A Review of the Queen Charlotte Sound Groundfish Bottom Trawl Survey (2003-2005)

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A REVIEW OF THE QUEEN CHARLOTTE SOUND GROUNDFISH BOTTOM TRAWL SURVEY (2003 – 2005)

by

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ABSTRACT

Stanley, R.D, Olsen, N., Workman, G., Cleary, J., and de la Mare, W. 2007. A review of the groundfish Queen Charlotte Sound bottom trawl survey (2003 - 2005). Can. Tech. Rep. Fish. Aquat. Sci. 2709: viii + 59 p.

The Queen Charlotte Sound groundfish bottom trawl survey was conducted jointly by the Canadian Groundfish Research and Conservation Society, and Fisheries and Oceans Canada in 2003, 2004 and 2005. The survey covers Queen Charlotte Sound and the southern portion of Hecate Strait. The purpose of the survey is to provide relative abundance indices for as many benthic and near benthic fish species as is reasonable while obtaining the supporting biological samples of size and age composition. It covers the populations on the continental shelf region of the central coast and complements the three other outer coast trawl surveys, as well as numerous other surveys which provide groundfish indexing. The purpose of this document is to review the results and costs of this survey after the first three years. The document specifically addresses the following elements: 1) the precision/accuracy of the survey; 2) the costs of the survey; 3) the expectations of the survey; 4) whether the survey should be continued, and 5) how, or if, the survey should be modified. The analysis makes use of a survey simulator to characterize the effectiveness of the survey, as well as explore potentially more cost-effective designs. The document recommends that the survey should be continued in its current configuration with relatively minor operational changes.

RÉSUMÉ

Stanley, R.D, Olsen, N., Workman, G., Cleary, J., and de la Mare, W. 2007. A review of the groundfish Queen Charlotte Sound bottom trawl survey (2003 - 2005). Can. Tech. Rep. Fish. Aquat. Sci. 2709: viii + 59 p.

L'enquête saine de chalut du fond de poisson de fond de la Reine Charlotte a été conduite conjointement par la société canadienne de recherches et de conservation de poisson de fond et la pêche et les océans Canada en 2003, 2004 et 2005. L'aperçu couvre le bruit de la Reine Charlotte et la partie méridionale du détroit de Hecate. Le but de l'aperçu est de fournir à index relatifs proportionnés d'abondance pour autant d'espèces benthiques de poissons de même que raisonnable tout en obtenant les échantillons biologiques le support de structure d'âge de taille et. Il couvre les populations sur la région de plateau continental de la côte centrale tandis que compléter les trois autres enquêtes externes de chalut de côte, comme encore 14 examine qui fournissent l'indexation de poisson de fond. Le but de ce document est de passer en revue les résultats et les coûts de cet aperçu après les trois premières années. Le document adresse spécifiquement les éléments suivants : la 1) précision/exactitude de l'aperçu ; 2) les coûts de l'aperçu ; 3) les espérances de l'aperçu ; 4) si l'aperçu devrait être continué, et 5) comment, ou si, l'aperçu est modifié. L'analyse se sert d'un simulateur d'aperçu pour caractériser l'efficacité de l'aperçu, aussi bien qu'explorent des conceptions potentiellement plus rentables. Le document recommande que l'aperçu devrait être continué dans sa configuration courante avec les changements opérationnels relativement mineurs.

INTRODUCTION

The intent of the Groundfish Queen Charlotte Sound survey (GF-QCSd) is to provide accurate relative abundance indices for as many benthic and near benthic fish species as is reasonable while obtaining the supporting biological samples of size and age composition (Sinclair *et al.* 2003, Stanley *et al.* 2004). The survey indexes populations in Queen Charlotte Sound (QCSd) and the southern portion of Hecate Strait (Figure 1). It complements the three other outer coast trawl surveys, as well as numerous other surveys which provide groundfish indexing (Figure 2, Appendix 1).

This document addresses the results, costs and expectations of the survey, whether the survey should be continued, and if so, should we consider any major changes with respect to frequency, or number of tows. This document is not intended as a user's guide to the survey data, nor does it document the evolution of the survey methodology. In particular, we plan a second Operations Manual that will document how we conduct the survey. This will emphasize the steps taken to standardize the fishing and sampling procedures. A second document and/or a website will provide guidance on data analysis.

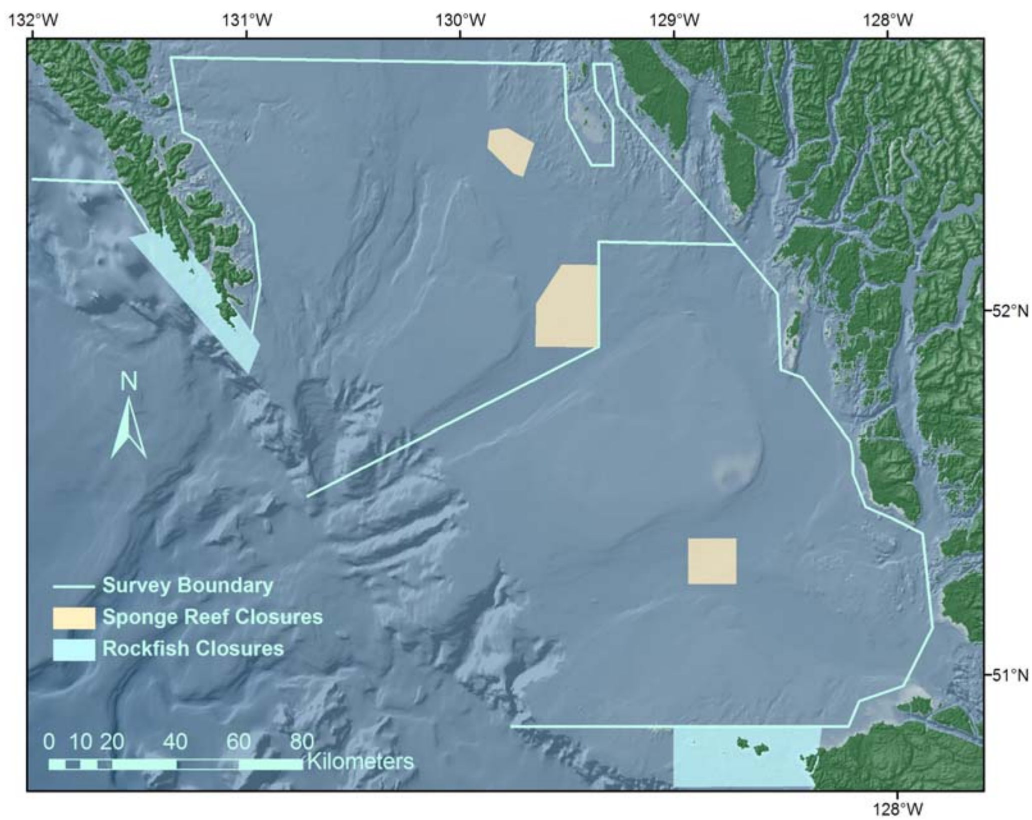


Figure 1. Coverage of GF-QCSd survey area, 50-500 m, point-to-point coastline boundaries, and closed areas.

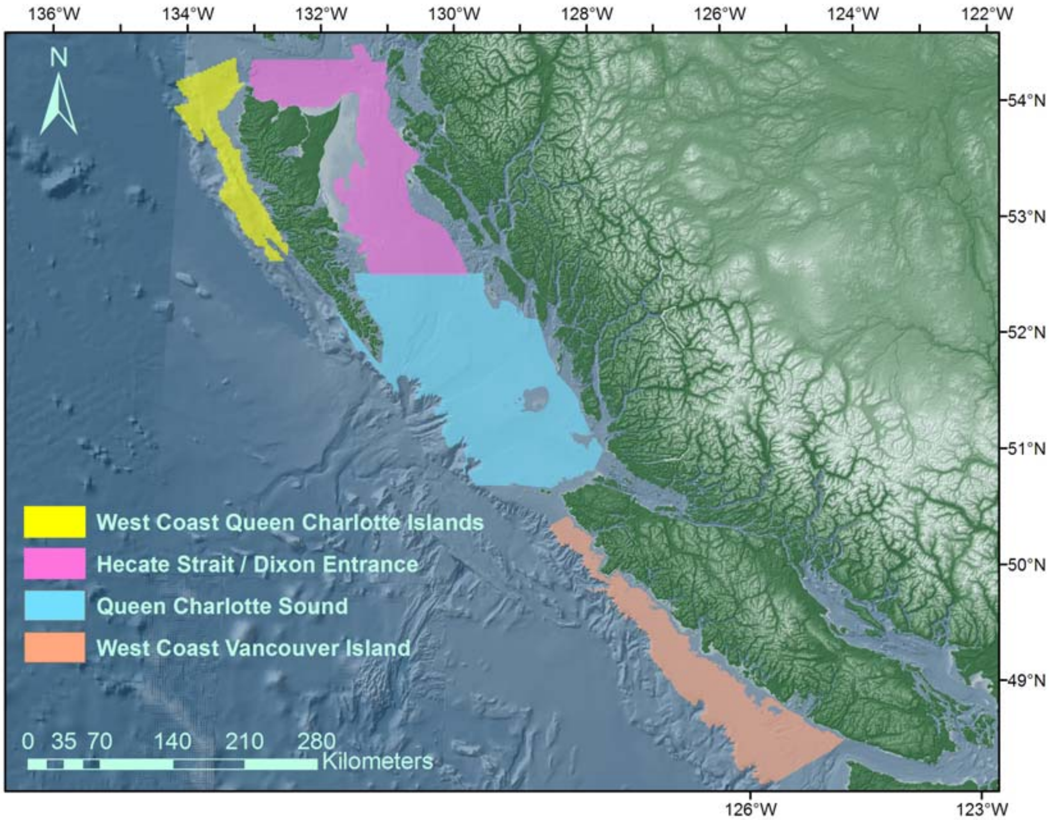


Figure 2. Location of GF-QCSd survey in relation to the other major groundfish bottom trawl surveys.

