British Columbia Groundfish Fisheries And Their Investigations in 1999

April 2000

Prepared for the 41st Annual Meeting of the Technical Sub-committee of the Canada-United States Groundfish Committee May 9-11, 1999. Nanaimo,B.C. CANADA

by

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REVIEW OF AGENCY GROUNDFISH RESEARCH, STOCK ASSESSMENT AND MANAGEMENT

A. Agency overview

Fisheries and Oceans Canada (FOC), Science Branch, operates three facilities in the Pacific Region: the Pacific Biological Station (PBS), the Institute of Ocean Sciences (IOS) and the West Vancouver Laboratory (WVL). These facilities are located in Nanaimo, Sidney and North Vancouver, B.C., respectively. Division Heads at these facilities report to the Regional Director of Science (RDS). Personnel changes within the Region Science Branch in 1999 include the appointments of Dr. Laura Richards as the Acting RDS and Mr. Ted Perry as the Head of the Stock Assessment Division (STAD). The current Division Heads in Science Branch are:

Stock Assessment Division	Mr. T. Perry
Marine Environment and Habitat Science	Dr. J. Pringle
Ocean Science and Productivity	Mr. R. Brown
Aquaculture	Dr. D. Noakes

Groundfish research and stock assessments are conducted primarily in two sections of the Stock Assessment Division, Fish Population Dynamics (Sandy McFarlane, Head) and Assessment Methods (Jeff Fargo, Head). The Assessment Methods Section includes the Fish Ageing Lab. A reorganization is imminent and the plan is to convene a single Groundfish Section and a new Pelagics Section. The section heads are yet to be determined.

Management of groundfish resources is the responsibility of the Pacific Region Groundfish Coordinator (Ms. Marilyn Joyce) within the Fisheries Management Branch. Fishery Managers receive advice from STAD through the Pacific Scientific Advice Review Committee (PSARC, formerly the Pacific Stock Assessment Review Committee). The Chair of PSARC (Dr. Max Stocker) advises the Regional Management Committees on stock status and biological consequences of fisheries management actions and works in consultation with the Canadian Stock Assessment Secretariat (CSAS) in Ottawa.

An Oceans Directorate within DFO was formed in 1998 to “lead the development and implementation of a national strategy for oceans management based on the principles of:

- sustainable development;
- integrated management of activities in estuaries, coastal and marine waters; and

- the precautionary approach".

The Oceans Strategy is defined by portions of the *Ocean's Act* which include basic authorities for:

- the establishment of Marine Protected Areas;
- the establishment and enforcement of marine environmental quality guidelines, criteria and standards designed to conserve and protect ecosystem health; and
- the development of management plans, including integrated coastal zone management plans.

B. Multispecies studies

None.

C. By species

1. <u>Pacific cod</u>

i. Research programs

The P. cod assessments in areas of the BC outside Hecate Strait suffer from a general lack of information. A review was conducted of aspects of the Hecate Strait groundfish assemblage survey design that may be modified to improve Pacific cod estimates while not compromising the main objectives of the survey. This included an analysis of past surveys and commercial fisheries data from the 1996-99 observer program. Consultations were held with Pacific cod fishermen on aspects of survey design and the interpretation of results. There are advantages to conducting bottom trawl surveys at times when the target species are dispersed throughout the survey area, to avoid seasons when the fish are highly aggregated, and to avoid periods when they have migrated out of the survey area. Cod spawning is reported in Hecate Strait between January and March. Commercial catch rates decline in the September – December period indicating that Pacific cod availability in Hecate Strait may be reduced then.

It would appear that the month of June, when the survey has been conducted, is a good choice for this survey. Less than half the area of Hecate Strait is covered by the survey. A crab fishery occurs over a large portion of the Strait east of the Queen Charlotte Islands and the bottom conditions there are unfavorable for trawling. It would be illustrative to examine the fish by-catch in the crab traps for Pacific cod. If cod are present in significant numbers, then it may be worthwhile having

the crab traps lifted at the time of the survey to allow fishing there.

There appears to be a depth dependent pattern in Pacific cod distribution in Hecate Strait that would justify a stratified survey design to reduce variance. Having one station per stratum makes the estimation of sampling variance difficult. It would be useful to consider modifying the survey design where fewer strata and more stations per stratum. The basis for stratification should be further examined, taking into consideration other species for which the survey is now used (e.g. flatfish). Consideration should be given to trade-off's in station allocation and stratification.

The current surveys have between 80 - 100 fishing sets. Increasing the number of sets would be expected to reduce the standard deviation of the mean in proportion to the square root of the number of observations. Roughly speaking, doubling the number of sets may result in a 30% reduction in the standard deviation. It is strongly recommended that length frequencies be taken for all Pacific cod catches made on the groundfish assemblage survey. Filling in for missing length frequencies introduces unnecessary uncertainties to the survey results.

The potential use of industry-based surveys will also be explored in 2000.

ii. Stock assessments

No assessment was conducted in 1999.

