CANADA
British Columbia Groundfish Fisheries and Their Investigations in 2002

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by

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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 Environment and Habitat Science	Dr. J. Pringle
Ocean Science and Productivity	Mr. R. Brown
Aquaculture	Dr. D. Noakes

Groundfish research and stock assessments are conducted primarily in 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) 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 and future directions associated with groundfish conservation and management of the commercial fishery. Issues to be addressed include bycatch, discarding, catch utilization, fishery monitoring and reporting and stock assessment.

B. Multispecies or Ecosystem Studies

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

   i. Research Programs in 2002

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.

This project is investigating the spatial and temporal distribution of the key marine populations and their habitats as described using data from bottom trawl research surveys, commercial fisheries, physical oceanographic surveys, surficial geology, and bathymetry.

Ecosystem models will be developed to investigate the relative importance of fishing, environmental forcing and biological interactions in affecting changes in the marine fish communities in the Hecate Strait area. These models will be used to integrate all of the physical and biological information. The ecosystem model parameters and structure will be calibrated by comparison of model predictions and time series of catch, fishing effort, and research survey indices.

Details of subprojects:

Mapping of Marine Populations and their Habitats

This descriptive phase of the project is 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 database for 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 of about 3500 grab samples collected during approximately 20 research cruises. Statistical values related to mean grain size, sediment sorting and other parameters were also compiled. These data are now available to serve as coverage for comparison of fish or invertebrate species distributions to seabed texture or in other analyses.
- Grab samples collected by the WE Ricker during a DFO research cruise in June 2001 (104 grab samples) are being processed in the laboratory at the Pacific Geoscience Centre and will be completed by March 31/2002. These data were 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 DFO and NRCAN in June 2002, and will facilitate multidisciplinary study of these areas in Hecate Strait.
- Selected pilot study areas were surveyed during a multiparameter geophysical survey aboard CCGS John P. Tully in June 2002 to examine seabed habitats associated with areas of interest for groundfish populations. The cruise collected data pertaining to the physical environment of the seabed including surficial sediment distribution and seabed geology. Systems employed in the surveying included sidescan sonar, high resolution seismic, sampling and seabed classification techniques. The geophysical data from the six pilot areas have been compiled into ESRI ArcMap products at 1:40,000 scale for comparison to trawl fishery catch data and acoustic seabed classification (Quester-Tangent) results.
- Underwater video obtained from ROV dives have been classified in terms of bottom type characteristics and biota.
- 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.
- HecSTep also provides support (5k per year) for a M.Sc. student -Sarah Cook- at the University of Victoria, Department of Biology is yielding ecological insight into the

importance of sponge reefs as habitat for fish and invertebrate communities. Sponge reefs represent a unique and potentially important habitat on the western Canadian shelf including Hecate Strait. Initial results will be presented as a poster at the international habitat conference GEOHAB Meeting in Hobart, Australia in June 2003. It is anticipated that this work will result in several additional publications related to sponge reef ecology.

- HecStEP is supporting a second M.Sc. student – Chris Grandin - at the University of Victoria Centre for Marine Acoustic Remote Sensing (C-MARS) who is comparing seabed classifications obtained from Quester-Tangent analysis and the detailed Surficial geology classifications from sidescan sonar, seismic and bottom grab samples. This project involves a comparison of groundfish species community distribution with Surficial geology.
- Models were developed to hindcast and forecast the circulation along the north coast of British Columbia. A collaborative effort was established with Emanule Di Lorenzo of Scripps, who applied a new model (ROMS) to the North Coast of BC to simulate Haida Eddies. Initial results suggest the outflow currents near Cape St. James, at the southern tip of the Queen Charlotte Islands, contribute strongly to eddy formation. A paper is in preparation.
- 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. Parks Canada also sponsored the development of computer animations of currents and drifter motion in southern Hecate Strait, showing the nature of tidal, wind-driven and permanent currents in this region.
- 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 have been used to parameterize a predictive model of primary and secondary production in Hecate Strait.
- A dynamic model of lower trophic level production in the Hecate Strait/Queen Charlotte Sound region has been developed. The Climate Forced –Nitrogen, Phytoplankton, Zooplankton (CD-NPZ) model is forced by daily measurements of hours of bright sunlight, water temperature, alongshore windspeed and direction. The model includes the dynamics of nitrogen and phytoplankton, and three functional groups of zooplankton: “Spring” zooplankton, copepods and euphausiids. The “Spring” zooplankton is a diverse assemblage of species; whose production is closely associated with the spring phytoplankton bloom. The model successfully reproduces this seasonal change in dominance, and the seasonal change in biomass of the phytoplankton and zooplankton.
- Daily measurements of the required climate input data were available from 1991 to 1999. During this period, model estimates of annual primary production varied from a low of 106 gC/m2/yr (in 1999) to 184 gC/m2/yr (in 1998). The mean primary production was 138 gC/m2/yr, and the coefficient of variation was 0.20. Total zooplankton production varied from a low of 13.9 gC/m2/yr (in 1999) to a maximum of 28.1 gC/m2/yr (in 1998). The mean zooplankton production was 20 gC/m2/yr, and the coefficient of variation was 0.23. Model output indicates that, on average, the

zooplankton consume about 57% of the primary production, and about 13 to 20% of the primary production sediments out of the euphotic zone.

