

CANADA
British Columbia Groundfish Fisheries and Their Investigations in 2001

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by

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**REVIEW OF AGENCY GROUND FISH RESEARCH, STOCK ASSESSMENT,
AND MANAGEMENT**

A. Agency overview

Fisheries and Oceans Canada (DFO), Science Branch, operates three principal 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 West Vancouver, BC, respectively. During the past two years, as part of a re-organization strategy, some stock assessment research has moved from the main Science facility at PBS to regional offices in Nanaimo, Kamloops, Prince Rupert, and Port Hardy. Dr. Laura Richards is currently the Acting Regional Director of Science. The Division Heads in Science Branch reporting to Dr. Richards are:

| | |
|--|---------------------------|
| Stock Assessment Division (STAD) | Mr. T. Perry (Director) |
| Marine Environment and Habitat Science | Dr. J. Pringle (Director) |
| Ocean Science and Productivity | Mr. R. Brown (Director) |
| Aquaculture | Dr. D. Noakes (Director) |

Groundfish research and stock assessments are conducted primarily in the Groundfish Section of the Stock Assessment Division, (Mr. Jeff Fargo, Head). Groundfish ageing and acoustics work is currently done in the Applied Technology Section (Mr. Mark Saunders, Head). DFO research vessels are operated by the Canadian Coast Guard. These vessels include the W.E. Ricker and J.P. Tully.

Management of groundfish resources is the responsibility of the Pacific Region Groundfish Coordinator (Mr. Al MacDonald, acting) within the Fisheries Management Branch in Vancouver, BC. Fishery Managers receive assessment advice from STAD through the Pacific Scientific Advice Review Committee (PSARC). The Chair of PSARC (Dr. Max Stocker) advises the Regional Management Committee on stock status and biological consequences of fisheries management actions and works in consultation with the Canadian Stock Assessment Secretariat (CSAS) in Ottawa. Research documents can be viewed on the website:<http://www.pac.dfo-mpo.gc.ca/sci/psarc/ResDocs/resdocs.htm>

Trawl, sablefish (trap and hook-and-line), and halibut (hook-and-line) fisheries continue to be managed with Individual Vessel Quotas (IVQ). IVQ's can be for specific areas or coastwide. Within the general IVQ context, managers also make use a suite of management tactics including time and area specific closures and bycatch limits. Specific management issues are addressed below when appropriate.

B. Multispecies or Ecosystem Studies

1. Ecosystem Approach to Fisheries Management in Hecate Strait:
(Website: <http://www-sci.pac.dfo-mpo.gc.ca/sa-hecate/default.htm>).

- i. Research Programs in 2001

A three-year research project was initiated in 2001 that involved fishery scientists, oceanographers and geologists from government institutes and universities. The objectives are to expand the knowledge of the major factors affecting the productivity of fisheries in the Hecate Strait region and to develop new stock assessment techniques that incorporate ecosystem considerations. These new techniques will then be introduced into the mainstream advisory process.

The initial year of the project was largely descriptive. It focused on locating all legacy data on marine populations and their habitats, improving data accessibility using modern database management technology, and developing analytical tools that allow integration of diverse indices on appropriate spatial and temporal scales. Work to date has accomplished the following:

- Compilation of existing surficial sediment sample data for the northern continental shelf of western Canada, including Hecate Strait, Dixon Entrance and Queen Charlotte Sound, was completed. Sample parameters were compiled into a GIS format (ArcInfo) and include percentage composition from about 3,500 grab samples collected during approximately 20 cruises. Statistical values related to mean grain size, sediment sorting and other parameters were also compiled. These data are now available to compare fish and invertebrate species distributions with seabed texture as well as conduct other analyses.

- Grab samples collected by the WE Ricker during a DFO research cruise in June 2001 (104 grab samples) are being processed at the Pacific Geoscience Centre (GSC-Pacific) and will be completed by March 31/2002. These data will be integrated into the regional compilation. Planning for a joint research cruise between DFO - PBS and GSC – Pacific is ongoing. The cruise will collect new data at sites of interest to both parties in June 2002, and will help facilitate multidisciplinary study of Hecate Strait.
- Summer and winter salinity, temperature, and wind fields were used in a diagnostic finite element model to compute background seasonal circulation fields for the entire BC coast. Boundary condition adjustments were made to incorporate additional features such as the California Undercurrent. The resultant surface elevations were then used to compute a mean sea level that could be used to provide absolute elevations, rather than anomalies, for the satellite altimeter observations that are used to track eddies.
- Models were developed to hindcast and forecast the water circulation along the north coast of BC and to simulate the generation of the Haida Eddies. To date, the precise generation mechanism has not been identified.
- In collaboration with Parks Canada, a series of particle tracking experiments were conducted to investigate the transfer of larvae among potential marine protected areas surrounding Hecate Strait and Queen Charlotte Sound.
- Existing physical, chemical, and biological oceanographic data including temperature, salinity, CTD, current meter, wind, nutrient, chlorophyll, and zooplankton data for the study area, were assembled and screened for further analysis. These data will be used to parameterize a predictive model of primary and secondary production in the study area.
- Analyses of groundfish species and assemblage distributions from the commercial fisheries data were undertaken. These will provide the basis for determining species groupings for ecosystem modelling and multispecies catch forecasts.
- Historical groundfish stomach contents data were analyzed to determine trophic interactions in the study area.
- Preliminary Ecopath/Ecosim model formulations were investigated and additional data requirements were identified.

ii Research activities planned for 2002

- Produce groundfish trawl fishery atlas.
- Compile oceanographic data relevant to modelling primary and secondary production.
- Analyse factors affecting Pacific cod recruitment.
- Complete groundfish diet analysis.
- Field test a video survey method.
- Analyse video survey design for forage species.
- Map surficial geology of different fish community habitats using high resolution sonar and echo sounding.
- Review Ecosim model results and integrate estimates of primary and secondary production.