2a. Rockfish - offshore

Slope Rockfish

i. Research programs

No field programs were conducted in 1999 and research is summarized in the assessment. During 2000 planning for industry-funded surveys will be conducted.

ii. Stock assessment

The 1999 assessment did not provide a new assessment, but rather a series of steps essential for future assessments, based on industry-sponsored surveys for slope rockfish. Our research

follows a strategic plan for collaborative work with the groundfish industry. The report presents the latest available data and makes the following major advancements on past work. First, we have developed a bathymetric database, cross-referenced with the observer data, from which we can calculate bottom area available to fishing as well as actual bottom areas swept and impacted. We have also provided estimates of biomass for each slope rockfish species by extrapolating observed estimates of density at depth to all available coastal bathymetry. Second, in collaboration with the Canadian Groundfish Research and Conservation Society, we have initiated the development of an industry-sponsored slope rockfish survey, independent of the fishery. To date, we have developed maps that record fishermen's impressions of trawl characteristics of the ocean floor. These classifications and preliminary estimates of fish density provide essential prior information in designing a survey that minimizes the variance of biomass estimates for a given level of available resources. Third, we have used biological data to calculate rough estimates of key reference points for the slope rockfish species. The report presents the complete mathematical framework for calculating reference point values from underlying biological parameters.

Analyses extended from last year suggest a continuing decline in the density of longspine thornyheads in the most heavily fished blocks in assessment unit region 3C. Although these results are not definitive, they suggest a cautious approach to the development of a new fishery on this species.

In response to a request from industry and management, we examine the possible justification for shifting the 5CD/5ES boundary 20 minutes north of its present location at 52°N. If the quota remains unchanged in each area, the impact on quota holders would be minimal. Furthermore, fishing pressure on the Morseby Gully region would be somewhat alleviated if 5CD quota holders shift some of their effort to the region off the southwest Queen Charlotte Islands.

Although we have observed a number of significant trends in CPUE, we do not specifically recommend that current TAC levels be adjusted. CPUE trends may indicate changes in abundance; however, there are so many confounding factors that we can only advise managers to be aware of potential problems. Until controlled surveys are implemented and/or confounding factors are statistically incorporated in CPUE measurements, we cannot with any degree of confidence provide reliable measures of stock abundance at this time and recommend that the 1999 yield options be extended to 2000.

Shelf rockfish

i. Research Programs

The widow rockfish acoustic study was continued for a second year. Year II objectives were to 1) examine the influence of “making” tides on biomass estimates, 2) obtain a second year estimate of the biomass of the Triangle Island shoal and, 3) test the ability for an “adapted” commercial sounder to collect quantitative acoustic estimates.

We found that the Year 2 biomass estimates were similar to those of Year 1, and that the biomass estimates during “making” tides did not differ significantly from “neap” tides. The experiment of adapting a commercial sounder was successful in that we collected quantitative estimates of acoustic backscatter. However, we found that the acoustic signal on the commercial vessel was easily corrupted during only moderate weather conditions (>25 knot winds and 2-3 m swell). While the concept seems appropriate for sheltered waters, we suggest that future attempts consider use of a towed body instead of relying on the vessel’s hull-mounted transducer. We would also suggest use of a completely independent portable sounder system such as the SIMRAD EY series.

Also in 1999, shelf rockfish staff participated in two submersible dives. The objective was to explore the potential of using submersibles for behavioural studies of shelf rockfish. The purpose is to examine the diel vertical behaviour of canary or silvergray rockfish to determine whether there are times of the day or tides when they are consistently off bottom and visible to acoustic equipment. Initial observations suggest this approach has promise. Current year efforts will continue to explore the potential of this tool as one of numerous secondary objectives during nearshore rockfish research on Bowie seamount and off the southwest coast of Vancouver Island.

ii Stock assessment

Stock assessment activities focussed on canary rockfish. The resulting document provided an analysis of the available stock assessment information on canary rockfish *(Sebastes pinniger*) in Canadian waters and harvest recommendations for the 2000/2001 fishing year. For Areas 3C+3D (west coast of Vancouver Island), the assessment proposed minimum and maximum harvests of 350-700 t, an increase from the 350-550 t range proposed the previous year. The document recommended a range of 175-350 t for Areas

5A+5B (Queen Charlotte Sound) down slightly from the 200-400 t range proposed a year earlier. There was little basis for determining optimal harvest levels for Areas 5C+5D (Hecate Strait) or 5E, (west coast of the Queen Charlotte Islands). However, for Areas 5C+5D; the document suggested consideration of a harvest range of 50-150 t. This brackets historical landings. A harvest range of 100-200 t was proposed for Area 5E, but noted that the hook-and-line fishery is providing significant landings from this area. The document summarises the history of Canadian and U.S. landings, management and assessment history for canary rockfish.

