CANADA

British Columbia Groundfish Fisheries

and Their Investigations in 2003

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REVIEW OF AGENCY GROUNDFISH 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. Dr. Laura Richards is the Regional Director of Science. The Division Heads in Science Branch reporting to Dr. Richards are:

Stock Assessment (StAD)	Mr. T. Perry
Marine Environnent and Habitat Science	Dr. J. Pringle
Ocean Science and Productivity	Mr. R. Brown
Aquaculture	Dr. J. Pringle

Section Heads within the Stock Assessment Division are:

Groundfish	Mr. Jeff Fargo
Shellfish	Mr. Jim Boutillier
Salmon	Dr. Chuck Parken
Conservation Biology	Dr. Chris Wood
Applied Technologies	Mr. Mark Saunders

Groundfish research and stock assessments are conducted primarily in the Groundfish Section of the Stock Assessment Division. Groundfish ageing and acoustics work is currently done in the Applied Technology Section. The Canadian Coast Guard operates DFO research vessels. These vessels include the W.E. Ricker, J.P. Tully and Neocaligus.

The Pacific Region Headquarters of Fisheries and Oceans Canada is located at 401 Burrard Street (Vancouver BC, V6C 3S4). 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 (Mr. Al Cass) 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/res docs.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 use a suite of management tactics including time and area specific closures and bycatch limits. Specific

management issues are addressed below when appropriate. Management plans can be viewed on the website http://www.pac.dfo-mpo.gc.ca/ops/fm/mplans/mplans.htm.

Managers are currently engaging industry in discussions to address issues associated with groundfish conservation and management of the commercial fishery. In particular, DFO and the various fishery sectors (geartypes) are working towards an integrated fishery plan.

Multispecies or ecosystem models
No update is currently available

By species

1. Pacific cod
No update is currently available

2a. Rockfish - offshore

i. Research programs

The third of three surveys for longspine thornyhead *Sebastolobus altivelis* along the west coast of Vancouver Island was conducted Sept 5-20, 2003) under the direction of the Canadian Groundfish Research and Conservation Society (CGRCS). As in 2002, the survey was conducted aboard the F/V Ocean Selector, Dave Clattenberg skipper.

The 2003 thornyhead survey covered 21 area-depth strata and completed 74 tows, 67 of which were useable for estimating biomass. Overall, 96 taxonomic groups were identified. Additionally, a total of 444 biological samples were taken for 18 fish species, yielding 16,100 specimens (16,089 lengths, 3,751 weights, and 3,752 otolith pairs). The top six species accounted for 86% of the total catch weight (24,924 kg): sablefish *Anoplopoma fimbria* (5,755 kg, 23%), roughscale rattail *Coryphaenoides acrolepis* (4,432 kg, 18%), longspine thornyhead (3,579 kg, 14%), shortspine thornyhead *Sebastolobus alascanus* (3,046 kg, 12%), Dover sole *Microstomus pacificus* (2,368 kg, 10%), and pectoral rattail *Albatrossia pectoralis* (2,293 kg, 9%). The time trends of bootstrapped swept-area biomass indices for each of these six species (Fig. 1) show no significant detectable change in abundance. Presumably, a few more years of surveys will be needed before any population changes are evident.

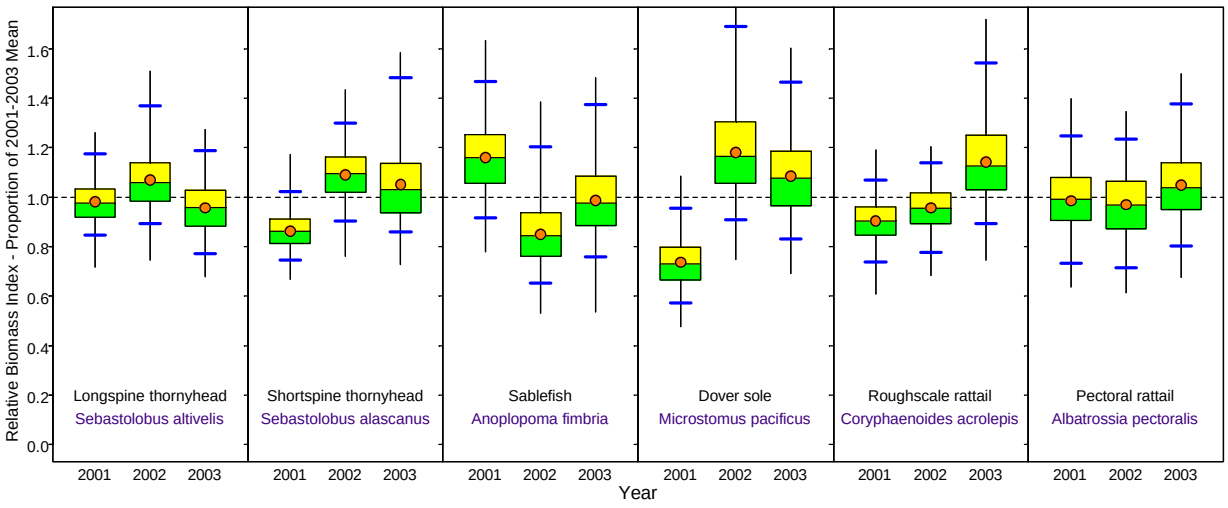

Figure 1. Bootstrapped swept-area biomass indices for the six major species caught in the longspine thornyhead survey (2001-2003), based on 1000 bootstraps per year. Estimates were stratified only by three depth zones (500-800m, 800-1200m, 1200-1600m). Also shown: the moment estimate of the mean (orange dot), and the 95% confidence interval after bias-correction and acceleration (blue horizontal lines).

ii. Stock assessment

No stock assessments were done for slope rockfish in 2003.

The five new management regions for longspine thornyhead were retained in 2003 (Fig. 2). The Flamingo area remains closed to any directed fishing for longspine thornyheads. The Triangle region acts as a *de facto* refugium due to very steep bathymetry. Table 1 reports historical catch in the new longspine management regions. Table 2 details the biological sampling activity in the primary regions since 1996.