- Additional CF-NPZ model experiments and refinements are planned in association with the Ecopath/Ecosim modeling group. The current and retrospective primary production time series estimated by the CF-NPZ model will be used to force the Ecosim model.
- 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.
- Compile oceanographic data relevant to modelling primary and secondary production.
- Analyse factors affecting Pacific cod recruitment.
- Map surficial geology of different fish community habitats using high resolution sonar and echo sounding.

ii Research activities planned for 2003

- Produce groundfish trawl fishery atlas.
- Analyse video survey design for forage species.
- 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 2002

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 provided 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 2002

The stock assessment for Pacific cod off the west coast of Vancouver Island (3CD) was carried out in November 2002. An abundance index was developed from by-catches of cod in a bottom trawl survey directed at shrimp stocks. The annual trend in this index was well correlated with the commercial CPUE time series. The cod TAC was reduced in this area in 2001 and 2002 and fishermen began to avoid fishing in areas where cod were traditionally found. The survey index provided valuable information on stock status during this period of reduced commercial fishing. The results of the assessment indicated an increase in Pacific cod abundance and there has been an increase in the TAC in 2003 as a result.

iii. Research activities planned for 2003

The Pacific cod monitoring survey will be continued in Hecate Strait through 2003 and 2004. A pilot Pacific cod ageing study was initiated in 2003. Otoliths and fin rays will be collected from monthly surveys in March to July and examined to determine which structures are best suited for age determination.

2a. Rockfish - offshore

i. Research programs

The second of three surveys for longspine thornyhead *Sebastolobus altivelis* along the west coast of Vancouver Island occurred (Sep 6-23, 2002) under the direction of the Canadian Groundfish Research and Conservation Society (CGRCS). After completion of the 2001 survey, the F/V Viking Storm indicated that it was not able to continue with its contract. Consequently, the survey was re-tendered in July 2002 and the contract for the 2002 survey was awarded to the F/V Ocean Selector, Dave Clattenberg skipper.

The 2002 longspine survey covered 21 area-depth strata and completed 74 tows, 67 of which were useable for estimating biomass (Fig. 1). Overall, 98 taxonomic classifications were identified. The top six species accounted for 81% of the total catch weight: roughscale rattail *Coryphaenoides acrolepis* (5,371 t, 18.1%), longspine thornyhead (5,241 t, 17.6%), sablefish *Anoplopoma fimbria* (5,041 t, 17.0%), shortspine thornyhead *Sebastolobus alascanus* (3,415 t, 11.5%), pectoral rattail *Albatrossia pectoralis* (2,598 t, 8.7%), and Dover sole *Microstomus pacificus* (2,404 t, 8.1%). Catch rates were highest for longspine thornyheads in the middle depth stratum (801-1200 m), for shortspine thornyheads, sablefish, and Dover sole in the shallowest depth stratum (501-800 m), and for the two rattail species in the deepest depth stratum (1201-1600 m). Additionally, a total of 455 biological samples were taken for 17 fish species, yielding 20,446 specimen lengths and 3,558 otolith pairs.