- Analyse associations among fish/invertebrate communities and bottom type in the study area.
- Conduct a project workshop to review project progress, determine year-3 goals and objectives and publish proceedings.

C. By species

1. Pacific cod

i. Research programs in 2001

The recent reduction in Total Allowable Catch (TAC) for Pacific cod (*Gadus macrocephalus*) in Hecate Strait has resulted in a virtual cessation of commercial fishing for the species. Consequently, traditional fishery dependent stock abundance indices are no longer available to track changes in stock size and potential recovery of the stock. A Pacific cod monitoring survey was started in March 2002 for this purpose. A commercial fishing vessel was chartered by the Canadian Groundfish Research and Conservation Society (CGRCS) for this survey. The survey plan is to conduct a series of 5 monthly surveys annually during March – July. The results will provide a relative index of stock size as well as information on maturity, growth, and distribution. The surveys will be conducted for 3 years.

ii. Stock assessment in 2001

The Pacific cod stocks off the west coast of Vancouver Island (3CD) and in Hecate Strait (5CDE) were assessed using the available commercial fisheries and research survey data. A delay-difference stock production analysis was used to synthesise these data. For the 3CD stock, indicators of biomass and recruitment are currently very low but have been increasing slightly in recent years. Fishing mortality and fishing effort on the stock have been reduced and this should aid stock recovery. The current TAC plus carry over is 893 t. Catches in this range in 2002 would result in a decline in stock biomass and further compromise stock rebuilding. However, the TAC for this stock has never been caught. If catches continue to be similar to those of recent years (less than 200 t), there may be improvement in stock biomass.

An index of sea level height in Prince Rupert was incorporated in the assessment model for the area 5CD stock. High sea levels during January-March have been associated with high transport through the Hecate Strait area and reduced recruitment for the stock. Conditions have been unfavourable for recruitment through most of the 1990s, however, sea levels have declined in the past 2 years and recruitment may be improving. Stock biomass is estimated to be very low. Fishing mortality and fishing effort had been relatively high prior to 2001, however these were reduced in 2001 due to the reduced TAC, and this should aid stock recovery. If the current TAC of 200 t is maintained for 2002, the stock biomass may increase 25-35% and allow some stock rebuilding.

iii. Research activities planned for 2002

The Pacific cod monitoring survey will be continued in Hecate Strait through 2002 and 2003.

2a. Rockfish - offshore

i. Research programs in 2001

A deep water bottom trawl survey was started in 2001 (Sep 15 - Oct 2) to estimate relative thornyhead biomass off the west coast of Vancouver Island (WCVI). The 3-year survey, funded by the CGRCS, will be conducted aboard the F/V Viking Storm each year. Survey design includes stratification by region and depth with random sample locations. CGRCS and Stock assessment staff at PBS will provide scientific input and analysis.

Biological information was gathered from 16 species including longspine thornyhead (*Sebastolobus altivelis*), shortspine thornyhead (*Sebastolobus alascanus*), sablefish (*Anoplopoma fimbria*), Dover sole (*Microstomus pacificus*), deepsea sole (*Embassichthys bathybius*), arrowtooth flounder (*Atheresthes stomias*), roughscale rattail (*Coryphaenoides acrolepis*), pectoral rattail (*Albatrossia pectoralis*), skates and other rockfish (*Sebastes* spp.). Ninety-nine species/groups were collected from 63 tows, and 58 of these tows were usable for biomass estimation. Bottom contact sensors were used to re-define estimates of effort in place of the traditionally used time, measured from winch lockup to winch release.

ii. Stock assessment in 2001

Stock assessments were performed for Pacific ocean perch (*Sebastes alutus*) and longspine thornyhead in 2001. Schnute *et al.* (2001) provide the most extensive compilation to date of scientific data currently available for Pacific ocean perch in BC waters. Following the rationale in the 1997 assessment, they present an updated catch-age analysis for the Goose Island Gully (GIG) stock and extend these results to the rest of the coast. The analyses take account of spatial distributions and other biological features investigated in slope rockfish stock assessments since 1998. The catch-age analysis indicates that the GIG stock currently experiences low recruitment at age 7, probably associated with an ocean climate regime starting in 1988. They urge caution in setting quotas, so that adequate biomass remains for the future when productivity improves. Additional analyses, using swept-area biomass estimates, indicate that the current quota distributions among management areas match available biomass levels fairly well, with some possible opportunities for quota redistribution.