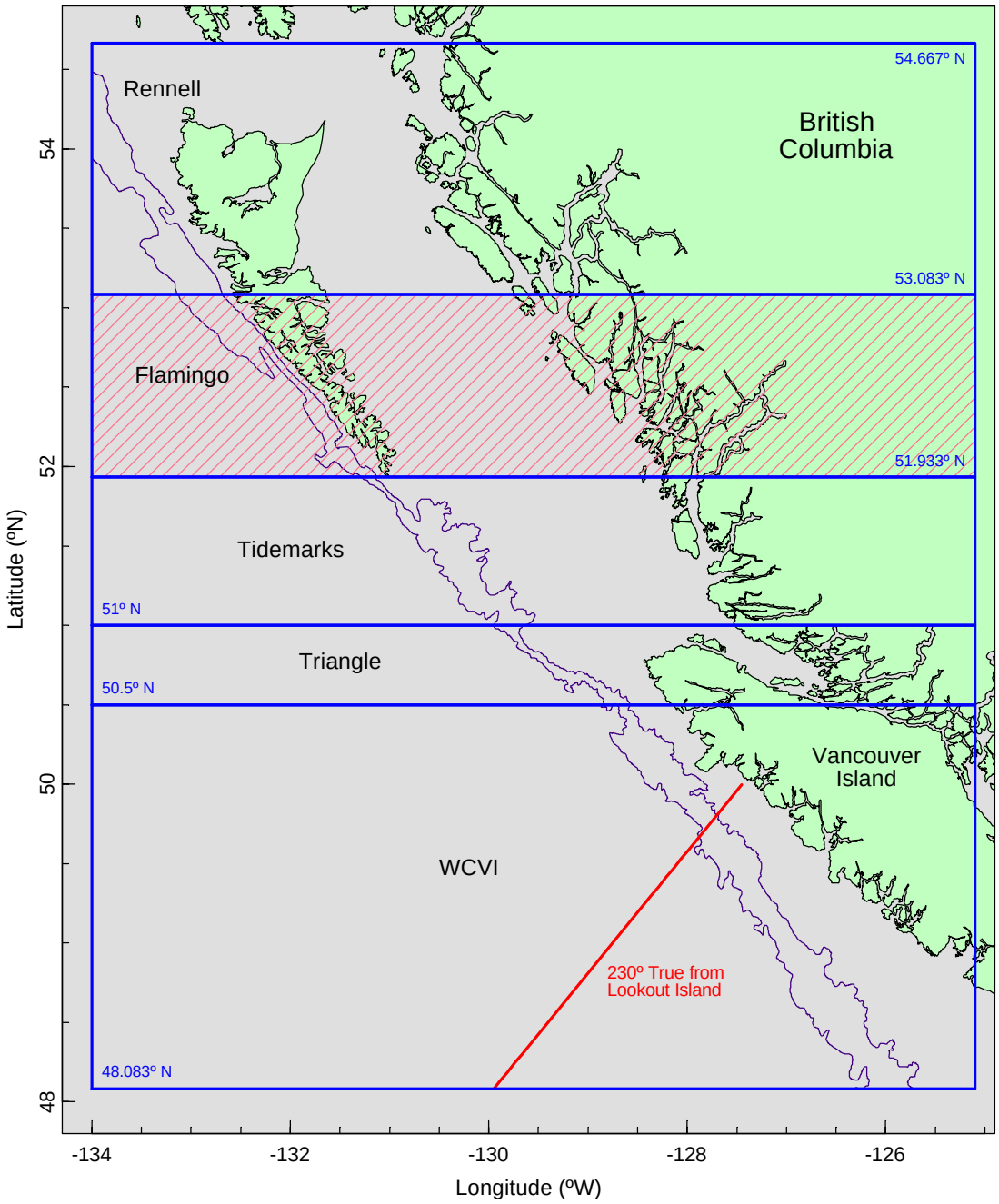

Figure 2. Management regions for the longspine thornyhead fishery (blue boundaries) in effect since 2002. During 2000-2001 the only boundary was a line (red) 230º true from Lookout Island. Prior to 2000, there were no spatial limits on the fishery. Longspine thornyhead habitat is approximated by the bottom area between the 500 m and 1,600 m isobaths. The Flamingo region is closed to directed fishing on longspine thornyheads.

Table 1. Longspine thornyhead catch (t) in the current management regions (for this species) applied across all years since 1996. The boundaries delimiting these areas are illustrated in Figure 1 and correspond to lines of latitude – WCVI (48° 05′ N to 50° 30′ N); Triangle (50° 30′ N to 51° 00′ N); Tidemarks (51° 00′ N to 51° 56′ N); Flamingo (51° 56′ N to 53° 05′ N); Rennell (53° 05′ N to 54° 40′ N). Unless otherwise noted, fishing years run from April 1 to March 31. Values of 0 indicate catch < 0.5 t.

Fishing Year	WCVI South	WCVI North	Triangle	Tide-marks	Flamingo	Rennell	Unknown	Total
1996[1]	862	1	<0.5	3	<0.5	1	10	877
97[2]	291	<0.5	<0.5	<0.5	<0.5	1	0	293
1997	564	1	<0.5	8	<0.5	2	1	577
1998	823	<0.5	<0.5	6	<0.5	9	1	840
1999	732	160	0	1	<0.5	19	1	913
2000	389	286	0	85	<0.5	144	5	909
2001	351	105	0	49	1	144	<0.5	650
2002	428	38	0	75	<0.5	116	13	670
2003[3]	167	40	0	75	0	70	22	374

[1] Fishing year: Feb 15, 1996 – Dec 31, 2003
[2] Interim period: Jan 1, 1997 – Mar 31, 1997
[3] Catches only for Apr 1 – Oct 15, 2003

Table 2. Summary of commercial samples taken from the longspine thornyhead fishery (1996-2003).

Fishing year	WCVI			Tidemarks			Rennell		
	Samples	Lengths	Otoliths	Samples	Lengths	Otoliths	Samples	Lengths	Otoliths
1996[1]	8	653	100						
1997	16	1,967	425						
1998	127	21,631	916						
1999	222	33,811	1,094				6	726	0
2000	665	28,744	12,248	130	2,943	2,689	220	5,772	3,420
2001	135	19,946	3,671	19	2,582	403	48	7,227	891
2002	128	21,598	2,280	15	2,294	398	55	9,032	735
2003[2]	70	10,708	984	12	2,435	0	36	5,123	484

[1] Fishing year: Feb 15, 1996 – Dec 31, 2003
[2] Apr 1 – Dec 31, 2003

iii Research activities for 2004

Based on the pending 2004 longspine assessment, DFO is considering recommending a thornyhead surveys of the Tidemarks and Rennell management regions. This will be discussed with the Canadian Groundfish Research and Conservation Society in June. The target species will be the two thornyhead species, with sablefish, Dover sole, and deepsea sole *Embassichthys bathybius* as secondary targets.

