# CANADA

British Columbia Groundfish Fisheries and Their Investigations in 2012

**May 2013**

Prepared for the 54th Annual Meeting of the
Technical Sub-Committee of the Canada-United States Groundfish Committee
April 30-May 1, 2013, NWAFSC, Seattle, Washington, USA.

Compiled by
K. L. Rutherford
Fisheries and Oceans Canada
Science Branch
Pacific Biological Station
Nanaimo, British Columbia
V9T 6N7

**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, British Columbia (BC), respectively. Dr. Laura Richards is the Regional Director of Science. The Divisions and Sections are as follows:

Division Heads in Science Branch reporting to Dr. Richards are:

| | |
|---|---|
| Canadian Hydrographic Service | Mr. David Prince (Acting) |
| Ocean Science | Mr. Robin Brown |
| Salmon & Freshwater Ecosystems | Mr. Mark Saunders |
| Marine Ecosystems & Aquaculture | Dr. Laura Brown |

Section Heads within the Marine Ecosystems & Aquaculture Division (MEAD) are:

| | |
|---|---|
| Groundfish | Mr. Greg Workman |
| Invertebrates | Mr. Graham Gillespie |
| Pelagic Fish Research & Conservation Biology | Mr. Jacob Schweigert |
| Applied Technologies | Mr. Henrik Krieberg |
| Aquaculture and Environmental Research | Dr. Steven MacDonald |

Groundfish research and stock assessments are conducted in the Groundfish Section. Groundfish specimen ageing and hydroacoustic work are conducted in the Applied Technologies Section. The Canadian Coast Guard operates DFO research vessels. These research vessels include the *W.E. Ricker, J.P. Tully, Vector*, and *Neocaligus*. A replacement vessel for the *W.E. Ricker* has been delayed until 2014 or beyond.

The Pacific Region Headquarters (RHQ) of Fisheries and Oceans Canada is located at 401 Burrard Street, in Vancouver, BC, V6C 3S4. Management of groundfish resources is the responsibility of the Pacific Region Groundfish Regional Manager (Mr. Neil Davis, Acting) within the Fisheries and Aquaculture Management Branch (FAM). Fishery Managers receive assessment advice from MEAD through the Canadian Centre for Scientific Advice Pacific (CSAP) review committee which is headed by Mrs. Marilyn Hargreaves. The Groundfish Section has at least two review meetings per year, in which stock assessments or other documents undergo scientific peer review (including external reviewers who are often from NOAA). The resulting Science Advisory Report summarises the advice to Fishery Managers, with the full stock assessment becoming a Research Document. Both documents can be viewed on the Canadian Stock Assessment Secretariat website: http://www.dfo-mpo.gc.ca/science/advice-avis/index-eng.html.

The Trawl, Sablefish, Rockfish, Lingcod, North Pacific Spiny Dogfish, and Halibut fishery sectors continue to be managed with Individual Vessel Quotas (IVQs). IVQs 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. Details for the February 2013 Groundfish Integrated Fisheries Management Plan can be viewed at http://www.pac.dfo-mpo.gc.ca/fm-gp/ifmp-eng.htm#Groundfish.

A shift in the funding of industry collaborations, particularly in conducting cooperative surveys, was required after the *Larocque* court decision of June 23, 2006. Prior to the *Larocque* decision, compensation provided to fishers for their data collection services took the form of the proceeds of the unavoidable fish kills in the research surveys, less any samples retained for detailed scientific analysis. In instances where these proceeds did not cover the cost of the research survey, the department allowed fishers to catch additional fish for payment purposes. Post-*Larocque* these "top up" payments for fishing activities were no longer possible. Larocque Relief Funding, to replace fish allocations, was provided in 2007 and continued to fund surveys through March 2013. Recent legislative changes grant the Minister of Fisheries and Oceans the authority to allocate fish or fishing gear for the purpose of financing scientific and fisheries management activities that are described in a joint project agreement entered into with any person or body, or any federal or provincial minister, department, or agency. Larocque Relief funded projects are targeted for transitioning to the new Fisheries Act provisions for the 2013-14 fiscal year, where feasible and where the current stakeholders are willing.

Allocations of fish for financing scientific and management activities are identified in the Groundfish Integrated Fisheries Management Plan. Joint project agreements outlining how industry and DFO will collaborate to support science and management activities through an allocation of fish are currently being developed for the 2013-14 fiscal year.

## B. Multispecies or ecosystem models and research

1. Stock Assessment Prioritization

A Groundfish Section stock assessment prioritization and scheduling plan was developed in 2011 and early 2012. This first plan covers 10 years (2012-2021) but the process calls for it to be reviewed and updated every five years, rolling forward over time. The current schedule focuses on 39 "Type A" species which includes species identified as being conservation concerns (i.e., Bocaccio, Basking Shark, etc.) and species which are important to the First Nations, commercial and recreational fisheries. The frequency of assessment for Type A species ranges from 1 year (i.e., Pacific Hake), to 2 years (Sablefish and Pacific Cod), to 5 or 10 years for the remaining Type A species depending upon biological characteristics, stock status, and FAM priorities.

The timing of assessment for species that have been flagged as conservation issues by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) is synchronized with the timing of COSEWIC re-assessments.

The remaining 200+ non-commercial fish species that can be considered to lie within the Groundfish research mandate are classified as Type B species. The current process calls for a fast

screening of the relative abundance trends in surveys and commercial CPUE for each of these species every five years. The fast screening is designed to provide a short-list of the 20-30 Type B species that should receive more detailed consideration in order for them to be scheduled into the coming 10 year workplan.

2. NSERC Canadian Capture Fisheries Research Network (CCFRN)

Starting in 2010, Groundfish staff have been participating in the National Sciences and Engineering Research Council of Canada's (NSERC) *Canadian Capture Fisheries Research Network*. The CCFRN is a collaboration of academic researchers, the fishing industry, and government researchers and managers from across Canada. The Network includes 33 academics from 13 universities, working with collaborators in the Canadian fishing industry, DFO, and provincial governments. The Network is industry-driven and focussed on projects that have the active collaboration of each sector. The Network will link with other strategic networks and coordinate with DFO programs, where appropriate.

The vision of the Network is to re-shape fisheries research in Canada, bringing together industry, academia and government on priority research questions and linking existing research so that it is useful to industry and management. The research of the Network is aimed at increasing knowledge that will enhance the ecological sustainability, socio-economic viability and management of Canadian fisheries. Specifically, the research objectives are to:

- overcome information gaps for important commercial fisheries and improve the use of industry information in assessment and management;
- enhance ecological sustainability while achieving operational efficiency; and improve the basis for the ecosystem approach to fisheries management.

The Network will provide a forum for sharing research objectives and results that will build capacity in each sector; as well as establish a tradition of collaborative, strategic fisheries research in Canada that is expected to extend beyond its timeline. In addition, the Network will train a cohort of new researchers that will be equipped to meet the research challenges of a new fisheries management regime.

The information and technological advances gained through the research of the Network will have a significant impact on the sustainability, viability and competitiveness of Canada's capture fisheries industry, and will provide environmental and socio-economic benefits. The research will build upon and inform the development of policies and strategies for the management of capture fisheries in Canada and internationally. Details can be found at: http://www.nsercpartnerships.ca/How-Comment/Networks-Reseaux/CCFRN-CCRRN-eng.asp

3. Summary of research surveys in 2012

A number of multi-species trawl surveys are conducted by the Groundfish Section and Groundfish staff participate in trawl surveys conducted by other groups. For a summary of research trawl survey activity in 2012, please see Appendix 2. Other research surveys conducted in 2012 include longline and trap surveys. These surveys are described under their respective species programs below.

## C. By species

1. Pacific Cod

i. Research program

1355 dorsal fin rays from the 2010 and 2011 groundfish surveys, covering all four major survey areas (West Coast Vancouver Island, West Coast Haida Gwaii, Hecate Strait and Queen Charlotte Sound) were analysed for ageing in 2012. Age and length data are now available in the groundfish database, GFBio. In addition, fins and otoliths from specimens less than 35 cm in length were collected during the 2012 shrimp and synoptic surveys. These samples will be analysed with the intention of developing improved techniques for ageing young Pacific Cod. A genetics expert was contracted to review literature and identify gaps in current understanding of the stock structure of Pacific Cod throughout the northeastern Pacific Ocean. Based on the recommendations of this review, genetic samples will be collected during the 2013 and 2014 synoptic surveys. Fishery observers will also be asked to collect genetic samples from spawning fish in the spring 2014 fishery. These samples will be analysed and used to address the question of whether or not Pacific Cod in Canada's waters are part of a larger population centred in Alaska. The genetic analyses will also be used to address the question of whether there are sub-populations within Canada's waters, as is currently assumed by management.

ii. Stock Assessments

No new stock assessments for Pacific Cod were conducted in 2012. Dr. Robyn Forrest and Mr. Rob Kronlund have made significant progress for an assessment in 2012, due for review in November 2013. This work will include feedback simulation studies to explore the performance of alternative management procedures for this species.

2. Rockfish – inshore

i. Research programs in 2012 and planned for 2013

1. Surveys on the Inside (PMFC Area 4B)

A research longline survey designed for the Inside waters east of Vancouver Island and initiated in 2003, surveyed the northern half of the study area in 2012. Hard bottom areas were identified through bathymetric analyses, inshore rockfish fishing records and fishermen consultations. The hard bottom survey areas were then overlain with a 2 km by 2 km grid and survey blocks were stratified by area and depth (41 – 70 m and 71 – 100 m) and selected for sampling at random. Twenty-one days of DFO ship time are allocated in August for this survey in 2013 which will cover the southern half of the study area.

Visual surveys are not planned for 2013.

2. Surveys on the Outside (PMFC Areas 3CD, 5ABCDE)

Since 2003, a third technician has been deployed on the annual International Pacific Halibut Commission (IPHC) Area 2B setline survey to collect hook-by-hook catch data and conduct

biological sampling of non-Halibut catch (Yamanaka et al. 2011; Flemming et al. 2011). The third technician was supported by Larocque funds between 2007 and 2012. A transition to other funding mechanisms has not been completed in time for this survey program in 2013.

In collaboration with the halibut industry, a research longline survey was designed and conducted in the outside BC coastal waters in 2006. Hard bottom areas were identified through bathymetric analyses, inshore rockfish fishing records and fishermen consultations. The hard bottom survey areas were then overlain with a 2 km by 2 km grid (matched with the adjacent trawl survey grid) and survey blocks were stratified by area and depth and chosen at random. Approximately 200 survey sets are targeted annually. The survey covers the coastwide Outside waters over two years, alternating annually between the north and the south. Three chartered fishing vessels conduct this survey between August 15 and September 15. The northern portion of BC was surveyed in 2012. Similar to the IPHC survey, alternative funding has not been secured for this program in 2013.

ii. Stock assessment

There were no stock assessments prepared in 2012 and no plans for 2013.

iii. Management

Public consultations on the potential Quillback Rockfish listing under SARA were conducted in 2012. Subsequent to the consultations, the Minister of Environment will make a decision on whether to list Quillback Rockfish as *threatened*.