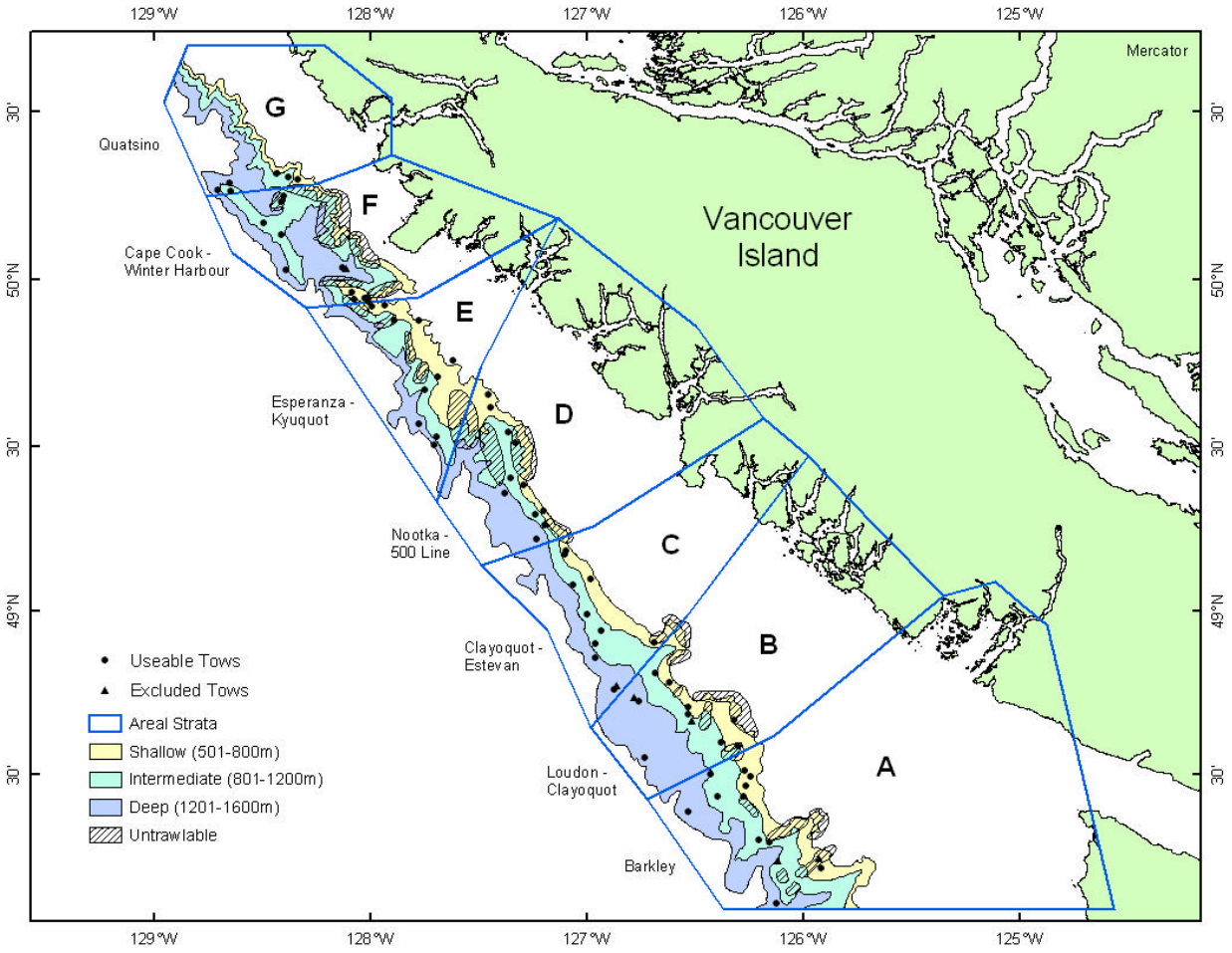

Figure 1. Longspine thornyhead survey (2002) with 7 areal strata (A-G) and 3 depth strata (501-800 m, 801-1200 m, 1201-1600 m). Number of tows = 74 (7 discarded).

ii. Stock assessment

No stock assessments were done for slope rockfish in 2002.

New rules were placed on the longspine thornyhead fishery in 2002. The traditional WCVI area retained a 405 t quota while experimental areas north of this line were allocated 230 t. The Flamingo area was closed to any directed fishing for longspines. Table 1 illustrates how catch has shifted from 1996 to 2002 within the current management boundaries. Table 2 details the 2002 biological sampling activity.

Table 1. Total catch (t) of longspine thornyheads in management years 1996-2002 along the BC coast and in each newly defined longspine management area (delimited by south and north latitudes, respectively). Catches include discards and bycatch from other Option B trawl fisheries.

Year	BC	Rennell 53°05´N	Flamingo 51°56´N	Tidemarks 51°00´N	Triangle 50°30´N	WCVI 48°10´N

		54°40´N	53°05´N	51°56´N	51°00´N	50°30´N
1996	867	1	< 0.5	3	< 0.5	863
1997	571	2	< 0.5	8	< 0.5	561
1998	837	9	< 0.5	6		821
1999	912	19	< 0.5	1		892
2000	905	144	< 0.5	85		675
2001	650	144	1	49	< 0.5	456
2002	618	113	< 0.5	75		430

Table 2. Summary of samples taken during the 2002 longspine thornyhead fishery (Apr 24–Nov 24, 2002).

Longspine Area	Samples	Length	Weight	Sex	Maturity	Otolith pairs
Rennell	53	8,759	0	711	0	398
Tidemarks	15	2,294	0	398	0	735
WCVI	119	19,977	0	2,107	0	2,119

iii Research activities for 2003

In 2003, the third year of the thornyhead survey will take place. All aspects of the survey should remain the same as in 2002. It is anticipated that this survey will continue after 2003, but switch to a biennial timetable. An ageing methodology for thornyheads is still in development.

A new groundfish synoptic survey (GFSS) will begin in 2003, targetting the 5AB (central coast) region. In subsequent years, the survey will range coastwide. It is expected that the depth range of the GFSS (50-500 m) will include a fair amount of slope rockfish habitat, especially that of Pacific ocean perch *Sebastes alutus*.

2b. Rockfish – shelf

i. Research Programs in 2002

The shelf rockfish program continued the genetics study of yellowtail rockfish (*S. flavidus*). BC and Washington-California samples have now been analyzed. A report will be produced in 2003.

A study was also completed with the International Pacific Halibut Commission (IPHC) and DFO staff at the Bedford Institute of Oceanography (Halifax) on the impacts of storing otoliths in glycerine on C^{14} ageing of groundfish. The study used pre-1960 and

new haddock otoliths and pre-1960 and new glycerine indicates that C^{14} dating is not affected by storage in glycerine. This paper is in review.

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 2003.

ii. Stock assessments in 2002

Canadian shelf rockfish stock assessment activities concentrated on preparation of a stock assessment report silvergray rockfish (*S. brevispinis)* for BC waters (Stanley and Olsen 2003) (http://www.pac.dfo-mpo.gc.ca/sci/psarc/ResDocs/res_docs.htm). The data indicated that central and northern BC stocks are stable, or perhaps increasing moderately. The stock in southern BC, off the west coast of Vancouver Island, has declined since 1980 but is not at risk.

Staff also continued to work with the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) regarding the status of bocaccio (*S. paucispinis*) in BC waters. COSEWIC recently classified the population in BC as "threatened". This designation obliges DFO and partners, with final passing of the Act in June 2003, to prepare a "recovery" strategy before June 2005.

iii. Research activities planned for 2003

During 2003, scientific staff will work with Faculty at the University of Simon Fraser (SFU) on developing new assessment/management approaches for rockfish. This work will be conducted in partnership with Dr. Bill de la Mare. It will attempt to test harvest control algorithms applicable to long-lived species of deepwater groundfish in BC in conjunction with measurable management objectives.

Staff within the shelf rockfish section are also taking a lead role in the design and conduct of a bottom trawl survey of Queen Charlotte Sound and southern Hecate Strait. The first survey will be initiated in 2003. It is planned to be the core survey within the development of a suite of surveys which will attempt to generate relative abundance indices for most species for groundfish.