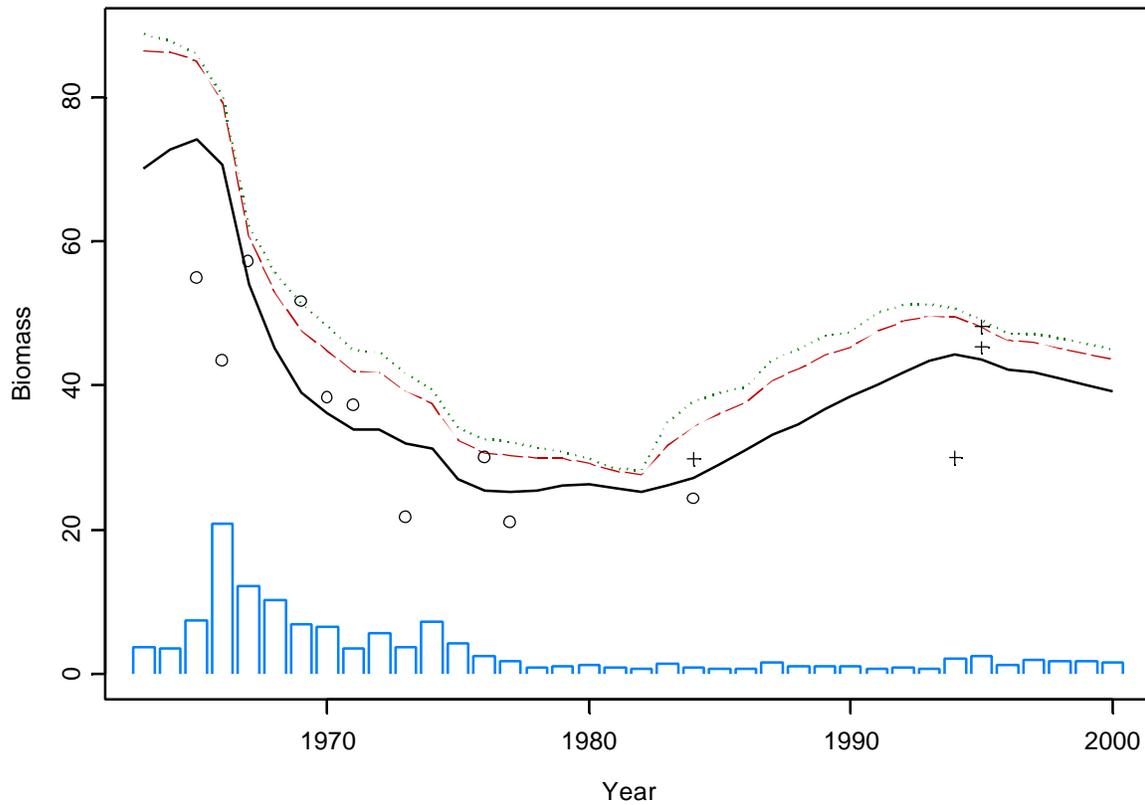


Figure 1. Results of the Goose Island Gully Pacific ocean perch catch-age analysis. Annual biomass estimates (kt): available to the fishery (solid black line); mature (dashed line); total (dotted line). Circles indicate government research vessel survey estimates, scaled to available biomass. Plus symbols indicate scaled commercial vessel charter survey estimates. The bar plot represents annual catches.

Starr (2001) provides a detailed compilation and analysis of the available data for longspine thornyheads found in BC waters. The length frequency data from the commercial fishery show that length distributions have been stationary over four years. Additionally, there are no obvious differences in length between the fisheries of the traditional WCVI area and the new northern exploratory areas. Relative abundance indices, estimated from CPUE data using general linear modeling methods, show a 25% decline in biomass over the five-year history of the fishery. This level of change is consistent with previous population modeling for longspines. The report suggests that the current level of fishing should continue for another year until results from the 2001 longspine survey (Section 2.a.i) and current comprehensive fishery monitoring are reviewed. The report also notes that the most important additional research requirement for longspine thornyhead is information on growth rates and productivity.

iii. Research activities planned for 2002

In 2002, the second year of the thornyhead survey will take place. All aspects of the survey will remain the same as in 2001. The only differences will be (i) an earlier start to the survey and (ii) the addition of net mensuration capabilities.

Science staff will likely update the longspine thornyhead assessment due to intense interest by managers and industry. Additionally, there is pressure to implement a more rigorous experimental design for this fishery to maximize the usefulness of observer-collected biological information. This might include selective openings and closures and depletion fishing. Such a design could induce contrasting stock sizes and biological responses to fishing pressure on the relatively pristine longspine thornyhead populations north of the traditional grounds off the WCVI.

Issues involving the other slope rockfish species have not yet been flagged for attention in 2002. There is some interest in delineating stocks of Pacific ocean perch along the WCVI. If the population here appears to comprise one stock, industry is interested in combining the two quota areas. Other species, such as rougheye rockfish (*S. aleutianus*), that are also harvested in significant numbers by the hook and line fleet may be identified for attention due to the recent coastwide conservation measures implemented to protect inshore rockfish.

2b. Rockfish – shelf

i. Research Programs in 2001

The shelf rockfish program continued the study of yellowtail rockfish (*S. flavidus*) genetics during 2001. Samples from the central and southern portions of the BC coast were analysed. Preliminary results indicate no structure in these samples. The project awaits completion of US analysis of Washington-California samples, scheduled for 2002. Subject to funding, this project should be completed in early 2003.

A study was also initiated with the International Pacific Halibut Commission (IPHC) and DFO staff at the Bedford Institute of Oceanography (Halifax) on C¹⁴ ageing of silvergray rockfish (*S. brevispinis*). The first step in the study is an experiment to examine whether archived otolith samples have been affected by storage in glycerine.

A second age validation study is being conducted on canary rockfish (*S. pinniger*) with staff the Moss Landing Marine Laboratory in California. BC and US samples are being aged using more traditional radiometric techniques. Results of this work should be completed in 2002-2003.

Research work also focused on preparation of a report on the role of “Participatory Research” in the BC groundfish fisheries. The paper summarizes two research case studies wherein commercial fishers played a major scientific role in the hypothesis formulation, design, execution and analysis of results. The paper emphasizes that fishers

have far more to offer the scientific process than is implied by such terms such terms as “fisher”, “local”, or “traditional” knowledge.

ii. Stock assessments in 2001

Canadian shelf rockfish stock assessment activities concentrated on preparation of a status report on bocaccio (*S. paucispinis*) for BC waters (Stanley, Rutherford, and Olsen 2001). This document was prepared in PSARC format (http://www.pac.dfo-mpo.gc.ca/sci/psarc/ResDocs/res_docs.htm) and was submitted in format acceptable for the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). It is currently under review by COSEWIC. Data are too limited for a stock assessment. Catch data from the trawl observer program indicate that bocaccio are still widespread over the entire outer coast. However, US triennial survey results indicate a significant decline over the Canadian waters covered in the survey, the southwest coast of Vancouver Island.

iii. Research activities planned for 2002

During 2002, scientific staff will update the silvergray rockfish assessment for the November 2002 PSARC cycle. Staff will also participate with fishers in the design of a coastwide groundfish survey, to be initiated in 2003. Age validation studies, as reported above, will also be continued.