The Queen Charlotte Sound synoptic survey will continue in 2004, targeting the 5AB (central BC coast) region between 50 and 500 m. This includes a fair amount of slope rockfish habitat, especially that of Pacific ocean perch *Sebastes alutus*.

2b. Rockfish – shelf

i. Research Programs in 2003

Collaborative ageing work with researchers in Germany on otolith shape analysis and the Moss Landing Marine Laboratory in California on C^{14} dating is in press. DFO Staff also participated in a widow rockfish working group meeting with U.S. National Marine Fisheries Service (NMFS) and Washington Department of Fish and Wildlife staff. U.S. staff is contemplating indexing widow rockfish abundance by generating a time series of acoustic estimates of persistent shoals in five locations along the U.S. coast.

ii Stock assessments in 2003

Canadian shelf rockfish stock assessment activities concentrated on preparation of a stock assessment report on bocaccio rockfish (*S. paucispinis*) for BC waters (Stanley et al. 2003). This work re-examined a stock assessment presented two years earlier. That document had provided the basis for a proposed listing of bocaccio as "Threatened" in Canadian waters. This designation was inferred mainly from the apparent decline in abundance off Vancouver Island since 1980 as indicated in a NMFS bottom trawl survey.

The update paper summarizes the available information on the stock status of bocaccio (*Sebastes paucispinis*) in B.C. waters. It updates information on catch, CPUE, and survey indices where appropriate, from the previous PSARC document (Stanley et al. 2001). In addition, given the importance of the results from the NMFS triennial and West Coast Vancouver Island (WCVI) shrimp surveys with respect to stock status, it provides more comprehensive analyses of these data to communicate more accurately the degree of certainty around the point estimates and the inference of a decline in abundance. The document notes the strong evidence of a significant decline in relative abundance from the early 1980's off the southwest coast of BC but also recent stability in the same indices and provides two management directions for consideration. Considering that the only remedial action available for managers is to control catches, Option #1 endorses capping catches at current levels provided existing indices do not decline. Option #1 might also be adopted as an interim measure until a more complex catch reduction strategy can be implemented. Option #2 endorses reducing catch to an arbitrary target level. A significant reduction in catch may be possible through implementation of a voluntary avoidance program, possibly in conjunction with regulatory disincentives to catch bocaccio. However, the document emphasizes that the available assessment information is not adequate to predict how much a given reduction in catch will affect the population nor able to provide specific advice on the amount of reduction required. The choice between options is dependent on the degree to which the southern BC area reflects all BC waters, and whether the higher relative abundance recorded in the early 1980's is indicative of the long term average abundance or reflects

peak levels resulting from periods of good recruitment. This uncertainty in the interpretation of the available abundance indices, along with their low precision, means that it is presently not feasible to reliably estimate stock status for British Columbia bocaccio.

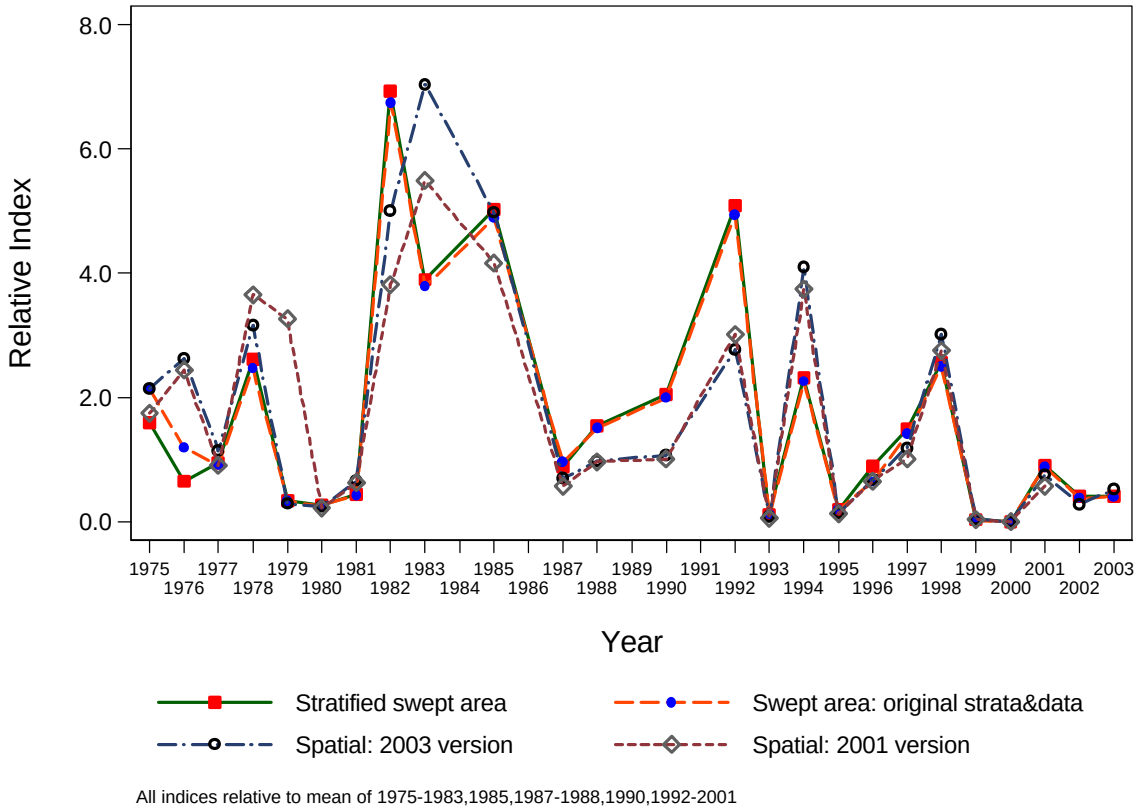

Figure 3. Comparison of a range of biomass indices using the WCVI shrimp trawl survey data: a) swept area using the stratification that was adopted by Starr et al. 2002; b) swept area using the original survey stratification and without dropping any tows; c) a recalculated spatial shrimp index and d) the original spatial index used in 2001

iii Research activities planned for 2004

No direct work on shelf rockfish is planned for 2004.

