1), while quotas and fishing opportunities have not increased. Many boats fishing in an area has resulted in many short area openings, with the quota being allocated to more vessels than before.

Processing At Sea - P (Processor) Licenced Vessels

Operators of vessels that are currently licenced (P licence) to process geoducks and sea cucumbers in the north coast, have expressed interest in processing sea urchins. They have informally requested permits to operate both in the north coast and on the west coast of Vancouver Island in the remote areas 25 to 27.

This is a complex policy problem dealing with the exploitation of underutilized stocks, but with concerns over fish quality and inspection and the economic conflicts regarding processing at sea rather than at shore based processing plants.

Recommendations

1. As north coast fisheries expand a management plan is required. A combination of rotating areas, minimum and maximum size limits is proposed, as the setting of explicit quotas could be arbitrary.

2. Limitation of effort for the south coast should be maintained. The number of vessels and the proximity to markets could likely result in over harvesting of populations without limits. The Washington approach of management with a maximum and minimum size limit, and a rotational fishery so that an area is only harvested once every four years should be examined.

3. Portions of Area 13 should remain closed for future research by DFO. It is an area with considerable unharvested stock immediately adjacent to a heavily harvested area.

4. A new, more detailed diver logbook program should be implemented in 1988, replacing the current Z licence log.

5. As identified in 1986, research support is required to examine:

   a) logbook data.

   b) the options of a minimum and maximum size limit.

   c) the reduction of the minimum size limit: the reproductive potential of various size classes, particularly the larger size classes.

ABALONE (I87-6 & 7)

The northern abalone (Haliotis kamtschatkana) fishery in British Columbia is a limited entry fishery, managed with 24 vessel quotas. Quotas have dropped, as stock was seen to decline, to the 1985 level of 47 t where they have remained. Demand continues to exceed supply and the price has increased over the last year ($6 - $10 per pound).

The current stock abundance and recruitment are low when compared with data from the late 1970s. A resurvey of a major fishing zone, Area 2E, has been completed; this and other recent information are considered in the formulation of recommendations.

1987 Survey

Abalone abundance remains essentially unchanged since the 1984 survey. There is no evidence of a return to the significantly greater levels of abundance seen in the late 1970s. These results are similar to those obtained in a 1985 survey of Eastern Hecate Strait and once again suggest that there may be a halt in the decline of abalone at this low level.

Catch per unit effort; although a poor measure of stock abundance in abalone fisheries has been included. A small increase in CPUE was seen in 1986; however the measure may only be useful for an examination of long term trends.

Continued catch sampling in the fall of 1986 and spring of 1987 suggests that animals remain in the fishery for up to two years after reaching legal size. Early 1987 samples indicate an average size in the catch of 116 mm (16 mm over legal size).

A detailed abalone review is in preparation and will form the basis of a review of management options.

Recommendations

1. Considering the stock abundance remains relatively unchanged in surveyed areas, the qutoa for 1988 should remain at 104,000 pounds (47 t).

2. Objectives of management should be reassessed at working group levels. Rehabilitation of the stock should be addressed.

3. The ability of the current survey design to detect change in stock size should be examined.

4. Dependent on above (2) and (3), surveys should be continued in 1989.

SEA CUCUMBERS (I87-10)

Management of the sea cucumber fishery changed in 1987, with a limit of 500 t in each of three areas of the coast. The areas were: the north coast (Areas 1 - 10), the west coast of Vancouver Island (Areas 20 - 27), and the inside waters of Vancouver Island and the mainland (Areas 11 - 19, 28, and 29).

There has been an increase in annual effort and landings from 20 t in 1980 to over 1000 t in 1987. Some vessels planned to fish sea cucumbers as their main source of income in 1987.

Seasonal Landings

Generally, landings of sea cucumbers have probably been greatly influenced by fisheries for geoducks or sea urchins.

More effort was directed at sea cucumbers in 1987. Monthly landings in 1987 increased greatly over previous years and resulted in early closures of the fishery in the south coast. The west coast of Vancouver Island was closed on May 26, 1987, and inside waters of Vancouver Island and the mainland on July 15, 1987. Minor landings have occurred in the north coast to September 1987, with some product being processed in north coast plants and on board P licenced vessels.

The sea cucumber fishery in Washington, U.S.A., has limited the season to the period, May 1 to October 31, "to prevent waste of the resource during the winter when the sea cucumber body weight declines." Sea cucumbers undergo resorption of their internal organs between September to December, believed to affect product recovery.

Some of British Columbia processors interviewed have found the recovery of muscle strips to vary according to location but have not reported any significant seasonal pattern. The processors in British Columbia have had quality problems in summer months due to the poor handling and storage practices by small open boats without refrigeration.

Area Landings

Much of the pattern of landings has been set by the limitation of open areas in earlier years (1980 - 1986).

Catch Per Unit Effort (CPUE)

A record of vessel CPUE is available from sales slip records and from harvest logs required as a condition of the Z licence (Table 5). Much of the CPUE data is difficult to interpret because of the nature of the market demand and price. In some years effort was directed at sea cucumbers, but even in 1987 some landings were incidental to geoduck or sea urchin harvesting.

Experimental Trawl Fishery

Over the period, October 1986 to April 1987, two vessels were given scientific permits to trawl sea cucumbers in the Sidney Area (subareas 19 - 5 and 19 - 6). The size of the trawls was limited to a maximum width of 2 m.

One of the processors that bought the trawl landed sea cucumbers (400 to 2,000 pieces per day) found that they were smaller and had lower meat recoveries than product landed in shallower water by divers.

Recommendations

1. Effort should be limited until further biological data is obtained. (CPUE appears to be declining and some fishermen have reported increased search time.)

2. A new, more detailed diver logbook program should be implemented in 1988 (replacing the current Z licence log).

3. Research is required to look at seasonal rates of recovery to maximize returns to the fishery.

4. Because of the small size of trawl-caught sea cucumbers, trawling should be prohibited until further study determines if deep water sea cucumbers contribute to the diving fishery.

5. Consideration should be given to rotating area openings, as in Washington State, so that an area is only fished once in a number of years. This may provide information about recruitment.

NET FISHERIES

SHRIMP TRAWL FISHERY (I87-18)

The shrimp trawl fishery targets primarily on three species of shrimp: *Pandalus jordani* (smooth pink); *P. borealis* (northern pink); and *Pandalopsis dispar* (sidestripe). *Pandalus hypsinotus* (humpback) and *P. platyceros* (prawn) are caught incidentally or in small, directed trawl fisheries in Area 1 for humpback and Areas 17, 23, and 28 for prawn.

The shrimp trawl fishery is a limited entry fishery which requires a valid S licence or special permit. In 1987 there were 249 S licence entitlements. Five scientific permits were issued to allow fishing in a portion of Barkley Sound.

In 1987, a mandatory logbook program was instituted as a requirement of licence. To date, reports have been received from 55 vessels fishing on the coast. However, the data is not available on computer for analyses.

In recent years, the fishery has been conducted mainly by smaller beam trawl vessels; most of which also have A licences and either gillnet or troll for salmon. The larger otter trawlers which were active in the mid-1970s have, to a large extent, been inactive since the collapse of the offshore fishery in the mid-1970's. In 1987, activity of a few of the larger otter trawlers has increased due to the increasing offshore shrimp stocks and strong market.

In 1986, shrimp trawling was a year-round fishery with a short local closure in Areas 28 and 29 in response to overfishing concerns expressed by fishermen. The three main areas of shrimp trawling are off the west coast of Vancouver Island, in Strait of Georgia, and in Chatham Sound.