2c. Rockfish – inshore

i. Research programs in 2001

Analyses of under water video and fishing sets from a two-week research cruise to Bowie Seamount (53°20' N 135° 40' W), and Gwaii Haanas (52°03' and 52°12' N, 131°13' and 131°27' W), was initiated in 2001.

A microsatellite DNA study was completed for quillback rockfish (*S. maliger*) in 2001. The study provided evidence for very high levels of genetic variation within quillback rockfish aggregations and very low levels of differentiation among the 19 samples collected from throughout BC. Samples collected in Puget Sound and the US portion of the Strait of Georgia were slightly differentiated from samples in BC but also displayed high levels of genetic variation. Over 99.5% of the observed variation was contained within samples, with less than 0.5% of variation accounted for by the differentiation of BC and US samples and the variability within each of those regions. The low level of sample differentiation and failure of multiple samples from the same location to consistently cluster suggests that gene flow, mediated by larval dispersal, among quillback breeding aggregations throughout BC is, or has been, extensive. If recent low levels of abundance have disrupted historical patterns of gene flow, it is not yet evident among mature quillback of the age groups encompassed in this study.

ii. Stock assessment in 2001

Inshore Rockfish (yelloweye rockfish, *S. ruberrimus*; quillback rockfish, *S. caurinus*; black rockfish, *S. melanops*; tiger rockfish, *S. nigrocinctus*, and china rockfish, *S. nebulosus*) Stock Assessment for the West Coast of Canada and Recommendations for Management was presented at the PSARC meetings in November 2001 (Yamanaka and Lacko 2001). Available data for stock assessment are insufficient to recommend species specific catch quotas for the five management areas on the Pacific coast of BC.

However, evidence of significant fishing effects on yelloweye and quillback rockfish populations at research survey sites and other fishing locations in BC were presented. Given the biology of inshore rockfish, together with the inability to assess total catch and evidence of excessive fishing mortality, it is recommended that a portion of the rockfish population in each management area be completely protected from harvest through spatial management measures such as harvest refugia (areas closed to fishing) as a precautionary measure to promote conservation. In addition, comparable reductions in fishing effort in the remaining areas open to fishing must be accomplished or exceeded if managers choose to remain with the status quo or begin the rebuilding of stocks. Efforts to improve catch data and stock monitoring indices as well as stock assessment methods must continue to enable the possibility of an assessment of inshore rockfish stock status in the future.

iii. New Management and Regulations related to Inshore Rockfish

On November 21 and 22, 2001, a multi-sector workshop was held in Nanaimo, BC, to focus on the conservation and sustainable use of BC's groundfish fisheries, particularly the inshore rockfish fisheries. Participants at the workshop included First Nations, commercial and recreational harvesting sectors, non-governmental organizations, DFO, the Province of BC and other interested parties. The workshop was intended as a step towards a more integrated process to address rockfish and groundfish management issues. The workshop focused on:

- Developing a common understanding of inshore rockfish and associated groundfish management issues.
- Examining the fisheries in the Strait of Georgia fisheries and elsewhere on the BC coast, which have an impact on inshore rockfish and associated groundfish species.
- Gathering input on the range of management options available.
- Developing specific recommendations on how to proceed with creation of a strategy and suite of tactics to achieve conservation-based sustainable management of these fisheries.

The Minister of Fisheries and Oceans announced in December 2001 that strong measures to rebuild inshore rockfish stocks would be put in place by April 2002. Management goals to be addressed through the consultative process for the conservation and rebuilding of inshore rockfish stocks are:

- Significant portions of rockfish habitat will be closed to all fishing as a buffer against scientific uncertainty and catch data gaps, as well as for the essential protection and rebuilding of inshore rockfish stocks. Specific sites will be identified in cooperation with First Nations, commercial, recreational, environmental, and local interests for the 2002 fishing season.
- Fishing mortality will be substantially reduced for the 2002 fishery. Initial management measures will be implemented both to reverse the trend of increasing total mortality rate and to reduce the harvest rate to less than two percent.
- Comprehensive catch monitoring programs will be established that will allow for an accounting of all inshore rockfish catch (retained and released). Specific measures to achieve this will be developed with harvesters and initiated for the 2003 fishing season and fully implemented in the following year.
- A stock assessment framework for inshore rockfish will be developed by December 2002. Complementary stock monitoring programs, which will include the collection of abundance and biological data, will be developed in consultation with and participation of commercial and recreational harvesters and First Nations.

In January, consultations on a Rockfish Conservation Strategy began with DFO's formal advisory bodies in the recreational and commercial fishing sectors. Public meetings were held at nine locations along the coast in February and March. Input from all the consultations have been used to formulate recommendations to the Minister for a decision on DFO's approach to inshore rockfish and associated groundfish conservation measures.

iv. Research activities planned for 2002

Analysis of Bowie Seamount data as well as continued participation in the development and implementation of the Rockfish Conservation Strategy will dominate inshore rockfish research activities in 2002.

3. Sablefish

i. Research programs in 2001

The annual longline trap survey was conducted under charter in the fall of 2001 aboard the chartered fishing vessel Ocean Pearl. Standardized sets were conducted at nine localities spatially dispersed along the B.C. offshore coast to provide a catch rate index. The localities were selected because they were fished by commercial vessels and are located about 60 nm apart such that normal weather conditions would permit all localities to be occupied within a 30 day period. The survey was depth stratified in the sense that sets in each locality were targeted within five depth ranges, but there is little replication of sets within each stratum. Additional sets were conducted within the survey localities to capture sablefish for tag application and release at the point of capture. A second component of the survey was conducted in the inshore waters of Hecate Strait and associated inlets to tag juvenile sablefish. In the course of 134 survey sets a total of 18,248 fish were tagged for release, 908 tagged fish were recovered, and 3,983 fish were

sampled for biological data (2,670 otolith pairs). Another survey is planned for the fall of 2002.

ii. Stock assessment in 2001

Stock assessment and management of sablefish in British Columbia is conducted cooperatively by the Canadian Sablefish Association (CSA) and DFO. The cooperative relationship is formalized under the auspices of a Joint Project Agreement (JPA) to:

- Ensure the proper management of the commercial sablefish fishery.
- Conduct necessary scientific research to assess the health and sustainability of the sablefish resource and assess ecosystem impacts.
- Provide adequate funding and resources.
- Carry out all other activities deemed necessary to support the fishery including enforcement, at-sea monitoring, maintenance of data systems, and provision of scientific advice to fishery managers and the industry.