3. Rockfish – shelf

i. Research Programs in 2012

There was no directed biological research work on shelf rockfish in 2012.

ii. Stock assessments in 2012

Work on the synchronous assessment of five rockfish (Splitnose, Sharpchin, Harlequin, Redstripe, and Greenstriped) was reviewed in the fall of 2012. Due to the paucity of historical information and unreliable stock reconstructions, the assessment of all five rockfish was inconclusive. A Bocaccio assessment was reviewed in May 2012; the assessment showed that the median estimate of the ratio of current stock size to that at maximum sustainable yield was 7.0%, with 90% confidence limits of 2.9-18.2%.

iii. Research activities planned for 2013

Completion of a Yellowtail Rockfish genetics paper is planned but requires a sample from the Strait of Georgia, which is proving difficult to obtain.

DFO staff continues to collaborate with NMFS-AFSC staff on the study of Blackspotted and Rougheye Rockfish. Genetics samples from all major surveys are now being collected and

analysed with the results shared with U.S. counterparts. Preliminary results were presented in a poster at the 2012 Western Groundfish Conference.

iv. Stock assessments planned for 2013

A coastwide Silvergray Rockfish assessment is planned for 2013, to be reviewed in November 2013.

4. Rockfish – slope

i. Research programs

The Slope Rockfish Program remains responsible for the assessment of rockfish species living on the marine continental slope of British Columbia (BC). The program also tackles a variety of other issues: COSEWIC (Committee on the Status of Endangered Wildlife in Canada) listing requirements, oceanographic exploration, software development for the R statistical platform, and scientific research in marine ecological modelling.

The Groundfish Section at the Pacific Biological Station (PBS, Nanaimo BC) conducts a suite of synoptic surveys that covers most of BC's ocean bottom ecosystems, including those on the continental shelf and slope. The survey team gathers information on abundance and biology (lengths, weights, maturity, otoliths, etc.). The Slope Rockfish Program, headed by Andrew M. Edwards (PBS research scientist) and including Rowan Haigh (PBS research biologist), focuses on the development of models and software tools for the analysis of data pertaining to groundfish and other species. The program retains the interest of two scientists – Jon T. Schnute (PBS scientist emeritus) who contributes time and expertise; and Paul J. Starr who works for the Canadian Groundfish Research and Conservation Society and plays an integral role in the stock assessments assigned to our program.

Work started on an International Governance Strategy (IGS) project entitled *Ocean Acidification and Impacts on Marine Ecosystems* headed by Debby Ianson at the Institute of Ocean Sciences (IOS, Sidney BC). Participants include Andrew Edwards (PBS), Rowan Haigh (PBS), Carrie Holt (PBS), and Holly Neate, a co-op student from the University of Victoria who worked at PBS for eight months. The first phase of the study involves a literature review and paper outlining the direct and indirect effects of ocean acidification on marine organisms and habitats along the Canadian west coast. The report will concentrate on the effects to BC fisheries.

In 2012, work continued on maintaining and upgrading the suite of PBS packages for the R statistical platform:

| | |
|---|---|
| PBSmodelling | http://cran.r-project.org/web/packages/PBSmodelling/index.html |
| PBSmapping | http://cran.r-project.org/web/packages/PBSmapping/index.html |
| PBSadmb | http://cran.r-project.org/web/packages/PBSadmb/index.html |
| PBSddesolve | http://cran.r-project.org/web/packages/PBSddesolve/index.html |
| PBStools | http://code.google.com/p/pbs-tools/ |
| PBSmapx | http://code.google.com/p/pbs-mapx/ |
| PBSdata | http://code.google.com/p/pbs-data/ |

PBSawatea http://code.google.com/p/pbs-awatea/

In particular, Nicholas Boers (Computer Science, Grant MacEwan University, Edmonton AB) worked on issues identified by developers and users of PBSmapping and PBSmodelling. Nick is the original computer programmer for the mapping package and remains the primary source for the C-code therein. Additionally, he has quickly learnt the programming behind PBSmodelling, which greatly simplifies the cumbersome mechanism of tcl/Tk (tool command language/ toolkit) for building graphical user interfaces (GUIs) in R.

Research continued in the wider area of marine ecological modelling, including a publication (Edwards *et al.*, 2012) that demonstrated methodological issues in recent *Nature* and *Science* papers concerning movements of marine animals (including Atlantic cod, basking sharks, bigeye tuna and mussels). Correcting the methodological issues (by using valid likelihood methods) led to opposite biological conclusions to those originally found.

We hosted a *Fisheries Applications of Remote Observations* workshop at PBS, 20-22nd March. Instructors came from Bedford Institute of Oceanography and Plymouth Marine Laboratory, UK. Participants came from government, academia, industry and First Nations. The workshop fostered many potential collaborations, and may lead to Remote Sensing (of ocean colour) being used in future Fisheries Applications, such as for albacore tuna.

ii. Stock assessment

In 2012, our group presented the first BC stock assessments for populations of Pacific Ocean Perch (POP, *Sebastes alutus*) along the west coast of Vancouver Island (Pacific Marine Fisheries Commission area (PMFC) 3CD) and the west coast of Haida Gwaii and Dixon Entrance (PMFC 5DE). These Bayesian models complete the coastwide assessment of POP started in 2010, when the Queen Charlotte Sound (PMFC 5ABC) stock was assessed for the first time since 2001.

For area 3CD, the spawning biomass (mature females only) at the beginning of 2013 ($B_{2013}$) was estimated to be 0.41 (0.19-0.68) of unfished spawning biomass ($B_0$); numbers in brackets denote median and 5$^{th}$ and 95$^{th}$ quantiles of the Bayesian posterior distribution. Also, $B_{2013}$ was estimated to be 1.53 (0.55-3.32) of the equilibrium biomass at maximum sustainable yield, $B_{MSY}$ (Figure 1).

For area 5DE, $B_{2013}$ was estimated to be 0.37 (0.16-0.67) of $B_{0,}$ and 1.61 (0.57-3.57) of $B_{MSY}$ (Figure 1).

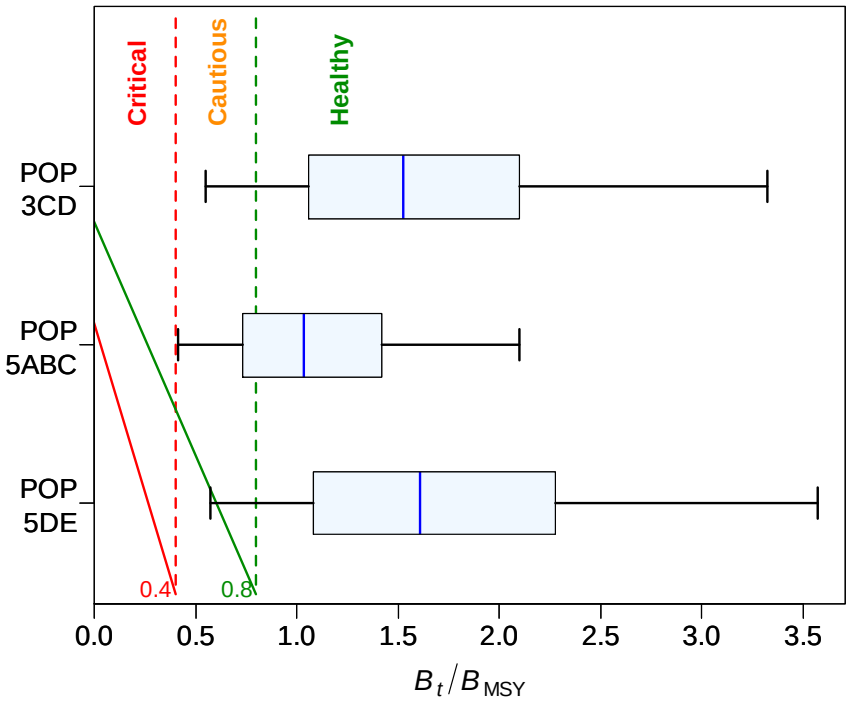


Figure 1. Current status of the three Canadian POP stocks relative to the DFO Precautionary Approach provisional reference points of $0.4B_{MSY}$ and $0.8B_{MSY}$. The value of $B_t/B_{MSY}$ is for $t$ = 2013 for 3CD and 5DE, and for $t$ = 2011 for area 5ABC. Boxplots show the 5, 25, 50, 75 and 95 percentiles from the Bayes posterior distribution of $B_t/B_{MSY}$.

An exceptionally strong recruitment of age-1 fish in 1977 was estimated for the stock in area 5DE, though not for area 3CD.

Decision tables were presented using the provisional reference points from the DFO *Sustainable Fisheries Framework* Precautionary Approach, namely a limit reference point of $0.4B_{MSY}$ and upper reference point of $0.8B_{MSY}$. For area 3CD, $B_{2013}$ is estimated to have a 0.99 probability of being $>0.4B_{MSY}$, and a 0.87 probability of being $>0.8B_{MSY}$ (i.e., of being in the healthy zone). The probability that the exploitation rate in 2012 is below that associated with MSY is 0.89.

For area 5DE, $B_{2013}$ was estimated to have a 0.98 probability of being $>0.4B_{MSY}$, and a 0.88 probability of being $>0.8B_{MSY}$. The probability that the exploitation rate in 2012 was below that associated with MSY is 0.84.

Advice to management was presented in the form of decision tables using ten-year projections for a range of fixed harvest levels. For both stocks, removals slightly above the recent mean catches in each of the next ten years indicate essentially no change in the aforementioned probabilities of the spawning biomass being above the reference points.

iii. Research activities for 2013

Preparatory work will start for a stock assessment on Redbanded Rockfish (*S. babcocki*) for 2014, and possibly for a future assessment of Shortraker Rockfish (*S. borealis*). Some of us will

also be assisting in the Rock Sole (*Lepidopsetta bilineatus*) assessment scheduled for review in November.

The collaborative project on ocean acidification will continue until 2014/15, including completion of the literature review and meshing biological responses to model predictions of $pCO_2$ and pH off the west coast of Vancouver Island.

If funding becomes available, we will collaborate with Jackie King (PBS) on a project called "Implementing Ecosystem-based Fisheries Management in the Groundfish Stock Assessment Process" funded by the Strategic Program for Ecosystem-Based Research and Advice (SPERA). The objectives are (i) to identify mechanisms linking climate-ocean variability to groundfish recruitment, and (ii) to construct and test the decision-based framework for commercially important groundfish species.