METHODS

SURVEY DESIGN

The survey follows a stratified random design. The survey area is divided into two area and four depth strata (Figure 3 and Table 1). We treat the total area as 6,920 4-km^2 potentially trawlable blocks. For each survey, a set of blocks is drawn randomly from the overall population, subject to proportional allocation by stratum.

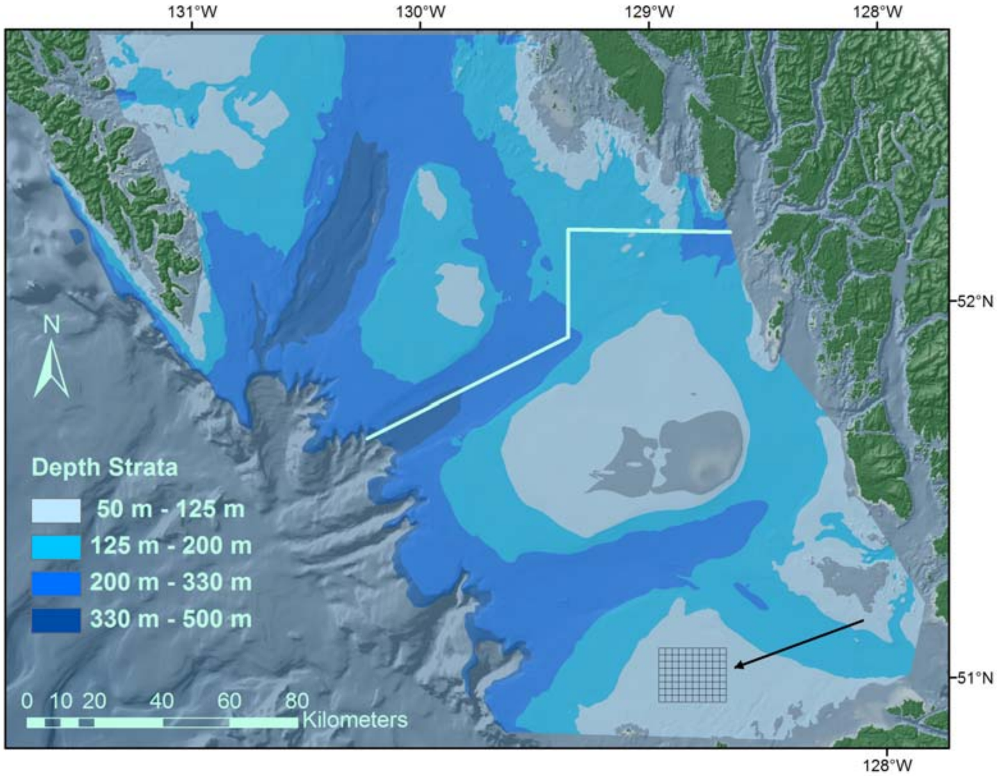


Figure 3. GF-QCSd survey region showing area strata boundary and depth strata. The arrow indicates a portion of the survey sampling frame to show the relative size of the 4-km^2 blocks.

Table 1. Number of blocks within each stratum.

Area Stratum	Depth Stratum (m)	Number of Blocks
South	50 - 125	1,420
	125 - 200	1,460
	200 - 330	760
	300 - 500	141
Sub-total		3,781
North	50 - 125	546
	125 - 200	1,172
	200 - 330	1,098
	300 - 500	323
Sub-total		3,139
Total		**6,920**

The survey was designed to be conducted by one charter vessel, commencing in early July and finishing in the second week of August. The timing was chosen to take advantage of good summer weather and a period when most species are not in transition from their late winter to late summer depths.

Previous work identified a target sampling density of 240 tows per survey (Sinclair *et al.* 2003, Stanley *et al.* 2004). The density was chosen based on the objective of achieving a relative error (estimated from observational error) for abundance indices of less than 0.40 for many of the higher profile populations in the survey area. This was based on the assumption that the survey would be conducted at least every two years.

For this discussion paper, we have adopted the following syntax with respect to the discussion of survey variance:

1. We reserve ***Coefficient of Variance* (*CV*)** to note the relative variation in the parent population of observations of catch rate within a survey.
2. We reserve ***Relative Error (RE)*** to note the relative variance in the overall estimate of catch rate for one year of survey. This statistic reflects the variance of the index point caused by combined effects of Process, Observation and Measurement Error.
3. With respect to sources of error in a survey, we reserve:
    a. ***Process Error (PE)*** to note the variance caused by changes in the fish abundance among years. Within *PE* we divide the source of the variance into two types:
        i. ***Process Error (PE-A)*** owing to an actual change among years in abundance within the survey error (we assume a closed system);
        ii. ***Process Error (PE-C)*** owing, for example, to a change among years in the catchability[1] for that population.
    b. ***Observation Error* (*OE*)** to note the sampling variance caused by the variation among catch rates within the set of observations from one survey year;
    c. ***Measurement Error (ME)*** to note the added variance caused by imprecision in estimating the catch by species in each tow. We treat this component as negligible in comparison with the others.

Because of the difficulty in separating the confounding influence of *PE-A* and *PE-C*, this additional source of error is usually ignored in presenting the imprecision of a survey (or for that matter CPUE analysis). The *OE* alone is used as a surrogate for the overall *RE* of the survey, although only one contributing component of the variance.

Stanley *et al.* (2004) proposed a set of crude RE_{OE} standards (based only on *OE*) for characterizing the capability of a survey to track a population as:

- excellent = < 0.20
- good = 0.20-0.30
- adequate = 0.30-0.40
- poor = 0.40-0.60
- very poor = > 0.60

Based on these standards, they reported that the GF-QCSd survey would yield at least adequate precision for 34 populations. These populations represented 80% of the commercial landings or the survey catches. The total effort of 240 tows was then allocated to the eight strata for the 2003 survey to minimize the sum of the $RE_{OE,s}$'s across the most abundant 50 populations (*s*), equating to equal weighting among populations.

[1] The fraction of a fish stock which is caught by a defined unit of fishing effort (Ricker 1975).

Each survey starts with a set of proposed blocks but since many of these blocks turn out to be un-trawlable, the execution requires a method for achieving 240 successful tows. After trying different approaches in 2003 and 2004, we settled in 2005 on a method wherein the survey commences with a primary set much greater than the target 240 (308 in 2005) under the condition that we accept the end result whether or not it is over or under the target of 240. We calculated the necessary overage by examining the failure rate by stratum in the first two years. The projected sample set was then fine-tuned after review by the charter skipper by removing or adding randomly chosen blocks.

A successful tow was defined as having been towed for at least 15 minutes, with a target tow time of 19 minutes. Originally a towing time of 20 minutes was the target, but the mensuration data indicated that the net continued to fish an extra 1-2 minutes after engaging the winches.

A block was either successfully fished or rejected. Sometimes it was rejected without inspection because the charter captain, based on prior knowledge of the area, said it would be a waste of time to travel to the block. This was a rare occurrence. The second means for rejecting a block was after inspection on the grounds revealed the block to be unsuitable for trawling. There were no formal rules about how much time should be spent examining the block prior to rejection. Finally, the block could be rejected after trying and failing to complete a successful tow.

GEAR AND ENVIRONMENTAL MONITORING

We monitored and captured SCANMAR sensor output for doorspread, headrope height, water temperature, and current velocity and attached a bottom contact sensor to the footrope to monitor whether the groundrope was in contact with the bottom. A Seabird SBE39 temperature/depth probe was used in all tows for 2003-2005. These probes were mounted on the headrope and downloaded along with the bottom contact sensor, twice daily. We will begin using an oxygen probe starting in 2007.

CATCH SORTING AND BIOLOGICAL SAMPLING

We sorted the entire catch unless it was estimated to be greater than 3,000 kg. In these cases, we obtained the captain's estimate of the gross weight, then sorted and weighed all but the dominant species, which was then estimated by subtraction.

The priority during field operations was to conduct as many tows as possible, so the overall amount of biological sampling was constrained by the time remaining to staff after sorting and weighing the catches (see Appendix 2 for the sampling protocol). The first sampling priority was to obtain length/sex (L/S) information on all fish species in the catch. The second priority was to obtain at least two length/sex/weight (L/S/W) samples per stratum for the most common species. The collection of ageing structures and macroscopic maturity classification was third in priority.

The intent of the ageing samples was to collect at least 10 samples of >30 fish for principal commercial populations. A secondary ageing target was to obtain at least one "starter" sample for lower profile species.

ESTIMATION OF THE RELATIVE CATCH RATE INDEX

Catches were converted to an area-swept biomass index as described in Appendix 3 (Stanley *et al.* 2004).

THE SIMULATOR

The effectiveness of the survey was examined through use of a survey simulator (Schnute and Haigh 2003, Stanley *et al*. 2004) to examine how closely we can expect a survey to track a given change in abundance over a specified time period. This simulator receives as input:

- a hypothetical scenario of population change;
- a configuration of the GF-QCSd survey;
- actual survey data for incorporating the variance.

A scenario is defined first by considering a hypothetical change in the population, for example a decline of 70% in arrowtooth flounder abundance over 10 years. A single run of the simulation generates one potential time-series of five additional biennial survey points over the specified period of 10 years, given the variance expected in the survey. The observed trend of five points is fit to a monotonic trend and the observed slope is compared with the modeled change. The simulator models a specified configuration of the survey with respect to the number of tows, allocation and frequency (annual, biennial, triennial). For this review, we only modeled the case where population change is manifest by a change in the catch rate of non-zero tows. The proportion of zero tows stays constant.

The single run is considered to have tracked the population accurately if the time series of simulated survey points indicates a change close to the modeled change. "Close" is defined as falling between arbitrarily chosen upper and lower tolerance limits, or design points. For example, if the true change were a decline of 70%, a run is considered to have provided a close result if it indicates a decline between 50 and 80%. Finally, the simulation is repeated 5,000 times. The survey is considered accurate for that scenario if a sufficient proportion of the runs, for example 80%, indicate a change within the design points.