Two assessments of sablefish were conducted during the 2001/2002 fiscal year. The November 2001 assessment of sablefish (Haist *et al.* 2001) relied primarily on the examination of abundance and exploitation rates computed from tag returns in the year following release. Trends in survey catch rates and, to a lesser extent, commercial trap fishery catch rates were used to corroborate the tag-recovery analysis. Based on the time series of exploitation rate estimates, the vulnerable biomass of sablefish in BC was considered to be low and stable from 1996 to 2000 at about 35,000 t. A TAC of 4,000 t coastwide was recommended for the 2002/2003 fishing year (Haist *et al.* 2001, Stocker and Cass 2001), the same harvest recommended for the previous fishing year (Haist *et al.* 2001, their Table 2).

Preliminary results from the 2001 sablefish survey became available subsequent to the preparation and review of the November 2001 assessment. Catch rates observed during the 2001 survey declined significantly compared to those observed in the previous five years (Fig. 2). The mean number of sablefish caught per trap declined to about 0.6 of the 1996 to 2000 mean catch rate for the southern stock. The observed decline was greater for the northern stock, with 2001 catch rates equalling about 0.2 of the 1996 to 2000 mean catch rate. In view of the preliminary results, fishery managers requested that the survey data and sablefish stock status be reviewed, and the tagging analysis updated in January 2002. A second assessment (Kronlund *et al.* 2002) was prepared as a supplemental to the November assessment to accommodate the new survey information and to help evaluate whether the current assessment of sablefish stock status should be revised.

Survey catch rates showed declines from 1990 to 2001 in seven of nine localities and generally showed declines in all depth strata surveyed. The decline was steepest in the first half of the time series, and slowed from 1996 to 2000. Catch rates in 2001 were the lowest in the time series, and generally exhibited much smaller variance in comparison to

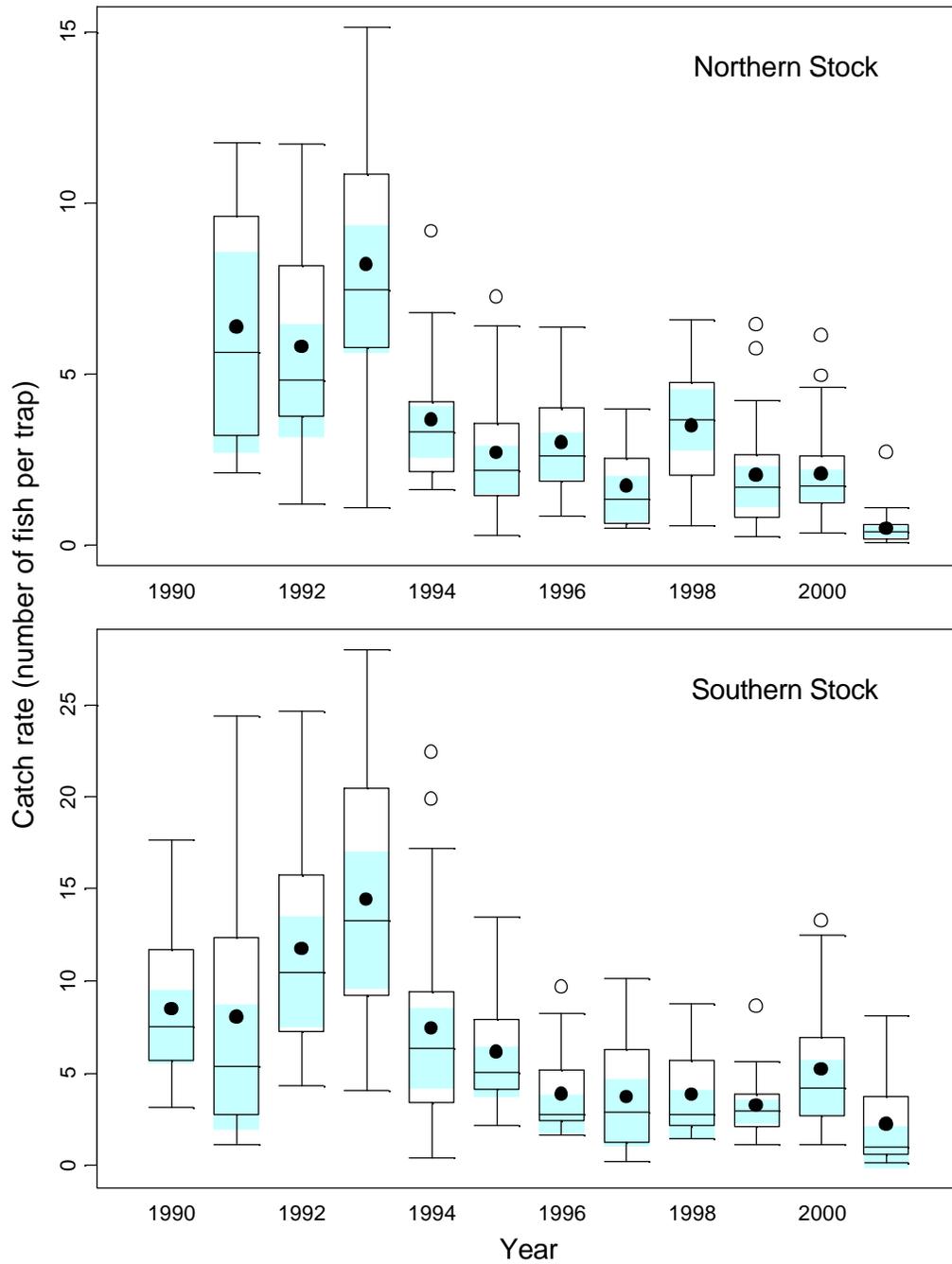


Figure 2. Distribution of sablefish survey catch rates (number of fish per trap) for each set by year and stock. Boxplots show the distribution of catch rates observed on each set. The filled circles show the mean annual catch rate. The lightly shaded rectangle indicates an approximate 95 percent confidence interval on the median annual catch rate.