2c. Rockfish – inshore

i Research programs in 2003

In May 2003, the second half of the inshore rockfish longline survey in the upper west coast of Vancouver Island and the lower west coast of the Queen Charlotte Islands was completed. This survey, together with a September 2002 survey, will be compared with similar surveys conducted in the same areas in 1997/98. The survey focuses on yelloweye rockfish (*Sebastes ruberrimus*) and involves two vessels fishing at four survey sites, both in the fall and the spring. Survey catch rate and biological data will be reviewed for seasonal and annual differences and compared with the fishery removals from each area.

A third technician, funded jointly by the Pacific Halibut Management Association, Canadian Sablefish Association, and DFO's inshore rockfish program, collected biological samples and catch data, from species other than halibut (*Hippoglossus stenolepis*), during the International Pacific Halibut Commission Area 2B setline survey conducted from May to August 2003. One hundred and seventy sets were completed in depths up to 250 M. Redbanded (*S. babcocki*) and yelloweye rockfishes were the dominant rockfish species taken on the survey. Rockfish to halibut catch ratios were highest in central portion of B.C. from the southern end of the Queen Charlotte Islands to the northern end of Vancouver Island but were generally low at 0.02 kg rockfish/kg halibut per skate (overall median). Preliminary simulation results indicate that if an annual catch rate index is collected, it will be useful to track abundance trends for redbanded and yelloweye rockfishes by 2009.

Underwater towed camera trials were conducted over 5 days in June 2003 in the Strait of Georgia, Statistical Areas 17-19. Fourty-two transects were conducted from 10 to 65 M. Habitat types and fish species were assessed. Puget Sound (*S. emphaeus*), quillback (*S. maliger*) and copper rockfishes (*S. caurinus*) were the most commonly seen rockfish during the survey. Low visibility due to the seasonal phytoplankton bloom hampered the survey in some areas but overall this technology is useful for monitoring and assessment of shallow water reef fishes and their habitat.

Longline research surveys were conducted in the Strait of Georgia, Statistical Areas 12 and 13 during August and September 2003. Eighty longline sets were completed from 40-100 M. Quillback and yelloweye rockfishes were the dominant rockfish in the catch. Other commercial species caught included spiny dogfish (*S. acanthias*), Pacific cod (*Gadus macrocephalus*), sablefish (*Anoplopoma fimbria*), halibut and lingcod (*Ophiodon elongatus*). Preliminary simulation results indicate that with 80 sets each year, the catch rate index will track trends in abundance for quillback rockfish in 9 -10 years. Increasing the number of sets to 120 will decrease the time to reliably track trends in abundance to 4 - 5 years. The ability of the survey to track yelloweye rockfish trends is not as good as that for quillback rockfish.

A visual survey was conducted in the Strait of Georgia in September 2003 using the AQUARIUS submersible (Nuytco Research). Nineteen dives and 38 transects were completed in nine dive days. Seven of the transects conducted in the Gabriola Reefs and Active Pass areas were designed to verify habitat maps developed by the Pacific Geoscience Centre (Natural Resources Canada), using multibeam backscatter, bottom

grabs and seismic data and to quantify rockfish densities by habitat type. The remaining 32 transects were conducted in Areas 15 and 16 and were designed to replicate similar dives completed in 1984 using the PISCES IV submersible. Determining the area swept by the surveys is difficult but the preliminary results show a decline in abundance over the 19 years separating the surveys.

In collaboration with Dr. Sean Cox from Simon Fraser University, preliminary work on a genetic tagging experiment was conducted in a Rockfish Conservation Area in the Strait of Georgia. Specialized "hooks" were developed to sample fish flesh at depth and release the fish before returning to the surface. Genetic fingerprinting techniques were used to identify the fish to species and determine individuals. Initial test fishing resulted in 373 sample hooks collected on 4 sample dates. Approximately 50% of the samples contained enough tissue to use in the species identification and fingerprinting analyses. Of these, 82% of the fish were quillback rockfish, 30% were copper rockfish, 1% was yelloweye and 1% was other unknown fish (no previous genetic identification). Analysis of individual identity showed that four quillback rockfish were sampled twice on the same sample date (blind experiments) and one quillback was resampled on two separate sampling dates. This genetic tagging technique is expensive, $20 per hook; however, it appears to show promise as a viable tagging method for rockfishes.

ii Stock assessment

No stock assessments were conducted in 2003.

iii Management actions for 2003

After a year of public consultations, 89 Rockfish Conservation Areas (RCAs) were implemented for the 2003 fishing year. RCAs are to protect rockfish and fishing activities that are likely to catch rockfish are prohibited (http://www-comm.pac.dfo-mpo.gc.ca/pages/release/p-releas/2004/nr018_e.htm).

Activities permitted within the RCAs include First Nations' harvests for food, social and ceremonial purposes. Recreation fishing for invertebrates by hand picking, crab and prawn fishing by trap and smelt by gillnet. Commercial fishing of invertebrates by hand picking; crab and prawn by trap; scallops by trawl; salmon by seine or gillnet; euphausiids and groundfish by mid-water trawl; opal squid by seine; herring by gillnet, seine and spawn-on-kelp; sardine by gillnet, seine and trap; and smelt by gillnet. All other fishing activities are prohibited.

iv Research activities planned for 2004

DFO will continue to coordinate and compile the catch composition and sample data collection for the non-halibut catch on the IPHC setline survey in 2004. The total cost of the third observer and additional vessel costs have been transferred to industry.

A repeat of the longline survey in the Strait of Georgia Areas 12 and 13 will be conducted between August 23 and September 10, 2004. Information on the annual variability of this survey will enhance the design of future surveys. Further simulation work is being conducted with 2000 set budgets over a 20-year time frame. The trade-offs of conducting annual surveys of 100 sets versus less frequent surveys with more sets is being investigated under various assumptions of process error and population trajectories.

A submersible survey using visual methods to assess rockfish abundance is planned for September 24 to October 11, 2004 in the Strait of Georgia. This survey is designed to develop habitat assessment methodology and assess stock status for inshore rockfish. Rockfish density estimates by habitat type may be expanded using habitat maps to a biomass estimate over an area much larger than that surveyed by submersible. Habitat maps are being developed with the Pacific Geoscience Centre (Natural Resources Canada) using multibeam backscatter, bottom grab and seismic data. The submersible project is a joint project with the Washington Department of Fish and Game.