5. Sablefish

i. Research activities in 2012 and planned for 2013

The Sablefish Research and Assessment Survey Program includes the following program components:

a) A **Traditional Standardized Program** (1990-2010)

This program was not conducted in 2011-2012 and is unlikely to be resumed. This program included standardized sets at nine (9) offshore fishing localities and biological sampling. Starting in 1990, one set was made in each of five (5) depth intervals in each locality. Since 1999, additional shallower and deeper depth intervals have been added, removed and changed. However, the 5 core intervals have remained the same over time. Catch rates from these core sets extend a stock abundance index series and Sablefish are sampled for data on size and growth.

b) A **Traditional Tagging Program** (1991-2007, hiatus in 2008-2012)

This program captures Sablefish for tagging and release at historical tagging locations. Sets are made in the 9 traditional standardized program localities as well as five (5) tagging-only localities. The protocol for this program is to release a specified number of tagged fish in each locality. Low catch rates in some areas in previous years have resulted in survey vessels being required to re-set additional strings in an area. Tag-recoveries from these sets can be used for studying movement, obtaining estimates of gear selectivity, and deriving an index of tagging-based abundance.

c) A **Randomized Tagging Program** (2003-2012)

This program captures Sablefish for tagging and release following a depth and area stratified random survey design. The catch rate data can be used to derive an index of stock abundance. Tag-recoveries can be used for deriving estimates of gear selectivity, studying movement, and deriving an index of tagging-based abundance. The survey also provides biological samples.

d) An **Inlets Program** (1995-2012)

This program includes standardized sets at four (4) mainland inlet localities. Sablefish are tagged and released from inlet sets and are sampled for biological data.

The annual Research and Stock Assessment Survey Program will be conducted in the fall of 2013 contingent on adequate resources from DFO and the Sablefish industry, but will include only the randomized program (c) and the inlets program (d).

ii. Stock assessment activities in 2012 and planned for 2013

A full assessment of Sablefish was conducted in 2010 (Cox et al. 2011). The next scheduled re-examination of the management strategy evaluation simulations is planned for late 2013, the results of which will provide advice for the 2014/15 fishing year and subsequent 2 fishing years. The coast-wide quota for the 2013/14 fishing year was set at approximately 1,900 t based on the catch recommendation from the preferred management procedure.

Sablefish stock assessment and management in British Columbia is conducted collaboratively by DFO and the Canadian Sablefish Association. The collaboration is formalized as a Joint Project Agreement that identifies the respective responsibilities of the two parties and provides a mechanism for joint contributions to fishery management and science activities for Sablefish. Annual survey activities are conducted using fishing vessels chartered from the Sablefish longline trap fleet.

Fishery reference points are based on a target spawning biomass at maximum sustained yield, $B_{MSY}$, with limit and upper stock reference points at $0.4B_{MSY}$ and $0.8B_{MSY}$, respectively. Conservation objectives relate to (*i*) maintaining the spawning biomass above the limit reference point of $0.4B_{MSY}$ in 95% of years projected over two Sablefish generations (~36 years), and (*ii*) implementing an acceptable probability of stock decline over 10 years that scaled from 0.5 at the target biomass to 0.05 at the limit reference point. A multi-gear, age-structured, catch-at-age model was fitted to historical data to create stock scenarios that captured uncertainty in natural mortality, growth, and future recruitment variability. Stock reconstructions suggest stock status is currently below $B_{MSY}$ for all scenarios. A closed-loop feedback simulation approach was used to evaluate the relative performance of candidate management procedures that are distinguished by the choice of survey data, assessment model assumptions, harvest control rule specifications, and future regulations related to at-sea release of sub-legal Sablefish. Candidate management procedures were robust to the uncertainties considered as indicated by a consistently low probability ($p < 5\%$) of breaching the limit reference point over two Sablefish generations (~36 years) regardless of the management procedure or stock scenario. Expectations for stock growth toward the target reference point over two Sablefish generations range from $B_{MSY}$ or greater to levels near, but not above $B_{MSY}$ under the more pessimistic scenarios.

Performance of management procedures based on the stratified random trap survey alone suggested the legacy standardized trap survey could be discontinued without creating a conservation concern, and could also achieve reduced catch variability relative to the use of both surveys. Increases in expected conservation and catch performance due to adopting an avoidance option for sub-legal Sablefish, or a full retention option, were small relative to the performance

attained by the existing size limit tactic, but these effects are likely underestimated due to suspected violations of assumptions related to trawl gear selectivity.

Development of the management strategy evaluation for BC Sablefish in 2010 added modeling of retained and released catches to the age-structured operating model. A 55 cm fork length minimum legal size limit in British Columbia means that sub-legal fish are released by regulation. Work in 2013 will focus on improvements to the modeling of releases by gear sector and simulation evaluation of the $B_{MSY}$-based reference points. The longline trap and longline hook sectors of the Sablefish fishery in BC received Marine Stewardship Council certification on July 29, 2010. Certification was awarded with conditions related to (*i*) assessment of stock status relative to fishery reference points and in particular whether the stock is fluctuating around the target reference point, (*ii*) evaluation of the impacts of bycatch of the rougheye/blackspotted rockfish complex, (*iii*) evaluation of existing sea-bird bycatch data and improvement of seabird bycatch monitoring data collection.

New research planned for the annual survey and commercial fishing trips to the northern seamount fishery in 2013 focuses on (1) quantifying bottom contact by fixed longline trap gear; (2) biological sampling and tagging of Sablefish at seamounts, and (3) continuing biological data collection for the Blackspotted/Rougheye Rockfish sibling species complex:

1. Quantifying bottom contact is a first step toward evaluating and (possibly) mitigating effects of fishing on benthic habitat, as per requirements under the DFO Policy for Managing the Impacts of Fishing on Sensitive Benthic Areas. This activity is also consistent with Marine Stewardship Council Condition 5 on the Sablefish fishery, which requires that the management system demonstrate "*… sufficient data are available to allow the nature of the interaction of the fishery on habitat types to be identified and that there is reliable information on the spatial extent of the interaction, and timing and location of use of the fishing gear*".

2. Biological sampling includes measurements of individual sablefish length, sex, maturity, and extraction of ageing structures (i.e., otoliths). The tagging activity includes the first attempts to release tagged sablefish at seamounts since a small release was conducted in 1987. Tag releases-recoveries obtained from this research work will be analyzed along with coastal tag releases-recoveries to determine the possible extent of sablefish movement between seamounts and coastal areas.

3. Sampling of Blackspotted and Rougheye Rockfish will be undertaken as opportunities arise to fulfill biological and genetic data needs in support of the *Management Plan for the Rougheye Rockfish Complex (Sebastes aleutianus and S. melanostictus) and Longspine Thornyhead (Sebastolobus altivelis) in Canada*.

Electronic equipment will be deployed affixed to Sablefish traps during permitted fishing operations. The following devices will be attached within traps:

1. Tri-axial accelerometers that produce measurements of quasi-continuous 3-axis motion and orientation of fishing traps;

2. Deep-water autonomous cameras affixed to traps that produces motion-activated and fixed-interval high definition video of benthic substrate type, gear interaction with the substrate, and biological communities);

3. Standard oceanographic temperature-depth recorders (Seabird SBE39's) that measure *in situ* depth and temperature data needed for gear mobility (depth) and habitat suitability modeling (both).

Successful development of the methodology for quantifying the nature of interaction between fishing gear and benthic habitat at seamounts will encourage application to continue similar activities during permitted commercial fishing operations in the future at seamounts, and for research on fishing gear interactions with benthic habitat during coastal commercial fishing.

6. Flatfish

i. Research program in 2012

Ongoing data collection in support of the flatfish research program continued in 2012 with samples being collected during two Groundfish synoptic bottom trawl surveys, the first off the west coast of Vancouver Island and the second off the west coast of Haida Gwaii. Additional samples were collected by port samplers in Vancouver as well as by at-sea observers deployed on bottom trawl vessels. During surveys biological data were collected from all flatfish species encountered.

ii. Research activities planned for 2013

Biological data collection for all flatfish species will continue in 2013 with fishery independent samples coming from Hecate Strait/Dixon Entrance and Queen Charlotte Sound synoptic surveys.

iii. Stock assessments planned for 2013

A coast wide assessment of Rock Sole is planned for 2013. The required aging is complete, a project charter has been drafted, a working group formed and the assessment is scheduled to be reviewed in November of 2013.

7. Lingcod

i. Research programs in 2012

A Lingcod (*Ophidodon elongatus*) egg mass survey was conducted by DFO SCUBA divers at Snake Island Reef and Entrance Island Reef in the Strait of Georgia in February 2013. This survey was undertaken to add to the existing time series from Snake Island Reef, one of the primary index sites, and to provide an ongoing source of biological and relative abundance information for Strait of Georgia Lingcod.

ii. Research activities planned for 2013

Starting in 2012, Dr. Murdoch McAllistair from the University of British Columbia will be leading a multi-year research project aimed at using management strategy evaluation to identify economically viable harvesting options for the BC small boat groundfish fleet. This project is funded by the National Sciences and Engineering Research Council of Canada's (NSERC) *Canadian Capture Fisheries Research Network.* The outside Lingcod fishery will be used as an initial case study for this research, with the Lingcod portion of the research focusing on the question of how seasonal differences in habitat use and vulnerability to capture between male and female Lingcod affect management performance for different harvest options. DFO staff will be collaborating on this project.

iii. Stock assessments planned for 2013

A stock assessment of the inside (Strait of Georgia) Lingcod stock is planned for May 2014. As part of the assessment, a management strategy evaluation (MSE) approach will be used to provide harvest advice. MSE will be used to compare performance measures based on stock status and yield for alternative harvest strategies identified by groundfish managers and a multi-stakeholder working group. This comparison will enable managers to identify which harvest strategy provides the most acceptable trade-off between performance measures, while ensuring that the objectives and risk tolerances identified by both the DFO Precautionary Approach Framework and stakeholders are met.

8. Pacific Hake

9. Research programs in 2012

Triennial (until 2001), then biennial acoustic surveys, covering the known extent of the Pacific Hake stock have been done since 1995. Though it was unscheduled, a full survey, ranging from California to northern British Columbia was done in 2012: this survey was done in response to concern about the status of the stock due to the 2012 survey biomass estimate of 521,000 metric tonnes, which was the lowest estimate since the beginning of the time series in 1995; the 2012 survey biomass estimate was 1,380,724 metric tonnes. The abundance was dominated by two and four-year old fish from the 2008 and 2010 year classes. Following the 2010 assessment, nearly all of the data sources available for Pacific Hake were reconstructed and thoroughly re-evaluated by US scientists, with input from Canadian scientists. These improved data streams were updated for 2013 with the addition of new age distributions from the 2012 fishery and acoustic survey, as well as the 2012 acoustic survey biomass index.

9. Stock assessments planned for 2013

Coastwide landing for Pacific hake in 2012 were 204,040 mt. In Canada, the assessment-based allocation for 2012 was 50,345 mt; with the additional overage carried forward from 2011 this became 65,772 mt. The fishery caught 46,776 mt, 92.9% of the 2012 allocation or 71.1% of the total allocation including the overages from 2011. Since the catch was only 71.1% of the total, the fishery will again be allowed the maximum 15% overage for the 2013 season. The 2012 catch was taken solely by the shore-based fishery; the JV fishery was not opened. The 2012 fishery followed the same spatial pattern as in the last several years with older, larger fish caught in Queen Charlotte Sound later in the year and a large portion of the total caught in the vicinity of

La Perouse Bank throughout the summer and fall months. Quatsino Sound and Brooks Peninsula have also become hotspots for the fishery in the last two years.