West Coast of Vancouver Island Fishery

Offshore Areas 123, 124, and 125 support fisheries for smooth pink shrimp. It is speculated that these offshore shrimp might be the northern limit of a single commercial stock of *P. jordani* which extends from Morro Bay, California, to mid-Vancouver Island. Over the entire offshore region of this stock, shrimp abundance fluctuates widely due, apparently, to factors independent of fishing. Biomass surveys of Area 124 (Tofino ground) and Area 125 (Nootka ground) have produced biomass estimates which fluctuate by a factor of 324 and 19 fold, respectively.

The most recent survey of Areas 124 and 125 was conducted August 4 - 14, 1987. This survey found that shrimp abundance was increasing in both areas.

Tofino Ground (124)

Surveys in 1987 found shrimp were concentrated in a 183 nautical square mile area.

Total shrimp biomass for the area was estimated to be 4270 metric tonnes (t); the greatest quantity observed since 1977.

Nootka Ground (125)

Nootka ground lies offshore from the west coast of Vancouver Island between 49°15' and 49°35'. During the 1987 survey, there was not enough time to conduct a thorough survey of the area.

Total shrimp biomass for the area was estimated to be 754 t; a slight increase over the 1985 and 1983 estimates. A comparison of the Tofino and Nootka grounds showed that the size of shrimp on the Nootka ground are consistantly smaller than the shrimp on the Tofino ground.

Strait of Georgia (Inshore) Shrimp Fisheries (Areas 14, 17, 28, and 29)

Area 14

Comox has a local small-boat, beam trawl fishery for smooth pink shrimp. Landings peaked in 1965 at 131 t; in 1986 16 vessels fished 357 days and reported landings of 38 t.

Area 17

Stuart Channel has a small-boat, beam trawl fishery composed of a local fleet and a transient fleet from Steveston and Vancouver. This is a mixed shrimp fishery with all five species being landed. The two main target species are smooth pink and sidestripe shrimp. Peak landings were 328 t in 1957. Current production, 1986, was 42 t landed by 41 vessels. There was a 38% reduction in fishing days and a 30% reduction in catch as compared to 1985.

Areas 28 and 29

English Bay, Sturgeon Bank, Davis Bay, and Howe Sound all have small-boat, beam trawl fisheries. As in Area 17, all five shrimp species are caught. However, the main target species for English Bay, Sturgeon Bank, and

Davis Bay are pink and sidestripe shrimp while the target species in Howe Sound is a mixture of pink and smooth pink shrimp. In more recent years, there has been an increase in over-the-dock sales in Steveston, much of which is not reported on sales slips. Peak production for Areas 28 and 29 was 443 t, reported in 1957. In 1986, 122 t were reported by 51 vessels.

Chatham Sound

Areas 4 and 5

Chatham Sound Consists mainly of a small-boat, beam trawl fishery which targets on pink and sidestripe shrimp and has incidental catches of humpback shrimp. The fishery thrived in the 1960s, with a peak in landings of 160 t in 1963. In the 1970s the fishery declined, collapsing completely in 1975 and 1976 because of marketing problems. In 1986, 14 vessels reported total landings of 38 t.

Management Issues

The major issue facing managers will be management of an expanding offshore fishery which is taking advantage of good *P. jordani* settlement and excellent markets, with prices of $1.76 to $2.20 per kg. Prospects for this fishery in 1988 are very good considering the relatively strong showing of 2+ animals in the survey. The index of 1+ animals is also very good. In fact, it is the second highest recorded showing of 1+ animals.

This offshore fishery is subject to extreme fluctuations in abundance depending on abiotic factors affecting the successful settlement of juveniles to the area. For these reasons, management cannot be on a sustained yield basis and should be more concerned with optimal yield exploitation. The fishery is presently showing signs of expansion with the re-introduction of larger otter trawlers into the fleet and expression of interest by processors to increase the peeling capability on the coast. To prevent serious over-capitalization by the industry, managers do not want uncontrolled expansion without industry understanding the nature of the fishery (i.e., the extreme fluctuations which abiotic factors can cause in recruitment).

Recommendations

Offshore Fishery Management

1. Due to the extreme fluctuations in abundance, based on abiotic factors affecting sucessful settlement of juveniles to an area, MSY is not considered to be practical. Management policy: requires a review of economic factors involved in highly fluctuatory stock abundance.

2. Further research is required to examine the optimal size or age of the shrimp harvested to avoid growth over fishing.

3. Stock surveys should be carried out in 1988, due to the current high stock abundance, to monitor the stock and optimize harvest.

4. An in-depth assessment of existing biological data should be conducted to investigate:

   a) procedures of estimating year-class abundance;

   b) abiotic and biotic mechanisms that may be affecting recruitment.

Inshore Shrimp Trawl Fishery

Further data is required to evaluate management options. It may be possible to manage on a sustained yield basis as stocks do not fluctuate in the extreme manner seen in the offshore stocks.

1. Logbook, sales slip and patrol vessel log data should be continued to be collected to document fishing effort and landings.

2. There should be increased biological sampling catches to determine species composition, size, and age classes.

3. The use of otter trawls in areas, such as Area 17, that serve as a nursery area for groundfish, should be reviewed. Only beam trawls should be permitted in these areas.

OFFSHORE SQUID (OMMASTREPHES) (DRIFT GILLNET) (I87-20)

Test fishing to date has demonstrated that flying squid are annually available. Drifting gill nets are affective in capturing these squid but because of their large size and low densities (120 squid.km^{-1}) jigging may be impractical. Further exploratory fishing by gill nets should be encouraged to define the resource, bycatch characteristics and to gather biological data on squid life history. Concern was expressed at the lack of control of research design and implementation.

Recommendations

1. Detailed records of fishing activity by qualified observers are required on all vessels, Canadian and Japanese.

2. An improved negotiating process is required to improve the quality of research and the terms and conditions of experimental fishing to

   a) determine the biology and distribution of the stock.

   b) evaluate water temperature as it is related to CPUE and by catch.

   c) evaluate fishing strategies to reduce or eliminate the bycatch of mammals--further jigging experiments may be required and other methods such as a hollow-core mesh in the nets require more rigorous evaluation.

SECTION 2 - MINOR OR DEVELOPING SHELLFISH (INVERTERBRATE FISHERIES)

TRAP FISHERIES

KING, TANNER, AND GALATHEID CRABS (I87-17)

Landings of these species are combined with those of Dungeness crab as no catch data specific to them is available. The fisheries for king crabs are entirely in the north coast. Small landings of some tanner crabs have been reported unofficially from the blackcod trap fishing areas. Some experimental fishing took place of Barkley Sound in 1986. Overall magnitude of landing remains low and no management issues require attention at this time.

Galatheid crabs are not currently being exploited in British Columbia, although the potential exists that they may be exploited in the future if the salmon mariculture feed industry can use them as an economical source of pigment to colour salmon flesh pink.

Recommendation

As in the last year's report, we recommend individual species codes be assigned for the various crab species. Logbooks should be required to monitor experimental fishing.

(SHRIMP BY TRAP - NO RECOMMENDATIONS FOR 1987/88)

NET FISHERIES

INSHORE SQUID (LOLIGO) (I87-19)

Landings in the 1986 appear to be down from that in 1985, mostly because of the decline in fishing in Areas 19, 23, and 24. Eight-three percent of the catch came from Areas 23 and 24.Biologically this is probably not significant since historically the fishery has been sporadic. A lack of landings doesn't imply that squid abundance is necessarily down, only perhaps that they were not as concentrated and/or located in areas where fishermen were prepared to fish for them.

Recommendation

Loligo is expected to continue as a minor, sporadic fishery in 1988. Logbook records should be continued, to document fishing effort, landings, and locations.

EUPHAUSIIDS (I87-21)

Euphausiid stocks in the Strait of Georgia have been harvested since 1970. Typically, vessels (40 - 50 ft) fish with surface trawls during darkness and freeze the catch which is sold to the pet food trade, fish hatcheries, and commercial aquaria. Total reported landings have never exceeded 167 t. Up to twelve vessels reported landings in some years. In the past harvesting has apparently been limited by market opportunities.