Observational error is derived from the actual survey results. The user has three options for incorporating the error (see Appendix 4):

- Option 1: $RE_{\mathrm{OE},s,y}$ is calculated as the *OE* from one population *s* and one specific survey year *y*;
- Option 2: $RE_{OE,s,\,pooled}$ is calculated as the *OE* after pooling 2003-2005 data, without scaling among years,

- Option 3: $RE_{OE,s,y} + PE$ is calculated as the OE from any one year plus process error input as a fixed amount.

Option 1 underestimates the variance (imprecision) of the survey by ignoring the *PE-C*. It therefore represents an overly optimistic view of the survey precision. Option 2, on the other hand, may overestimate the variance. While correctly incorporating *PE-C* (over the three years), it also, and incorrectly, adds the variance owing to a real change in abundance over the three years (*PE-A*). Option 3 is not necessarily pessimistic or optimistic but assumes there is information available on the *PE-C*, such as using the generalized estimate of *RE* of 0.2 from Francis *et al*. (2003) or 0.29 for haddock from Pennington (1985).

It should be noted that this modelling of the GF-QCSd survey tends to underestimate the precision of this survey by treating the start point of the simulation as being based on only one survey. The additional intervening survey point provided by the 2004 survey will help to anchor the start of each time series in the special case of the GF-QCSd survey.

We demonstrate the use of the simulator with a hypothetical case involving arrowtooth flounder. The recent decision by the Department to increase harvests of arrowtooth flounder was supported, in part, by the expectation that GF-QCSd and other surveys would provide accurate indexing of the populations. While reasonable, this statement begs an answer to the question of how well these surveys will index the population. We can directly pose the question to the simulator of whether the survey would reliably detect a hypothetical change over time. For example, do we expect the GF-QCSd survey to accurately track a 70% decline over 10 years? Would it consistently indicate a decline, and how often would it accurately indicate the size of the decline? Prior to supporting higher harvest, managers might request assurance that should the population decline by 70% over the next 10 years, the survey would not only show some level of decrease at least 99% of the time, but should accurately indicate a decrease of between 50% and 80% at least 80% of the time. Raising the quota would be conditional on knowing that the survey meets this or a similar performance criterion.

The simulator produces 5,000 possible survey outcomes for each survey year by generating 240 tow results (with stratification) from the parent population observed in the survey. For each year, a biomass index is calculated from the tow results and scaled by a constant representing the true population decrease (Figure 4). A single time series of the survey consists of any set of yearly indices over the 10 years of the simulation (Figure 5).

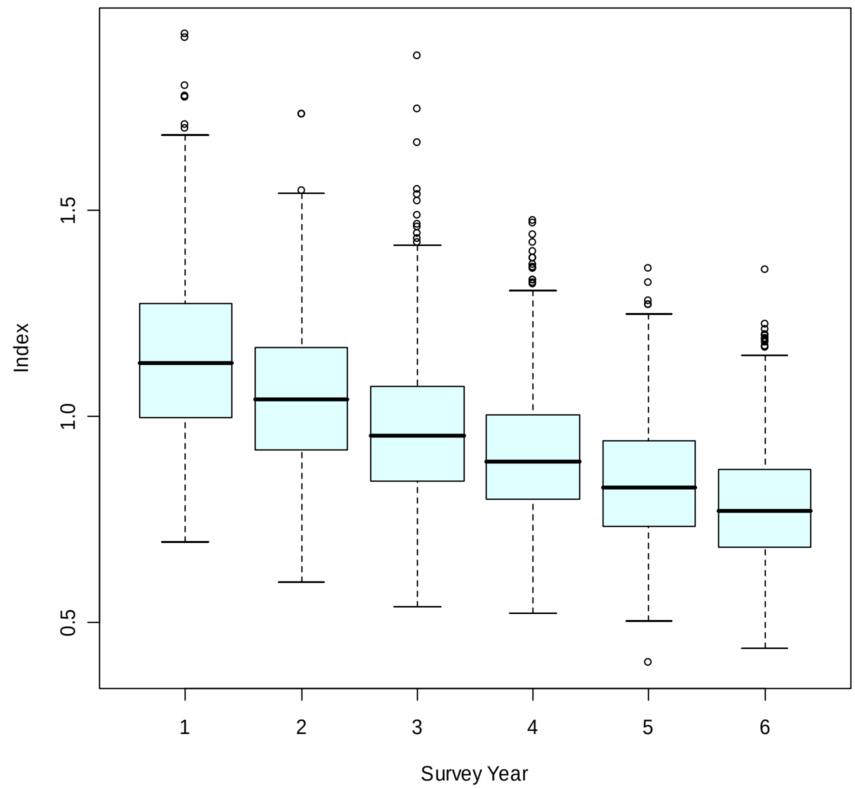


Figure 4. Boxplots of 5,000 simulated survey trajectories. Each boxplot indicates the distribution of survey estimates within each survey year; with the underlying population declining by 70% over 10 years (see Appendix 4: Figure 2 for explanation of boxplot graph)

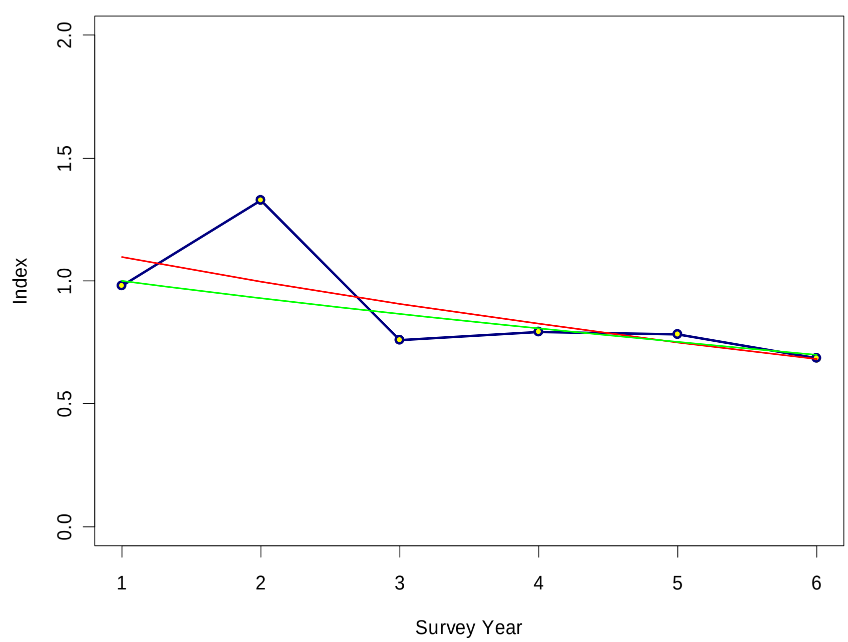


Figure 5. Example of a single simulated trajectory from the data presented in Figure 4. The red line indicates the best-fit slope of the trajectory and the green line indicates the actual simulated trend.

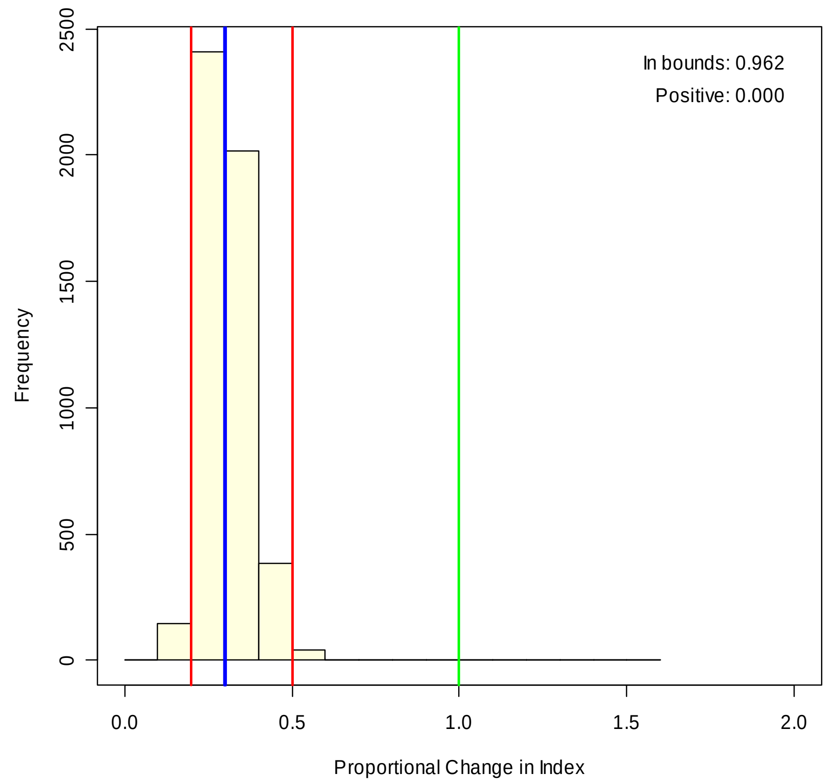


Figure 6. Number of runs out of 5000 grouped by the estimate of the proportional decrease of 70 % (indicated by the blue line) over 10 years for arrowtooth flounder. "In bounds" indicates the proportion of the simulation runs which indicated a decrease of between 20 and 50% of the original biomass (within the red vertical lines). "Positive" indicates the proportion of runs which indicated a positive change in biomass (to the right of the vertical green line).

The simulation suggests that the GF-QCSd survey will correctly indicate that the population has decreased 100% of the time, and estimated the "correct" amount of the decrease 96% of the time. Using this scenario as a test, it is reasonable to advise managers that this survey will provide adequate indexing to support a "test" of arrowtooth flounder productivity.

RESULTS

OPERATIONAL RESULTS

Each year the survey began in the first week of July and lasted about five weeks (Table 2). We were fortunate with the weather in losing only four days over the three years. We will probably continue to forecast three or four lost days per survey (weather and breakdown) in the specifications of the Request for Proposal (RFP).