Management of Pacific Hake is now under treaty between Canada and the United States. The Joint US-Canada Agreement for Pacific Hake (called the Agreement) was formally ratified in 2006 (signed in 2007) by the United States as part of the reauthorization of the Magnuson-Stevens Fishery Conservation and Management Act. Although the Agreement has been considered to be in force by Canada since June 25, 2008, an error in the original U.S. text required that the Agreement be ratified again before it could be implemented. This second ratification occurred in 2010. Under The Agreement, Pacific Hake stock assessments are to be prepared by the Joint Technical Committee (JTC) comprised of both U.S. and Canadian scientists and reviewed by the Scientific Review Group (SRG), with national representatives to both groups appointed by their respective governments.

In contrast to previous years, the 2013 assessment for Pacific Hake used a single assessment model. The JTC used the Stock Synthesis platform, with the same base-case parameterization that was used in the 2012 assessment. The assessment depends primarily upon the acoustic survey biomass index (1995, 1998, 2001, 2003, 2005, 2007, 2009, 2011 and 2012) for information on the scale of the current hake stock. The 2011 index was the lowest in the time-series but the 2012 index was much greater. The aggregate fishery age-composition data (1975–2012) and the age-composition data from the acoustic survey contribute to the model's ability to resolve strong and weak cohorts. Both sources show a somewhat strong 2008 cohort and a strong 2010 cohort, but the 2011 and 2012 age compositions differ slightly regarding the relative magnitude of the weaker 2005 and 2006 cohorts. Applying the default F40% target harvest rate with a 40:10 adjustment, led to a median predicted catch of 626,364 mt but the TAC was set to be much lower.

The key uncertainty in the 2013 assessment was the strength of the 2010 year class. The 2013 assessment showed that until cohorts are five or six years old, the model's ability to resolve cohort strength is poor. For many of the recent above-average cohorts (2005, 2006, and 2008), the size of the year class was overestimated when it was age 2, compared to updated estimates as the cohort aged and more observations were available from the fishery and survey. Accordingly, the 2013 TAC was set with some caution.

The final decision on catch advice for the 2013 fishing season was made at the meeting of the International Pacific Hake Joint Management Committee in Lynnwood, WA on March 18-19, 2013. The final, coast-wide, unadjusted quota was 336,200 mt with an adjusted quota (including carry overs) of 365,112 mt. All Pacific Hake Agreement documents are posted at: http://www.nwr.noaa.gov/fisheries/management/whiting/pacific_whiting_treaty.html

9. Elasmobranchs

i. Research programs in 2012

Ongoing collaboration with the Alaska Fisheries Science Center and Moss Landing Marine Labs, on a collaborative project on bomb dating for age validation of Big Skate (*Raja binoculata*) and Longnose Skate (*R. rhina*). A population genetics study for Salmon Shark in the North Pacific

began with collaborators from Alaska, California and Mexico. Age determination studies on Spotted Ratfish will be completed in 2012. A population genetics study for blue shark in the North Pacific was completed with collaborators from California, Alaska, Hawaii and Japan. Age determination studies on Spotted Ratfish was completed in 2012 using volmerine tooth plate ridge counts.

ii. Stock assessment in 2012

There were no elasmobranch assessments in 2012.

iii. Management

There were no new elasmobranch management iniatives in 2012.

iv. Research activities for 2013.

A stock assessment for Big Skate (*Raja binoculata*) and Longnose Skate (*R. rhina*) will be completed in May 2013.

**D. Other related studies**

1. Statistics and Sampling

i. Biological sampling and database work in 2012

Principal Statistics and Sampling activities in 2012 included the ongoing population of the groundfish biological database (GFBio). This database now includes almost 9,100,000 specimens. Data entry activities continue to concentrate on the input of current port sampling and observer biological data and recent research cruises. The groundfish trawl fishery continues to be covered by 100% dockside and virtually 100% observer coverage. These observers also provided 297 length/sex/age samples and 189 length samples in 2012. Port samplers provided an additional 29 samples, all except one sample with ageing structures (length/sex/age/weight). The focus of their sampling efforts was from those fisheries not covered by at-sea observers.

Statistics and Sampling staff also took the lead DFO role in assisting Industry and ENGO personnel in data analysis to support development of a plan to freeze and shrink the extent of bottom trawling on the BC coast. It is expected that the plan will be implemented in early 2012.

ii. Catch monitoring in 2012

Staff continued to play a key role in development of a new Regional Catch Monitoring information system as well being actively involved in the Groundfish Hook and Line Catch Monitoring Program and a Recreational Catch Monitoring Working Group.

iii. Field work in 2012

Staff participated on various bottom trawl surveys (see Summary of Groundfish Surveys below) including the west coast of Vancouver Island and west coast of Haida Gwaii (formerly called Queen Charlotte Island) groundfish trawl surveys, a new Strait of Georgia survey, the West Coast Vancouver Island, and Queen Charlotte Sound shrimp trawl surveys, as well as the Pacific Hake hydroacoustic survey and Sablefish survey. This group also included the port sampling activity (1 person-year) in the Vancouver area. Staff continued to enhance GFBioField, the integrated (paper-less) data capture system for surveys.

iv. Proposed field and database work for 2013

Port sampling in the Vancouver area will continue in 2013, and will include the addition of sampling sablefish tag recoveries and frozen samples from seamount trips.

Staff will participate in bottom trawl surveys to Hecate Strait and Queen Charlotte Sound, the shrimp trawl surveys off the west coast of Vancouver Island and in Queen Charlotte Sound, the Pacific Hake hydroacoustic survey and the Sablefish survey.

Development of "GFCatchAll" as a comprehensive database that will include all known sources of groundfish catch (1900-present) was to have been started in 2012. This focus of this project is currently being reexamined.

APPENDIX 1. REVIEW OF CANADIAN GROUNDFISH FISHERIES

1. Commercial fisheries

All catch figures for the 2012 calendar year are preliminary. Canadian domestic trawl landings of groundfish (excluding halibut) in 2012 were 80,310 t, a decrease of 1% from the 2011 catch. The major species in the trawl landings were Pacific Hake (58%), Arrowtooth Flounder (6%), Walleye Pollock (6%), Pacific Ocean Perch (5%), Yellowtail Rockfish (5%), and Dover Sole (3%). Trawl production was distributed amongst areas 3C (36%), 3D (27%), 5B (10%), 5A (10%), 4B (5%), 5D (5%), 5E (3%), and 5C (2%).

Canadian landings of groundfish caught by gear other than trawl in 2012 totalled 7,175 t. Landings of Sablefish by trap and longline gear accounted for 2,562 t, approximately 32% by trap gear, 62% by longline gear and 6% by unspecified. Landings of species other than Sablefish by trap, longline, handline and troll gear accounted for 4,250 t (46% rockfish, 22% Lingcod, 20% North Pacific Spiny Dogfish, and 11% skates).

2. Recreational fisheries

Each year, Fisheries Management Branch of DFO conducts creel surveys and collects fishing lodge logbooks for the recreational angling fishery in the four south coast regions.

For the Strait of Georgia, in 2012, the estimates were generated from a combination of creel surveys and fishing lodge reports and covered the months of January to September. Provisional estimates of 2012 catches, landings and releases, for this 9-month period were 23,150 fish for Lingcod, 27,356 fish for all rockfish species, 614 fish for Pacific Halibut, 7,109 fish for Rock Sole, 5,701 fish for Starry Flounder, 11,138 fish for North Pacific Spiny Dogfish, 5,117 fish for greenlings, 2,848 fish for Pacific Cod and 1,868 fish for other groundfish species.

For the Strait of Juan de Fuca catch estimates have been generated from creel surveys and fishing lodge reports for the months of January to September. Provisional estimates for this 9-month period are 6,447 fish for Lingcod, 15,992 for all rockfish species, 4,538 fish for Pacific Halibut, 1,137 fish for rock sole, 1,389 fish for other flatfish species, 9,966 fish for North Pacific Spiny Dogfish, 7,937 fish for greenlings, and 2,736 fish for other groundfish species.

Along the west coast of Vancouver Island catch estimates have been generated from creel surveys and fishing lodge reports. Data are available for May to September. Provisional estimates of 2012 catches were 32,376 fish for Lingcod, 40,374 fish for all rockfish species, 36,755 fish for Pacific Halibut, 1,244 fish for North Pacific Spiny Dogfish, 3,239 fish for greenlings, and 1,174 fish for other groundfish species.

In Johnstone Strait catch estimates have been generated from creel surveys and fishing lodge reports for June to August. Provisional estimates of 2012 catches were 4,292 fish for Lingcod, 10,547 fish for all rockfish species, 6,415 fish for Pacific Halibut, 1,434 fish for Pacific cod, 1,061 fish for greenlings, 614 fish for North Pacific Spiny Dogfish and 1,276 fish for other groundfish species.

3. Joint-venture fisheries

There were no joint-venture fisheries conducted off British Columbia in 2012.

4. Foreign fisheries

There were no national or supplemental fisheries for Pacific Hake off British Columbia in 2012.

APPENDIX 2. SUMMARY OF BOTTOM TRAWL SURVEYS IN 2012

**TABLE OF CONTENTS**



## 1. **Multi-Species Small mesh (SHRIMP) bottom trawl Survey**

An annual fixed-station survey of commercially important shrimp grounds off the West Coast of Vancouver Island was initiated in 1973. In 1998, areas in Eastern Queen Charlotte Sound were added to the survey. The survey is conducted using a shrimp bottom trawl without an excluder device. As a result, groundfish can make up a significant portion of the catch in many of the tows. Catch rate indices generated by the survey have been used to track the abundances of several groundfish stocks. Catch per unit effort is a useful indicator of stock status but additional information such as the size and age composition of the catch improves the usefulness of the index. Consequently, a program was initiated in 2003 to collect biological samples from all groundfish species caught during the survey.

The groundfish section routinely places two staff on board for the duration of the survey. Four different groundfish staff participated in the shrimp survey in 2012. Groundfish staff provide assistance in catch sorting and species identification and also collect biological samples from selected species. Since 2010 the goal has been to collect a small subset of information from as many different species in each tow as possible, as opposed to detailed information from only a few species. As such, most of the biological sampling effort has been focused on length by sex data as opposed to collecting ageing structures. Ageing structures were collected from Rougheye/ Blackspotted Rockfish, Bocaccio Rockfish, and Pacific Cod.

The 2012 survey was conducted onboard the W.E. Ricker and ran from April 26 to May 22. A total of 179 tows were conducted. The total catch weight of all species was 73,426 kg. The mean catch per tow was 410 kg, averaging 26 different species of fish and invertebrates in each. The most abundant fish species encountered was Arrowtooth Flounder (*Atheresthes stomias*) followed by Pink Shrimp (*Pandalus jordani*) and Eulachon (*Thaleichthys pacificus*). Biological data were collected from a total of 32,436 individual fish from 44 different groundfish species.