The euphausiids quota of 500 t is set at a conservative level of 0.1% of the estimated standing stock of euphausiids in the Strait of Georgia.

Resource Prospects

The salmon mariculture industry is currently evaluating euphausiids as a direct food source or as an additive for fish feeds. Based on the industry projection of 20,000 t of cultured salmon by 1995 there could be market demand for more than 100,000 t of euphausiids if used as the only protein source in salmon feeds or more than 10,000 t if used as an additive to improve color and taste of pen fish. Full utilization at current prices ($84 per ton) would provide a landed value of nearly $10 million placing euphausiids in a high economic position in British Columbia. Preliminary data on euphausiid production in British Columbia suggest an annual production up to 100,000 t from the Strait of Georgia and 1.2 million t on the British Columbia coast. Initially fish farm requirements could likely be obtained from the Strait of Georgia. Expansion of the fishery to the west coast would be required if euphausiids were developed as a major food source.

Environmental

Stock size and annual production are not well established. Also there is concern that fishing with plankton trawls might impact larval and juvenile fish stocks.

Technological

Processing the catch is inefficient and costly. The industry is experimenting with preserving the catch in hydrochloric acid (ensilage).

Marketing

Market potential is closely connected to the expansion of the aquaculture industry.

Current Research

DFO (Institute of Ocean Science) has two proposals under review for euphausiid research in conjunction with the University of Victoria and the private sector. They are aimed at developing the technology to estimate eupausiid biomass with commercial echo sounders prior to the initiation of acoustical mapping of inshore waters.

Recommendations

1. Close monitoring of catch and fishing effort through logbooks.

2. No change in present quota or regulations.

3. A research program should be designed to evaluate stocks, in the event that there is a rapid expansion in the fishery.

DIVING FISHERIES

SCALLOPS (I87-11)

Scallop landings increased to 71.1 t in 1986, a 33% increase over the previous year; landed value was approximately $227,000 (Table 1), a 68% increase in value. Almost all scallops landed in the commercial fishery were spiny scallops (*Chlamys hastata*), there were only minor landings of pink scallops (*C. rubida*). These landings reflect fishing practices. Most scallops in the commercial fishery were landed by divers who target on spiny scallops because they occur at shallower depths than pink scallops. Pink scallops are caught mainly in the dragging fishery but few boats dragged for scallops in 1986 and none are currently dragging for scallops in 1987. It is expected this trend will continue. A major drag area off Victoria has been closed due to sewage contamination.

A few weathervane scallops were landed by divers and as incidental catch in trawls but amounts were so small they were not recorded in the statistics.

Growth rates were measured for two samples of pink and spiny scallops and results confirmed estimates of growth rates of both species reported last year. Few pink scallops grow larger than 60 mm shell height. At age 5 spiny scallops are approximately 72 mm shell height and pink scallops are approximately 60 mm shell height.

Further information on time of spawning indicated that spiny scallops spawn in late summer (July - August) and pink scallops spawn in late winter (February - March) although there may be a second spawning period in the early fall (September).

Sampling of commercial catches confirmed that most scallops landed were spiny scallops. Sampling undertaken in a small drag fishery in Area 14 in August of 1986 produced interesting results. With spiny scallops, 17% of the catch was 60 mm shell height or larger and 25% of the catch was 55 - 59 mm shell height. Retaining the size group, 55 to 60 mm would have increased the landings by 67% during the period of sampling. Even with a size limit of 55 mm shell height, virtually no pink scallops would have been retained. Consideration may have to be given for separate regulations for pink and spiny scallops if a trawl fishery develops that targets on pink scallops.

Weathervane Scallops

Occasional landings of small numbers of weathervane scallops are made, presumably by divers. An application has been received by a person who wants to attempt harvest of this species by dragging in the Gulf Islands area which is presently closed for research purposes.

Recommendations

1. Reduce present size limit regulation of 60 mm shell height for both pink and spiny scallops to 55 mm shell height.

2. Continue studies to determine if separate size limits are appropriate for pink and spiny scallops. (Industry does not currently want scallops <55 mm.)

3. Permit small experimental dragging fishery for weathervane scallops in the Gulf Islands area but insure proper logbooks are kept to provide data on catch and effort.

4. Increase sampling of catches in the commercial fishery.

HORSE CLAMS (I87-8)

Two species of horse clams, _Tresus_ _nuttallii_ and _T._ _capax_ are landed in the diving fishery in British Columbia. Little is known of their subtidal distribution and abundance. Fishing for horse clams subtidally is limited to those 55 vessels with G licences.

Landings increased to 96 t in 1986, with 15 vessels participating. Most of the landings were in the period October - December, after the major geoduck fishery.

There have been a number of inquiries in 1987 from fishermen and processors regarding horse clams and currently two processors are buying them. The recovery of neck meat from the horse clams is considerably less than geoducks, 10 to 17% as opposed to 22%. In addition, processing labour and costs are higher for horse clams as it is very difficult to remove the skin from the horse clam neck. The price paid to fishermen in 1987 has increased from $0.27 per pound to $0.35 per pound for small clams to $0.40 per pound for large horse clams.

There has been a great deal of controversy in Area 24 and other areas on the west coast where harvesting has been prohibited or limited due to concerns that harvesting may physically disrupt eelgrass or other vegetation that supports herring spawn.

CPUE

Due to low levels of effort, CPUE data is limited.

Recommendations

1. An assessment of horse clam distribution and abundance should be carried out during dive assessments for herring spawn.
2. Landings of horse clams should be monitored and the new diver logbook should be implemented in 1988/89 if possible.
3. Some dive assessment should be carried out to examine abundance and distribution of horse clams in areas of active fishing.
4. Periodic commercial catch sampling should be undertaken to record species composition, age, weight, and other biological data.

OCTOPUS (187-12)

Most octopus are currently taken by divers. Some divers now fish octopus year round as their major source of income. Octopus are also landed as incidental catch in trawl and trap fisheries. Octopus landings in 1986 are up about 56% over those in 1985 but overall the fishery remains relatively small (53 t). Main fishing areas in 1986 were Statistical Areas 19, 17, 20, and 18. They accounted for 55% of the total catch.

Recommendations

With current low level of exploitation, this species has low research priority and current management practices should be continued. A more detailed log for divers is proposed. Experimental fishing should be encouraged.

INTERTIDAL FISHERIES

GOOSENECK BARNACLES (I87-2)

This newly developing fishery still remains relatively small, with most interest currently in the Tofino and Port Hardy areas. Official landings indicate that only a few tonnes (14 t) have been landed in 1987, mostly from the Tofino and Port Hardy areas with a total value of $80,247.

Recommendation

With the current low level of exploitation, this species has low research priority and mandatory logbooks to be completed by harvesters should be continued.

MUSSELS (I87-3)

Reported landings in 1986 are up over 1985, with a cultured mussel harvest of 15 t and a wild harvest of 2.2 t. Mussel culture is expected to expand slowly in British Columbia as production techniques are improved.

Current research is investigating both site and "strain" effects on production and in 1988 is expected to focus on developing culture techniques to reduce further late summer mortality. The best growing sites identified to date have been Indian Arm and Okeover Inlet.

Table 1. List of shellfish fisheries (21) in 1986.