Further development of a rockfish conservation areas (RCAs) strategy is planned and will involve the investigation of a spatial model based on bathymetric data to identify habitat areas of 'high complexity'. These 'high complexity' areas, identified through the model, will be overlain with all available fishery data to assess the potential of using 'high complexity' areas, as well as fishery data, as surrogates for rockfish habitat. These areas will also be compared with the 89 RCAs implemented in 2004 for the protection of rockfish and may provide a methodology for the identification of additional RCAs.

A project is planned cooperatively with Simon Fraser University to develop simulation models to explore 1) genetic tagging as a new method for monitoring abundance and fishing mortality both inside and outside closed areas and 2) optimal spatial and temporal distributions of genetic tagging effort that maximise information for scientific evaluation and assessment of closed areas while minimising research survey costs.

3. Sablefish

i Research programs in 2003

The annual longline trap survey was conducted under charter in the fall of 2003 aboard the fishing vessels Viking Star (standardized survey) and Ocean Pearl (tagging survey). Standardized sets were conducted at nine localities spatially dispersed along the B.C. offshore coast and at four selected mainland inlet localities. The offshore localities were selected because they include areas 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. Historical depth stratification used since 1990 was retained, except the deepest depth stratum was dropped in favour of a new shallow 50 to 150-fm stratum. In general, there has been little replication of sets within each stratum. However, in 2002 three replicates were conducted within each depth stratum at three of

the nine survey localities. The fishery independent catch rate index time series started in 1990 was extended by conducting 64 standardized sets. A total of 7,515 sablefish were sampled for biological measurements and otoliths (2,620 otolith pairs) and 40 tagged sablefish were recovered. Nineteen tagging sets conducted within the survey localities resulted in the release of 8,808 fish at the point of capture and the recovery of 155 tagged fish. A second component of the survey conducted in the inshore waters of Hecate Strait and associated inlets resulted in the release of 4,407 tagged sablefish.

A new stratified random survey was introduced as a pilot project in 2003. The B.C. coast was stratified into 5 spatial and 3 depth strata and 5 trap gear sets (75 sets in total) were randomly positioned within each stratum. Sablefish were tagged and released, standardized catch rate data collected, and biological samples were obtained. After a period of overlap, the intent is to replace the existing protocols for tagging and standardized indexing with the stratified random design.

ii. Stock assessment in 2003

Sablefish stock assessment and management in British Columbia is conducted cooperatively by Fisheries and Oceans Canada (DFO) and the Canadian Sablefish Association (CSA). 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.

An assessment of sablefish was presented in January 2004 (Haist et al. 2004). The assessment of stock status relied on the interpretation of trends in four stock indices that relate to the trap vulnerable component of the British Columbia (B.C.) sablefish population. No stock reconstruction is available due to the absence of age data since 1996 and unresolved difficulties in the modelling of tag recovery data. Sablefish were last assessed using an age-structured population dynamics model that integrated tag recovery information in 2000. Three indices are in terms of catch per unit effort (CPUE) and the tagging index is expressed in biomass units:

Standardized commercial trap CPUE (1990-2003). Trap fishery catch rates (kg/trap) for the north coastal area declined from 1991 to 1998, prior to the mandatory adoption of escape rings. Subsequent to 1998 the four-year trend indicated a decline, with a historical low in 2001 and improvement in 2002 in agreement with the standardized survey trend. Catch rates increased substantially (63%) in 2003. The south coastal area catch rates initially increased and then declined from 1992 through 1998. Subsequent to 1998, the

four-year trend was relatively flat. No south coastal estimate was available for 2003 due to the lack of trap fishing in the first half of that year.

Nominal commercial trap CPUE (1979-2002). Recent coast wide CPUE (kg/trap) is near levels experienced in the early 1980s. The peak of nominal trap CPUE during the early 1990s was consistent with a similar pattern observed for the Gulf of Alaska, though slightly lagged. Catch rate estimates for 2003 were not available due to very limited trap fishing early in the year. This time series is not standardized and coincides with a period of change in fishery management practice.

Standardized survey CPUE (1990-2003). Coast wide results for 2003 show substantially increased catch rates (numbers per trap) in both the north and south coastal areas. The historical trend shows a general decline in CPUE from highs in the early 1990s. Beginning in the mid 1990s the rate of decline in the north slowed and entered a period of relative stability through to 2000. The 2001 survey resulted in the lowest CPUE estimates in the time series. The northern catch rate improved in 2002 relative to 2001 and was comparable to those observed in the mid 1990s. The 2003 CPUE estimate was the highest in the time series. Catch rates in the south exhibited a continuous decline from the mid-1990s to 2002, but showed significant improvement in 2003 largely due to improved catches in the three shallow depth strata.

Tag-recovery estimates of vulnerable biomass (1991-2002). Estimates of trap vulnerable biomass derived from trap fishery tag recoveries declined from a high in 1993 through to 1998. Estimated biomass remained at low levels from 1998 through 2002, with a historical low in 2001 in agreement with the commercial and standardized survey time series. Trap vulnerable 2003 biomass was not estimated due to the lack of commercial trap effort after February of 2003.

There was general agreement among the trends in stock indices that sablefish vulnerable to trap gear experienced a decrease in abundance from (relatively) high levels in the early 1990s to low levels in the mid 1990s (Figure 1). The rate of decline slowed markedly in the mid-1990s for both stock areas. For the north stock area, a period of relative stability occurred in the mid 1990s until 2001 when historically low catch rates were observed for the commercial trap fishery and the standardized survey. Standardized survey catch rates for the north improved in 2002, and were comparable to those observed in the mid 1990s. There was substantial improvement in 2003 survey catch rates to a level similar to highs observed in the early 1990s. The pattern of tagging model estimates of vulnerable biomass was generally consistent with the trends indicated by the commercial catch rate and standardized survey series.