2c. Rockfish – inshore

i. Research programs in 2002

The fall portion of a two season longline yelloweye rockfish assessment survey was conducted in September by two chartered commercial fishing vessels. This survey follows the initial survey conducted in September of 1997 and May 1998 at four index

sites, two on the west side of the Queen Charlotte Islands and two off the upper west coast of Vancouver Island. Since 1999, two of the four index sites were closed to all groundfish hook and line fishing.

ii. Stock assessment

No stock assessments were conducted in 2002.

iii. Management actions for the 2002 directed hook and line rockfish fishery

Management actions to support the Rockfish Conservation Strategy introduced in November 2001 included:

- Total allowable catches for the 2002 fishing season were reduced by 75% and 66% from 2001 levels for the Strait of Georgia (4B) and all other outside areas, respectively.
- Onboard observer coverage was increased in the directed ZN (hook and line rockfish), halibut and schedule II (lingcod and dogfish) fisheries.
- Thirty-two IARFs (interim areas of restricted fishing) were implemented in August of 2002. These areas are closed to all fishing activities that intercept inshore rockfish.

The Rockfish Conservation Team, composed of management and science personnel, was renamed the Rockfish/Lingcod Sustainability Team in 2003 and is chaired by Gary Logan at the regional headquarters in Vancouver, B.C.. The Team will be working on the review, development and implementation of areas closed to fishing.

iv. Research activities planned for 2003

A review and development of the IARFs (areas closed to fishing) is planned and will involve GIS development with the layering of logbook and observer records as well as traditional knowledge.

The spring portion of the two season longline surveys conducted by chartered commercial fishing vessels will be conducted for yelloweye rockfish in May 2003. This survey, together with the September 2002 fall survey will be used to monitor stock status in the four index sites off the Upper west coast Vancouver Island and the Queen Charlotte Islands. Similar assessment surveys for quillback rockfish maybe developed for the North Coast and Central Coast areas in 2003.

A project is planned cooperatively with Simon Fraser University which will 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. In the summer of 2003, development of the fish sampling methods and the genetic screening techniques will be investigated.

DELTA submersible and drop camera survey are planned for August 2003 in the Strait of Georgia. These surveys are designed to develop habitat assessment methodology for inshore rockfish as well as begin the collection of baseline data within the newly designated IARFs in the Strait of Georgia.

3. Sablefish

i. Research programs in 2002

The annual longline trap survey was conducted under charter in the fall of 2002 aboard the fishing vessels Pacific Viking (index survey) and Viking Sunrise (tagging survey). Standardized sets were conducted at nine localities spatially dispersed along the B.C. offshore coast. The 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, with the addition of two deep strata at each of the nine survey localities. 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 was extended by conducting 125 standardized sets. A total of 7,369 sablefish were sampled for biological measurements and otoliths (5,682 otolith pairs) and 152 tagged sablefish were recovered. Ninety tagging sets conducted within the survey localities resulted in the release of 14,942 fish at the point of capture and the recovery of 415 tagged fish. A second component of the survey conducted in the inshore waters of Hecate Strait and associated inlets resulted in the release of 3,557 tagged sablefish.

ii. Stock assessment in 2002

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 2003 (Kronlund et al. 2003). The assessment of sablefish stock status in recent years has depended upon the interpretation of three stock abundance indices: (1) annual estimates of vulnerable

biomass derived from a tagging model that utilizes tags recovered in the first year after release, (2) catch rates obtained from a fishery-independent trap gear survey, and (3) commercial catch rates derived from sablefish trap fishery logbooks. No stock reconstruction is available due to the absence of age data since 1996 and unresolved difficulties in the modeling of tag recovery data. Sablefish were last assessed using an age-structured population dynamics model that integrated tag recovery information in 2000. There is 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. 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 commercial CPUE and indexing survey results were observed. Index survey catch rates in the north improved in 2002, and were comparable to those observed in the mid 1990s. In contrast, the decline in commercial trap and survey indices for the south stock area was more gradual through the mid 1990s, but has continued through 2002. The pattern of monthly tagging model estimates of vulnerable biomass was generally consistent with the trends indicated by the commercial catch rate and index survey series, though it is variable through the late 1990s. A synopsis of the stock indicators for vulnerable biomass is provided in the following list:

1. *Standardized commercial trap CPUE (North).* Trap fishery catch rates for the north coastal area declined from 1991 to 1998 prior to the mandatory adoption of escape rings in the trap fishery. Subsequent to 1998 the four-year trend indicates a decline, with a historic low in 2001 and improvement in 2002 in agreement with the indexing survey trajectory.
2. *Standardized commercial trap CPUE (Central).* Catch rates in the central coastal area increased in the early 1990s, and then experienced a large decrease from 1994 to 1996. The trend subsequent to 1998 indicates a decline. The central B.C. coast did not decline between 2000 and 2001.
3. *Standardized commercial trap CPUE (South).* The south coastal area catch rates initially increased and then declined from 1992 through 1998. Subsequent to 1998, the four-year trend indicates a decline. Like the north area, it is noteworthy that the index for the southern region decreased substantially between 2000 and 2001, as occurred in the indexing survey.
4. *Standardized commercial longline CPUE*. Longline catch rates show no long-term trend over the period 1987 to 2002.
5. *Indexing survey (North).* Results for the north stock area in 2002 indicated improvement in catch rates to a level comparable to the mid 1990s. This change was largely driven by the two most northern indexing localities. The compression of catch rate variance observed in 2001 was not evident in 2002.
6. *Indexing survey (South).* Results for the south stock area in 2002 show no improvement from levels in the mid 1990s.
7. *Tag-recovery estimates of vulnerable biomass*. Assuming the estimated tag reporting rates, the vulnerable biomass indicated a decline in abundance from 1993 through 1998, an increase from 1998 to 1999, followed by a decline through 2002.

8. *Nominal trap CPUE in British Columbia 1979-2001*. Recent catch rate levels are at, or slightly below, levels experienced in the early 1980s. This time series is not standardized and coincides with a period of change in the fishery management regime and fishing practices. The timing of the peak of nominal trap CPUE during the early 1990s is consistent with a similar pattern observed for the Gulf of Alaska stock.
9. *Gulf of Alaska stock status*. The U.S. stock assessment concluded that abundance is moderate and increased from recent lows, in large part due to the influence of the 1997 year class.