<u>Intertidal Fisheries (3)</u>
Clams (littleneck, manila, butter, razor)
Mussels
Gooseneck barnacles

<u>Diving Fisheries (7)</u>
Geoduck
Horse clam
Sea urchin
Sea cucumber
Octopus
Pink and spiny scallops
Abalone

<u>Net/Trap Fisheries (11)</u>
Dungeness crab by trap
Prawn by trap
Shrimp by trap (coonstripe, humpback, pink)
Shrimp by trawl
Squid (inshore) by seine
Squid (offshore) by gillnet
Octopus by trap and trawl
Sea cucumbers by trawl (experimental)
Tanner crab by trap (experimental)
King crab by trap

Table 2. Ranking of species according to total landing (tonnes) and landed values (1986, data preliminary).

Ranking	Landings (tonnes)
Geoduck	5003
Intertidal clams[1]	2975
Sea urchin	2073
Crab	1329
Sea cucumber	786
Shrimp trawl	768
Squid (offshore)	627
Prawn	545
Plankton	166
Horse clams	96
Squid (inshore)	79
Scallops	71
Octopus	53
Abalone	52
Shrimp-trap	4.6
Mussels	2.2
Gooseneck barnacle	2

Ranking	Landed value ($1000)
Crab	$5150
Geoduck	4090
Intertidal clams[1]	3715
Prawn	2907
Offshore squid	2400
Shrimp-trawl	1148
Sea urchin	854
Abalone	500 (est.)
Scallops	217
Sea cucumber	212
Octopus	102
Plankton	98
Horse clams	62
Squid (inshore)	27 (est.)
Shrimp-trap	12
Gooseneck barnacle	4.7
Mussels	3.8

[1]Intertidal clams; sum of:

Manila	$2713 (1889 t)
Mixed	497 (363 t)
Native	319 (279 t)
Razor	127 (142 t)
Butter	59 (122 t)

Appendix 1. Participants.

1987 PSARC-Invertebrate Subcommittee Meeting

List of participants

August 31 - September 1, 1987

Biological Services Branch, Pacific Biological Station:

Max Stocker	Jim Boutillier
Glen Jamieson	John Fulton
Neil Bourne	Don Noakes

Fisheries Branch:

Frances Dickson	Barry Ackerman
Rick Harbo	Sue Farlinger
Bruce Adkins	Rob Wilson
R. A. (Kip) Slater	Morley Farwell

Doug McKone, Fisheries and Biological Sciences Directorate, Ottawa.

Bob Cox, Province of British Columbia, Ministry of Agriculture and Fisheries, Victoria.

Reviewers, Biological Services Branch, Pacific Biological Station:	Laura Richards
	Ray Foucher
	Bill Shaw

Appendix 2. List of working papers submitted for 1987 PSARC Shellfish (invertebrate) Subcomittee.

		Author(s)
Intertidal fisheries		
I87-1	Intertidal clam fisheries - manila, littleneck, butter and razor clams.	N. Bourne
I87-2	Gooseneck barnacles	G. Jamieson
I87-3	Mussels	G. Jamieson
Diving fisheries		
I87-4	Geoduck clams	R. Harbo
I87-5	North coast geoduck fishery and processing at sea .	S. Farlinger
I87-6	Abalone resurvey in the southeast Queen Charlotte Islands, June 1987.	W. Carolsfield S. Farlinger B. C. Kingzett N. A. Sloan G. Thomas
I87-7	Abalone.	S. Farlinger N. Sloan
I87-8	Horse clams.	R. Harbo
I87-9	Sea urchins (a and b).	R. Harbo S. Farlinger
I87-10	Sea cucumbers.	R. Harbo
I87-11	Scallops	N. Bourne R. Harbo
I87-12	Octopus.	G. Jamieson
Trap fisheries		
I87-13	Mesh selection modifications in wire-mesh traps. .	J. Boutillier R. Harbo B. Adkins
I87-14	Proposed prawn trap escapement modifications as a condition of the Z Licence for shrimp by trap. .	B. Adkins R. Harbo J. Boutillier
I87-15	Prawn trap fishery and fishery monitoring.	J. Boutillier
I87-16	Recruitment of Dungeness crab off the west coast of Vancouver Island.	G. Jamieson
I87-17	Crab fisheries - Dungeness, king and tanner crabs.	G. Jamieson
Net fisheries		
I87-18	Shrimp inshore and offshore fisheries.	J. Boutillier
I87-19	Squid-inshore.	G. Jamieson
I87-20	Squid-offshore	G. Jamieson
I87-21	Plankton-euphausiids	J. Fulton

Appendix 3. Comparison of 1986 recommendations and actions in 1987.

Recommendations	Actions
1. <u>Euphausiids</u>	
1. Due to current low levels of effort there should be no seasonal harvest restrictions.	- No seasonal restriction.
2. A cooperative research program should be developed with harvesters to estimate biomass and production and day/night changes in concentrations. Year round data is needed.	- No action - harvesting program did not develop.
3. Monitoring of the fishery, through catch sampling, to determine by-catch of fish/shellfish larvae should be reinstated if the fishery continues beyond the period of December through March.	- No action - fishery season short, did not extend beyond March
2. <u>Inshore Squid</u> (<u>Loligo</u>)	
1. Monitoring of effort and landings by logbooks should be continued.	- Action - logbook data collected. Minor increase in landings in 1986, fewer areas of fishing.
3. <u>Offshore Squid</u>	
1. Determine the biology and distribution of the stock, particularly if this fishery develops further.	- Observers program continued in the 1987 fishery.
2. Better evaluation of water temperature on CPUE and bycatch characteristics.	- Equipment (thermometers) proved to be inefficient.
3. Evaluate how by-catch can be minimized.	- Attempted in 1987, but questionable program design - jigging not efficient in catching squid; hollow core netting was fished regularly and was not fished in sufficient quantities for statistical analysis.

Appendix 3 (cont'd)

Recommendations	Actions
4. <u>Octopus</u>	
1. No significant management or biological research effort should be devoted to this fishery at this time. Catch and effort should be monitored through the logbook program in place.	- Action - continued logbook program. More detailed log for all diving fisheries developed. Individual fishermen solicited to keep more detailed logs and supply biological samples to S.F.U. researcher.
5. <u>B.C. Shrimp Trawl Fishery</u>	
A. Offshore - West Coast of Vancouver Island	
1. Offshore shrimp landings are being reported incorrectly on sales slips and should be reported for areas of catch, not point of landing.	- Action - Statistics Division advised.
2. Stock surveys of west coast areas should be conducted biannually in odd-numbered years, beginning in 1987.	- Action - survey undertaken in August, 1987. Due to high levels of abundance, annual surveys may be required in the next few years.
3. An in-depth assessment of existing biological data should be conducted to investigate:	
(a) procedures of estimating year-class abundance;	- Action - some work in progress.
(b) abiotic and biotic mechanisms that might be affecting recruitment;	- Action - study in progress.
(c) management options, and their biological implications.	- Action - referred to Shellfish Working Groups to discuss.
B. Inshore	
1. A mandatory logbook system for "S" licences should be established in conjunction with biological monitoring in 1987.	- Action - logbook program discussed at public meetings. Mandatory log introduced as condition of 1987s license.

Appendix 3 (cont'd)

Recommendations	Actions
2. The problem of <u>incidental and targeted catches of prawns in the shrimp trawl fishery</u> should be investigated. An acceptable level of by-catch of prawns should be determined.	- No action - lack of resources.
3. When areas are closed to prawn trapping, non-retention of prawns must be enforced to keep trawlers off prawn areas.	- Action - endorsed by Shellfish Working Group and enforced.
4. The use of otter trawls in areas, such as Area 17, that serve as a nursery area for a variety of fish, should be restricted. Only beam trawls should be used.	- No action in 1987. Proposed for 1988 with consultation with Groundfish Sections.
5. Enforcement/surveillance of the inshore fishery via patrol vessel log reports should be increased to confirm logbook and sales slip reports.	- Action - Patrol vessel logbooks issued in 1987. Vessel reports being submitted to act as independent checks on sales slip and harvest log reports.
6. <u>Intertidal Clam Fisheries</u>	
1. Management by minimum size limit is the most practical option available to manage intertidal clam fisheries at this time. There needs to be continued enforcement of size limits to ensure adequate breeding stock.	- Action - continued active enforcement of minimum size limits.
2. The rationale for existing size limits needs to be documented based on current biological data.	- Action - report in progress (N. Bourne).
3. Yield per recruit predictions should be made to determine optimum size limits for maximum yield.	- No action - considered low priority at this time.