Table 2. Summary of GF-QCSd survey operational days (2003-2005).

	2003	2004	2005
Start day: Depart Nanaimo	July 3	July 5	July 5
End day: Offload Nanaimo	August 10	August 9	August 7
Fishing days	28	26	24
Travel (begin and end)	3	3.5	3
Offload days	4	4	4
Weather days	2	0	2
Breakdown	1	1.5	0
Total Days	38	35	33
Keeper tows	239	240	228
Unusable tows	21	37	32
Inspected un-fished blocks	16	53	49
Tows/overall days	6.3	6.9	6.9
Usable tows/fishing day	8.5	9.2	9.5

The workload on deck is at the upper limit for research surveys, mostly owing to the fact that we follow a sunrise to sunset workday, during the longest days of the year. In early July, the first tow comes out of the water at 0600 and last tow at about 2100, with data still to process. The survey averages over nine tows per full fishing day, and sometimes reaches 12 successful tows per day. As designed, only rarely did we have to pause in the fishing to clear up a backlog of sorting and sampling.

The net cost of the survey ranged from $380-420K, with the cost borne at a ratio of about 80:20 between the Canadian Groundfish and Research Society (CGRCS) and DFO (Table 3).

Table 3. Estimated costs ($) of the GF-QCSd survey (2003-2005).

		2003	2004	2005
Charter		330,000	330,000	330,000
CGRCS contracts		23,500	36,750	33,600
DFO Employees (on board)	@550	66,500	40,000	36,300
DFO Employees (prep)	@250	9,000	5,250	5,250
DFO Employees (Data)	@250	9,000	9,000	8,250
Nets		6,000	4,000	8,000
Scientific supplies		3,000	3,000	3,000
Scales etc (cost per survey)		5,000	3,000	3,000
Revenue from Fish		35,000	50,000	50,000
Cost to CGRCS		324,500	320,750	321,600
Cost to DFO		92,500	60,250	55,800
Total Coast		417,000	381,000	377,400

Completed Tows by Stratum

After examining the 2003 results, we re-allocated a few tows to the shallow stratum in 2004 (Table 4). It appeared that a modest reallocation would greatly improve precision for the shallow species with negligible impact on the deeper species (Stanley *et al.* 2004). However, we found that we lost a significant amount of time searching for trawlable locations in the shallow stratum. Furthermore, these tows are consistently on marginally towable bottom. Towing on rough bottom in shallow water (50 m) adds significantly to the risk of losing or damaging the net and sensors, as well as representing an increased safety risk to the vessel and staff should the gear hang-up. We therefore moved to an allocation between the 2003 and 2004 versions for the 2005 survey (Table 4). We have not re-examined the allocation for this discussion and do not anticipate a re-evaluation prior to the 2007 survey. In subsequent years, as the shallow stratum becomes fully mapped, we can re-allocate to the shallow since the costs and risks will diminish.

Table 4. Targeted and delivered allocation per stratum (2003-2005).

Area	Depth Stratum		2003		2004		2005	
Stratum	Meters	Fathoms	Targeted	Delivered	Targeted	Delivered	Targeted	Delivered
South	50 - 125 /	27 - 68	26	30	47	46	32	31
	125 - 200 /	68 - 109	62	56	49	49	63	61
	200 - 330 /	109 - 164	28	30	27	31	27	29
	330 - 500 /	164 - 273	2	6	8	8	8	8
Area Sub-Total			*118*	*122*	*131*	*134*	*130*	*129*
North	50 - 125 /	27 - 68	8	5	21	20	11	8
	125 - 200 /	68 - 109	42	39	38	39	49	45
	200 - 330 /	109 - 164	53	54	43	40	43	38
	330 - 500 /	164 - 273	19	19	7	7	7	8
Area Sub-Total			*122*	*117*	*109*	*106*	*110*	*99*
Survey Total			***240***	***239***	***240***	***240***	***240***	***228***

We fell short of our target 240 tows in 2005 although we started with a set of 308 blocks. As the number of previously surveyed blocks increases, we will become more accurate in estimating the required overage.

Completion of the Sampling Frame

We successfully fished 74% of all randomly chosen blocks over the three years (Figure 7, Table 5). Our success rate will increase and search time decrease as we slowly delete untrawlable blocks from the sampling frame. We have now visited 897 blocks or 13% of the 6,920 blocks in the sampling frame.

Table 5. Number of blocks allocated and successfully completed by stratum (2003-2005).

Area	**Depth Stratum**		**2003**			**2004**			**2005**		
Stratum	**Meters**	**Fathoms**	**Alloc.**	**Comp.**	**%Success**	**Alloc.**	**Comp.**	**%Success**	**Alloc.**	**Comp.**	**%Success**
South	50 - 125 /	27 - 68	38	30	78.9	61	46	75.4	46	31	67.4
	125 - 200 /	68 - 109	63	56	88.9	60	49	81.7	76	61	80.3
	200 - 330 /	109 - 164	34	30	88.2	40	31	77.5	36	29	80.6
	330 - 500 /	164 - 273	5	5	100.0	9	8	88.9	10	8	80.0
Area Sub-Total			*140*	*121*	*86.4*	*170*	*134*	*78.8*	*168*	*129*	*76.8*
North	50 - 125 /	27 - 68	9	5	55.6	44	20	45.5	24	8	33.3
	125 - 200 /	68 - 109	47	39	83.0	61	39	63.9	59	45	76.3
	200 - 330 /	109 - 164	56	54	96.4	49	40	81.6	49	38	77.6
	330 - 500 /	164 - 273	24	19	79.2	10	7	70.0	8	8	100.0
Area Sub-Total			136	117	86.0	164	106	64.6	140	99	70.7
Survey Total			276	238	86.2	334	240	71.9	308	228	74.0

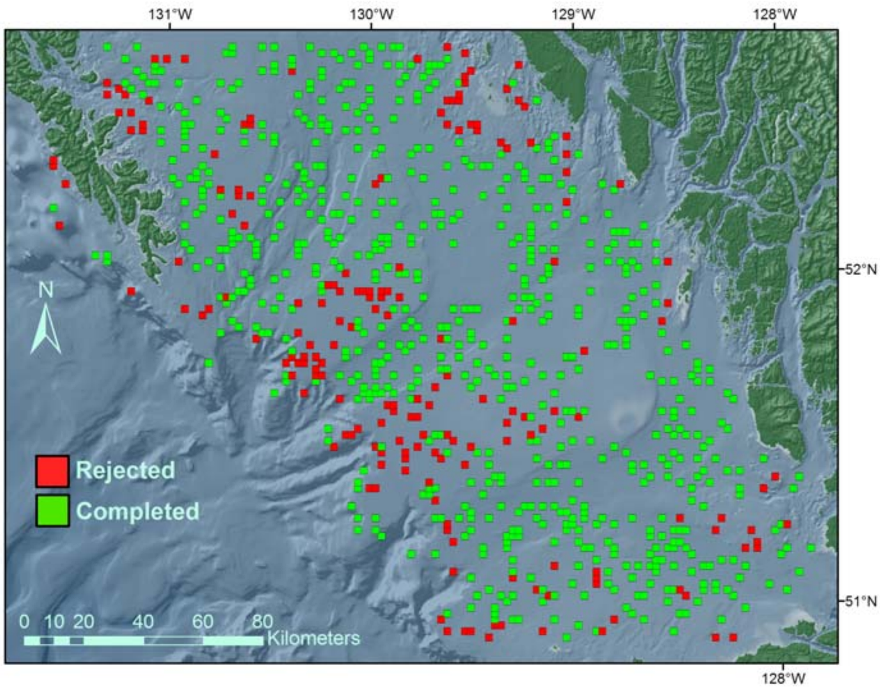


Figure 7. Composite of all three years with all successfully completed (green) or rejected (red) blocks.

It is obvious from Figure 8, which compares the set of tows for 2005 with the main areas of trawl fishing, that we can expect a significant contribution of observational error owing to the chance distribution of tows. The number of tows that fall within blocks that are associated with high commercial catch rate blocks will vary among years.

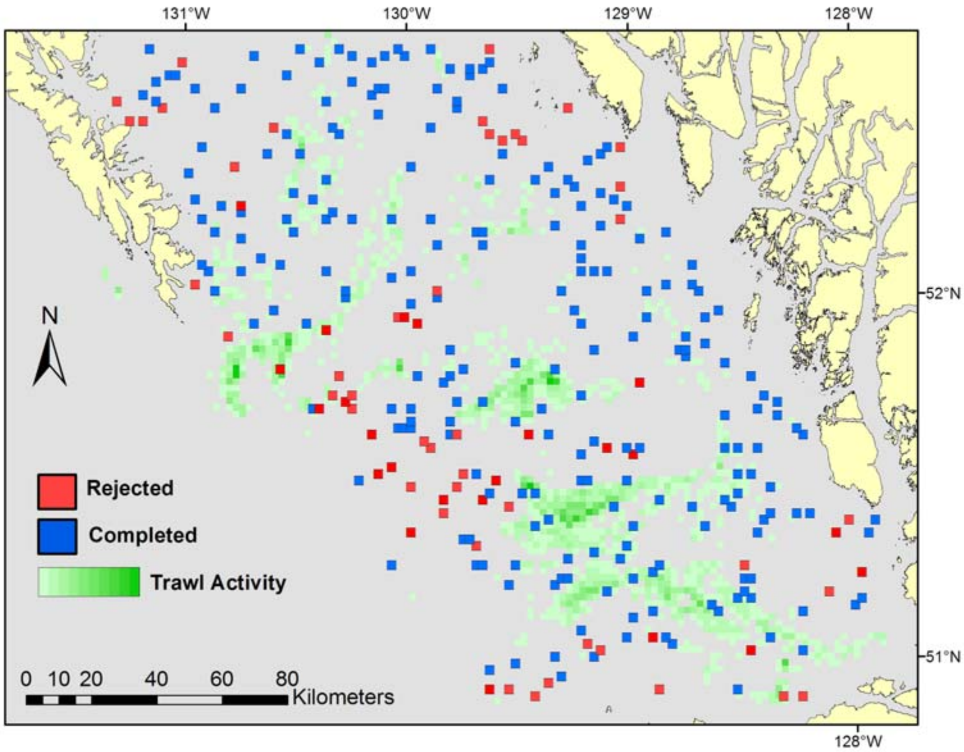


Figure 8. Comparison of the 2005 sampling frame with main areas of bottom trawl activity.