The following list of indicators relate to expected increases in sablefish production through recruitment and/or immigration to the Canadian zone:

1. *Gulf of Alaska stock status*. Exploitable biomass is expected to increase 6 percent from 2002 to 2003 due to the above average 1997 year class, which now accounts for 24 percent of the 2003 spawning biomass. The 1998 year class may also emerge as being above average with the accumulation of one or two more years of data.
2. *Continental U.S. indicators*. Relatively strong 1999 and 2000 year classes were observed by the triennial shelf survey, and the 2001 shelf survey results are the highest in the 1980 to 2001 series. This optimism that the 2001 year class might be very good follows poor recruitment through the 1990s (King et al. 2001) and a consequent decline in sablefish spawning stock biomass in the lower 48 States.
3. *Shrimp survey*. WCVI shrimp survey shows marked increase in sablefish catch rates in 2001 and 2002, in agreement with results from the lower 48 shelf and slope surveys and U.S. Pacific hake fishery bycatch, which suggest above average 1999 and 2000 year classes.
4. *Hecate Strait Observer Data*. Analyses of these data suggested an increase in the abundance of juvenile sablefish in 1998 and 1999 attributed to the 1998 year class.

The assessment incorporated the results of the fall 2002 abundance indexing survey, a new standardized commercial catch rate index, and a new tag-recovery model that adjusts tag returns for month effects. Analysis of sablefish recruitment indicators from various sources in British Columbia and the United States suggested that future production of sablefish should improve over low levels experienced in the 1990s. A simple biomass dynamics model was used to combine the stock indices and to examine the consequences of assumed levels of future production on projected stock biomass, where production, $\bar{P}$, was considered to be the combined effects of recruitment, immigration, emigration, and growth. It was recommended to pursue fishery objectives that will increase abundance from current levels. The decision-making procedure based on output from the simple biomass dynamics model depended explicitly on two considerations external to available data:

1. the degree of optimism regarding future production during the 2003 to 2008 projection period, e.g. $1\,\bar{P}$ to $1.5\,\bar{P}$, relative to the 1996 to 2002 reference period;
2. the desired trade-off between fishery yield and the objective to increase stock biomass, *B*, in 2008 relative to 2003, e.g. $P\left(B_{2008} > B_{2003}\right)$ and $E\left(B_{2008}/B_{2003}\right)$.

Advice to managers was cast in the form of decision tables and was not intended to set harvest levels for the five-year duration of the projection period. By necessity, frequent review of the stock indicators will be required pending the development of a satisfactory population dynamics model for examining the consequences of long-term harvest strategies for sablefish.

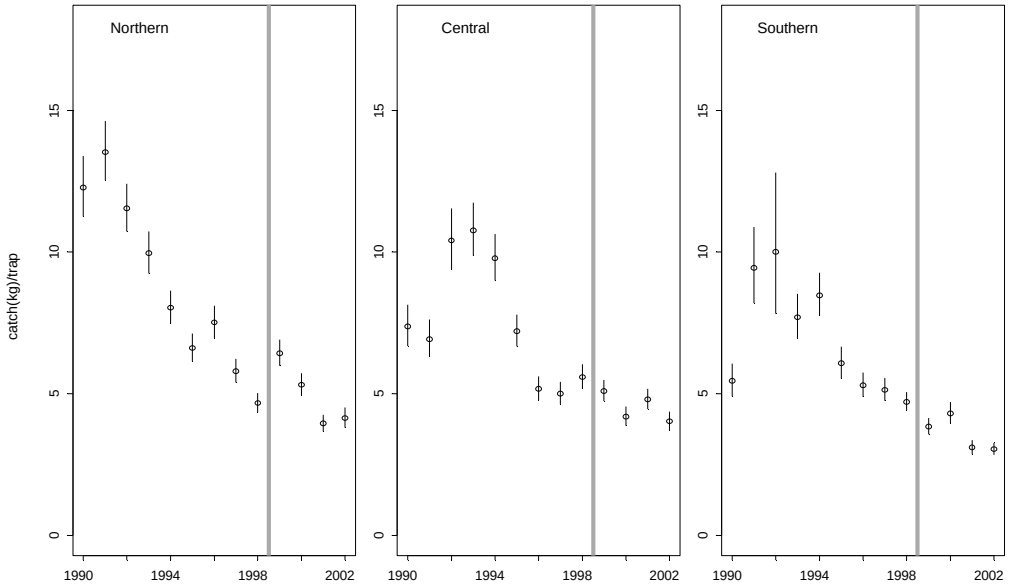

Figure 1: Year and region effects from standardized trap fishery model (kg/trap). Vertical lines indicate +/- two standard errors.