A biomass dynamics model used to integrate stock indices allowed estimation of annual production parameters that represented the net changes in biomass resulting from fish growth, recruitment, immigration, emigration, and changes in trap vulnerability. A Bayesian approach, based on the Markov Chain Monte Carlo (MCMC) algorithm was used to estimate the joint posterior distribution of the biomass dynamics model parameters. The biomass dynamics model was used to project trap vulnerable stock

biomass and production trends over the 2003 to 2008 period for a range of potential future catch levels. Each simulation held the annual catch fixed over the projection period. Long term (1000 year) simulations were conducted for no-catch scenarios to provide estimates of the distribution of unfished trap vulnerable biomass. The long-term simulations suggested that if switching between equal-length periods of good and poor production occurred; the biomass would fall below 19,000 t about 5 percent of the time and was considered a level that should not lead to conservation concerns.

The performance measures evaluated for the assessment were relative to the trap vulnerable biomass in 2002 and to the 5th percentile of the distribution of unfished trap vulnerable biomass, $B^{0.05}$=19,000 mt:

The *probability* that vulnerable stock biomass is above 19,000 mt at the end of the projection period, $P\left(B_{2009} > B^{0.05}\right)$;

The *probability* that vulnerable stock biomass is above B_{2002} at the end of the projection period, $P\left(B_{2009} > B_{2002}\right)$;

The *magnitude* of the expected change in vulnerable stock biomass over the projection period, $E\left(B_{2009} / B^{0.05}\right)$, and

The *magnitude* of the expected change in vulnerable stock biomass over the projection period, $E\left(B_{2009} / B_{2002}\right)$.

Based on the stock indices, the model outputs suggested there is little risk that the TAC levels of up to 6,000 mt will lead to a short-term conservation concern. However, the model projection outputs were strongly influenced by the substantial increase observed in the 2003 standardized survey and northern trap fishery indices relative to results in 2002.

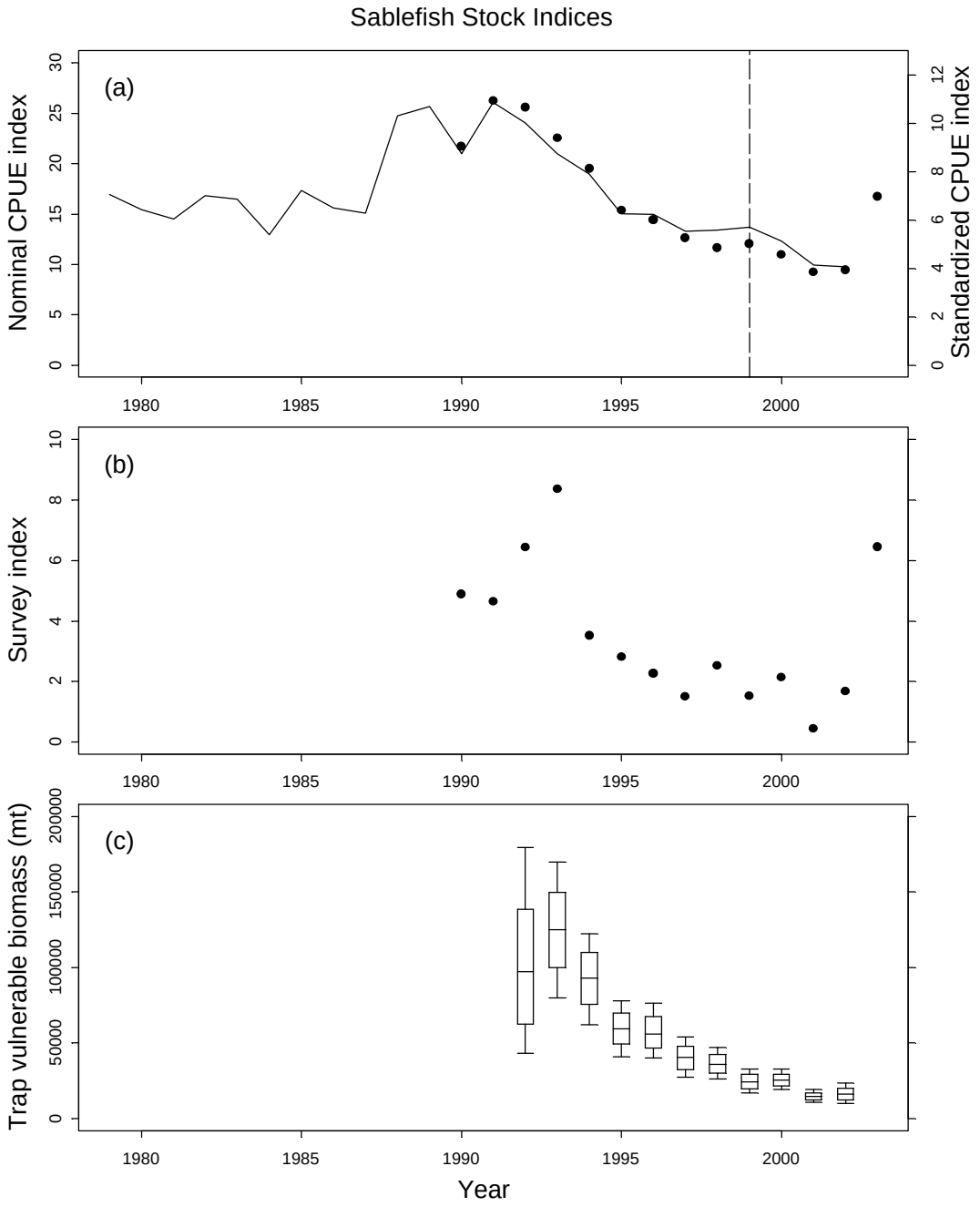

Figure 1: Coast wide stock indices: (a) nominal trap fishery catch rates (solid line) and standardized trap fishery index (filled circles), (b) standardized survey index abundance, and (c) tagging model marginal posterior distributions of trap vulnerable biomass. The dashed vertical line in panel (a) indicates the inception of trap escape rings.

iii. Research activities planned for 2004

Routine ageing of sablefish has not been conducted in BC since 1996, although structures have been collected annually. Plans for 2003/2004 include continued work on diagnosing the reasons for observed differences between burnt-section and thin-section otolith preparations and continued development of stratified random coast wide tagging and stock indexing survey is planned. The annual research and stock assessment survey is planned for the fall of 2004.