Fate of Rejected Blocks

Discussions in 2003 recommended that if a block were rejected during a survey, the same block would be maintained in the sampling frame for future surveys until it was rejected two more times. The concern was that a charter captain might be too cautious and tend to permanently remove too many fishable blocks from the sampling frame. We were trying to obtain the most complete coverage possible and were concerned that a high rejection rate might result in less representative coverage.

However, after three years, it appears that, with the exception of the shallow strata, we are covering most of the survey area. Furthermore, as the set of successful blocks grows, it becomes increasingly difficult for a future skipper to be overly cautious. An increasing number of the blocks will have already been fished, or the new blocks will be surrounded by fishable blocks. We recommend changing the protocol to remove a block after one rejection. Searching for towable blocks is a major cost and having to return two more times to a previously rejected block seems pointless.

Fishing within a Block

The fishing captain is requested to fish the block approximately through the centre and parallel to the depth contours. However, many of the bocks would be unfishable if this rule had to be strictly followed. Therefore, the captain is allowed to choose a different path if is necessary to complete the block (Figure 9). As the surveys are repeated, and we begin repeating blocks, we will request that the skipper attempt to follow the previous track. This will reduce time spent searching for trawlable bottom, and minimize the footprint of the survey, such that not all the area within a block will be fished.

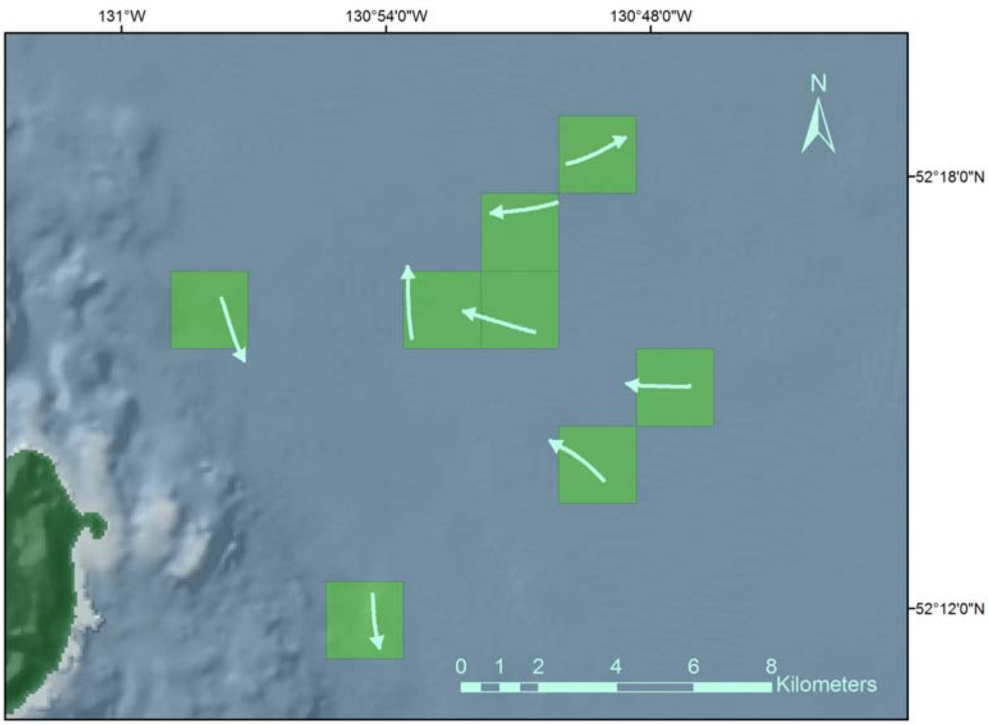


Figure 9. Selected tow tracks from the southeast coast of Moresby Island in 2004.

FISHING MENSURATION/BRIDGE LOG DATA CAPTURE

We did not encounter any significant problems with the gear mensuration or capturing oceanographic data (Figure 10 to Figure 13). In addition to providing background data for tracking environmental change and supporting ecosystem research, we expect that analyses of these data will be useful for explaining some of the *PE-C* in catch rates, leading to more precise indexing.

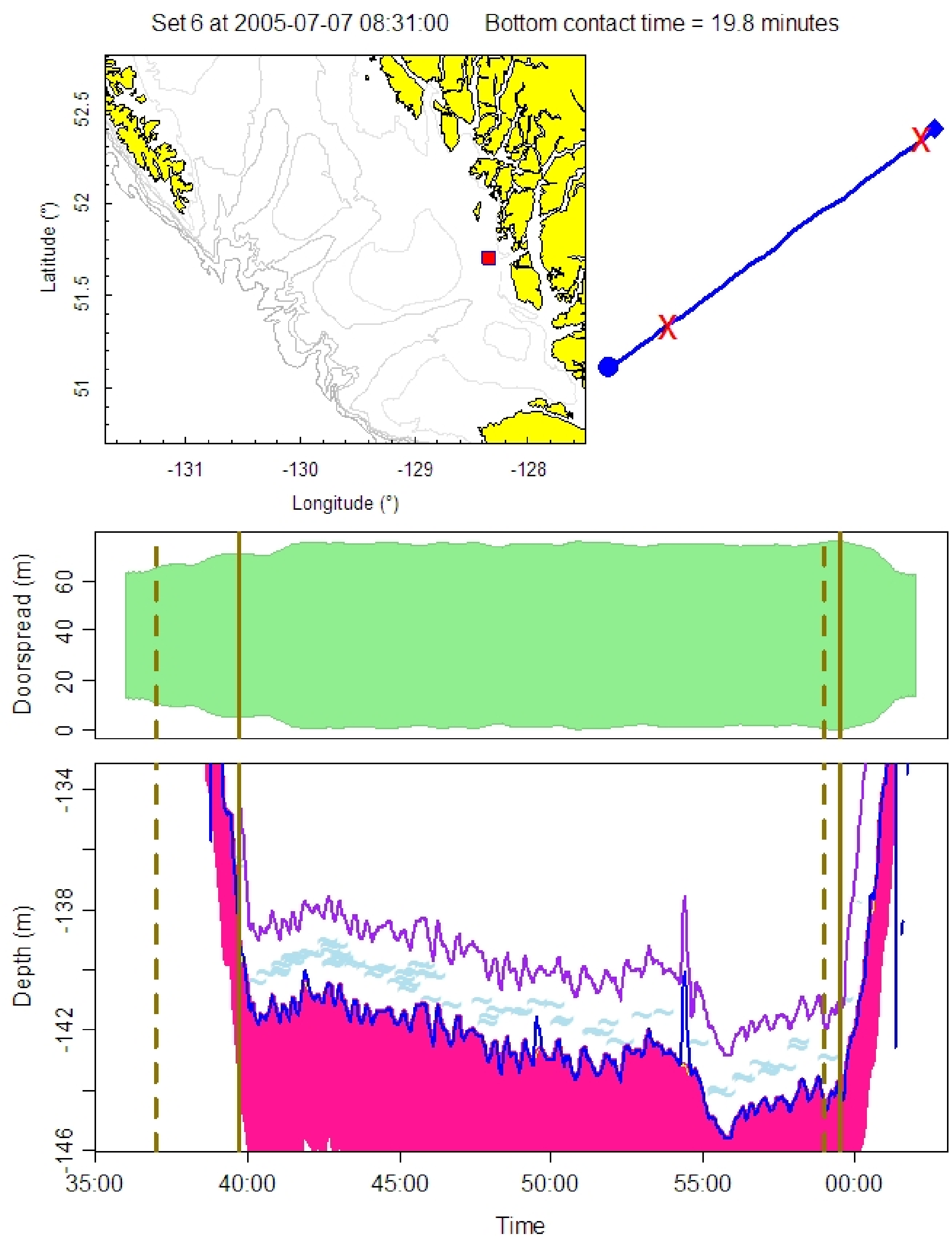


Figure 10. Gear mensuration overview. The top panel shows the location of the fished block and the trajectory of the tow track with start and end bottom contact times indicated by red Xs. The middle panel represents the doorspread and the bottom panel the net opening height and distance off bottom, over the duration of the tow. The light blue symbols on the bottom panel indicate catch sensor activity and probably represent fish entering the net. Note on the bottom panel the location where the trawl net jumps off the sea floor at approximately 54 minutes after the hour. The dashed and solid lines on the middle and bottom panels represent the gear deployment/retrieval times, and the begin/end bottom contact times, respectively.