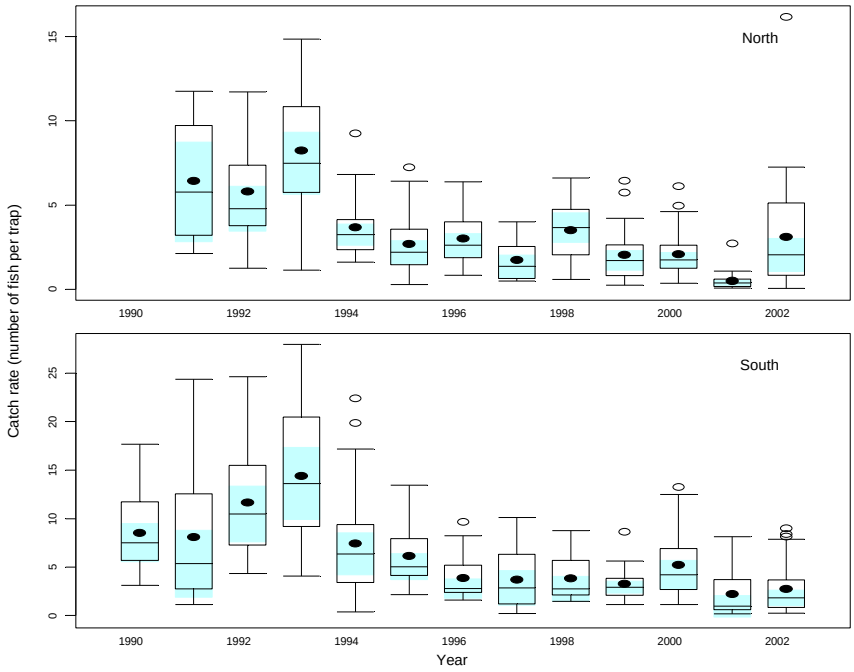

Figure 2: Distribution of sablefish survey catch rates (number of fish per trap) for each set by year and stock. Boxplots show the distribution of catch rates observed on each set. The filled circles show the mean annual catch rate. The lightly shaded rectangle indicates an approximate 95% confidence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

Figure 3: Relative trap vulnerable biomass (t) from tag-recovery model.

Research activities planned for 2003

Routine ageing of sablefish has not been conducted in BC since 1996, although structures have been collected annually. 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 spring of 2003 and should provide direction for subsequent assessment and research efforts.

An abundance index/tagging survey is planned for the fall of 2003.

4. Flatfish

i. Research programs in 2002

A Multispecies trawl survey was conducted in Hecate Strait in 2002. 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 (*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 isolepis*) and sand sole (*Psettichthys melanostictus*). The relative abundance indices for flatfish species in Hecate Strait were updated for future assessment work.

ii. Stock assessment in 2002

No stock assessments for flatfish were conducted in 2002

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). No work is planned for other areas of the coast.

6. Elasmobranchs

i. Research programs in 2002

An examination of potential age determination methods for big skate was undertaken. 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.

ii. Stock assessment in 2002

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.

Skate species are not actively managed in British Columbia. 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.

iv. Research activities planned for 2003

A tag/recapture program for Hecate Strait/Queen Charlotte Sound big skates to examine stock delineation will be initiated in 2003. The age determination method developed for big skate will be examined for its appropriateness for other skate species (e.g. longnose and black skate).

7. Lingcod

i. Research programs in 2002

Genetic results from egg mass samples collected in 2001 indicated that egg masses often receive contributions from more than one male, sometimes up to four males. Only one female contributed to a given egg mass. These results have been published in a primary paper. Fin rays from juvenile lingcod (1-3 year olds) were used to develop ageing criteria and estimate average 1 and 2 annuli measurements to aid in age determination. These results were published in a departmental Technical Report. Nest site affinity study was completed and will be published as a primary paper.

ii. Stock assessment

Offshore

No assessment was conducted on offshore lingcod stocks in 2002.

Inshore

No assessment was conducted on Strait of Georgia lingcod stocks in 2002. The Strait of Georgia remains closed to all commercial and recreational fishing.

iii. Research activities planned for 2003

Lingcod abundance surveys will be initiated in the Strait of Georgia in 2003. Final selection of the type of surveys will depend on budgetary constraints, however will likely include hook and line for juveniles and adults, bottom trawl for young of year, and submersible survey for juvenile and adults. An archival tagging program will be conducted to examine the seasonal distribution of lingcod in the Strait of Georgia.

D. Other related studies

1. Statistics and Sampling

Principal Statistics and Sampling activities in 2002 included the ongoing population of the groundfish biological database (GFBio). This database represents about 4,930,000 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 hake 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 about 350 length/sex/age samples and 760 length samples in 2002. 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 2002 the target of 10% was not achieved. The port sampling unit continued to use the hand-held data-logging unit that was field-tested in 2001. The data recording program of this new system can be adapted in the field. Due to the large number of samples being collected by observers in the trawl fishery the port samplers shifted their efforts towards gathering samples from non-trawl fisheries in 2002.

On the technical end, we continue to expedite and streamline our 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 we 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 GROUNDFISH FISHERIES

1. Commercial fisheries

All catch figures for 2002 are preliminary. Canadian domestic trawl landings of groundfish (excluding halibut) in 2002 were 97,981 t, an increase of 24% above the 2001 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 (58%), Pacific ocean perch (6%), turbot (5%), yellowtail rockfish (4%) and pollock (4%).

Canadian landings of groundfish caught by gear other than trawl in 2002 totalled 8,929 t. Sablefish landings by trap and longline gear accounted for 2,398 t, approximately 78% by trap gear and 22% by longline gear. Landings of species other than sablefish by longline, handline and troll gear accounted for 6,531 t (61% dogfish, 22% rockfish and 13% lingcod).

2. Recreational fisheries

Each year, Fisheries Management Branch (Fisheries and Oceans Canada) conducts creel surveys of the recreational angling fishery in the Strait of Georgia. Principal target species are chinook and coho salmon. In 2002 these surveys covered the months of April to September. Provisional estimates of 2002 catches, landings and discards, for this 6-month period were 3,745 fish for lingcod, 28,550 fish for all rockfish species, 473 fish for halibut and 22,709 fish for all other groundfish species, including dogfish, flatfish, greenling, cabezon, herring and ratfish.

Creel surveys were also conducted in Juan de Fuca Strait during 2002. These surveys covered the months of January to November. Provisional estimates of 2002 catches were 12,395 fish for lingcod, 14,771 fish for all rockfish species, 6,733 fish for halibut and 780 fish for other species.