The assessment methodologies followed recommended procedures for “data poor” stocks. Historical mean harvests were evaluated as quota guidelines subject to: observed trends in age composition, catch curve analysis, CPUE trends and comments from fishers. We include a discussion of the information content of each data source. Also included is a brief review of a canary rockfish assessment provided by Walters and Bonfil (1999) and incorporation of those authors’ concerns in the quota recommendations. Yield recommendations are discussed relative to current perceptions of decadal scale variation in groundfish recruitment.

Shelf rockfish stock assessment emphasis for the next cycle (2000) will be placed on silvergray rockfish and summarizing life history data for this species.

2b. ROCKFISH - inshore

i. Research programs.

Since 1997, an annual allocation of 5% of the overall inshore rockfish TAC has been set aside to fund research. A research program directed at collecting biological samples and CPUE data for yelloweye and redbanded rockfishes (*Sebastes ruberrimus* and *S. babcocki)* was initiated in September of 1997. Chartered fishing vessels repeated this data collection in May of 1998. Additional biological samples, which included tissues for DNA analysis, were collected from the nearshore and seamount fisheries in 1999/2000.

Over 2500 individual yelloweye rockfish tissues were sampled over two years in 25 collections from nine locations in British Columbia and one in southeast Alaska. Samples were screened on ABI 377 at 13 highly polymorphic *Sebastes* microsatellite loci. Genetic differentiation among all yelloweye samples was low; F_{ST} values by locus ranged from 0 to 0.005, with an average value of 0.001. Over 98% of genetic variation was contained within yelloweye rockfish samples. No significant structure was accounted for by site, season of collection, phenotype (bright and dark colour variants), or region of collection (west coast Vancouver Island, west coast of Queen Charlotte Islands, Bowie Seamount).

Non-destructive, *in-situ* assessment methods are being assessed as a means to estimate inshore rockfish abundance. Over-the-side cameras in shallow water (<35 m) provide copper rockfish (*S. caurinus*) density estimates that are comparable to traditional catch indices from fishing surveys. However, this is not the case for quillback rockfish (*S. maliger*), which occupy depths deeper than the camera can be deployed.

Inshore rockfishes exclusively occupy high relief, complex, rocky habitat. The Quester-Tangent “QTC-View” acoustic seafloor classification system easily distinguishes hard substrates from sand and mud. Further refinement of the QTC-View system is required to reliably identify high-relief/complex substrates that provide good rockfish habitat from low relief rock substrates that do not.

Database development work is continuing with the transfer of the logbook database to a SQL server with modifications to match the regional standard. Dockside validation data was also transferred to the SQL server.

ii. Stock assessment

The 1999 inshore rockfish stock assessment outlined a number of resource concerns. Biologists and managers are faced with several fundamental problems. These include:
-unknown fishing mortality (including discard mortality)
-inability to limit fishing mortality across all fishing sectors
-extremely long stock rebuilding time
-data and management mismatched to the scale of depletion
-lack of a coherent data time series
-no abundance estimate or index
-no precise, cost-effective means of estimating abundance

Recommendations to managers included:
-reduction of fishing mortality from all sources
-estimate fishing mortality (including discards from all fishing sectors)
-consider closed areas as an additional management tactic

iii. Management and Regulations

In 1999, a process was initiated to address assessment and management of inshore rockfish. The Groundfish Management Unit, Stock Assessment Division, Recreational Fish Division, Enforcement, Oceans Sector and participants from all fisheries developed a plan to resolve problems identified in stock assessments. Internal and external working groups were established and a conservation plan was developed to address:
-methods to increasing gear selectivity
-area closures under the Fisheries Act
-coordinating area closures with MPA initiatives under the Oceans Act
-evaluate options to reduce mortality in the recreational fishery
-review management options for minimizing local area depletions
-review the long-term viability of a directed rockfish fishery

The hook and line rockfish fishery is managed by limited entry licensing with fishing region designations (area licensing), regional catch quotas, fishing seasons, trip limits, fishing period limits and directed species fishery options. The logbook and dockside monitoring programs are continuing. The directed 2000 rockfish hook and line fishery quotas remain unchanged from 1999. Area closures instituted for the directed hook and line rockfish fishery in 1999 were extended to include the directed halibut fishery in 2000.

3. Sablefish

i. Research programs

In 1999, cost-recovered funding was allocated to cover salaries, contracts and purchases for research projects that were approved by the Sablefish Finance Committee and the Science Branch of the Department of Fisheries (DFO) and Oceans. The committee consists of industry (Canadian Sablefish Association) and DFO representatives whose mandate is to ensure that research is conducted in a cost-effective manner. Secondarily, the industry representatives have provided input regarding the direction of the proposed research.

Larval Survey

A survey of larval abundance was conducted off the west coast of Vancouver Island from April 14 to May 2, 1999 aboard the charter vessel F/V NOPSA under the direction of Mr. Mike Smith. The purpose of the survey was to examine the distribution and abundance of larval sable in surface waters. These data are to be used in the development of recruitment indices for early detection of sablefish year-class strength to be applied in forward-looking assessment studies. Two night-time Neuston tows and a CTD were conducted at each of 71 stations. The Neuston sampler was towed at the surface at 2 knots and captured plankton in the top metre in a fine mesh net. The preserved samples were sorted in the lab to identify and count sablefish and other fish in the samples. The implications of the presence of fish at the offshore extreme of the two transects we extended well to the west will have to be addressed for future surveys. CTD data have been processed and entered into an oceanographic data base.