Appendix 3 (cont'd)

Recommendations	Actions
4. Different exploitation options should be evaluated, for example, one year spawning prior to entering the fishery versus two or more years of spawning.	- No action - considered low priority at this time.
5. If the razor clam fishery expands at Masset, Queen Charlotte Islands, then the effectiveness of the size limit and the possibility of an annual quota should be examined.	- No action - some increase in landings and value of fishery in 1987. Considered low priority at this time.
11. Sooke coonstripe shrimp trap fishery	
1. Initial advice suggests a TAC of 2 t.	- Action - in-season monitoring of catches and test fishery indicated a stronger fishery, 15 t, than projected. Fishery remained open to January/87 with landings of 7 t.
12. Mussels	
1. An integrated research/extension service should be developed to ensure that a maximum harvest can be routinely produced.	- No action - considered low priority at this time.
13. Gooseneck barnacles	
1. Determine stock abundance distribution and market grades of gooseneck stock.	- Action - report in preparation. Summary Report circulated by Communication Branch.
14. King, tanner, red rock and galathid crabs	
1. Tanner and galathid crabs should be specified in the regulations and licence requirements so that fishery monitoring can be more easily achieved.	- Action - recommendation to Shellfish Working Group for inclusion of tanner crabs (and galatheid crabs) to Pacific Shellfish Regulations.

Appendix 3 (cont'd)

Recommendations	Actions
2. A size limit for golden king crab (181 mm) should be discussed, with no size size limit in effect for rhizocephalan parasitized crabs.	- No action - to be reviewed by Shellfish Working Group for possible regulation change.
15. Dungeness crab	
1. Key problems are the landing of soft shell crabs and ghost fishing by lost gear. Biological advice has been provided and economic evaluations may be required.	- Action - soft shell closures in Fraser River area, Tofino grounds. Review of trap escapement modifications to prevent ghost fishery by lost gear - to be discussed with industry at public meetings.
2. Establish explanations for fluctuations in magnitude of landings in the various fisheries.	- Action - continued crab research into recruitment and fishery dynamics.
16. Options for escape opening regulations for traps in the B.C. prawn fishery	
1. Further studies are to be carried out in Saanich Inlet during November 1986, to establish specific optimum mesh size regulations.	- Action - further research carried out and presented to industry at public meetings. Review undertaken at Shellfish Working Group.
17. Prawn Trap Fishery	
1. Various alternate management scenarios should be developed and evaluated using biological data collected from experimental prawn fishing areas.	- Action - programs in study areas continued in 1986/87.
2. The usefulness of the logbook data base, in conjunction with the biological sample data base, should be evaluated for stock assessment purposes. Biological sampling procedures should be standardized for all fisheries staff gathering biological information on prawn stocks.	- Action - logbook data for study areas under evaluation for stock assessment.

Appendix 3 (cont'd)

Recommendations	Actions
3. For independent checks on logbook and sales slip data quality, we need to develop: (a) a standard format for data to be submitted from the biological monitoring program; (b) standardized patrol vessel logs.	- Action - standardized patrol vessel logs initiated in 1987. No action - regarding standard format for biological sample data.
18. Size limits for pink and spiny scallops	
1. Further biological data is required on pink scallops before final recommendations can be made for size limits.	- Samples of pink scallops collected in 1986 and 1987, leading to a report in 1987.
19. Abalone	
1. An exploratory fishery to determine stock distribution, for one or two vessels in Area 27, should be considered.	- Action - Shellfish Working Group reviewed closures in south coast and as a result many areas were opened on the west coast of Vancouver Island. Portions of Area 20 and all of Area 23 remained closed as an allocation to sport fishing. There were some closures in other areas to protect native food fishing areas.
2. A survey of fishery officers should be conducted to estimate levels of poaching in specific areas.	- No action - on estimates of poaching. Report on enforcement costs in the abalone fishery (R.Jacobson).
3. Fishing effort should remain the same for 1987 as there are indications of stock stabilization in central cost areas.	- Action - quota remained at same level as 1986, with some additional fishing opportunities on the west coast of Vancouver Island.
4. A study should be conducted to examine benefits from an increased size limit.	- No action - no resources.
5. The Queen Charlotte Islands should be resurveyed in 1987 to document any possible abalone stock improvement.	- Queen Charlotte Island survey carried out; report to 1987 PSARC meeting.

Appendix 3 (cont'd)

Recommendations	Actions
6. Stock estimation by stock reduction analysis should be examined further.	- No action - considered to have little potential.
20. Geoduck clams	
1. Fishing effort should remain the same for 1987 unless sufficient additional sufficient fishing areas are identified to warrant an increase.	- Action - quotas much the same as 1986.
2. The extent of deepwater stocks should be investigated.	- No action on research topics- no resources available.
3. Survey techniques and stock assessment require more resources than are presently available.	
4. At least three study areas should be established to investigate stock abundance and to monitor recruitment after harvest.	
5. An assessment of recruitment on harvested grounds (areas to be identified by industry) should be carried out.	
6. The development of hatchery techniques should be monitored and trial seeding of juvenile geoducks should be considered.	
21. Horse clams	
1. There has not been a recent market for horse clams and little fishing activity has taken place. Accordingly, no changes are recommended. Some areas (Area 24) are closed to protect herring spawn vegetation. Harvesters need to discuss area closures with the herring working group committee.	- No action.

Appendix 3 (cont'd)

Recommendations	Actions
22. <u>Red sea urchins</u>	
1. Quota levels in the 1986 management plan should continue for 1987.	- Action - quotas remained much the same for the south coast. No restrictions on the north coast. Size limit enforced.
2. Additional "arbitrary" quotas may have to be implemented in-season depending on fishing locations and intensity of harvest.	
3. The 100 mm minimum size limit should remain in effect.	- Minimum size limit enforced.
4. Logbook data should be analyzed in areas of heavy exploitation. Stocks in Areas 14 and 19 are reported to be depleted.	- No action - on analysis of logbook data due to lack of resources.
24. <u>Sea cucumbers</u>	
1. All south coast areas should be opened to cucumber fishing. Logbooks should be continued to monitor landings and CPUE.	- Action - all areas of the coast were opened. Mandatory logbooks continued to monitor landings and CPUE.
2. Effort in the north coast should be limited until more is known about stock abundance and recruitment.	- Action - Quotas were set for the north and south coast in 1987. This resulted in closurers in the south coast-May for the west coast of Vancouver Island and July for inside waters. Little effort to date in north.
3. The logbook data base should be analyzed to determine appropriate levels of harvest.	No action - due to lack of resources.

Appendix 4. Priority of fisheries requiring research support. Overall weighted score for each species/fishery calculated by multiplying the score for each species/fishery for various critera[1] by the average weight for each criterion and summing over all criterion.

Rank	Species/fishery	Weighted score[2]
1	Crab	2.66
2	Squid (offshore)	2.66
3	Clams	2.62
4	Prawn	2.47
5	Geoduck	2.12
6	Sea urchin	2.11
7	Abalone	2.07
8	Shrimp	1.99
9	Octopus	1.97
10	Euphausiids	1.94
11	Goose barnacles	1.91
12	Sea cucumber	1.85
13	Aquaculture (wild)	1.84
14	Squid (inshore)	1.79
15	Aquaculture (hatchery)	1.76
16	Horse clam	1.75
17	Scallops	1.55
18	Marine plants	1.52

[1]Criteria employed to priorize the direction of biological and economic research for invertebrate fisheries.