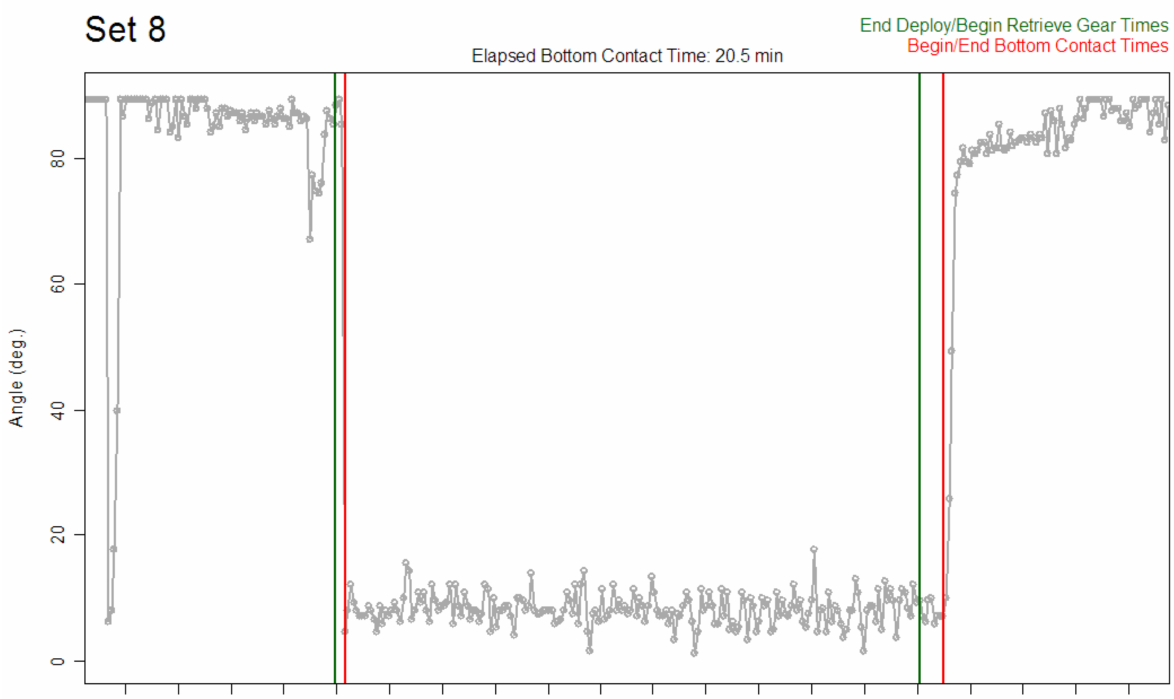


Figure 11. Example bottom contact profile from the NMFS bottom contact sensor.

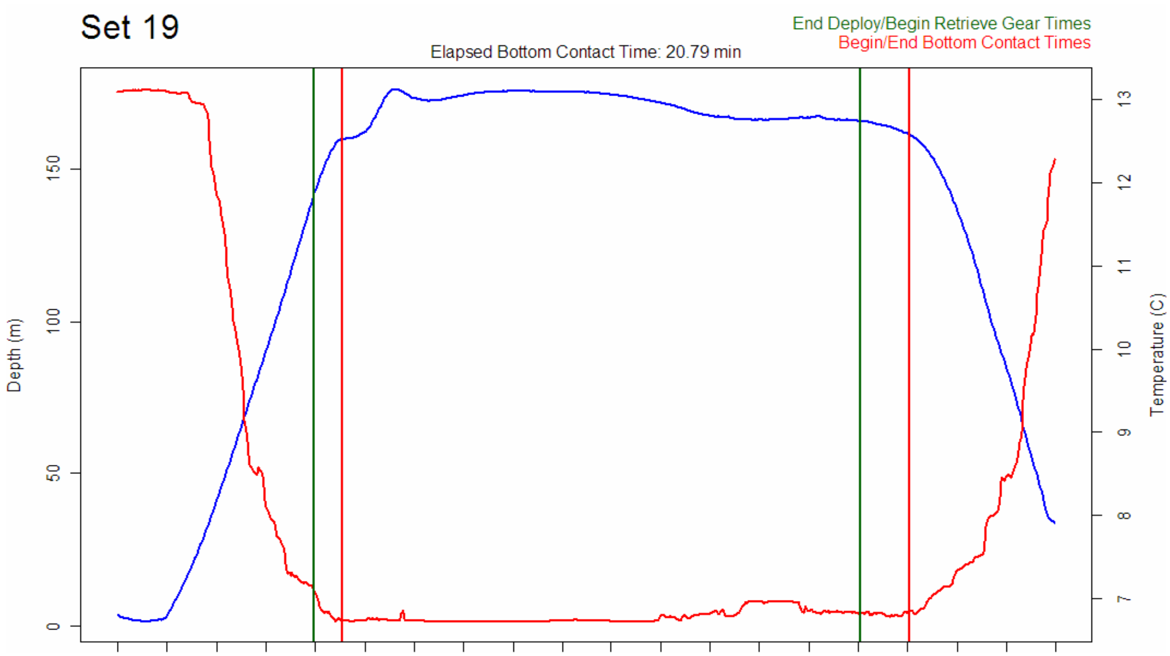
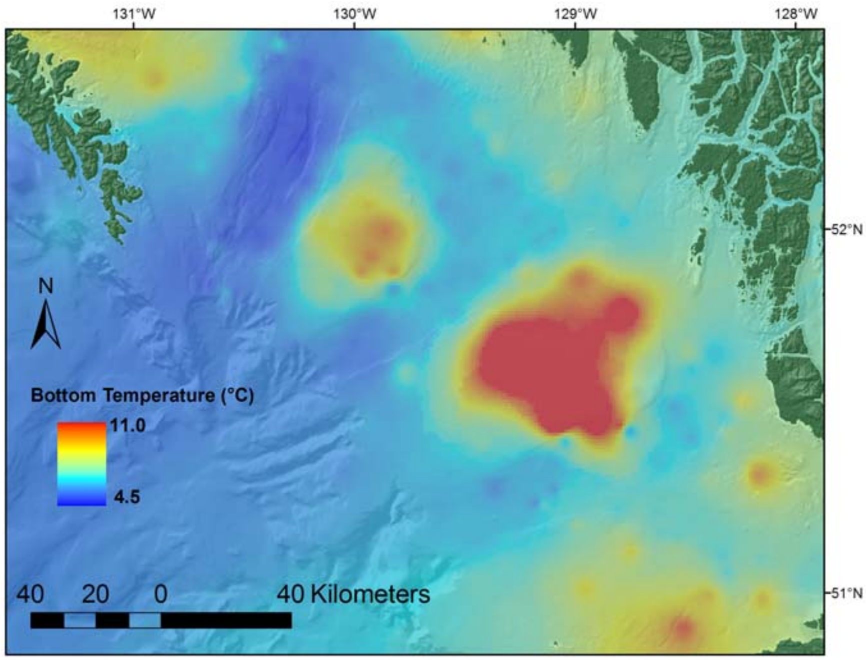
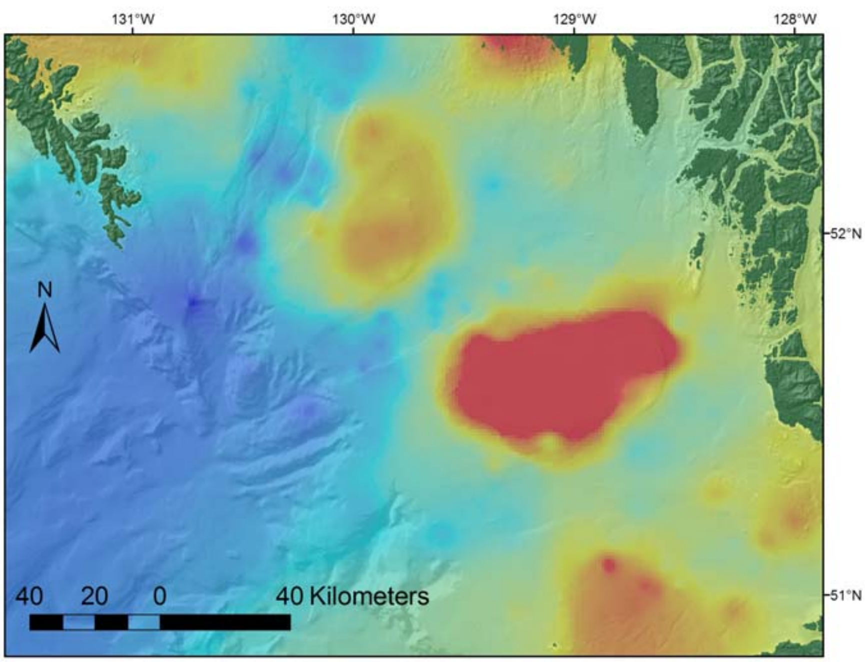


Figure 12. Example temperature and depth profiles from the Seabird 39 probe.



(a)



(b)

Figure 13. Interpolated bottom temperature from Seabird 39 temperature data in 2003 (a) and 2004 (b). Note the interpolation will be affected by location of the tows, which varies among years.

TOTAL CATCH AND CATCH FREQUENCY

About 100 t of fish are captured during each survey, with 30-40% retained for sale (Table 6, Figure 14). We conducted a full sort of most tows. When we made a large tow of a retained species the weight was usually visually estimated but we were able to corroborate the values using the dockside monitoring program (DMP) estimates. Most of the tows during each trip were completely weighed, thus the large tows would be the difference between the DMP estimate and the weighed tows.

Table 6. Total catch and number of species caught (2003-2005).

	2003	2004	2005
Total Catch (kg)	90,116	116,683	107,034
Retained Catch (kg)	37,476	47,291	39,591
Retained Catch (%)	42	41	37
Retained Catch Estimated Value (approx. $)	34,600	48,900	49,600
Discarded Catch (kg)	52,640	69,393	67,443
Mean catch per tow (kg)	377	486	469
Total number of species	172	244	254
Total number of fish species	105	125	124
Total number of invertebrate species	65	115	127
Mean number of species per tow	16	20	25
Mean number of fish species per tow	13	14	16
Mean number of invertebrate species per tow	3	6	8

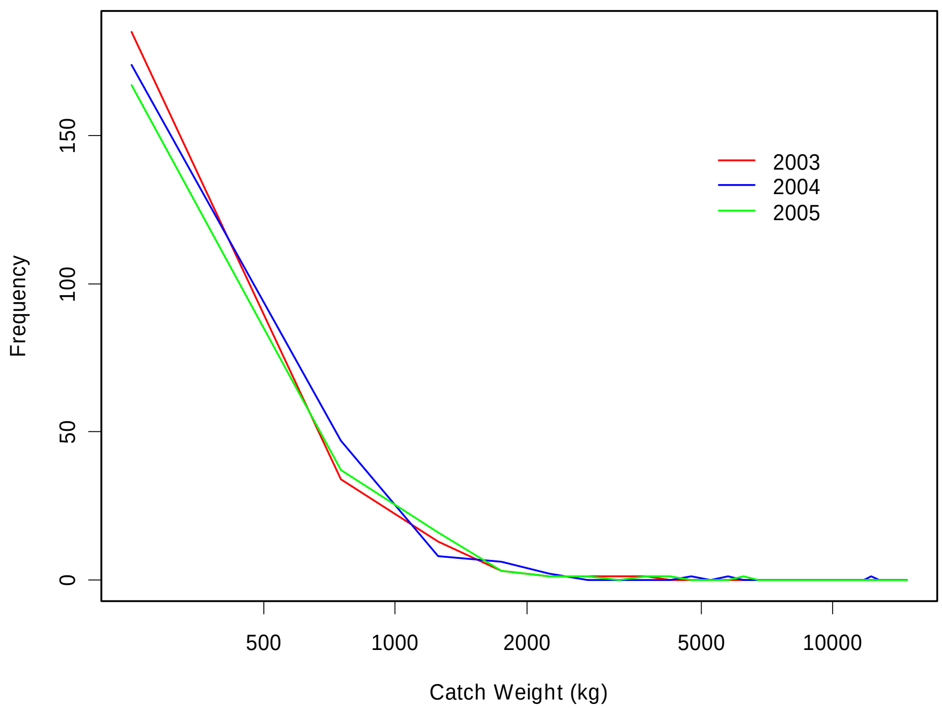


Figure 14. Frequency plot of catch weight per tow for each year of the survey.