Trap Survey

A fall sampling longline trap charter was conducted between September 28 and October 30, 1999 aboard the chartered fishing vessel OCEAN PEARL under the direction of Mr Mike Smith. This survey has been conducted since 1986. The purpose of the survey was to collect biological data from discrete depths at standard index sites along the coast and to conduct tagging. These data are used to monitor changes in age, growth and abundance (based on tagging release/recoveries) and are the major inputs for annual assessments. A total of 109 sets were made (not including the excluder work), 27,231 fish were tagged, 3571 otoliths collected for ageing and 75 tagged fish were recovered. Results will be incorporated into the next assessment.

Excluder Study

Industry wished to explore the possibility of modifying trap tunnels to exclude a small proportion of large females from the commercial trap catch. As well as protecting the female brood stock, this approach may enhance recruitment since larger females produce relatively larger and potentially more viable eggs. Consultation with industry representatives guided the types of trap modifications to consider, plus seasonal timing for a formal field study. The excluder study was completed during the 1999 Fall Charter trip in October.

Three ring sizes (6″, 6¾″, 7½″) plus two reduced (puckered) tunnel openings (9½″, 12½″) were tested. Each string had a total of 50 excluder traps plus 10 control traps randomly ordered along its length. Individual traps were sampled separately.

Preliminary analysis indicates that the presence of an excluder produced two effects: 1) a reduction in the relative catch of large females and 2) a decline in the overall catch rate. Both the number of all legal fish, plus the number of legal fish above a certain size (e.g. 30″) are important factors to consider when evaluating the results. The length distribution of males was not affected by excluder sizes, but cropping of larger females occurred. A reduced catch of larger sablefish was observed as either ring size or tunnel opening decreased. This response is expected, but excluder dimensions need to be fine-tuned to minimize the drop in catch rate while still maintaining some reduction in large female catches.

Climate/Recruitment Study

Climate and ocean conditions in the north Pacific exhibit stable states on decadal scales but can rapidly shift from one state to another. Since climate and ocean conditions determine the nature of regional marine ecosystems, these decadal-scale patterns and rapid shifts will have consequences for fish. Previous research has suggested that the year class success of sablefish exhibits decadal-scale patterns that correspond to the patterns of variability in climate-ocean conditions. Detection of the rapid shift in climate and ocean conditions would indicate important years to monitor the potential change in the relative year class success of sablefish. Changes in climate and ocean conditions might prove to be useful in predicting long-term recruitment success.

Objective
Conduct research on the influence of climate on the recruitment of sablefish.

Milestones
1. Identified relevant Pacific climate-ocean system indices that are available in a reasonable time frame.
2. Developed an atmospheric forcing index that incorporates the variability of relevant climate-ocean indices.
3. Theoretical development of a 'recruitment report card' that
   i. can be used to identify important monitoring years
   ii. helps develop long-term assessment and management plans.

Deliverables
1. Procured north Pacific climate indices.
2. Modelled regional atmospheric circulation patterns.
3. Updated Pacific atmospheric circulation data for 1997 and 1998.
4. Produced atmospheric forcing index.
5. Procured and collated regional environmental indices (on-going).
6. Developed pre-recruitment biological indices (on-going).

Future Research

1. Update indices for 1999.
2. Collate and interpret report card matrix.
3. Final report by July 2000.

Age Determination Study

There is no doubt that sablefish are long-lived and slow growing. The marking of otoliths with oxytetracycline confirmed that the annual growth increments are narrow for older fish. It was also confirmed that there is an annual pattern of growth that can be used to determine age. The difficulty is that the pattern of growth is difficult to interpret in some otoliths. This means that normal methods of estimating accuracy and precision need to be modified for sablefish aging. This is the major conclusion of this study.

We examined 100 pairs of otoliths from sablefish that had been injected with a dosage of 50 to 100 mg of oxytetracycline / kg body weight. This antibiotic is taken up quickly in the otolith and forms a thin yellow line when viewed under UV light. One otolith from each pair was embedded in epoxy and cured for 24 to 48 hours. Thin sections (0.7 to 1mm) were cut from the

center of this otolith and mounted on a glass slide using thermal resin. Sections were polished using 0.3um grade lapping film. The second otolith was examined using the break and burn method.

The polished otolith section was examined with a Leitz Laborlux 12 compound microscope equipped with an internal UV light source. Not all otoliths had a UV mark and some marks were too faint to use in the study. Approximately 40 otoliths had acceptable marks. This is an adequate number to carry out a meaningful study. The interval between the mark and the capture date (the years of liberty) ranged from two years up to 20 years.