A. The degree of industry and public attention that sampling would receive.

B. The present overall value of all the fisheries for this species.

C. The present overall value of the actual fishery being sampled.

D. The current exploitation level.

E. The current stock status.

F. The degree to which the question being asked was general or site specific in nature.

Appendix 4. (cont'd)

G. The degree of scientific merit associated with the resolution of this problem.

H. The probability that the information drawn from these data will result in a solution of the problem.

I. The probable timeliness of the advice to managers.

J. The acceptability and relevance of the advice, i.e., were the managers prepared to act on the advice or would problems of enforcement and administration prevent action.

K. Potential for increase in $ values of the fishery.

[2]All scores between 1 and 3. An expansion of the scale should be examined to give a greater distribution in the values.

Pacific Stock Assessment
Review Committee

PSARC Advisory Document 87-4

BIOLOGICAL ADVICE ON BRITISH COLUMBIA CHINOOK SALMON

PSARC reviewed the Salmon Subcommittee Report as contained in this document.

The Salmon Subcommittee met at the Department of Fisheries and Oceans Headquarters, 555 West Hastings Street, on October 26 and 27, 1987. The Committee considered: productivity of B.C. chinook stocks, the size limit increase for chinook salmon in B.C. troll fisheries, incidental mortalities of chinook salmon in B.C. salmon fisheries, juvenile chinook salmon catch estimates, and 1988 salmon expectations. A list of participants and a list of working papers are appended (Appendix 1, 2 respectively).

REVIEW OF DOCUMENTS TO BE PREPARED FOR THE MARCH SUBCOMMITTEE MEETING:

The committee reviewed the list of documents (prepared at the July 3, 1987 subcommittee meeting) to identify problems anticipated in the completion of these documents. Authors were notified of their responsibilities by memo in September following acceptance of the list by Regional senior management. Authors were to discuss with their supervisor before the October 26 subcommittee meeting any problems anticipated in the completion of their task. Very few concerns were expressed. Harrison and Riddell were to review the expected completion date of the Transboundary River chinook assessment, and the appropriate authorship of the run reconstruction methodology paper was discussed. Several versions of this method exist in the Region. It was suggested that a workshop in April 1988 might be a more efficient means to achieve a standardized model. Riddell was to discuss this suggestion with users of this analytic model. Other discussions involved the addition of authors to some documents.

CHINOOK PRODUCTIVITY (WORKING PAPER S87-1):

Throughout the Pacific coast of North America natural populations of chinook salmon are considered to be depressed in abundance relative to historical observations. In the late 1970's concern heightened that chinook were not only reduced in abundance but were severely over-exploited. In British Columbia chinook escapements had declined by about 50% since 1951 while catches had expanded significantly. However, until the early 1980's an analytical basis for concerns about overexploitation had not been evaluated. In 1982 three analyses indicated that B.C. chinook stocks were overexploited but the degree of overexploitation varied between analyses.

The status of individual chinook stocks in British Columbia cannot be determined because of an inability to allocate catch in mixed stock salmon fisheries to stocks of origin. The accuracy of chinook assessments is further complicated by uncertainty in escapement estimates and statistical biases recently identified in estimation of stock-recruitment relationships. Stock-recruitment relationships determined for B.C. natural chinook stocks in 1982 aggregated all B.C. stocks into one stock and estimated an average productivity (returns per spawner) for chinooks across stocks. Recommendations about optimal escapement levels were dependent upon assumptions about the accuracy of escapement data and how this varied between years and stocks. Significant differences of opinion existed concerning these assumptions and resulted in substantial uncertainty in desirable escapement goals. Target escapement goals for B.C. chinooks (330,900 visually observed spawners in aggregate across all naturally spawning chinook populations) are not based upon these stock-recruitment analyses but were derived from a 1982 policy decision to double the average escapement reported for 1979 through 1982. This decision reflected the uncertainty in defining escapement goals and a desire to increase escapements sufficiently so that resultant production changes were likely to be detectable.

Information collected since the 1982 analyses are inadequate to improve upon the previous recommendations. However, recently identified sources of bias in stock-recruitment relationships for Pacific salmon lead us to advise that the 1982 analyses probably overestimated productivity and underestimated optimum escapement goals. Given these biases and the previous analyses, the likely range of exploitation rates for maximum sustained yield from the aggregate B.C. stock is 60 to 70 percent. Average productivity values for naturally spawning chinook stocks are likely in the range of 5 to 6 returns per spawner (Ricker 'a' values of 1.6 to 1.8). Chinook stocks maturing at younger ages, such as the lower Strait of Georgia stock, will have higher productivities and conversely stocks maturing at older ages, such as the Quinsam type stocks, will have lower productivities. Management actions taken to rebuild chinook production under the Pacific Salmon Treaty were expected to reduce the exploitation rate on southern B.C. chinook to about 70 percent. However, the tagged indicator populations (Big Qualicum, Quinsam, Robertson Creek) in this area still indicate that present exploitation rates exceed 70 percent. Continued harvest exceeding this level will prevent rebuilding and sustained production less than optimal. (It should be noted, however, that changes in fishing pressure since 1985 will not be fully reflected in exploitation rate changes for 2 to 3 years until recent broodyear returns are completed.) These indicator populations are representative of fall chinooks in southern B.C. Recent increases in escapement to spring and summer chinooks are probably due to reduced harvest rates resulting from delayed openings in troll and net fisheries.

Recommendation: Further given the biases identified, it is probable that escapements in excess of the aggregate total will continue to increase production from natural chinook populations (assuming that the increased escapement can be spread relatively evenly across all populations). We are unable at this time to provide any further information on desirable target escapements and would recommend continuing with the program to double escapements and monitor resultant production.

Documentation on how stock specific estimates of productivity and carrying capacity were calculated in the 1986 U.S./Canada chinook model was also presented. These calculations were undertaken to provide consistent input data (productivity rates, escapement trends, harvest rates) for the model and should not be considered as providing new insights into chinook stock status. The technique presented uses stock specific exploitation rates (from coded-wire tagging programs) and escapement goals (assumed to be the optimal escapement for solution of the equations) to solve for productivity and carrying capacity parameters. Since escapement goals for B.C. chinook stocks are not biologically determined optimal and exploitation rates may be biased high due to incomplete recoveries of coded-wire tags in escapements, the parameters estimated are again of unknown accuracy with respect to characterizing production relationships for natural chinook stocks. The technique may, however, present a very useful procedure for determining a stock's productivity and optimum escapement goal if accurate and independently derived values for exploitation rates and habitat carrying capacity can be provided.

The reviewer of this paper requested extensive revisions to clarify the purpose of the paper and the addition of data to substantiate certain statements. A revised manuscript report should be prepared for distribution.

Recommendation: Chinook population dynamics in the U.S./Canada chinook rebuilding program involve uncertain escapement goals and are heavily reliant on exploitation rates estimated from coded-wire tag data. We recommend examination of three important issues:

a) examination of the accuracy and precision of the coded-wire tag program, particularly with respect to sources of bias in recovery programs and the statistical confidence associated with exploitation rate calculations;

b) examination of the assumption that exploitation patterns determined for hatchery stocks are representative of proximal natural populations (i.e. hatchery rearing environments do not influence migration and/or maturity patterns);

c) re-evaluation of fixed escapement goal objectives in salmon management since limited information will be gained to assist in evaluation of optimum escapement goals. For example, constant harvest rate objectives would provide greater variation in spawning numbers without any likely long-term loss of yield.