Along the west coast of Vancouver Island catch estimates have been generated from creel surveys and fishing lodge reports. Data are available for April to September. Provisional estimates of 2002 catches were 16,697 fish for lingcod, 30,274 fish for all rockfish species, 15,971 fish for halibut and 379 fish for other species.

3. Joint-venture fisheries

There were no joint-venture fisheries for Pacific hake off southwest Vancouver Island (Area 3C) in 2002.

4. Foreign fisheries

There were no national or supplemental fisheries for Pacific hake off southwest Vancouver Island (Area 3C) in 2002.

APPENDIX 2. GROUNDFISH RELATED REPORTS PUBLISHED BY THE STOCK ASSESSMENT DIVISION IN 2002.

1. Primary Publications

Benson, A.J., G.A. McFarlane, S.E. Allen, and J.F. Dower. 2002. Changes in Pacific hake (Merluccius productus) migration patterns and juvenile growth related to the 1989 regime shift. Can. J. Fish. Aquat. Sci. 59: 1967 - 1979.

Crawford, W.R. , J.Y. Cherniawsky, M.G.G. Foreman, and J.F.R. Gower, 2002, "Formation of the Haida-1998 oceanic eddy", *Journal of Geophysical Research* 107(C7): 10,1029/2001JC000876.

Crawford, W.R., 2002: Physical characteristics of Haida Eddies. *J. Oceanography*., 58(5): 703-713.

Jiddawi, N. S., R. D. Stanley and A. R. Kronlund. 2002. Estimating fishery statistics in the artisanal fishery of Zanzibar, Tanzania. How big a sample size is required? Western Indian Ocean, Journal of Marine Science, 1(1): 19-33.

McFarlane, G.A., P.E. Smith, T.R. Baumgartner, and J.R. Hunter. 2002. Climate variability and Pacific sardine populations and fisheries. Am. Fish. Soc. Sym. 32: 195 - 214.

Schnute, J.T., and A.R. Kronlund. 2002. Estimating salmon stock-recruitment relationships from catch and escapement data. Canadian Journal of Fisheries and Aquatic Sciences 59: 433-449.

Schnute, J.T., and L.J. Richards. 2002. Surplus production models. Chapter 6, p. 105-126. In: Hart, P.J.B., and J.D. Reynolds. Handbook of Fish Biology and Fisheries, Volume 2: Fisheries. Blackwell Science Ltd. Oxford, UK.

Stanley, R. D., R. Kieser and M. Hajirakar. 2002. 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

Haigh, R., Schnute, J., Lacko, L., Eros, C., Workman, G., and Ackerman, B. 2002. At-sea observer coverage for catch monitoring of the British Columbia hook and line fisheries. Canadian Science Advisory Secretariat, Research Document 2002/108, 55 p.

King, J.R. and P. M. Winchell. 2002. Lingcod (*Ophiodon elongatus*) Egg Mass Density SCUBA Survey in the Strait of Georgia, January 15 – March 13, 2002. Canadian Technical Report of Fisheries and Aquatic Sciences 2437. 23 p.

McFarlane, G.A. 2002. 2001 Pacific Region State of the Ocean - Report of the Fisheries Oceeanography Working Group. Can. Tech. Rep. Fish. Aquat. Sci. 2423: 69p.

Schweigert, J. and G.A. McFarlane. 2002. Stock assessment and recommended harvest for Pacific sardine in 2003. Can. Sci. Ad. Sec. Res. Proc.

Sinclair, C. A. and N. Olsen. 2002. Groundfish research cruises conducted by the Pacific Biological Station, Fisheries and Oceans Canada. 1944-2002. Can. Man. Rep. Fish. Aquat. Sci. 2617.

Stanley, R. D. and N. Olsen. 2002. Update assessment of Silvergray rockfish (Sebastes brevispinis). DFO Canadian Science Advisory Secretariat Research Document G2002-03.

Stanley, R. D., K. Rutherford and N. Olsen. 2002 COSEWIC Status Report on Bocaccio, Sebastes paucispinis Ayres, 1854 from B.C. waters. Prepared for the COMMITTEE ON THE STATUS OF ENDANGERED WILDLIFE IN CANADA.

Starr, P.J., Krishka, B., and Choromanski, E. 2002. Trawl survey for thornyhead biomass estimation off the west coast of Vancouver Island, September 15 – October 2, 2001. Canadian Technical Report of Fisheries and Aquatic Sciences 2421, 60 p.

APPENDIX 3. STOCK ASSESSMENT DIVISION GROUNDFISH STAFF IN 2001

W. Andrews	Sablefish and hake
E. Choromanski	General stock assessment and biology, flatfish
K. Cooke	Database technician
J. Fargo	Section Head, stock assessment and biology, flatfish
R. Haigh	Statistical and exploratory data analysis
S. Hardy	Groundfish port sampling
G. Jewsbury	Sablefish and hake
K. Kastle	Groundfish port sampling
J. King	Lingcod and sablefish, climate studies
B. Krishka	Biological data control and analysis
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
N. Olsen	Biologist/programmer/GIS
K. Rutherford	Biologist/database manager
J. Schnute	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