The increments that were identified for this period generally agreed with the time at liberty, but there were exceptions. There is no question that in some cases the number of increments did not correspond to the number of years at liberty. The reason for the differences was not an absence of increments but an inability to differentiate the very narrow structures. For example, a fish that had been in the ocean for 13 years after tagging should have 13 increments, but we observed 16 increments using a section and 9 increments using the breaking, burning and measuring technique. We know that the breaking and burning technique is less accurate than the sectioning for older fish because of the loss of annuli on the edge so this difference in methods was expected. The observations of 3 more increments than expected is a consequence of small lines that form within an increment, possibly as a result of spawning. We stress that this kind of difficulty is a common source of error in age determination and is less important for older individuals.

Currently, more accurate ages can be estimated by using a combination of the two techniques; the polished section technique will provide more accurate estimates of the number of annuli on the edge of the otolith while the burnt section will provide accurate estimates of the number of annuli present in the core area (up to the age of maturity).

For the future, we believe that we have a solution to the problem that involves developing otolith growth models. The theory is that we know of no examples of growth patterns that change significantly when blackcod are old. Thus the increment width for females of age 15 to 30 declines gradually, from 30 to 50 years it declines very slightly and after 50 years, the increments are so narrow that they could be considered to be constant. We would produce otolith growth curves that would be adjusted to a standard such as size at maturity (for each sex). It is also important that the assessment model that uses these

ages, is not sensitive to errors of a few years for older fish. It is not appropriate to suggest that the ages are not informative if they are not accurate for older fish. It is very informative to know that 20% of the catch consists of females on the age range of 25 to 30 years. We believe that the use of otolith sections and the reference to standardized otolith growth curves will provide useful age determination estimates.

Research being conducted during 2000 includes:

- a fall trap survey including the release of 15,000 tagged fish.
- Examination of the potential for inlet survey stations to index recruitment.
- Examination of the initial rapid decline in recovery rates for tagged fish observed in the first year after release.

ii. Stock assessment

A major assessment of sablefish was conducted during 1999. The population modelling and tagging analysis components were conducted by Vivian Haist and Ray Hilborn under a private contract with the Canadian Sablefish Association. PBS staff wrote the first section of the document providing a summary of the sablefish fishery, a discussion of catch per unit effort and description of fall charter survey design. The results of the assessment work are provided in the full assessment submitted to the Groundfish sub-committee of the Pacific Scientific Advice Committee (PSARC) entitled G99-6 Sablefish stock assessment for 1999 and recommended yield options for 2000 and 2001 by V. Haist, R. Hilborn, and M. W. Saunders.

Briefly, analytical stock assessments are conducted using an integrated catch-age mark-recapture model. The stock reconstructions suggest that from 1972 to 1998 the available biomass of sablefish decreased by 50% in northern B.C. and by 48% in southern B.C. The 1998 female spawning stock biomass (SSB) is estimated at 50-67% of the virgin level for the southern B.C. stock, and from 38-48% of the virgin level for the northern B.C. stock. These SSB levels are well above “high risk” levels, hence, there are no short-term conservation concerns for these stocks.

Deterministic stock projections are conducted for the 2000 to 2008 period at three levels of fixed harvest. Stock projections suggest that current removals in the north are not sustainable, and that in the next 8 years considerable reduction in removals from the north may be required if recruitment does not increase. Recent reductions in trawl by-catch and reduced mortality of small sablefish from escape rings may result in increased recruitment.

The Groundfish PSARC Subcommittee accepted this paper subject to revision. The Subcommittee recommended that the yield options remain unchanged from 1999, that the differential exploitation rates between the north and south stocks be considered in developing management strategies for this fishery, and cautioned that current removals in the north may not be sustainable.

4. FLATFISH

i. Research programs

A groundfish trawl survey in Queen Charlotte Sound was conducted in 1999. The objective of the cruise was to obtain biological data and data on the distribution of groundfish species in this region. Biological samples were collected for arrowtooth flounder, Dover sole, English sole, flathead sole, Petrale sole, rex sole, rock sole, canary rockfish, Pacific ocean perch, quillback rockfish, redbanded rockfish, redstripe rockfish, rougheye rockfish, yellowmouth rockfish, yellowtail rockfish, Pacific cod, lingcod, and spiny dogfish.

ii. Stock assessment

Interim assessments were prepared for flatfish stocks in 1999. The 1999 trawl fishery focused on stocks of rock and English soles in Hecate Strait and Dover sole off the west coast of Vancouver Island and the west coast of the Queen Charlotte Islands. The fishing reference point F_{med} is used to manage rock sole and English sole. Spawning stock biomass per recruit analysis indicated that the current fishing rate will not reduce the biomass of these two stocks. Both the southern and northern Dover sole stocks are being harvested near the MSY level. Petrale sole stocks remained at a low level of abundance in 1999. Only incidental landings of this species have been permitted since 1995. Managers have set a bycatch cap of 480 t. The fishery for this species will continue to be non-directed until stocks show signs of recovery from the intensive fishery on

spawning aggregations in the 1970s and 1980s. An analysis of the population dynamics of rock sole in the north Pacific is being jointly prepared by NMFS and DFO staff.