previous years. Commercial catch rates calculated from logbook records showed trends similar to the survey data within the survey localities. Trends were less well defined outside of the survey areas, but suggested a decline from 1990 to 2001 and reduction in variance in the latter few years of the series. Interpretation of these trends is complicated by the adoption of escape rings in trap gear in 1998. Estimates from the tagging program for 2001 indicated a biomass of 37,300 t with an exploitation rate of 0.096. The estimates of abundance were without trend from 1995 to 2001, with no significant outliers evident within this period. The tagging program estimates showed no evidence of such a dramatic decline in abundance from 2000 to 2001.

In order to accommodate concerns that the stock may be experiencing continued decline since the mid 1990s, it was recommended that the TAC be reduced for the 2001/2002 fishing year, which began August 1, 2001. The recommended yield range was 2,100 to 2,800 t based on harvest rates of 0.06 to 0.08, as measured by the tag-recovery analysis. The harvest rates were selected from the low end of a range determined to be appropriate for sablefish using a modified spawning biomass per recruit model presented in Haist *et al.* (2001). Managers adopted a quota of 2,800 t for 2001/2002, in place of the original 3,600 t allocated to the directed sablefish fishery. The total allocation for all fisheries was reduced accordingly from 4,000 to 3,200 t. A target quota of 2,450 t was adopted for the 2002/2003 fishing year and the stock will be re-assessed in early 2003.

iii. Research activities planned for 2002

Routine ageing of sablefish has not been conducted in BC since 1997, although structures have been collected. Plans for 2002/2003 include conducting a comparison between the break-burn and thin-section methods of otolith preparation to determine whether uncertainties in ageing can be reduced.

The Joint Project Agreement for sablefish stipulates that science programs be reviewed every three years by an independent panel. The first such Triennial Review is tentatively scheduled for the fall of 2002 and should provide direction for subsequent assessment and research efforts.

Another abundance index/tagging survey is planned for the fall of 2002.

4. Flatfish

i. Research programs in 2001

A groundfish survey of flatfish demographics was conducted in Hecate Strait in 2001. The objective of the survey was to obtain data on the life history characteristics of flatfish species in this region. Biological samples were collected for arrowtooth flounder, Dover sole (*Microstomus pacificus*), English sole (*Pleuronectes vetulus*), flathead sole (*Hippoglossoides elassodon*), petrale sole (*Eopsetta jordani*), rex sole (*Errex zachirus*),

rock sole (*Pleuronectes bilineatus*), Pacific sanddab (*Citharichthys sordidus*), butter sole (*Pleuronectes isolepis*) and sand sole (*Psettichthys melanostictus*).

ii. Stock assessment in 2001

A stock assessment was completed for arrowtooth flounder in 2001 (Fargo and Starr 2001). Results of analysis of biological data, research survey data and observer data were summarised. Results from the analysis of observer data indicated that the variability in the CPUE index from the commercial fishery is mainly due to area and seasonal effects (and in some cases, depth) and that these variables change among years. The analysis of the discard data indicates that this fishery appears to be passive with little evidence of targeting behaviour on the part of the trawl fleet. The arrowtooth flounder CPUE index from research surveys conducted in Hecate Strait between 1984 and 2000 showed no trend but does show cyclic fluctuations over that period. Size and age composition data show no distinct trends over time. The instantaneous total mortality rate estimates for 1980, 1998 and 2000 did not differ despite a 20-y exploitation history. The study concluded that the current fishing mortality rate for arrowtooth flounder stocks off the West Coast of Canada is at or below the sustainable level.

iii. Research activities for 2002

In 2002, the relative abundance indices for flatfish species in Hecate Strait will be updated using the multispecies trawl survey for this region. In addition, the assessment will examine the effect of long-term changes in growth on yield for rock sole and English sole. A research cruise aboard the J.P. Tully will collect habitat data to examine flatfish associations across habitat areas. These results will be used to refine estimates of biomass for those species.

5. Pacific hake

i. Research programs in 2001

The joint U.S./Canada triennial echo-integration/trawl survey was conducted during July/August 2001 using the NOAA research vessel Miller Freeman and the W.E. Ricker. The resulting estimate of total biomass declined to 738 kt from 1,200 kt in 1998, the lowest observed biomass in the survey time series. There was some indication of moderate recruitment from the 1999 year-class (age 2's) accounting for 400 kt of the 738 kt of total biomass. The age 2's were present from California to Washington but did not show in the Canadian portion of the survey.

ii. Stock assessment in 2001

Canadian researchers participated in the preparation of a major assessment of hake that incorporated the results of the 2001 triennial surveys. A joint Canada/US

(PSARC/STAR) panel review of the assessment was conducted in February 2002 in Seattle.

iii. Research activities planned for 2002

During August and November 2002, a towed body with 38 and 120KHz transducers will be used to examine bias in deepwater estimates in hake target strength. During the August cruise, a synoptic set of hake biological samples will be collected throughout the coast but acoustic data will not be collected. An echo integration/trawl survey of the Strait of Georgia hake stock is planned for March 2003.

6. Elasmobranchs

i. Research programs in 2001

There were no directed research projects on sharks and skates in BC during 2001.

ii. Stock assessment in 2001

A “Phase 0” report on skates and rays (Benson *et al.* 2001) was prepared in 2001. This document addressed questions raised by managers in order to form the basis for subsequent research and management actions. This report compiles fisheries and biological statistics from BC, reviews assessment and management approaches used in other jurisdictions, and examines which of these approaches may be most appropriate for BC.