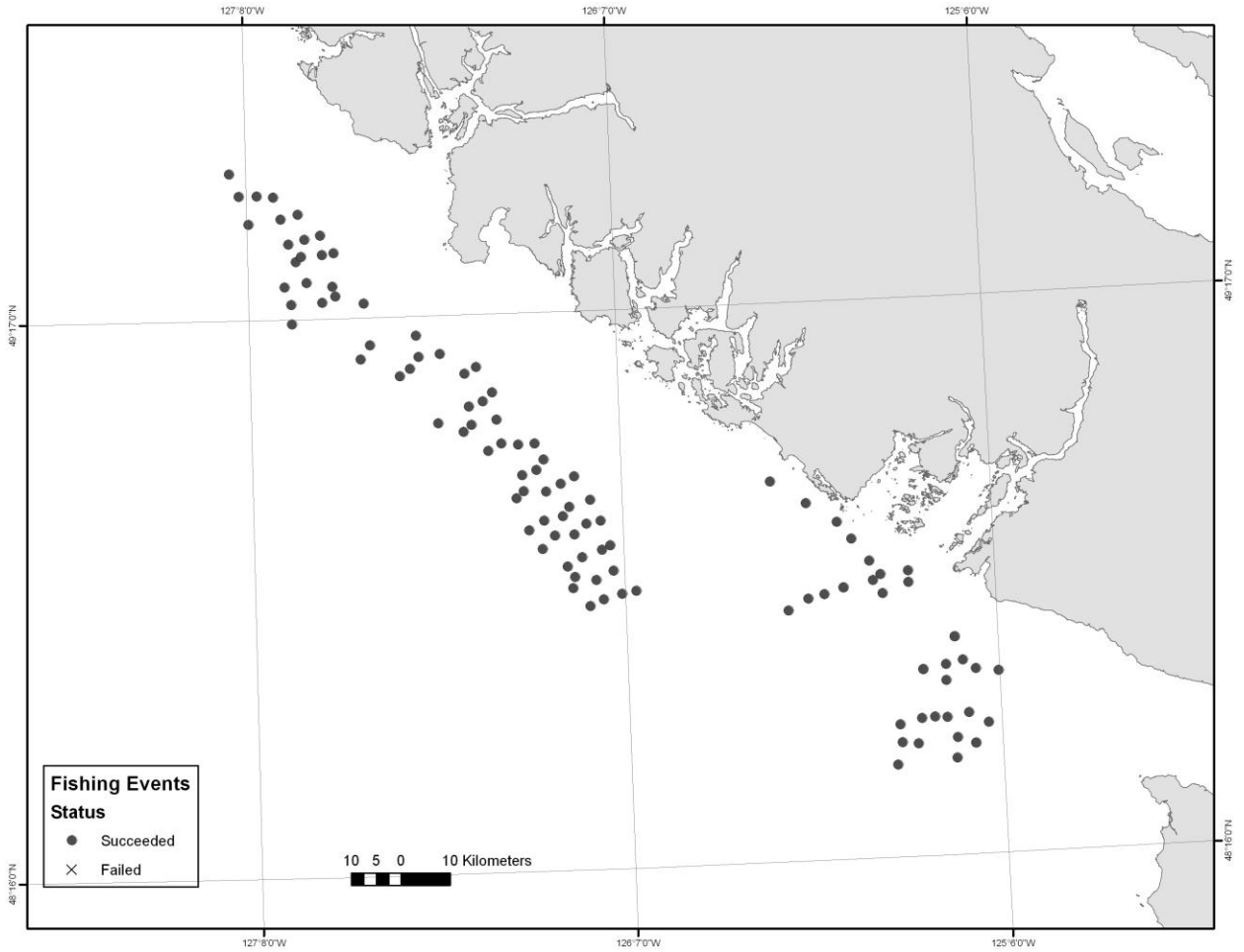

Figure 2. West Coast Vancouver Island set locations of the 2012 Multi-species Small Mesh Bottom Trawl Survey

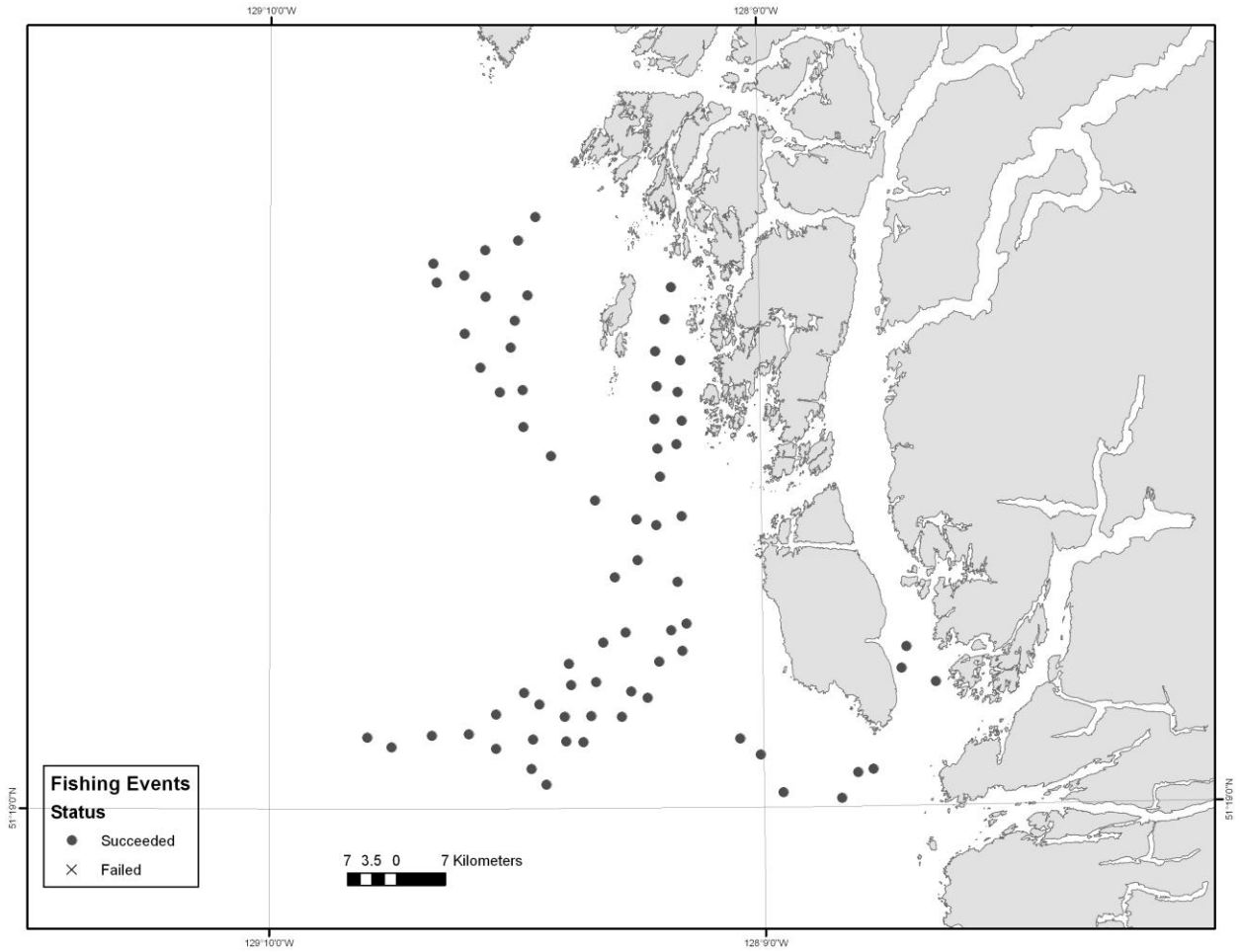

Figure 3. Eastern Queen Charlotte Sound set locations of the 2012 Multi-species Small Mesh Bottom Trawl Survey

Table 1. Number of tows, catch weight, estimated biomass, and relative survey error for the top 25 species (by weight) captured in the West Coast Vancouver Island set locations of the 2012 Multi-species Small Mesh Bottom Trawl Survey.

| Species | Num. Tows | Catch (kg) | Biomass (t) | Rel. Error |
|---|---|---|---|---|
| Eulachon | 67 | 2222 | 2559 | 0.18 |
| Arrowtooth Flounder | 71 | 1747 | 1917 | 0.18 |
| Pacific Herring | 59 | 1394 | 1795 | 0.37 |
| Pacific Cod | 55 | 1356 | 1388 | 0.34 |
| Rex Sole | 71 | 1070 | 1251 | 0.09 |
| Walleye Pollock | 42 | 791 | 911 | 0.43 |
| Spotted Ratfish | 70 | 694 | 767 | 0.09 |
| Dover Sole | 69 | 478 | 498 | 0.17 |
| Yellowtail Rockfish | 30 | 455 | 509 | 0.41 |
| Pacific Sanddab | 33 | 427 | 407 | 0.28 |
| Slender Sole | 71 | 329 | 372 | 0.11 |
| Flathead Sole | 61 | 290 | 291 | 0.15 |
| Lingcod | 36 | 234 | 283 | 0.20 |
| English Sole | 44 | 227 | 273 | 0.26 |
| Pacific Halibut | 32 | 204 | 243 | 0.18 |
| Greenstriped Rockfish | 22 | 200 | 293 | 0.61 |
| Silvergray Rockfish | 2 | 190 | 289 | 0.80 |
| Blackbelly Eelpout | 47 | 176 | 165 | 0.32 |
| Canary Rockfish | 10 | 114 | 168 | 0.55 |
| Longnose Skate | 42 | 110 | 122 | 0.18 |
| Petrale Sole | 44 | 107 | 119 | 0.18 |
| Sablefish | 29 | 89 | 84 | 0.32 |
| North Pacific Spiny Dogfish | 15 | 72 | 78 | 0.35 |
| Pacific Ocean Perch | 38 | 53 | 48 | 0.78 |
| Redstripe Rockfish | 3 | 25 | 37 | 0.92 |

Table 2. Number of tows, catch weight, estimated biomass, and relative survey error for the top 25 species (by weight) captured in the eastern Queen Charlotte Sound set locations of the 2012 Multi-species Small Mesh Bottom Trawl Survey.

| Species | Num. Tows | Catch (kg) | Biomass (t) | Rel. Error |
|---|---|---|---|---|
| Arrowtooth Flounder | 67 | 9928 | 8663 | 0.13 |
| Eulachon | 55 | 1792 | 1511 | 0.29 |
| North Pacific Spiny Dogfish | 34 | 1605 | 1349 | 0.49 |
| Spotted Ratfish | 64 | 1194 | 965 | 0.13 |
| Blackbelly Eelpout | 60 | 1121 | 934 | 0.25 |
| Flathead Sole | 59 | 1069 | 886 | 0.16 |
| Dover Sole | 67 | 873 | 768 | 0.16 |
| Pacific Ocean Perch | 43 | 661 | 593 | 0.53 |
| Rex Sole | 67 | 409 | 349 | 0.19 |
| Walleye Pollock | 36 | 354 | 268 | 0.26 |
| Longnose Skate | 35 | 311 | 267 | 0.20 |
| Yellowtail Rockfish | 29 | 265 | 228 | 0.39 |
| Slender Sole | 58 | 230 | 191 | 0.15 |
| Big Skate | 10 | 130 | 108 | 0.37 |
| English Sole | 19 | 106 | 86 | 0.28 |
| Silvergray Rockfish | 14 | 104 | 91 | 0.57 |
| Pacific Halibut | 18 | 104 | 89 | 0.28 |
| Pacific Cod | 19 | 86 | 66 | 0.29 |
| Pacific Sanddab | 4 | 78 | 66 | 0.64 |
| Sablefish | 34 | 61 | 50 | 0.16 |
| Bocaccio | 3 | 44 | 28 | 0.75 |
| Petrale Sole | 24 | 34 | 29 | 0.20 |
| Lingcod | 7 | 32 | 27 | 0.43 |
| Sandpaper Skate | 18 | 29 | 25 | 0.26 |
| Redbanded Rockfish | 17 | 28 | 25 | 0.29 |

## 1. Multi-species Synoptic bottom trawl surveys

Fisheries and Oceans, Canada (DFO) together with the Canadian Groundfish Research and Conservation Society (CGRCS) have implemented a comprehensive multi-species bottom trawl survey strategy that covers most of the BC Coast. The objectives of these surveys are to provide fishery independent abundance indices of as many benthic and near benthic fish species available to bottom trawling as is reasonable while obtaining supporting biological samples from selected species. The abundance indices and biological information are incorporated into stock assessments, status reports, and research publications.