5. Pacific hake

i. Research programs

Strait of Georgia

A synoptic fishing survey of hake distribution and biology was conducted during March 1999 and hydroacoustic surveys of hake distribution abundance and biology are scheduled for March, April and August of 2000.

Offshore

The monitoring of catch, estimation of species composition, and biological sampling in the Vancouver INPFC Area fishery was continued through an extensive offshore observer and shore-side monitoring programs.

The distribution of juvenile offshore hake has been anomalous since 1994 with young fish, that had previously been restricted to California have been found throughout U.S. and Canadian waters, as far north as 57.8 deg. N.(YOY in 1997). The implications of this shift in recruitment pattern will require considerable research attention since the juveniles are subjected to increased mortality from the fishery and potentially cannibalism. We plan to conduct a synoptic fishing survey to monitor the distribution of hake in the Canadian zone during August 2000. The next triennial survey is planned for 2001.

ii. Stock assessment

Strait of Georgia

The fishery in the Strait of Georgia decreased substantially to 3,996t in 1998 from 6,561t in 1997, a result of low market demand. Age and growth data continued to indicate strong recruitment during the 1990’s and a coincidental decline in the mean size-at-age. Yield options remained unchanged from the previous assessment with a range of 7,554-14,687 t. Due to uncertainty in the current assessment, including evidence of

increasing seal predation it was recommended that managers choose a quota from the lower half of the yield range.

Offshore

No assessment was conducted in 1999 but an update is planned for 2000.

6. Dogfish

i. Research programs

Processing and analysis of dogfish tag recoveries was continued. The purpose of this experiment is to assess long-term movements, in particular the rate of exchange between the Strait of Georgia and offshore stocks.

ii. Stock assessment

A major assessment of dogfish has not been conducted for ten years although catches have been monitored. Landings, in particular hook and line, have increased in recent years although current harvests levels are below the optimal yield in both areas.

7. LINGCOD

i. Research programs

Collaborative genetics research into stock membership for lingcod throughout area 4B (Strait of Georgia) and areas 3C/D will be initiated in the summer and continued through March 2001. It is likely that a second year of research will be required. A genetic baseline will be developed for lingcod to be eventually applied to identifying stock membership.

Aging methodology will be re-examined for lingcod in the upcoming year, with the collection of juveniles for fin ray annular measurements and the comparison of these measurements to those from previous decades and from various ecosystems.

ii. Stock assessment

Offshore:

A stock assessment for offshore lingcod will be produced for the fall groundfish meeting of PSARC. Ongoing biological data collection from the commercial trawl fishery will be continued throughout the year.

Ecosystem considerations will be applied to the offshore lingcod stock assessment using the ‘report card’ approach developed for sablefish. We will examine north Pacific climate-ocean indices along with regional environmental indices in an attempt to holistically incorporate the ecosystem dynamics into lingcod recruitment assessments.

Inshore:

There is ongoing interest in the stock status of inshore lingcod (area 4B, Strait of Georgia) and a nest density survey is planned for the spring of 2001.

8. Walleye pollock

i. Research programs

Monitoring of catches and collection of biological samples were conducted during 1999 for pollock stocks in northern Hecate Strait/Dixon Entrance, Queen Charlotte Strait, the southwest coast Vancouver Island and the Strait of Georgia.

ii. Stock assessment

No assessment work was conducted during 1999.

10. Other

Pelagics - Sardine and Mackeral

Monitoring of sardine and mackeral stocks has been ongoing since their arrival in the early 1990's. What follows is a brief summary of the monitoring and studies to date. Research on the relationship of their distribution and abundance to climate change is ongoing. Midwater trawl research cruises have been conducted annually off the west coast of Vancouver Island since the early 1970s. Biological data were collected from sardine during all research trawling operations since they reappeared in catches in 1992. Fork length, sex and maturity were recorded for all sardine sampled. Paired otoliths were collected for age determinations from fish from selected sets, according to the procedures described in Beamish and McFarlane (2000).

No sardines were captured in nearly 1500 reasearch trawl sets conducted off the west coast of Vancouver island between 1977 and 1992 (DFO Groundfish database). From 1992 to 1995 small numbers of sardines were captured in both commercial and research catches of Pacific hake (*Merluccius productus*). The catches in the hake fishery have continued through 1999, but are not an indication of sardine abundance as hake are fished at depths below the concentrations of sardines (McFarlane & Beamish, 1999).

Since 1995 catches in an experimental fishery have increased from 200t to over 1200t in 1999. The sex ratio of 50% male and 50% female sardines in the catch in the 1990s was similar to that determined during the 1930s (45% male). The average length of fish captured during the summer in 1992 (244mm)

and 1993 (262mm) was similar to the average length from 1936 to 1940 (258mm). From 1997 to 1999 the average length (230mm) was smaller than previously reported. Similarly, the average age of sardine in 1997, 1998 and 1999 (4.1 years) was younger than that in the 1930s (6.2 years) and 1940s (4.6 years), and the range of ages was smaller.