EVALUATION OF INCREASING THE TROLL SIZE LIMIT FOR CHINOOK SALMON (WORKING PAPER S87-2):

In July 1987, the size limit for chinook salmon in B.C. troll fisheries, excluding the Strait of Georgia troll, was increased from 62 to 67 cm fork length. This increase equalized the size limits for chinook in ocean troll fisheries from Washington through S.E. Alaska. The impact of this change will vary between stocks depending upon their growth rate, maturity schedule, and exploitation pattern. However, the size distribution of a stock in a fishing area and stock-specific growth rates are largely unknown.

Stock-specific impacts can be inferred from age-at-maturity and exploitation patterns for stocks which have been coded-wire tagged but most of these stocks will be hatchery stocks. A fishery oriented analysis was, therefore, felt to more accurately reflect the information available for an impact analysis. Fishery impact was defined as the adult equivalent catch of female chinook plus the mortality of chinook shaken during trolling. Fishery impact estimated for the new size limit accounted for increased shaker incidence due to the portion of the size distributions between the old and the new size limit and an estimated savings of adult equivalent female chinook from this portion, assuming a conservative harvest rate of 50%. The effect of the change was evaluated under three possible management scenarios: equal catch ceilings in numbers of chinook, equal landed weight, and equal impact before and after the change. The evaluation assumed catch ceilings of 200,000 chinook in the northern troll and 360,000 in the west coast of Vancouver Island troll fishery. Landed weight and impact under the old size limit were estimated and then re-estimated for the new size limit by truncating the old size distribution at the new size limit. The tables below compare the effect of the change relative to the old size limit.

In the northern troll fishery (areas 1-11, 30) the potential effect was:

	% CHANGE FROM CALIBRATED VALUES		
CRITERIA	CATCH	LANDED WT.	IMPACT
EQUAL CATCH	0%	+6.4%	+8.8%
EQUAL WT. LANDED	-5.9%	0%	+2.3%
EQUAL IMPACT	-8.0%	-2.3%	0%

In the west coast of Vancouver Island troll fishery (areas 21-27) the potential effect was:

	% CHANGE FROM CALIBRATED VALUES		
CRITERIA	CATCH	LANDED WT.	IMPACT
EQUAL CATCH	0%	+16.4%	+9.6%
EQUAL LANDED WT.	-14.1%	0%	-5.9%
EQUAL IMPACT	-8.7%	+6.2%	0%

The effect on the west coast Vancouver Island troll fishery would be greater if the true size distribution in the catch was more skewed than the one in this analysis. Uncertainty about the current size distribution arose because of an uncharacteristic dome-shaped distribution in the 1985 biological sampling data. A distribution averaged between the characteristic distribution strongly skewed towards the old size limit and the dome-shaped distribution was used in this analysis. If the true distribution is skewed then the impact of the change assuming equal catch ceilings increased by 12% relative to the old size limit impact.

Increasing the size limit without reducing the catch ceiling is estimated to increase the impact of the outside troll fisheries by 9 to 12%. However, these estimates may be inflated because of:

- the complete truncation of the new size distribution at the size limit, no sub-legal fish were assumed to be landed in the catch ceiling (previous observations indicate about 2% of the catch is below the size limit);

- no size dependent mortality was assumed in estimating the revised shaker mortalities;

- encounter rates with sub-legal chinooks (by areas and averaged over the season) were assumed to be similar to the 1981-83 troll logbook observations;

- and past size distributions were assumed to still be valid. The distribution will vary due to recruitment variation and may change as the abundance of chinook increases (i.e., more older, larger chinook are expected to be available to fishing gear) during chinook rebuilding.

Inferences about stock-specific impacts vary depending upon the age-at-maturity of the stocks. Later-maturing stocks, such as the Robertson Creek or Quinsam Hatchery stocks, will likely be subjected to higher harvest rates on older age classes. Conversely, early-maturing stocks, such as the Big Qualicum stock, may experience reduced harvest rates. Whether any saving of this stock actually materializes depends on growth rate, maturity schedules, and how many fish escaping the troll fishery actually avoid other fisheries on their spawning migration. For example, what portion of the chinook between 62 and 67 would recruit to the new size limit later in the same season, or what portion of the 3-year old chinook would mature at 4-years of age and be susceptible to fishing for another season?

Increasing the size limit on chinook salmon without compensating for the increased impact would be inconsistent with the program to conserve chinook stocks in British Columbia. Since the size limit was changed without reduction of the catch ceilings compensation was implemented through area closures (Swiftsure Bank - Area 21 and 121-1 and that portion of 121-2 located easterly of a line connecting the following co-ordinates: 48°37'21" N, 125°12'90" W and 48°29'48" N, 124°58'02" W) to reduce catch rate of sub-legal sized chinook. Further opportunities for compensation through reductions in shaker mortality rates and time/area closures in central and northern B.C. should still be considered. It should be emphasized that the impact of this regulatory change <u>on stocks</u> can not be evaluated for 2-3 years until tag recoveries from recent broodyears are complete.

Both reviewers of this paper agreed with the procedure and conclusions. One reviewer recommended the development of statistical error estimates about the predicted impacts and the use of sensitivity analysis to evaluate the effect of assumptions. The second reviewer's comments were largely editorial and will be incorporated in the final manuscript. Sensitivity analyses recommended will not be undertaken at this time since the regulation change has already occurred and we can evaluate the actual changes in size distributions observed in the catch. The Subcommittee recommends publication of this analysis in a Manuscript Report but recommends that 1986 biological sampling data for the chinook caught in B.C. troll fisheries be included in the size limit evaluation before publication. These data would reduce the uncertainty about the recent size distributions in the west coast of Vancouver Island troll catches.

INDUCED MORTALITY ON CHINOOK SALMON (WORKING PAPER S87-3):

Information on fishing associated non-catch sources of chinook mortalities during salmon fishing in British Columbia was collated for the years 1977 through 1986. The largest source of mortality is the hook and release of sub-legal sized chinook (shakers) in troll and sport fisheries. Estimates of troll shaker rates were available from troll logbook programs from 1981-83. Resulting mortalities were estimated assuming a 30% mortality rate. Information on sport fishing impacts are less certain because the species composition of under-sized fish released is not recorded by the creel survey. Information that is available from other surveys is of unknown accuracy since the ability of fishermen to identify small chinooks from other species is unknown and encounter rates are provided voluntarily. The second largest source of mortality is the catch of small chinook (chinook under 5 lbs.) in seine fisheries. Landings of small chinook are only partially recorded in catch statistics. Further, the landed catch of small chinook is only a portion of the total catch of small chinook. The fraction of the total catch reported is unknown and probably quite variable. However, recent studies suggest that catch statistics are a small portion of the total catch.

Conservative estimates of the loss of small chinook, from fisheries where we have some data, range from 33 to 40 percent of the reported catch of large chinook (the range is determined by the effect of doubling the reported catch of small chinooks in seine fisheries). The vast majority of this loss being attributable to shaker mortality. Unreported loss of chinooks represents a significant loss of potential yield in adult chinooks. To-date these mortalities have been confounded with natural mortality rates in various assessment models.

The paper also addressed changes in the magnitude of these losses since 1977, as per request by the Pacific Salmon Commission. Mortalities since the implementation of the Treaty in 1985 were to be compared with a base period (1977-82) used in the calibration of the U.S./Canada chinook rebuilding model. Shaker mortalities in west coast troll fisheries in British Columbia have likely been reduced since the base period. Reductions have not been proportional to reduction in days fishing due to increased fishing effort being exerted per day open to trolling. Incidental mortalities in the sport fishery have likely increased due to the larger recent size limits on chinook salmon. However, the overall impact of the sport fishery (catch plus incidental mortality) has probably decreased because of substantial reductions in catch since the base period. The catch of small chinook in net fisheries is incidental to the catch of target species. Recent catches of chinook under 5 lbs. have been less than the base period but this is not likely to be a continuing trend. Increased catches of small chinook due to increased abundance of chinook during the rebuilding program should be anticipated.