Elasmobranch catches in BC waters averaged 550 t in the 1970s and 1980s and increased to a maximum of 1,850 t in 1997. The average catch between 1998 and 2000 was 1,400t. Three species of ray, ten species of skate and fourteen sharks have been reported from BC waters. Only big skate (*Raja binoculata*), longnose skate (*Raja rhina*), black skate (*Bathyraja interruta*) and sixgill shark (*Hexanchus griseus*) are regularly components of the bycatch in BC fisheries. There is targeting on big and longnose skate.

iii. Management

There are no directed fisheries allowed for sharks (excluding spiny dogfish, *Squalus acanthius*) in BC waters; therefore catches are bycatch only. There is no immediate concern regarding the bycatch of sharks in BC fisheries, therefore no specific recommendations are made. However, the bycatch should be monitored by species and area in order to ensure that future productivity of BC sharks is not compromised.

Skate species are not actively managed in British Columbia. Recent increases in directed catch of skate have prompted management to examine options for the 2002/2003 and subsequent fishing years. These option could include area/species specific caps on catch levels.

iv. Research activities planned for 2002

No research on elasmobranchs is planned for 2002.

7. Lingcod

i. Research programs in 2001

A lingcod (*Ophiodon elassodon*) nest density survey program was conducted in 2001 at Snake Island reef in the Strait of Georgia to augment data collected in 1990, 1991, and 1994. The 2001 nest densities estimates were higher than in 1990 and 1991. This study will be continued in subsequent years.

Preliminary genetic results from egg mass samples collected in 2001 indicate contributions from more than two parental components. Age validation on the fin ray method of lingcod was completed in 2001, with publication of OTC research conducted earlier. Fin rays from juvenile lingcod (1-3 year olds) were collected in 2001 and will be used to develop ageing criteria and estimate average 1 and 2 annuli measurements to aid in age determination.

ii. Stock assessment

Offshore

No assessment was conducted on offshore lingcod stocks in 2001.

Inshore

An assessment of lingcod in the Strait of Georgia was conducted in 2001. Recreational CPUE indices indicated an increase in juvenile (<65 cm) lingcod since 1999, however recruitment to the ≥65 cm size class has not increased. Strait of Georgia lingcod are considered to be at very low and stable levels. In order to foster an increase in abundance of the spawning population, recreational restrictions were recommended.

iii. Research activities planned for 2002

The lingcod nest density study will be continued in 2002. Genetics analysis of males and egg masses and will also be continued in 2002 to further examine paternal and maternal genetic contributions. Nest site affinity research will be initiated in 2002 and continued in 2003.

D. Other related studies

1. Statistics and Sampling

Principal Statistics and Sampling activities in 2001 included the ongoing population of the biological specimen database (GFBio). This database currently archives data on about 4,300,000 specimens. Data entry activities concentrate on input of current port sampling and observer biological data and recent research cruises. When time is available, the database is backfilled with research cruise data collected before 1997. Approximately 50% 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% dockside and virtually 100% observer coverage. These observers also provided about 500 length/sex/age samples and 700 length samples in 2001. Hook-and-line and sablefish trap landings have 100% dockside validation. Observer coverage in the hook-and-line fishery was initiated in 2000 and in 2001, however, the target of 10% was not achieved. The port sampling unit field-tested a new hand-held data-logging unit in 2001. This model will replace the previous non-DOS based system. The data recording program of the new system can be adapted in the field.

Staff continue to expedite and streamline the data collection and data processing methods, as well as provide more efficient and easy-to-use tools for data extraction and reporting. For example, all biological research cruises now make use of a computerized data-entry application designed specifically for GFBio. This system allows for rapid migration of data into GFBio at the completion of each survey. For data extraction and reporting, staff have developed both stand-alone and web-based tools that offer features such as interactive mapping, tabular data summaries, and advanced graphical analyses.

APPENDIX 1. REVIEW OF CANADIAN GROUND FISH FISHERIES

1. Commercial fisheries

All catch figures for 2001 are preliminary. Canadian domestic trawl landings of groundfish (excluding halibut) in 2001 were 78,784 t, an increase of 80% over 2000. The main cause for the rise was the increase in landings of Pacific hake to domestic plants. The major species in the trawl landings were Pacific hake (50%), arrowtooth flounder (10%), Pacific ocean perch (7%), yellowtail rockfish (5%), and Dover sole (4%).

Canadian landings of groundfish caught by gear other than trawl in 2001 totalled 11,546 t. Sablefish landings by trap and longline gear accounted for 3,280 t, (80% by trap gear and 20% by longline gear). Landings of species other than sablefish by longline, handline and troll gear accounted for 8,266 t (52% dogfish, 28% rockfish 16% lingcod).

2. Recreational fisheries

Each year, the Fisheries Operations Branch conducts creel surveys of the recreational angling fishery in the Strait of Georgia. Principal target species are chinook (*Oncorhynchus tshawytscha*) and coho (*O. kisutch*) salmon. In 2001, these surveys covered the months of April to November. Provisional estimates of 2001 catches, landings and discards, for this 8-month period were 9,181 lingcod pieces, 76,024 “rockfish”, 40,963 fish “flatfish”, 1,565 dogfish, 3,146 fish halibut, and 23,564 of other species, including greenling (*Hexagrammos* spp.), cabezon (*Scorpaenichthys marmoratus*), herring (*Clupea pallasii*) and ratfish (*Hydrolagus colliei*).