The surveys follow a random depth stratified design. Fishing sites are predetermined by randomly selecting survey blocks (2 km x 2 km) within each depth strata. If a survey block is not fishable for any reason it will be abandoned and the vessel will proceed to the next block.

There are four surveys, two of which are conducted each year. The Hecate Strait survey and the Queen Charlotte Sound survey are conducted in odd-numbered years while the West Coast Vancouver Island survey and the West Coast Haida Gwaii (formerly Queen Charlotte Islands) survey are conducted on even-numbered years. Surveys are conducted on both chartered commercial vessels and government research vessels. The Hecate Strait survey and the West Coast Vancouver Island survey are conducted on a Canadian Coastguard research trawler while the Queen Charlotte Sound survey and the West Coast Haida Gwaii are conducted on chartered commercial fishing vessels.

In 2012 the West Coast Vancouver Island and West Coast Haida Gwaii surveys were conducted. In addition, a Strait of Georgia Multi-species Synoptic Bottom Trawl Survey was conducted in March. The Strait of Georgia survey follows all the same protocols as the other multi-species synoptic bottom trawl surveys. A smaller bottom trawl net (Yankee 36) is used but otherwise all fishing and sampling protocols are the same. The Strait of Georgia survey is planned to be repeated every three to five years.

## 2.1 West Coast Vancouver Island Multi-species Synoptic Bottom Trawl Survey

The West Coast Vancouver Island Multi-Species Synoptic Bottom Trawl Survey was conducted on the Canadian Coast Guard Ship W. E. Ricker between May 22 and June 16. We conducted a total of 157 tows; 150 were successful and 7 were failures due to hang ups or insufficient bottom time. We assessed a total of 200 blocks (Table 3).

A total of 12 different DFO staff, one summer co-op student and two contractors participated in the survey.

The total catch weight of all species was 109,192 kg. The mean catch per tow was 700 kg, averaging 25 different species of fish and invertebrates in each. The most abundant fish species encountered were North Pacific Spiny Dogfish (*Squalus suckleyi*), Redstripe Rockfish (*Sebastes proriger*), Pacific Ocean Perch (*Sebastes alutus*), and Arrowtooth Flounder (R*einhardtius stomias*). Biological data, including individual length, weight, sex, maturity, and age structure were collected from a total of 31,913 individual fish of 73 different species. Oceanographic data, including water temperature, depth, salinity, and dissolve oxygen were also recorded for most tows.

Table 3. 2012 West Coast Vancouver Island Multi-Species Synoptic Bottom Trawl Survey final block summary showing the number of blocks rejected based on fishing master's knowledge or by on-ground inspection, number of failed blocks (due to hang-ups or insufficient bottom time), number of successful tows, and number of un-fished blocks (due to other reasons such as tide, weather, or other vessels) per survey stratum.

| Depth Stratum (m) | Rejected Prior | Rejected Inspected | Failed | Success | Not Fished | Total |
|---|---|---|---|---|---|---|
| 50 - 125 | 4 | 17 | 2 | 59 | 0 | 82 |
| 125 - 200 | 7 | 7 | 0 | 46 | 0 | 60 |
| 200 - 330 | 2 | 4 | 1 | 25 | 0 | 32 |
| 330 - 500 | 2 | 3 | 0 | 20 | 1 | 26 |
| **Total** | **15** | **31** | **3** | **150** | **1** | **200** |

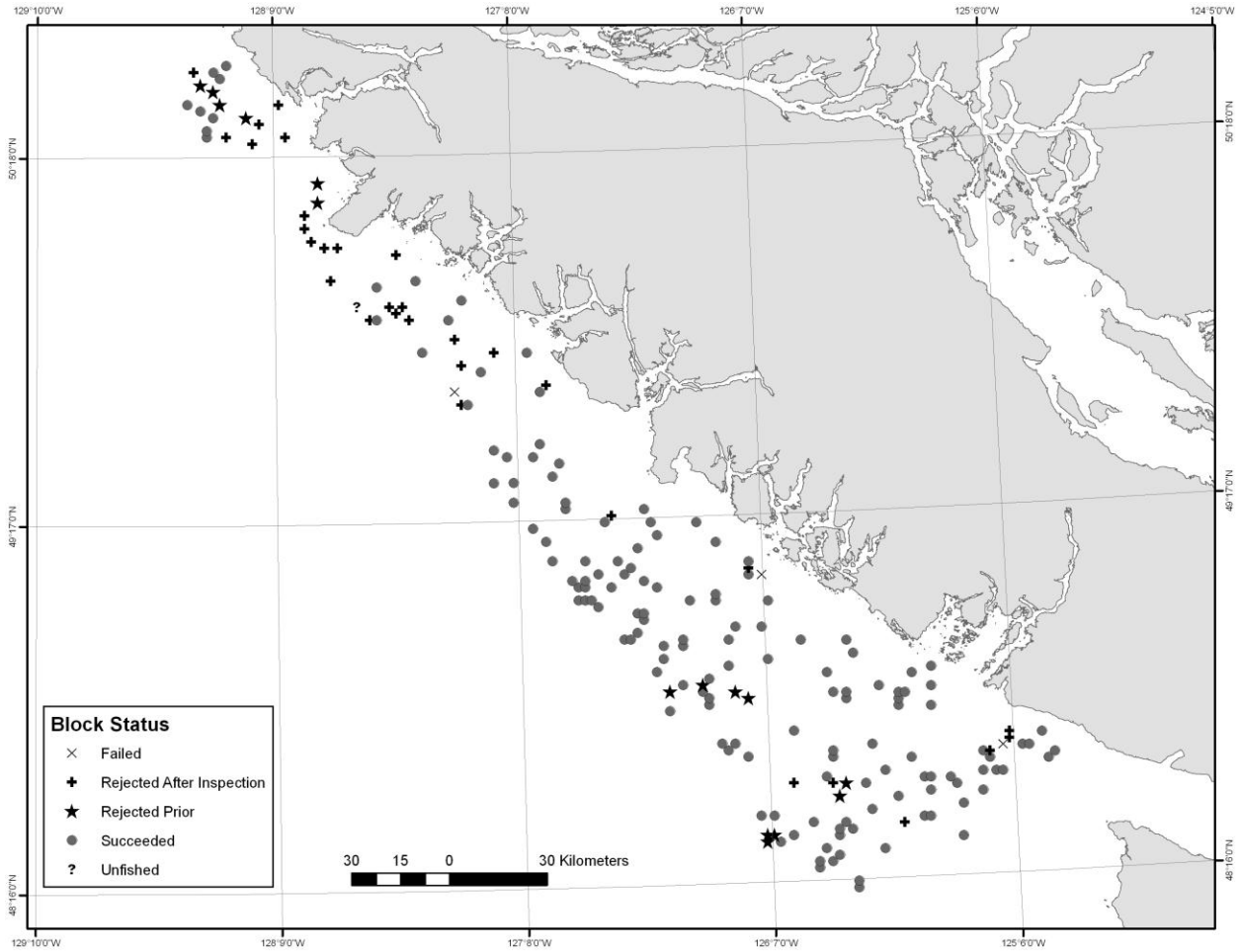

Figure 4. Final status of the allocated blocks for the 2012 West Coast Vancouver Island Multi-Species Synoptic Bottom Trawl Survey.

Table 4. Number of tows, catch weight, estimated biomass, and relative survey error for the top 25 species (by weight) captured in the 2012 West Coast Vancouver Island Multi-Species Synoptic Bottom Trawl Survey.

| Species | Num. Tows | Catch (kg) | Biomass (t) | Rel. Error |
|---|---|---|---|---|
| North Pacific Spiny Dogfish | 92 | 15812 | 11128 | 0.44 |
| Redstripe Rockfish | 44 | 12067 | 7722 | 0.66 |
| Arrowtooth Flounder | 136 | 10723 | 5807 | 0.14 |
| Pacific Ocean Perch | 62 | 10519 | 2998 | 0.26 |
| Sharpchin Rockfish | 58 | 9240 | 3267 | 0.40 |
| Splitnose Rockfish | 37 | 6227 | 1716 | 0.34 |
| Silvergray Rockfish | 46 | 4883 | 2927 | 0.76 |
| Sablefish | 70 | 4740 | 1553 | 0.34 |
| Spotted Ratfish | 136 | 4533 | 3343 | 0.26 |
| Canary Rockfish | 49 | 3105 | 2090 | 0.61 |
| Dover Sole | 132 | 3016 | 1515 | 0.11 |
| Rex Sole | 137 | 2456 | 1532 | 0.08 |
| Yellowtail Rockfish | 41 | 1794 | 1161 | 0.30 |
| English Sole | 91 | 1484 | 1211 | 0.23 |
| Pacific Hake | 52 | 1411 | 708 | 0.59 |
| Greenstriped Rockfish | 67 | 1376 | 837 | 0.17 |
| Pacific Cod | 95 | 1295 | 974 | 0.18 |
| Pacific Sanddab | 48 | 1006 | 834 | 0.31 |
| Flathead Sole | 55 | 964 | 760 | 0.28 |
| Lingcod | 88 | 882 | 640 | 0.16 |
| Shortspine Thornyhead | 42 | 866 | 252 | 0.12 |
| Petrale Sole | 90 | 815 | 676 | 0.22 |
| Pacific Halibut | 61 | 774 | 587 | 0.21 |
| Redbanded Rockfish | 46 | 745 | 280 | 0.31 |
| Longnose Skate | 62 | 649 | 358 | 0.22 |

## 2.2 West Coast Haida Gwaii Multi-species Synoptic Bottom Trawl Survey

The West Coast Haida Gwaii Multi-Species Synoptic Bottom Trawl Survey was conducted on the F/V Nordic Pearl between August 24 and September 19. We conducted a total of 141 tows; 130 were successful and 11 were failures due to hang ups or insufficient bottom time. We assessed a total of 141 blocks (Table 5). Note that some blocks may have multiple failed tows and a successful tow.