The two reviewers of this report supported the procedures and results. Editorial comments will be incorporated into a manuscript report in preparation. Both reviewers commented on values in Table 15. The derivation of these values will also be clarified. The subcommittee noted that these analyses were premised on the assumption that shaker rates estimated during the 1981-83 period are still representative of troll fisheries. These rates may be higher than actual current values since management actions have been implemented to reduce incidental mortalities. The Subcommittee recommends new sampling programs to monitor sub-legal encounter rates in hook and line fisheries to ensure confidence in the data used.

JUVENILE CHINOOK CATCH ESTIMATION:

The subcommittee was requested by G. Jones to review contract reports from J. O. Thomas & Assoc. which provided revised catch estimates for small chinooks caught in B.C. net fisheries between 1980 and 1985. Five reviewers were requested to provide comment on the report (Riddell, Starr, Lapi, Argue, Staley). These reviews were discussed at the subcommittee meeting with the external reviewers present.

The reports indicate that catch statistics only partially report the landings of small chinooks. In several instances the catch reported for small chinooks is less than the number of small chinooks sampled for a gear, catch week, and area strata. Three procedures for expanding the reported catch to total landings were presented:

(1) estimation of total landed catch by multiplying the average catch of small chinook per landing observed during port sampling by the reported total landings in a stratum;

(2) expansion of the number of small chinook sampled by the catch/sample ratio for coho salmon reported for the same sample stratum;

(3) expansion of the number of small chinook sampled by the catch/sample ratio for large chinook reported for the same sample stratum.

Catch per unit of effort expansions were dismissed in the reports because of concerns about landing biases (biased selection of boats or mis-reporting of areas fished). The reviewers felt that this option had not been adequately evaluated and had been prematurely dismissed. Coho expansion factors may be reasonable because of how sampling effort is applied to landings but the reports did not adequately substantiate that the sampling rate within strata across species were similar. Other concerns expressed about the appropriateness of coho expansions were:

- catch reporting of coho may not be as accurate as assumed;
- the applicability of coho expansions may vary within a season (seine fisheries early in the season do not catch many coho).

Consequently, without more analysis of the use of coho expansions the subcommittee could not support the application of this procedure. Riddell demonstrated that the report provides as much evidence of under-reporting of large chinook catches as for small chinooks. If small chinooks were always under-reported and large chinooks accurately reported, as is assumed for the use of the third procedure, then the portion of chinook which is classified as small chinook in the observed sample should always be greater than the portion that small chinook constitute in the catch statistics. However, the reports indicated that the expected relation between sampled and reported portions was actually only observed 50% of the time. Consequently, the use of adult chinook catch/sample ratios is also a dubious procedure.

The reports do indicate that reporting errors exist for chinook but the subcommittee could not support the application of the procedures proposed without further examination of the data and validation against independently collected information. Application of a new procedure without validation may simply introduce new sources of error without improving the accuracy of the present reported catches. The reports also indicate that seine fisheries are likely the source of most of the error in small chinooks.

Recommendations:

i) The subcommittee recommends that the J. O. Thomas reports on catch of juvenile chinooks NOT be distributed. The subcommittee supported the use of existing sampling programs to estimate the reporting errors but recommended that other procedures be examined. For example, the determination of numbers of small chinook per total landed weight sampled and subsequent expansion by the total weight reported in the catch statistics within each sampling strata (recommendation provided by M. Staley). Further, more detailed examination of the options for expansion of reported catches should be undertaken. In particular, examination of the use of catch per unit effort statistics, consistency of sampling rates between species and the use of coho catch/sample ratios, and the landed weight option should be considered. Comparisons of these statistical expansions should be made with independent sampling programs such as the Chinook Net Mortality Study being conducted by the Biological Sciences Branch.

ii) The subcommittee recommends that the catch reporting problems identified for chinook salmon be evaluated for their effect on the coded-wire tag program; particularly the effect of pooling the catch and sampling information across small and large chinook grades, pooling seine and gillnet gears, and variation in sampling intensity between grades. Biases introduced may be underestimating the number of tagged chinooks actually caught. The feasibility of examining this potential bias back through 1975 by the use of landed weight expansions should be evaluated. It may only be efficient to conduct this review under the umbrella of a general statistical review of the coded-wire tag program.

PRELIMINARY EXPECTATIONS FOR 1988:

The subcommittee had intended to review preliminary expectations that are to be provided to the Pacific Salmon Commission in November. Overviews of the expectations were presented for each Division and for the Salmonid Enhancement Operations Unit. However, due to the simplicity of most forecasts (average returns per spawner times broodyear escapements with fixed age structure) and a lack of evaluation of previous forecasting accuracy the subcommittee is unable to provide any biological advice following from these presentations. For the stocks with more quantitative procedures developed (Skeena sockeye, southern B.C. chum, and Fraser sockeye) the information from the 1987 catch and escapements is not available in October. More rigorous documentation of forecasting procedures will be expected in the preparation of the March 1988 documents.

Except for some major stocks, fishery managers assign relatively little importance to the preparation of expectations. Most fisheries are managed on the basis of in-season estimates of abundance. Until a more complete evaluation of expectation procedures is complete, the subcommittee is unable to comment on what expectations to present to the Pacific Salmon Commission. The subcommittee did recommend that expectations should be presented as a range of possible values so as not to imply confidence in one number unless confidence is warranted. A range would also indicate the variability expected in these forecasts.

More rigorous expectation procedures should be developed and evaluations of these procedures should be undertaken if PSARC is to review forecasts and provide biological advice on expected harvests and/or options for management planning. The development of these procedures should begin with the major stocks. These may be the only expectations reviewed by PSARC until procedures are developed for the other stocks. Consideration should also be given to how these forecasts are incorporated into the in-season management process in order to stimulate greater effort in preparing these forecasts.

SUBCOMMITTEE COMMENT:

The Subcommittee noted several problems in determining the productivity of chinook salmon. Productivity estimates in working paper S87-1 noted the inability to estimate catch by stocks and the need to account for hatchery contributions (U.S. and Canadian) to catch. Further, these analyses did not account for errors in catch statistics, unreported catches, or incidental mortalities. These latter sources of error were outlined in this subcommittee report and must be accounted for to accurately evaluate total production from maturally spawning chinook salmon. More accurate evaluation may not benefit rebuilding rates, however, since the relative change in harvest rates required to rebuild would likely be very similar under the present or revised data. Reducing losses to these sources would of course benefit rebuilding by increasing the potential number of spawners.

Appendix 1. List of Participants

B. Riddell - Chairman
T. Beacham (26th only)
C. Wood (26th only)
T. Perry
D. Schutz
M. Stocker- Recorder
K. McGivney - Recorder
R. Harrison
D. Anderson
P. Starr
D. Peacock
R. Kadowaki
D. Meerburg (26th and intermittent on 27th)

Reviewers of the J. O. Thomas & Assoc. reports and present at October 27 a.m. meeting.

S. Argue
M. Staley

Reviewers not present at meeting.

M. Healey
T. Gjernes
J. Schweigert
L. Lapi

Appendix 2. List of Working Papers

Number:Pages	Title	Authors
S87-1:37	Status of naturally spawning chinook salmon (*Oncorhynchus tshawytscha*) stocks in British Columbia through 1986.	B. Riddell P. Starr
S87-2:14	Evaluation of increasing the size limit in west coast troll fisheries, excluding the Strait of Georgia troll.	B. Riddell
S87-3:47	Unaccounted for sources of fishing associated mortalities of chinook salmon in B.C. salmon fisheries (1977-1986).	B. Riddell