Frequency of occurrence was similar among years for most species. Exceptions included Pacific hake which increased in frequency over the three years (Table 7).

Table 7. Frequency of occurrence per year (2003-2005).

Species	2003	2004	2005	Average
Arrow tooth flounder	0.89	0.85	0.92	0.88
Rex sole	0.84	0.71	0.89	0.81
Pacific ocean perch (north)	0.82	0.65	0.72	0.73
Dover sole	0.72	0.65	0.79	0.72
Spotted ratfish	0.63	0.67	0.75	0.68
Pacific ocean perch	0.75	0.60	0.66	0.67
Silvergray rockfish (north)	0.64	0.50	0.72	0.62
Pacific ocean perch (south)	0.69	0.55	0.61	0.62
Pacific hake	**0.36**	**0.50**	**0.73**	**0.53**
Sablefish	0.56	0.46	0.56	0.53
Silvergray rockfish	0.53	0.43	0.56	0.51
Pacific cod	0.44	0.53	0.55	0.50
Redbanded rockfish	0.54	0.43	0.53	0.50
Spiny dogfish	0.53	0.40	0.55	0.49
Walleye pollock	0.38	0.46	0.60	0.48
Slender sole	0.40	0.41	0.50	0.44
Silvergray rockfish (south)	0.43	0.38	0.44	0.42
Shortspine thornyhead	0.44	0.36	0.38	0.40
Longnose skate	0.34	0.33	0.39	0.36
English sole	0.31	0.36	0.36	0.34
Flathead sole	0.34	0.24	0.37	0.32
Petrale sole	0.28	0.33	0.29	0.30
Rougheye rockfish	0.33	0.25	0.29	0.29
Pacific halibut	0.20	0.31	0.36	0.29
Redstripe rockfish (south)	0.24	0.23	0.40	0.29
Lingcod	0.23	0.33	0.28	0.28
Sharpchin rockfish	0.18	0.25	0.38	0.27
Blackbelly eelpout	0.28	0.20	0.32	0.27
Greenstriped rockfish	0.21	0.25	0.29	0.25
Redstripe rockfish	0.20	0.23	0.33	0.25
Yellow mouth rockfish (south)	0.20	0.24	0.22	0.22
Redstripe rockfish (north)	0.16	0.22	0.25	0.21
Yellow tail rockfish	0.13	0.16	0.31	0.20
Canary rockfish (south)	0.18	0.15	0.26	0.20
Yellow mouth rockfish	0.17	0.22	0.20	0.19
Canary rockfish	0.15	0.15	0.26	0.19
Southern rock sole	0.15	0.23	0.15	0.18
Canary rockfish (north)	0.13	0.14	0.26	0.18
Eulachon	0.17	0.12	0.22	0.17
Yellow mouth rockfish (north)	0.14	0.19	0.17	0.17
Pacific sanddab	0.14	0.20	0.12	0.15
Pacific herring	0.13	0.13	0.19	0.15
Rosethorn rockfish	0.15	0.15	0.11	0.14
Yellow eye rockfish	0.09	0.15	0.18	0.14
Splitnose rockfish	0.12	0.13	0.14	0.13
Blackfin sculpin	0.11	0.11	0.16	0.13
Darkblotched rockfish	0.10	0.10	0.09	0.10
Black eelpout	0.02	0.13	0.14	0.10
Sandpaper skate	0.11	0.06	0.08	0.08
Widow rockfish	0.05	0.05	0.14	0.08
Threadfin sculpin	0.09	0.07	0.07	0.07
Curlfin sole	0.05	0.09	0.07	0.07
Pygmy rockfish	0.02	0.08	0.11	0.07
Bocaccio	0.05	0.06	0.08	0.07
Pacific sand lance	0.03	0.13	0.03	0.06
Big skate	0.05	0.07	0.05	0.06
Bigfin eelpout	0.04	0.05	0.06	0.05
Quillback rockfish	0.03	0.06	0.06	0.05
Blacktip poacher	0.01	0.00	0.10	0.04
Wattled eelpout	0.02	0.04	0.04	0.03

SURVEY PRECISION

The $RE_{OE,s,y}$'s are similar among years, with a few exceptions such as Pacific hake, Pacific cod and rougheye rockfish (Table 8), Appendix 5). The relation between the average estimate of $RE_{OE,s,y}$ over the three years tends to equal the pooled estimate ($RE_{OE,s,Pooled}$) for the lowest variance populations (RE<0.20). The discrepancy appears to accelerate with the *RE*. Averaged over the species shown in Table 9, the discrepancy equates to adding a *PE* of about 0.13, not unlike the value of 0.2 noted by Francis *et al.* (2003), especially if we were to include the additional species with a *RE* greater than 0.60.

Table 8. Survey $RE_{OE,s,y}$'s for each year and all three years combined (pooled) for species with a mean $RE_{OE,s,y} < 0.4$.

Species	2003	2004	2005	Average	Pooled
Shortspine thornyhead	0.10	0.11	0.09	0.10	0.11
Rex sole	0.10	0.12	0.08	0.10	0.12
Dover sole	0.12	0.12	0.10	0.11	0.11
Pacific ocean perch (south)	0.17	0.12	0.15	0.15	0.17
Arrowtooth flounder	0.11	0.18	0.17	0.15	0.18
Longnose skate	0.21	0.14	0.11	0.15	0.14
Silvergray rockfish	0.15	0.19	0.12	0.15	0.19
Redbanded rockfish	0.16	0.18	0.16	0.17	0.18
Pacific ocean perch	0.13	0.20	0.17	0.17	0.16
Sablefish	0.12	0.23	0.15	0.17	0.16
Slender sole	0.27	0.16	0.13	0.19	0.16
Silvergray rockfish (north)	0.20	0.23	0.14	0.19	0.19
Walleye pollock	0.18	0.19	0.21	0.19	0.24
Pacific halibut	0.24	0.16	0.20	0.20	0.19
Pacific hake	0.14	0.32	0.14	0.20	0.27
English sole	0.24	0.21	0.19	0.21	0.23
Greenstriped rockfish	0.27	0.19	0.23	0.23	0.23
Lingcod	0.27	0.20	0.23	0.23	0.23
Pacific cod	0.16	0.26	0.33	0.25	0.31
Petrale sole	0.18	0.21	0.36	0.25	0.27
Rougheye rockfish	0.40	0.23	0.15	0.26	0.31
Pacific herring	0.28	0.32	0.19	0.26	0.35
Silvergray rockfish (south)	0.27	0.39	0.19	0.28	0.30
Flathead sole	0.19	0.47	0.21	0.29	0.42
Pacific ocean perch (north)	0.20	0.34	0.35	0.29	0.27
Southern rock sole	0.25	0.37	0.31	0.31	0.39
Pacific sanddab	0.28	0.30	0.38	0.32	0.35
Sandpaper skate	0.33	0.40	0.25	0.33	0.32
Blackfin sculpin	0.29	0.47	0.26	0.34	0.41
Rosethorn rockfish	0.25	0.32	0.45	0.34	0.33
Bigeye poacher			0.35	0.35	0.63
Curlfin sole	0.31	0.29	0.47	0.35	0.42
Bigfin eelpout	0.52	0.27	0.27	0.36	0.42
Yelloweye rockfish	0.38	0.47	0.22	0.36	0.43
Yellowtail rockfish	0.42	0.38	0.28	0.36	0.40
Blackbelly eelpout	0.36	0.37	0.37	0.37	0.41
Redstripe rockfish	0.56	0.32	0.26	0.38	0.43
Blacktip poacher			0.39	0.39	0.69
Yellowmouth rockfish	0.34	0.46	0.40	0.40	0.49

SURVEY ACCURACY

We used the survey simulator to examine the accuracy of the survey for tracking populations in Queen Charlotte Sound. In the first set of scenarios, we examined the accuracy of the survey in tracking a doubling of a population over 10 years (Table 9, Figure 15 to Figure 20). All results used $RE_{OE,s,Pooled}$.

Table 9. Summary of results in testing how well the GF-QCSd survey can track a doubling of population over 10 years using $RE_{OE,s,Pooled}$.

Species	$RE_{OE,s,Pooled}$	$RE_{OE,s,2005}$	% correct within 1.5 and 3.0 times	% positive	Approx. tows required to be correct 80%
Dover sole	0.11	0.11	99	100	70
Arrowtooth flounder	0.18	0.15	89	100	150
Rougheye rockfish	0.31	0.26	65	97	450
Southern rock sole	0.39	0.31	54	93	700
Canary rockfish	0.51	0.43	42	87	1000
Bocaccio	0.82	0.65	28	77	inf.