A total of 5 different DFO staff and three contractors participated in the survey.

The total catch weight of all species was 148,939 kg. The mean catch per tow was 1063 kg, averaging 19 different species of fish and invertebrates in each. The most abundant fish species encountered were Pacific Ocean Perch (*Sebastes alutus*), Rougheye/ Blackspotted Rockfish (*Sebastes aleutianus/ melanostictus*), Sharpchin Rockfish (*Sebastes zacentrus*), and Silvergray Rockfish (*Sebastes brevispinis*). Biological data, including individual length, weight, sex, maturity, and age structure were collected from a total of 17,137 individual fish of 53 different species. Oceanographic data, including water temperature, depth, salinity, and dissolve oxygen were also recorded for most tows.

Table 5. 2012 West Coast Haida Gwaii Multi-Species Synoptic Bottom Trawl Survey final block summary showing the number of blocks rejected based on fishing master's knowledge or by on-ground inspection, number of failed blocks (due to hang-ups or insufficient bottom time), number of successful tows, and number of un-fished blocks (due to other reasons such as tide, weather, or other vessels) per survey stratum.

| Depth Stratum (m) | Rejected Prior | Rejected Inspected | Failed | Success | Not Fished | Total |
|---|---|---|---|---|---|---|
| 180 - 330 | 0 | 5 | 1 | 75 | 0 | 81 |
| 330 - 500 | 0 | 3 | 1 | 29 | 0 | 33 |
| 500 - 800 | 0 | 1 | 0 | 10 | 0 | 11 |
| 800 - 1300 | 0 | 0 | 0 | 16 | 0 | 16 |
| **Total** | **0** | **9** | **2** | **130** | **0** | **141** |

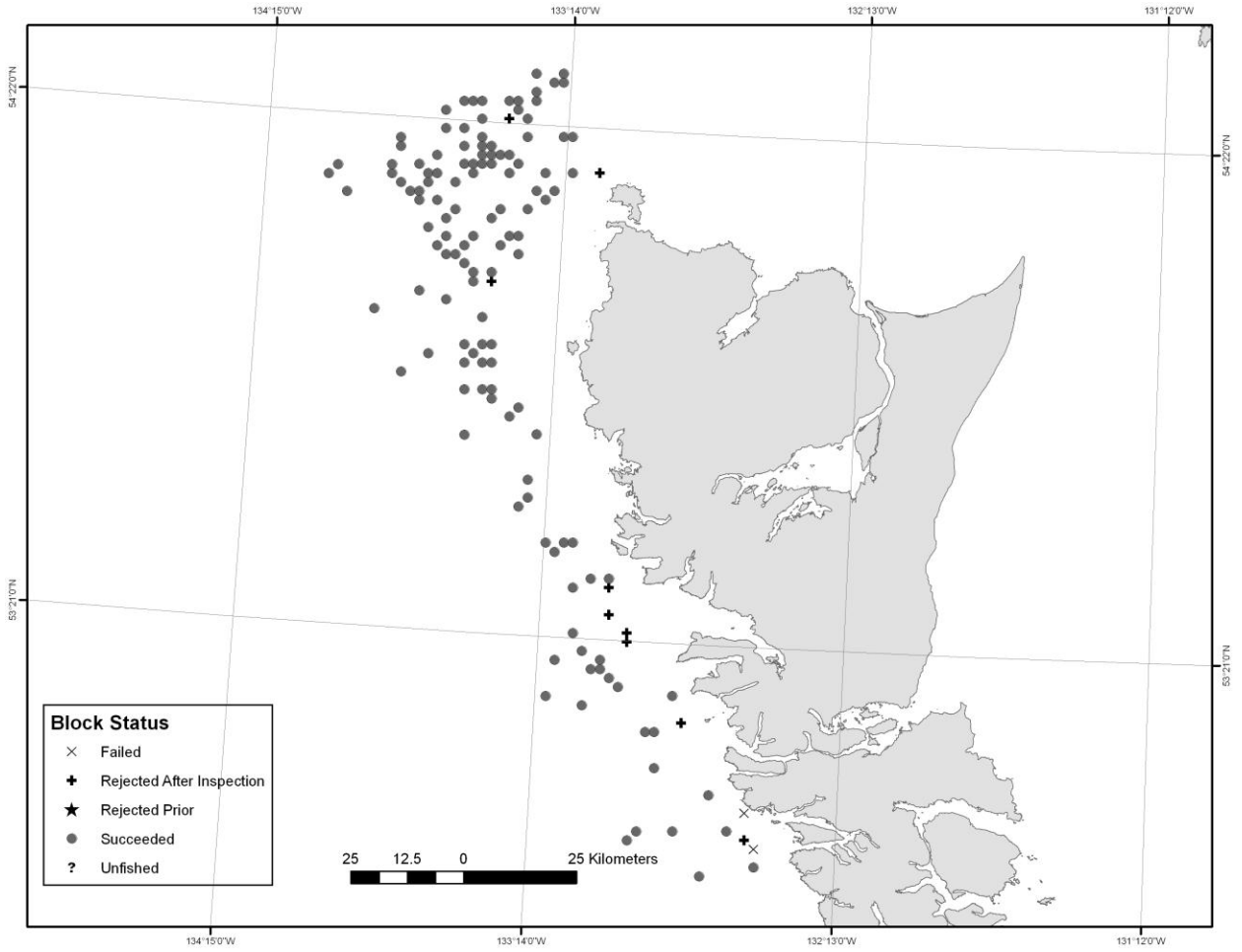


Figure 5. Final status of the allocated blocks for the 2012 West Coast Haida Gwaii Multi-Species Synoptic Bottom Trawl Survey.

Table 6. Number of tows, catch weight, estimated biomass, and relative survey error for the top 25 species (by weight) captured in the 2012 West Coast Haida Gwaii Multi-Species Synoptic Bottom Trawl Survey.

| Species | Num. Tows | Catch (kg) | Biomass (t) | Rel. Error |
|---|---|---|---|---|
| Pacific Ocean Perch | 86 | 58824 | 4699 | 0.22 |
| Rougheye/ Blackspotted Rockfish | 66 | 17558 | 3006 | 0.38 |
| Sharpchin Rockfish | 67 | 15108 | 1215 | 0.49 |
| Silvergray Rockfish | 75 | 12405 | 1058 | 0.30 |
| Yellowmouth Rockfish | 24 | 9081 | 1041 | 0.34 |
| Redstripe Rockfish | 39 | 6342 | 314 | 0.43 |
| Shortspine Thornyhead | 116 | 4346 | 630 | 0.14 |
| Arrowtooth Flounder | 104 | 3145 | 316 | 0.25 |
| Sablefish | 69 | 2568 | 640 | 0.29 |
| Pacific Hake | 47 | 1649 | 312 | 0.32 |
| Widow Rockfish | 21 | 1102 | 111 | 0.48 |
| Shortraker Rockfish | 22 | 971 | 179 | 0.53 |
| Dover Sole | 92 | 743 | 121 | 0.23 |
| Rex Sole | 99 | 718 | 80 | 0.20 |
| Pacific Halibut | 45 | 708 | 70 | 0.29 |
| Splitnose Rockfish | 16 | 638 | 149 | 0.61 |
| Pacific Grenadier | 23 | 629 | 271 | 0.26 |
| Redbanded Rockfish | 83 | 618 | 66 | 0.28 |
| Rosethorn Rockfish | 76 | 509 | 48 | 0.20 |
| Longspine Thornyhead | 26 | 462 | 164 | 0.24 |
| Giant Grenadier | 22 | 450 | 199 | 0.37 |
| Walleye Pollock | 67 | 425 | 60 | 0.23 |
| Pacific Cod | 34 | 381 | 36 | 0.37 |
| Popeye | 22 | 368 | 61 | 0.37 |
| Harlequin Rockfish | 37 | 363 | 25 | 0.65 |

## 2.3 Strait of Georgia Multi-species Synoptic Bottom Trawl Survey

The Strait of Georgia Multi-Species Synoptic Bottom Trawl Survey was conducted on the Canadian Coast Guard Ship W. E. Ricker between March 14 and 24. We conducted a total of 53 tows; 52 were successful and 1 was a failure due to hang ups or insufficient bottom time. We assessed a total of 108 blocks (Table 7).

A total of 11 different DFO staff and one contractor participated in the survey.

The total catch weight of all species was 14,855 kg. The mean catch per tow was 280 kg, averaging 23 different species of fish and invertebrates in each. The most abundant fish species encountered were English Sole (*Parophrys vetulus*), North Pacific Spiny Dogfish (*Squalus suckleyi*), Spotted Ratfish (*Hydrolagus colliei*), and Walleye Pollock (*Theragra chalcogramma*). Biological data, including individual length, weight, sex, maturity, and age structure were collected from a total of 9,913 individual fish of 46 different species. Oceanographic data, including water temperature, depth, salinity, and dissolve oxygen were also recorded for most tows.

Table 7. 2012 Strait of Georgia Multi-Species Synoptic Bottom Trawl Survey final block summary showing the number of blocks rejected based on fishing master's knowledge or by on-ground inspection, number of failed blocks (due to hang-ups or insufficient bottom time), number of successful tows, and number of un-fished blocks (due to other reasons such as tide, weather, or other vessels) per survey stratum.

| Depth Stratum (m) | Rejected Prior | Rejected Inspected | Failed | Success | Not Fished | Total |
|---|---|---|---|---|---|---|
| 10 - 75 | 9 | 5 | 0 | 7 | 0 | 21 |
| 75 - 150 | 9 | 9 | 0 | 8 | 0 | 26 |
| 150 - 250 | 4 | 7 | 1 | 16 | 0 | 28 |
| 250 - 500 | 7 | 6 | 0 | 20 | 0 | 33 |
| **Total** | **29** | **27** | **1** | **51** | **0** | **108** |