Sardine in spawning condition were sampled off southern Vancouver Island in July 1997, and large numbers of young of the year (x = 10mm) were captured in the same area in February, 1998, juvenile sardines were a common componenet of the fish community in Vancouver Island surface waters, outnumbering catches of 1997 year class herring (*Clupea harengus*) 2 to 1. These young sardines have remained off the coast and have been captured throughout British Columbia waters including the Strait of Georgia, northern Hecate Strait and Alaska. Sardines remained abundant and spawned off the west coast of Vancouver Island in 1998.

Stomach contents for sardine from selected sets during cruises in 1997, 1998 and 1999 were identified to lowest taxonomic group possible and volume (cc) estimated for each prey item.

During 1997 and 1998 sardines fed mainly on phytoplankton (diatoms, *Coscinodiscus* spp.) and zooplankton (copepods and euphausiids), similar to the diet in the late 1920's. During 1999, a major portion of the diet was composed of surface water tunicates (*Oikopleura* spp.) as well as diatoms, copepods and euphausiids.

Abundance of sardines off the west coast of Vancouver Island was estimated using the volume fished in each of 6 regions from the northern part of Vancouver Island (region 1) to the southern part (region 6). Tracklines were predetermined to ensure maximum coverage within the limited cruise time available. Only sets which fished the top 30m of the water column were used as 99% of sardines were captured in the top 30m (McFarlane & Beamish, 1999). Swept volume for each set was determined according to the procedures described by Beamish et al. (2000).

The minimum estimated abundance of sardines in coastal waters off the west coast of Vancouver Island was 85, 993t in 1997 and 72, 080t in 1999. These assume a catchability of 1, and do not include sardines occupying large inlets along the west coast of Vancouver Island, or large concentrations just outside of the survey area on the northern tip of Vancouver Island. From 1992 until 1996 most sardine were captured off the west coast of Vancouver Island. Sardines were captured in Queen Charlotte

Sound and Dixon Entrance in 1997 and 1998, and some were captured in waters off south – east Alaska in 1998. During 1999, no research fishing for sardines was conducted in waters north of Queen Charlotte Sound

D. Other related studies

1. Statistics and Sampling

The principal Statistics and Sampling activities in 1999 included the ongoing population of the overall biological database (GFBio). This database now contains information on about 4,000,000 specimens. Data entry activities concentrate on input of current port sampling and observer biological data and recent research cruises. When time is available, we backfill the database with research cruise data collected before 1997.

Approximately 25% of the person year dedicated to Groundfish Statistics and Sampling was committed to assisting in data uploads of the trawl observer data and providing catch data summaries.

The groundfish trawl fishery continues to be covered by 100% observer and dockside coverage. These observers also provided about 1,000 length/sex/age samples and 2,000 length/sex samples. Hook-and-line and sablefish trap landings have 100% dockside validation.

Port sampling staff produced a first draft of a maturity atlas to aid field workers in classification of the maturity developmental stages of groundfish. These staff also conducted experiments with voice translation software to see if this technology would be appropriate for data recording during port sampling. We found that the error rate (>10%) was too high even under the background noise conditions of an office building. We plan to re-visit this in 2-3 years.

APPENDIX 1. REVIEW OF CANADIAN GROUNDFISH FISHERIES

1. Commercial fisheries

All catch figures for 1999 are preliminary. Canadian domestic trawl landings of groundfish (excluding halibut)in 1999 were 110,874 t, an increase of 31% above the 1998 catch. The major species in the trawl landings were Pacific hake (67%), Pacific ocean perch (5%), yellowtail rockfish (5%), turbot (3%), and dover sole (3%).

Canadian landings of groundfish caught by gear other than trawl in 1999 totalled 14,572 t. Sablefish landing by trap gear accounted for 3,844 t. Landings by longline, handline and troll gear accounted for 10,694 t (67% dogfish, 14% rockfish, 13% lingcod and 5% sablefish). Catches incidental to other gear types, including shrimp trawl, crab traps, seines and gillnets, totalled 34 t (92% dogfish).

2. Recreational fisheries

Each year, Fisheries Branch (Fisheries and Oceans Canada) conducts creel surveys of the recreational angling fishery in the Strait of Georgia. Principal target species are chinook and coho salmon. In 1999 these surveys covered the months of April to September. Provisional estimates of 1999 catches, landings and discards, for this 6-month period were 32,991 fish for lingcod, 107,636 fish for all rockfish species, 17,665 fish for flatfish species, 49,710 fish for dogfish, 2,494 fish for halibut, 2,089 fish for ratfish and 96 fish for herring. There was also an estimate of 1,552 fish for other unspecified groundfish.