Fisheries and Oceans lists of genetics samples for groundfish

species	date	vessel		area	# of fish	tissue sampled
babcocki	May-98	Double Decker	W.C.Qu.Char.Is.	Tasu	100	dorsal fin clip
babcocki	May-98	Double Decker	W.C.Qu.Char.Is.	Flamingo	100	dorsal fin clip
babcocki	May-98	Double Decker	W.C.Vanc.Is.	Top Knot	100	dorsal fin clip
babcocki	May-98	Double Decker	Northern tip Vanc.Is.	Triangle	100	dorsal fin clip
caurinus	17-Jul-98	Mariko/Striker	Strait of Georgia	Cooper Reef	30	opercular punch
flavidus	16-Nov-99	Ocean Achiever	Qu.Char.Sd.	Mexicana		
flavidus	29-Nov-99	Ocean Fisher #1	W.C.Vanc.Is.			
flavidus	26-Jan-00	Blue Waters	W.C.Vanc.Is.	Father Charles		
flavidus	27-Jan-00	Ocean Rebel	W.C.Vanc.Is.	Barkley		
flavidus	6-Dec-99	Nemesis	W.C.Vanc.Is.			
flavidus	22-Dec-99	Challenger	W.C.Vanc.Is.			
flavidus	25-Jan-00	Knight Dragon	W.C.Vanc.Is.			
flavidus	14-Feb-00	Gulf Spirit	W.C.Vanc.Is.			
flavidus	16-Feb-00	Zeal	W.C.Vanc.Is.			
flavidus	14-Dec-00	Kawadi	Qu.Char.Sd.	Goose Island		
flavidus	00-Nov-00	unknown	W.C.Washington	Gray's Harbour		
flavidus	23-Feb-01	Royal Fisher	Hecate Strait	5D		
maliger	17-Jul-98	Mariko	Strait of Georgia	Darcy Island	31	opercular punch
maliger	3-Feb-00	Tricia Lynn	Strait of Georgia	Stenhouse Reef	70	fin clips
maliger	10-Feb-00	Born Free	Strait of Georgia	Christie Pass - inside	100	fin clips
maliger	26-Sep-00	Tricia Lynn	Strait of Georgia	Stenhouse Reef	54	fin clips
maliger	27-Sep-00	Mariko	Strait of Georgia	Race Rocks	55	fin clips
maliger	27-Sep-00	Mariko	Strait of Georgia	Cooper Reef	68	fin clips
maliger	28-Sep-00	Mariko	Strait of Georgia	Gabriola Pass - Flat Tops	41	fin clips
maliger	13-Oct-00	Born Free	Strait of Georgia	Christie Pass - Gordon Channel	92	fin clips
maliger	25-Oct-00	Mariko	Strait of Georgia	Gabriola Pass - Pylades Channel	58	fin clips
maliger	1-Mar-01	Alert Bay	Strait of Georgia	Baronette Pass/Parsons Bay	391	fin clips
maliger	1-Apr-01	Alert Bay	Strait of Georgia	Baronette Pass/Parsons Bay	160	fin clips
maliger	24-Apr-01	Canadian Mist	W.C.Vanc.Is.	West Coast Vancouver Is. (24)	27	fin clips
maliger	2-May-01	Mariko	Strait of Georgia	Gabriola Reefs	49	fin clips

maliger	4-May-01	Mariko	Strait of Georgia	Pylades Channel	76	fin clips
maliger	16-May-01	Canadian Mist	W.C.Vanc.Is.	West Coast Vancouver Is. (24)	61	fin clips
maliger	31 Jun-00	WE Ricker	Hecate Strait	Hecate Strait	49	fin clips
ruberrimus	31-Jan-98	Covenant/Little Bonanza	Southern tip Qu.Char.Is.	S.W. Kunghit Island	165	pectoral fin
ruberrimus	May-98	Double Decker	W.C.Qu.Char.Is.	Tasu	100	dorsal fin clip
ruberrimus	May-98	Double Decker	W.C.Qu.Char.Is.	Flamingo	100	dorsal fin clip
ruberrimus	May-98	Double Decker	W.C.Vanc.Is.	Top Knot	100	dorsal fin clip
ruberrimus	May-98	Double Decker	Northern tip Vanc.Is.	Triangle	100	dorsal fin clip
ruberrimus	Jul-98	Double Decker	Bowie Seamount	Bowie Seamount	100	caudal punch
ruberrimus	Jul-98	Double Decker	Bowie Seamount	Bowie Seamount	100	caudal punch
ruberrimus	28-Sep-98	Double Decker	Bowie Seamount	Bowie Seamount	25	caudal punch
ruberrimus	15-Oct-98	Double Decker	Northern tip Vanc.Is.	127-4	100	caudal punch
ruberrimus	7/1/1999	Double Decker	Bowie Seamount	Bowie Seamount	205	pectoral fin
ruberrimus	7/1/1999	Double Decker	Bowie Seamount	Bowie Seamount	92	pectoral fin
ruberrimus	9/10/1999	Double Decker	Bowie Seamount	Bowie Seamount	100	pectoral fin
ruberrimus	9/10/1999	Double Decker	Bowie Seamount	Bowie Seamount	108	pectoral fin
ruberrimus	9/17/1999	Double Decker	W.C.Qu.Char.Is.	Barber Point	70	pectoral fin
ruberrimus	9/17/1999	Double Decker	W.C.Qu.Char.Is.	Barber Point	70	pectoral fin
ruberrimus	9/21/1999	Miss TJ	W.C.Vanc.Is.	Esperanza	47	pectoral fin
ruberrimus	10/6/1999	Miss TJ	Southern tip Qu.Char.Is.	Cape St. James	161	pectoral fin
ruberrimus	12/1/1999	Swan	S.E.Alaska	S.E.Alaska	100	pectoral fin
ruberrimus	1/26/2000	Triana	W.C.Qu.Char.Is.	Flamingo	75	pectoral fin
ruberrimus	3/14/2000	Ocean Gem	W.C.Vanc.Is.	TopKnot	104	pectoral fin
ruberrimus	3/15/2000	Ocean Gem	W.C.Vanc.Is.	TopKnot	74	pectoral fin
ruberrimus	Aug-00	Mariko	Strait of Georgia	Strait of Georgia Area 17		pectoral fin