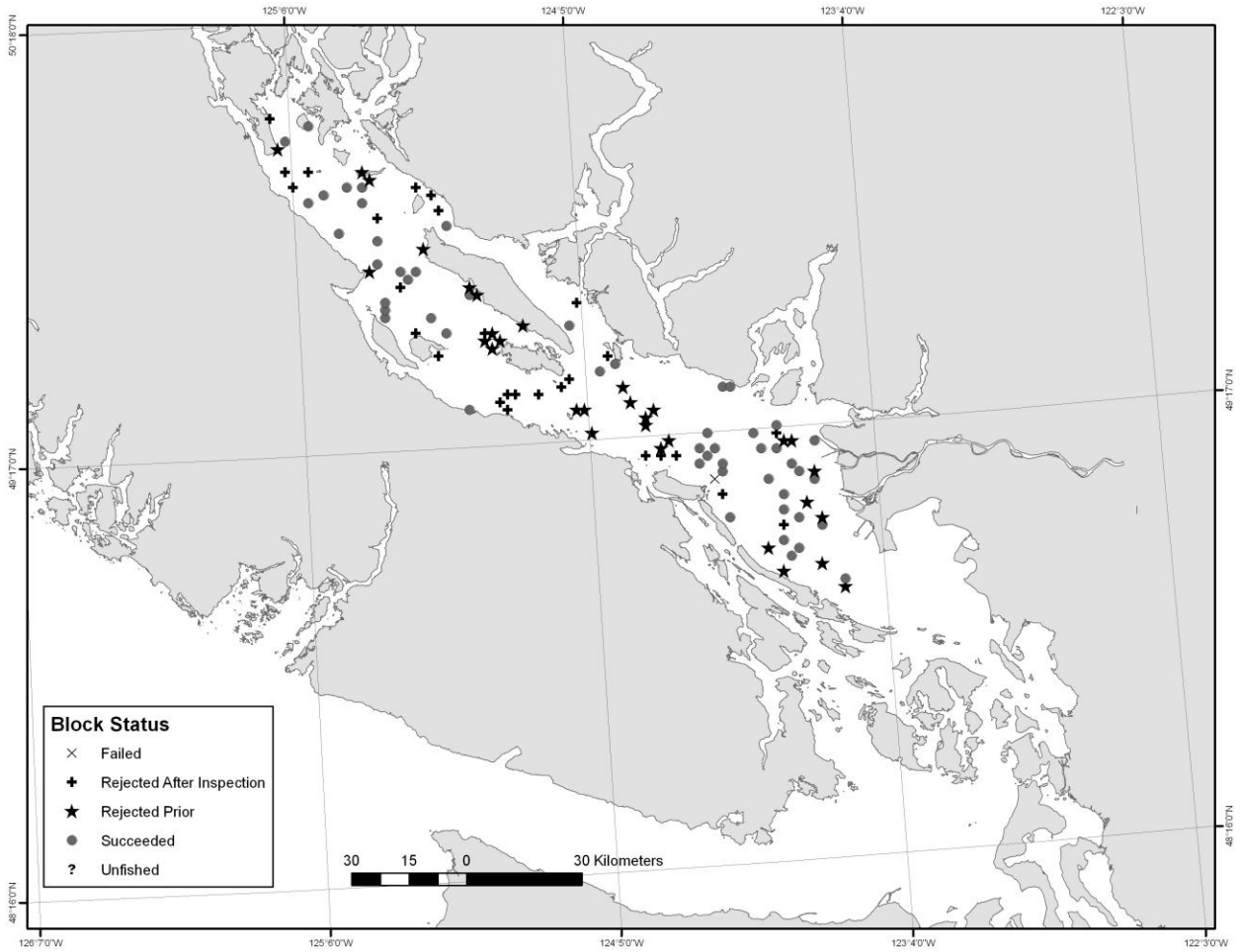

Figure 6. Final status of the allocated blocks for the 2012 Strait of Georgia Multi-Species Synoptic Bottom Trawl Survey.

Table 8. Number of tows, catch weight, estimated biomass, and relative survey error for the top 25 species (by weight) captured in the 2012 Strait of Georgia Multi-Species Synoptic Bottom Trawl Survey.

| Species | Num. Tows | Catch (kg) | Biomass (t) | Rel. Error |
|---|---|---|---|---|
| English sole | 48 | 2615 | 4834 | 0.45 |
| North pacific spiny dogfish | 48 | 2271 | 1926 | 0.14 |
| Spotted ratfish | 50 | 2250 | 1924 | 0.13 |
| Walleye pollock | 44 | 2084 | 1791 | 0.36 |
| Shiner perch | 8 | 948 | 917 | 0.7 |
| Slender sole | 48 | 776 | 826 | 0.3 |
| Pacific hake | 45 | 591 | 538 | 0.24 |
| Pacific cod | 14 | 388 | 518 | 0.77 |
| Southern rock sole | 11 | 373 | 397 | 0.52 |
| Flathead sole | 22 | 336 | 1422 | 0.82 |
| Starry flounder | 3 | 236 | 369 | 0.53 |
| Plainfin midshipman | 18 | 192 | 224 | 0.42 |
| Dover sole | 41 | 188 | 141 | 0.2 |
| Pacific sanddab | 6 | 164 | 291 | 0.47 |
| Rex sole | 33 | 51 | 71 | 0.34 |
| Arrowtooth flounder | 26 | 51 | 47 | 0.29 |
| Longnose skate | 29 | 50 | 44 | 0.23 |
| Blackbelly eelpout | 16 | 47 | 123 | 0.65 |
| American shad | 21 | 30 | 25 | 0.25 |
| Pacific herring | 17 | 26 | 28 | 0.26 |
| Greenstriped rockfish | 14 | 22 | 26 | 0.3 |
| Lingcod | 5 | 21 | 21 | 0.55 |
| Splitnose rockfish | 13 | 20 | 18 | 0.42 |
| Brown cat shark | 23 | 19 | 13 | 0.2 |
| Eulachon | 11 | 12 | 11 | 0.33 |

**APPENDIX 3. PARTIAL LIST OF GROUNDFISH RELATED REPORTS WITH 2012 PUBLICATION DATES.**

PRIMARY

Edwards, A.M., Freeman, M.P., Breed, G.A., and Jonsen, I.D. 2012. Incorrect likelihood methods were used to infer scaling laws of marine predator search behaviour. ***PLOS ONE,* 7(10)**: e45174.

King, J.R., McFarlane, G.A., **Jones**, S.R.M., Gilmore, S.R., and Abbott, C.L. 2012. Stock delineation of migratory and resident Pacific hake in Canadian waters. Fisheries Research **114**: 19-30.

Montes, R.M., Perry, R.I., Pakhomov, E.A., Edwards, A.M., and Boutillier, J.A. 2012. Multifractal patterns in the daily catch time series of smooth pink shrimp (*Pandalus jordani*) from the west coast of Vancouver Island, Canada. *Canadian Journal of Fisheries and Aquatic Sciences,* **69**:398-413.

Yamanaka, K.L., Picard, K., Conway, K.W., and Flemming, R. 2012. Rock Reefs of British Columbia, Canada: Inshore Rockfish Habitats. pp 509-522 *In* Seafloor Geomorphology as Benthic Habitat. GEOHAB Atlas of Seafloor Geomorphic Features and Benthic Habitats. Harris, P.T. and Baker E.K. *Eds*, Elsevier London 2012. 900 p.

OTHER PUBLICATIONS

DFO (2012). Recovery Potential Assessment for Yellowmouth Rockfish (Sebastes reedi) along the Pacific Coast of Canada. *DFO Canadian Science Advisory Secretariat, Scientific Advisory Report* **2011/060** 20p.

Edwards, A.M., Haigh, R., and Starr, P.J. 2012. Stock assessment and recovery potential assessment for Yellowmouth Rockfish (*Sebastes reedi*) along the Pacific coast of Canada. *Canadian Science Advisory Secretariat, Research Document* **2012/095**: iv + 188 p.

Edwards, A.M., Starr, P.J., and Haigh, R. 2012. Stock assessment for Pacific Ocean Perch (*Sebastes alutus*) in Queen Charlotte Sound, British Columbia. *Canadian Science Advisory Secretariat, Research Document* **2011/111**: viii + 172 p.

Flemming, R.G., Yamanaka, K.L., Cooke, K., and Dykstra C. 2012. Summary of non-Halibut catch from the standardized stock assessment survey conducted by the International Pacific Halibut Commission in British Columbia from June 3 to August 27, 2010. Can. Tech. Rep. Fish. Aquat. Sci. 2989: viii + 99 p.

Holt, K.R., Ackerman, B., Flemming, R., Forrest, R.E., Kronlund, A.R., Lacko, L., Olsen, N., Rutherford, K., Stanley, R.D., Taylor, N.G., and Workman, G. 2012. Ecological risk assessment for the effects of fishing: a pilot study for British Columbia groundfish fisheries. Canadian Technical Report of Fisheries and Aquatic Sciences 2990. Available online at: http://waves-vagues.dfo-mpo.gc.ca/waves-vagues/search-recherche/display-afficher/347602

Kerr, L.A., S.X. Cadrin, D.H. Secor & N. Taylor 2012. A Simulation Tool to Evaluate Effects of Mixing between Atlantic Bluefin Tuna Stocks. ICCAT SCRS/2012/153.

Stewart, I.J., Forrest, R.E., Taylor, N., Grandin, C., Hicks, A.C. 2012. Status of the Pacific hake (whiting) stock in U.S. and Canadian waters in 2012. International Joint Technical Committee for Pacific hake. 194 p. Available online: http://www.pcouncil.org/wp-content/uploads/Hake_2012_Assessment.pdf

Yamanaka, K.L., McAllister, M.K., Etienne, M.-P., and Flemming, R. 2012. Stock Assessment and Recovery Potential Assessment for Quillback Rockfish (*Sebastes maliger*) on the Pacific Coast of Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2011/135. vii + 151 p.

Yamanaka, K.L., McAllister, M.K., Olesiuk, P.F., Etienne, M.-P., Obradovich, S. and Haigh, R. 2012. Stock assessment for the inside population of Yelloweye Rockfish (*Sebastes ruberrimus*) in British Columbia, Canada for 2010. *Canadian Science Advisory Secretariat, Research Document* **2011/129**: xiv + 131 p.

## APPENDIX 3. GROUNDFISH STAFF IN 2013

| | |
|---|---|
| Greg Workman | Section Head |
| Schon Acheson | Technician, Pacific Hake, port sampling and surveys |
| Bill Andrews | Technician, surveys |
| Kristina Anderson | Technician, Sablefish and surveys |
| Karina Cooke | Technician, Database support and surveys, Inshore Rockfish |
| Andrew Edwards | (Program Head) Statistical and mathematical modelling, stock assessment |
| Robyn Forrest | Scientist, Pacific Cod, Pacific Halibut, stock assessment |
| Chris Grandin | Program Head, Pacific Hake stock assessment and Port sampling |
| Rowan Haigh | Statistical and exploratory data analysis, stock assessment, R packages |
| Kendra Holt | Program Head, Lingcod, Flatfish stock assessment, ERAEF |
| Jackie King | Scientist, Elasmobranchs, Climate studies |
| Brian Krishka | Biologist, Database support and analysis, Flatfish |
| Rob Kronlund | Program Head Sablefish, Analytical programs |
| Lisa Lacko | Biologist, GIS specialist and database manager, Sablefish |
| Sandy McFarlane | Emeritus scientist |
| Wendy Mitton | Technician, Sablefish |
| Norm Olsen | Biologist, Programmer/GIS, Groundfish Statistics, Shelf Rockfish |
| Kate Rutherford | Biologist, Database manager, Groundfish Statistics, Shelf Rockfish |
| Jon Schnute | Emeritus scientist |
| Alan Sinclair | Emeritus scientist |
| Rick Stanley | Program Head, Shelf Rockfish assessment and biology, Groundfish Statistics. |
| Maria Surry | Technician, Elasmobranchs |
| Nathan Taylor | Program Head, Groundfish surveys, Shelf Rockfish, Pacific Hake stock assessment |
| Malcolm Wyeth | Biologist, Groundfish surveys |
| Lynne Yamanaka | Program Head, Inshore rockfish research and stock assessment |