3. Joint-venture fisheries

In 1999, 35 Canadian catcher vessels delivered Pacific hake and incidental species to two processing vessels in co-operative fishing arrangements. These fisheries take place off the southwest coast of Vancouver Island (Area 3C). A total of 17,201 t of Pacific hake was processed by 2 Russian vessels. The quotas and catches are outlined below:

Nation	Species	Quota (t)	Catch (t)
Poland	Hake	17,226	17,201
	Pollock	incidental	tr.
	Rockfish	incidental	74
	Other	incidental	18

4. Foreign fisheries

There were no national or supplemental fisheries for Pacific hake off southwest Vancouver Island (Area 3C) in 1999.

APPENDIX 2. GROUNDFISH RELATED REPORTS PUBLISHED BY THE STOCK ASSESSMENT DIVISION DURING THE PERIOD JANUARY 1, 1999 TO DECEMBER 31, 1999 ARE LISTED BELOW:

PRIMARY

King, J.R. and D.A. Jackson. 1999. Variable selection with principal components analysis of environmental data. Environmetrics 10: 67-77.

King, J. R., B. J. Shuter and A. P. Zimmerman. 1999. Empirical links between thermal habitat, fish growth and climate change. Trans. Am. Fish. Soc. 128: 656-665.

King, J. R., B. J. Shuter and A. P. Zimmerman. 1999. Signals of climate trends and extreme events in the thermal stratification pattern of multibasin Lake Opeongo. Can. J. Fish. Aquat. Sci. 56: 1-6.

King, J. R., G. A. McFarlane and R.J. Beamish. 2000. Decadal scale patterns in the relative year class success of sablefish (*Anoplopoma fimbria*). Fish. Oceangr. 9.

Beamish, R.J., D. McCaughran, J. King, R. Sweeting and G.A. McFarlane. 2000. Estimating the relative abundance of juvenile coho salmon in the Strait of Georgia using surface trawls. N. Am. J. Fish. Man. 20: 369-375.

Beamish, R.J, G.A. McFarlane and J.R. King. 2000. Fisheries Climatology: Understanding the Decadal Scale Processes that Regulate British Columbia Fish Populations Naturally. *In* Fisheries Oceanography: Science for the new millenium. P. Harrison and T. Parsons [eds.].

Hajirakar, M., R. Kieser, R. D. Stanley, A. M. Cornthwaite, and P. Y. Huang. 1999. Three-dimensional visualisation of fishery acoustic data and bathymetry using IBM Visualisation Data Explorer. Can. Man. Rep. Fish. Aquat Sci. 2486.

Stanley, R. D., A. M. Cornthwaite, R. Kieser, K. Cooke, G. D. Workman, and B. Mose. 1999. An acoustic biomass survey of the Triangle Island Widow rockfish (*Sebastes entomelas*) aggregation by Fisheries and Oceans, Canada and the Canadian Groundfish Research and Conservation Society, January 16 – February 7, 1998. Can. Tech. Rep. Fish. Aquat. Sci. 2262.

OTHER PUBLICATIONS

King, J.R. and T.W. Gjernes. 1999. Estimate of 1998 recreational halibut catch in British Columbia waters. Can. St. Ass. Sec. Res. Doc. 99/121. 25 p.

APPENDIX 3. STOCK ASSESSMENT DIVISION GROUNDFISH STAFF IN 1999

W. Andrews	Sablefish and hake technician
K. Charles	Fish Ageing technician
K. Cooke	Population hydroacoustics estimation
G. Kronkite	Acoustic development methods
R. Kronlund	Analytical programs
J. Fargo	Stock assessment and biology
C. Fort	Herring assessment
D. Gillespie	Fish Ageing technician
R. Haigh	Statistical analysis, exploratory data analysis
L. Hamer	Herring data base management
S. Hardy	Statistics/sampling
S. Janz	Fish Ageing technician
G. Jewsbury	Sablefish and hake technician
T. Johansson	Statistics/sampling
R. Kieser	Population hydroacoustics estimation
J. King	Lingcod assess, Sablefish climate studies
B. Krishka	Sablefish biologist
D. Little	Fish Ageing technician
G. A. McFarlane	Marine Fish stock assessment, population dynamics and biology, fish/ocean interaction
S.E. MacLellan	Fish Ageing Supervisor
W. Mitton	Sablefish, hake, dogfish and pollock
T. Mulligan	Acoustic development methods
N. Olsen	Analytical programs, statistical analysis
K. Poier	Sablefish ageing technician
J. Rankin	Fish Ageing technician
K. Rutherford	Statistics/sampling
M. Saunders	Groundfish stock assessment and biology
J. Schweigert	Herring stock assessment and stock identification
J. Schnute	Multispecies stock assessment, mathematical analysis
R. Stanley	Shelf rockfish stock assessment biology, sampling studies
M. Surry	Lingcod technician
R. Tanasichuk	Hake/herring/euphausiid interactions
N. Venables	Statistics/sampling
G. Workman	Technical support
L. Yamanaka	Rockfish stock assessment and biology