4. Flatfish

i. Research programs in 2003

A multispecies trawl survey was conducted in Hecate Strait in 2003. The objective of the survey was to obtain fishery independent data on flatfish assemblages in this region. Biological samples were collected for arrowtooth flounder *(Atheresthes stomias*), 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 slopes*), Starry flounder (*Platichthys stellatus)* and sand sole (*Psettichthys melanostictus*). The relative abundance indices for flatfish species in Hecate Strait were updated for future assessment work. Rock sole and English sole abundance has increased over the last three years and remains above the 50 year average for both species.

ii. Stock assessment in 2003

A petrale sole stock assessment was conducted in 2003 (. Three types of analysis were used: 1) estimation of mortality rates using life history characteristics; 2) Analysis of CPUE for fishery independent surveys and commercial data for estimation of trends in abundance; and 3) Estimates of biomass and yield using a delay-diffference model. Results from the three available trawl surveys indicate that there has been a significant increase in biomass over the last three years. The regression models fitted to the commercial catch and effort data also show an increasing trend over the last three years. The estimate of F based on survey age composition information in 2000 was well below the best estimate for M (0.2). Delay difference model runs indicate that current biomass is at or above B_{msy}. The delay-difference model runs indicate that the current catch level of 479 t (the bycatch cap level set by DFO management) is well below a safe level of harvest for the coming fishing year. The PSARC subcommittee recommended raising the cap by 25% for the 2004-05 fishing season.

iii Research activities for 2003

Future research and stock assessment work on flatfish in Hecate Strait will be covered by the Hecate Strait ecosystem project (HecStEP). A multi-species groundfish survey of Queen Charlotte Sound conducted in the summer of 2003 will provide biological data and fishery independent abundance indices for arrowtooth flounder, Dover sole, English sole, flathead sole, petrale sole, rex sole, rock sole in that area.

5. Hake

i. No research was directed on hake (Merluccius productus) in 2003, nor planned for 2004,

6. Elasmobranchs

i Research programs in 2003

An examination of potential age determination methods for Big skate was completed (*Raja binoculata*). Vertebral centra sectioned longitudinally, immersed in ethanol, stained with crystal violet and enhanced with a thin layer of mineral oil produced the best results. Age compositions were produced and growth curves estimated. The method appears appropriate for age determination of big skate and the production of growth rates and productivity for input into ecosystem models. The method was also utilized on centra of Longnose skate with good results.

A tag/recapture program to examine stock discreteness of Big skate was initiated in 2003. A total of 1,800 skates and 366 skates ranging in length from 49 to 199 cm, were tagged and released in Hecate Strait and Queen Charlotte sound respectively in March 2003. A further 1400 skate were tagged and released in Queen Charlotte Sound in August 2003.

ii Stock assessment in 2003

No assessments were conducted on BC elasmobranches.

iii Management

There are no directed fisheries allowed for sharks (excluding spiny dogfish, *Squalus acanthias*) in BC waters; therefore sharks 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. Recent increases in directed catch of skate prompted management to examine options for the 2002/2003 and subsequent fishing years. This resulted in a catch "cap" of 850 t on Hecate Strait big skate in 2002/03, which was continued in 2003/04.

iv Research activities planned for 2004

The tag/recapture program for Hecate Strait/Queen Charlotte Sound big skates to examine stock delineation initiated in 2003 will be continued in 2004

7. Lingcod

i Research programs in 2002

The nest site affinity study was completed and was published as a primary paper. Lingcod abundance surveys were initiated in the Strait of Georgia in 2003: hook and line for juveniles and adults, bottom trawl for young of year, and dive survey for juvenile and adults. An archival tagging program was conducted to examine the seasonal distribution of lingcod (adults vs. juveniles; males vs. females) in the Strait of Georgia.

ii Stock assessment

Offshore

No assessment was conducted on offshore lingcod stocks in 2003.

Inshore

No assessment was conducted on Strait of Georgia lingcod stocks in 2003. The Strait of Georgia remains closed to all commercial and recreational fishing.

iii Research activities planned for 2004

Lingcod abundance surveys will be continued in the Strait of Georgia in 2004. Larval and post-larval surveys will be initiated to address the spatial limitations for lingcod dispersion in the Strait of Georgia. Community dive surveys for lingcod and rockfish densities, coupled with egg mass surveys will be sponsored by DFO in the upcoming year. A lingcod management framework will be completed in 2004 outlining rebuilding targets and management options for the Strait of Georgia population.

D. Other related studies

1. Statistics and Sampling

i Database work in 2003

Principal Statistics and Sampling activities in 2003 included the ongoing population of the groundfish biological database (GFBio). This database now includes about 5,600,000 specimens. Data entry activities continue to 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. This past year involved a considerable effort in the entry of historic sablefish research cruises. 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 646 length/sex/age samples and 351 length samples in 2003. Port samplers provided 220 samples with ageing structures (length/sex/age/weight) and 11 without structures (length/sex/weight).

Hook-and-line and sablefish trap landings have 100% dockside validation. Observer coverage in the hook-and-line fishery was initiated in 2000 and continues to provide about 5-15% coverage.

ii. Field work in 2003

Stat/Sampling staff organized and led the 2003 QCSd bottom trawl survey (Stanley et al. 2003). The survey conducted 239 usable tows in depths of 50-500 m from July 3-August 9 on board the commercial trawler the F/V Viking Storm. The survey was jointly conducted and funded by the Canadian Research and Conservation Society and Fisheries and Oceans Canada. The objective of the survey, which will be conducted at regular intervals, is to provide long term indices of relative abundance for most fish species affected by bottom trawling. The indices would not only reflect populations in the survey area but, since it covers the core area of the coast, could provide an indicator of coastwide abundance of many species for which other information is not available. The tactical intent of the first year was to test whether the survey could generate acceptable precision at a reasonable cost.

Results indicate that if the survey were repeated in its current design it could meet its primary objective and would cost approximately $312,000/y. It will also provide a research platform that will contribute essential biological samples, and oceanographic information. The document recommends that the survey be continued with minor modifications that can be identified with additional analyses of the 2003 results.

iii Proposed field work for 2004

Stat/sampling staff will lead the 2nd year of the QCSd bottom trawl survey and initiate the 1st year of a similar survey off the west coast of Vancouver Island (WCVI) in 2004. The WCVI survey will follow the design of the QCSd survey. Staff is also planning to provide a Strategic plan for longterm surveys.