3. Joint-venture fisheries

In 2001, 38 Canadian catcher vessels delivered Pacific hake and incidental species to five processing vessels in co-operative fishing arrangements. This fishery took place off the southwest coast of Vancouver Island (Area 3C). A total of 21,650 t of Pacific hake was processed by 5 Polish vessels. The quotas and catches are outlined below:

| Nation Species | Quota (t) | Catch (t) |
|----------------|------------|-----------|
| Hake | | 21,650 |
| Pollock | incidental | 1,326 |
| Rockfish | incidental | 176 |
| Other | incidental | 673 |

4. Foreign fisheries

There were no national or supplemental fisheries for Pacific hake, or any other species, in BC waters in 2001.

APPENDIX 2. GROUND FISH RELATED REPORTS PUBLISHED BY THE STOCK ASSESSMENT DIVISION IN 2001.

1. Primary Publications

King, J.R., G.A. McFarlane and R.J. Beamish. 2001. Incorporating the dynamics of marine systems into the stock assessment and management of sablefish. *Prog. Oceanogr.* 49: 619-639.

McFarlane, G.A. and R.J. Beamish. 2001. The reoccurrence of sardines off British Columbia characterize the dynamic nature of regimes. *In: Beyond El Nino: A conference on Pacific climate variability and Marine Ecosystem impacts.* *Prog. Oceanog.* 49:151-165.

McFarlane, G.A., R.J. Beamish and J. Schweigert. 2001. Common factors have opposite impacts on Pacific Herring in adjacent ecosystems. *In: Herring 2000: Expectations for the new millennium.* Ak-SG-01-04: 51-67.

McFarlane, G.A. and J. R. King. 2001. The validity of the fin-ray method of age determination for lingcod (*Ophiodon elongatus*). *Fish. Bull.* 99: 459-464.

Schnute, J.T., and L.J. Richards. 2001. Use and abuse of fishery models. *Can. J. Fish. Aquat. Sci.* 58:10-17.

Stanley, R.D., R. Kieser and M. Hajirakar. 2001. Construction of a three-dimensional visualization of a widow rockfish (*Sebastes entomelas*) shoal over interpolated bathymetry. *Int. Jour. Mar. Sci.* 59:151-155.

2. Other publications

Benson, A.J., G. A. McFarlane and J.R. King. 2001. A phase '0' review of Elasmobranch biology, fisheries, assessment and management. DFO Canadian Science Advisory Secretariat Research Document 2001/129.

Benson, A.J., C.M. Neville and G.A. McFarlane. 2001. An Update for the British Columbia Experimental Fishery for Pacific Hagfish (*Eptatretus stoutii*). DFO Canadian Science Advisory Secretariat Research Document 2001/149.

Fargo, J. and P.J. Starr. 2001. Turbot stock assessment for the west coast of Canada for 2001 and recommended yield options for 2002. DFO Canadian Science Advisory Secretariat Research Document 2001/150.

Haist, V., R. Hilborn, and M. Wyeth. 2001. Sablefish Stock Assessment for 2001 and Advice to Managers for 2002. DFO Canadian Science Advisory Secretariat Research Document 2001/135.

- King, J.R. 2001. Assessment of lingcod in the Strait of Georgia. DFO Canadian Science Advisory Secretariat Research Document 2001/132.
- King, J.R. and B.W. Beath. 2001. Lingcod (*Ophiodon elongatus*) nest density SCUBA survey in the Strait of Georgia, January 16 - April 26, 2001. Can. Tech. Rep. Fish. Aquat. Sci. 2374: 21 p.
- Kronlund, A.R. and K.L. Yamanaka. 2001. Yelloweye rockfish (*Sebastes ruberrimus*) life history parameters assessed from areas with contrasting fishing histories. In Spatial processes and management of marine populations. University of Alaska Sea Grant, AK-SG-01-02, Fairbanks.
- Schnute, J.T., R. Haigh, B.A. Krishka, and P. Starr. 2001. Pacific ocean perch assessment for the west coast of Canada in 2001. DFO Canadian Science Advisory Secretariat Research Document 2001/138.
- Stanley, R.D., K. Rutherford and N. Olsen. 2001. Preliminary status report on Bocaccio, *Sebastes paucispinis* Ayres, 1854 from B.C. waters. DFO Canadian Science Advisory Secretariat Research Document 2001/148.
- Starr, P. J. 2001. Assessment of the Canadian longspine thornyhead (*Sebastolobus altivelis*) for 2001. DFO Canadian Science Advisory Secretariat Research Document 2001/136.
- Yamanaka, K.L. and L. C. Lacko. 2001. Inshore Rockfish (*Sebastes ruberrimus*, *S. maliger*, *S. caurinus*, *S. melanops*, *S. nigrocinctus*, and *S. nebulosus*) Stock Assessment for the West Coast of Canada and Recommendations for Management. DFO Canadian Science Advisory Secretariat Research Document 2001/139.

APPENDIX 3. STOCK ASSESSMENT DIVISION GROUND FISH STAFF IN 2001

| | |
|-----------------|---|
| W. Andrews | Sablefish and hake |
| E. Choromanski | General stock assessment and biology, flatfish |
| J. Fargo | Section Head, stock assessment and biology, flatfish |
| R. Haigh | Statistical analysis, exploratory data analysis |
| S. Hardy | Groundfish port sampling |
| G. Jewsbury | Sablefish and hake |
| J. King | Lingcod and sablefish, climate studies |
| B. Krishka | Slope rockfish |
| R. Kronlund | Analytical programs |
| L. Lacko | Inshore rockfish stock assessment and biology |
| G. A. McFarlane | Groundfish population dynamics and biology, fish/ocean interaction |
| K. Mathias | Pacific cod assessment and ecosystem research |
| W. Mitton | Sablefish, hake, dogfish and pollock |
| K. Rutherford | Statistics/sampling |
| J. Schnute | Multispecies stock assessment, mathematical analysis |
| A. Sinclair | Pacific cod assessment and ecosystem research |
| R. Stanley | Shelf rockfish stock assessment and biology, groundfish statistics. |
| M. Surry | Lingcod |
| M. Wyeth | Sablefish stock assessment and biology |
| L. Yamanaka | Inshore rockfish stock assessment and biology |