APPENDIX 1. REVIEW OF CANADIAN GROUNDFISH FISHERIES

1. Commercial fisheries

All catch figures for 2003 are preliminary. Canadian domestic trawl landings of groundfish (excluding halibut) in 2003 were 110,746 t, an increase of 13% above the 2002 catch. The main cause for the rise in landings was the increase in landings of Pacific hake. The major species in the trawl landings were Pacific hake (62%), Pacific ocean perch (6%), pollock (5%), yellowtail rockfish (4%) and turbot (4%). Principal areas of trawl production were 3C (57%), 5B (10%), 4B (8%), 5A (5%) and 3D (5%).

Canadian landings of groundfish caught by gear other than trawl in 2003 totalled 8,685 t. Sablefish landings by trap and longline gear accounted for 2,341 t, approximately 72% by trap gear and 28% by longline gear. Landings of species other than sablefish by longline, handline and troll gear accounted for 6,344 t (72% dogfish, 13% rockfish and 12% lingcod).

2. Recreational fisheries

Each year, Fisheries Management Branch of DFO conducts creel surveys of the recreational angling fishery in the Strait of Georgia. Principal target species are chinook and coho salmon. In 2003 these surveys covered the months of April to September. Provisional estimates of 2003 catches, landings and discards, for this 6-month period were 731 fish for lingcod, 12,657 fish for all rockfish species, 1,237 fish for halibut and 17,709 fish for all other groundfish species, including dogfish, flatfish, greenling, cabezon, herring and ratfish.

3. Joint-venture fisheries

There were no joint-venture fisheries for Pacific hake off southwest Vancouver Island (Area 3C) in 2003.

4. Foreign fisheries

There were no national or supplemental fisheries for Pacific hake off southwest Vancouver Island (Area 3C) in 2003.

APPENDIX 2. GROUNDFISH RELATED REPORTS PUBLISHED BY THE STOCK ASSESSMENT DIVISION IN 2003.

1. Primary Publications

Haigh, R. and J. T. Schnute. 2003. The longspine thornyhead fishery along the west coast of Vancouver Island, British Columbia, Canada: portrait of a developing fishery. North American Journal of Fisheries Management. 23: 120-140.

McFarlane, G. A., J. R. King. 2003. Migration dynamics of Spiny dogfish (*Squalus acanthias).* In the North Pacific Ocean. Fish. Bull. 101: 358-367.

King, J. R., and G. A. McFarlane. 2003. Marine fish life history strategies: applications to fishery management. Fish. Man. and Ecology 10:249-264.

Schnute, J. T. 2003. Designing fishery models: a personal adventure. Natural Resource Modeling 16: 393-413.

Schnute, J. T. and R. Haigh. 2003. A simulation model for designing groundfish trawl surveys. Canadian Journal of Fisheries and Aquatic Sciences. 60: 640-656.

2. Other publications

Haist, V, A. R. Kronlund, and M. R. Wyeth. 2004. Sablefish (*Anoplopoma fimbria*) in British Columbia, Canada: Stock Assessment for 2003 and Advice to Managers for 2004. PSARC Working Paper G2004-01.

King, J.R., G.A. McFarlane and A.M. Surry. 2003. Stock Assessment Framework for Strait of Georgia Lingcod. Can. Sci. Ad. Sec. Res. Doc. 2003/062. 57 p.

McFarlane.G. A. 2003. 2002 Pacific Region State of the Ocean- Report of the Fisheries Oceanography Working Group. Can. Tech. Rep. Fish. Aquat. Sci. 2484:65p.

Schnute, J. T., N. M. Boers, and R. Haigh. 2003. PBS Software: maps, spatial analyses, and other utilities. Canadian Technical Report of Fisheries and Ocean Sciences 2496, 82 p.

Sinclair, A., J. Schnute, R. Haigh, P. Starr, R. Stanley, J. Fargo, and G. Workman. 2003. Feasibility of multispecies groundfish bottom trawl surveys on the BC coast. Canadian Science Advisory Secretariat, Research Document 2003/049.

Stanley, R. D., P. Starr and N. Olsen. 2003 (in press). Bocaccio Update. Canadian Science Advisory Secretariat, Research Document 2003/xxx.

Stanley, R. D., P. Starr, N. Olsen, and R. Haigh. 2003 (in press). Queen Charlotte Sound Bottom trawl survey. Canadian Science Advisory Secretariat, Research Document 2003/xxx.

Surry, A.M. and J.R. King. 2003. Diameter Measurements for Identification of the First and Second Annulus on Dorsal Fin Ray Sections from Lingcod (*Ophiodon elongatus*). Can. Tech. Rep. Fish. Aqu. Sci. 2490. 24 p.

APPENDIX 3. STOCK ASSESSMENT DIVISION GROUNDFISH STAFF IN 2003

W. Andrews	Elasmobranchs and hake
E. Choromanski	General stock assessment and biology, flatfish, field technician
K. Cooke	Database technician
J. Fargo	Section Head, stock assessment and biology, flatfish
C. Grandin	Ecosystem research programmer
R. Haigh	Statistical and exploratory data analysis, thornyhead and slope rockfish
S. Hardy	Groundfish port sampling
G. Jewsbury	Seconded to salmon group
K. Castle	Groundfish port sampling
J. King	Lingcod and sablefish, climate studies
B. Krishka	Biological data control and analysis, thornyhead and slope rockfish
R. Kronlund	Sablefish, analytical programs
L. Lacko	Inshore rockfish stock assessment and biology
J. Lochead	Inshore rockfish stock assessment and biology
G. A. McFarlane	Groundfish population dynamics and biology, fish/ocean interaction, elasmobranchs
J. Martin	Inshore rockfish stock assessment and biology
K. Mathias	Lingcod
W. Mitton	Sablefish
N. Olsen	Biologist/programmer/GIS, Shelf rockfish
K. Rutherford	Biologist/database manager, Shelf rockfish
J. Schnute	Stock assessment; mathematical analysis, thornyhead and slope rockfish
A. Sinclair	Pacific cod assessment and ecosystem research
R. Stanley	Shelf rockfish stock assessment and biology, groundfish statistics.
M. Surry	Lingcod
G. Workman	Port sampling, Pacific Cod, Survey design
M. Wyeth	Sablefish stock assessment and biology
L. Yamanaka	Inshore rockfish stock assessment and biology