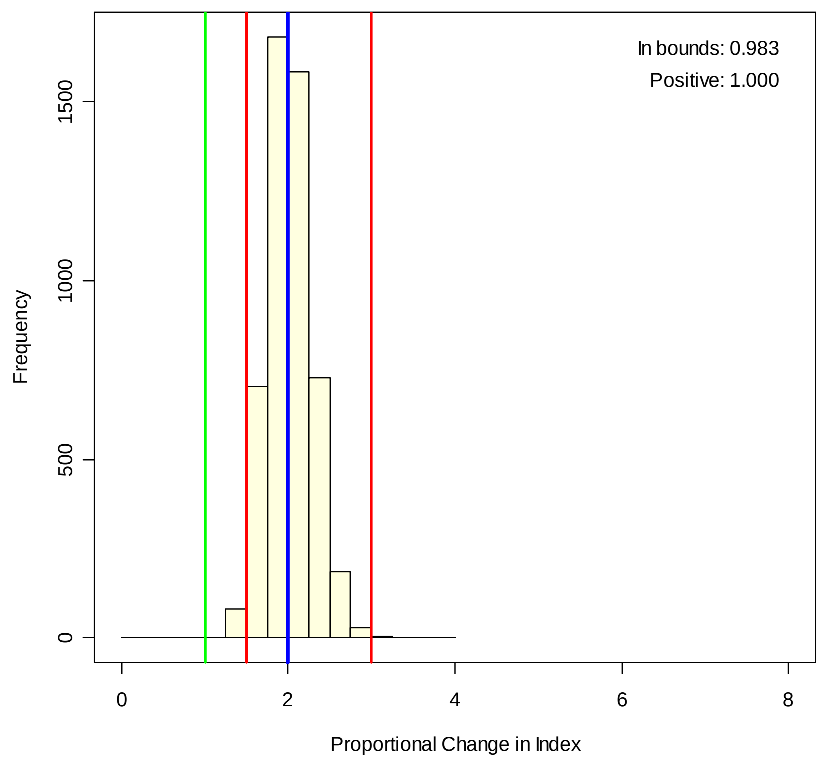


Figure 15. Simulation results for Dover sole under the 2X increase scenario. “In bounds” indicates the proportion of the simulation runs which indicated an increase from 1.5 times and 3.0 times the original biomass (within the red vertical lines). “Positive” indicates the proportion of runs which indicated a positive change in biomass (to the right of the vertical green line).

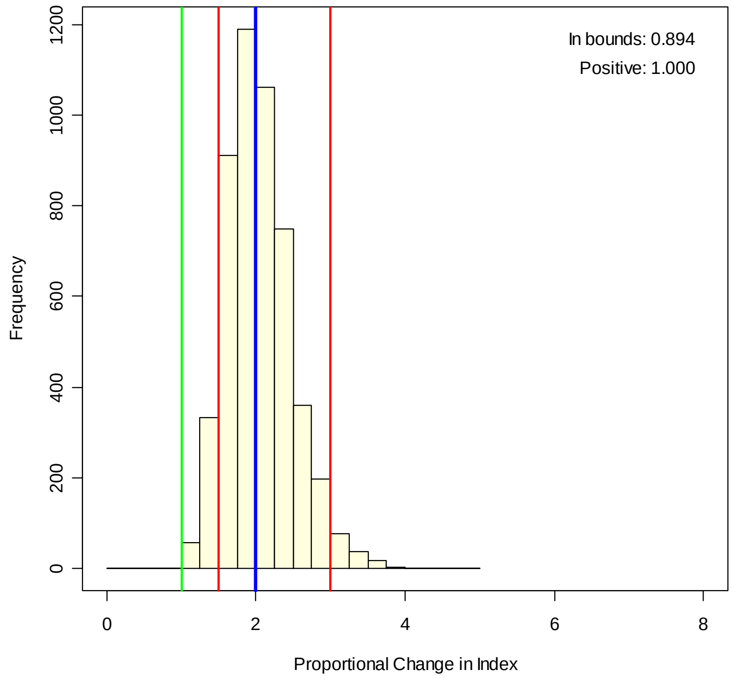


Figure 16. Simulation results for arrowtooth flounder under the 2X increase scenario. "In bounds" indicates the proportion of the simulation runs which indicated an increase from 1.5 times and 3.0 times the original biomass (within the red vertical lines). "Positive" indicates the proportion of runs which indicated a positive change in biomass (to the right of the vertical green line).

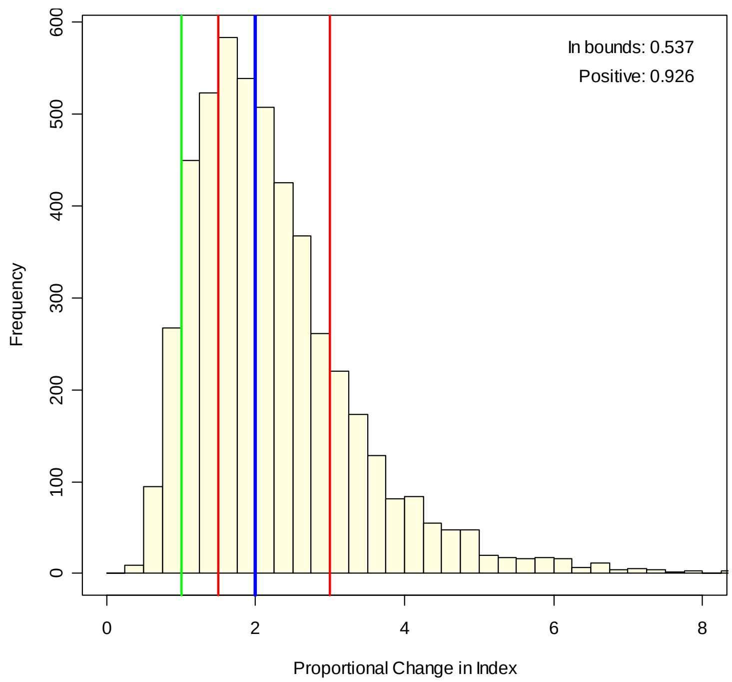


Figure 17. Simulation results for southern rock sole under the 2X increase scenario. "In bounds" indicates the proportion of the simulation runs which indicated an increase from 1.5 times and 3.0 times the original biomass (within the red vertical lines). "Positive" indicates the proportion of runs which indicated a positive change in biomass (to the right of the vertical green line).

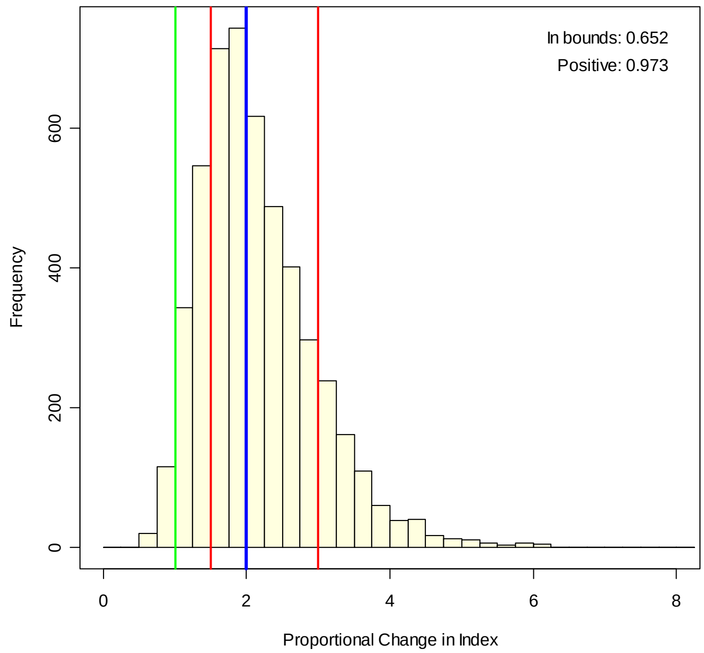


Figure 18. Simulation results for rougheye rockfish under the 2X increase scenario. “In bounds” indicates the proportion of the simulation runs which indicated an increase from 1.5 times and 3.0 times the original biomass (within the red vertical lines). “Positive” indicates the proportion of runs which indicated a positive change in biomass (to the right of the vertical green line).

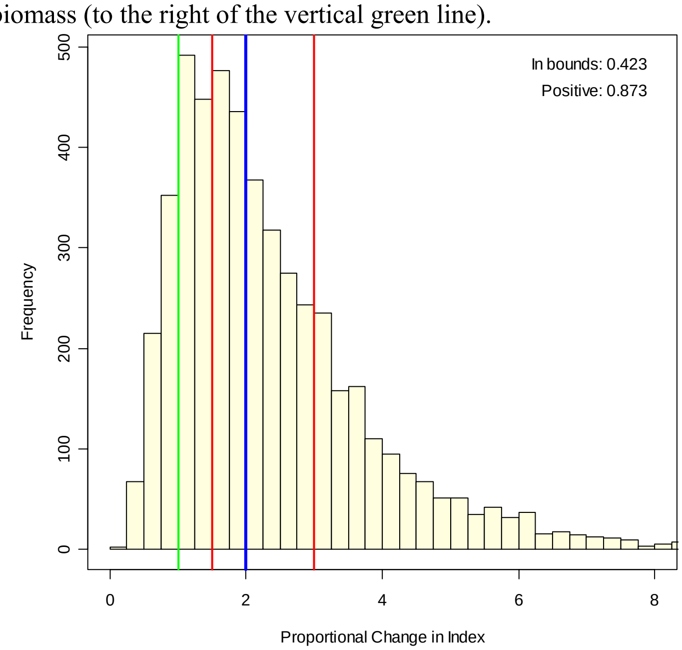


Figure 19. Simulation results for canary rockfish under the 2X increase scenario. “In bounds” indicates the proportion of the simulation runs which indicated an increase from 1.5 times and 3.0 times the original biomass (within the red vertical lines). “Positive” indicates the proportion of runs which indicated a positive change in biomass (to the right of the vertical green line).

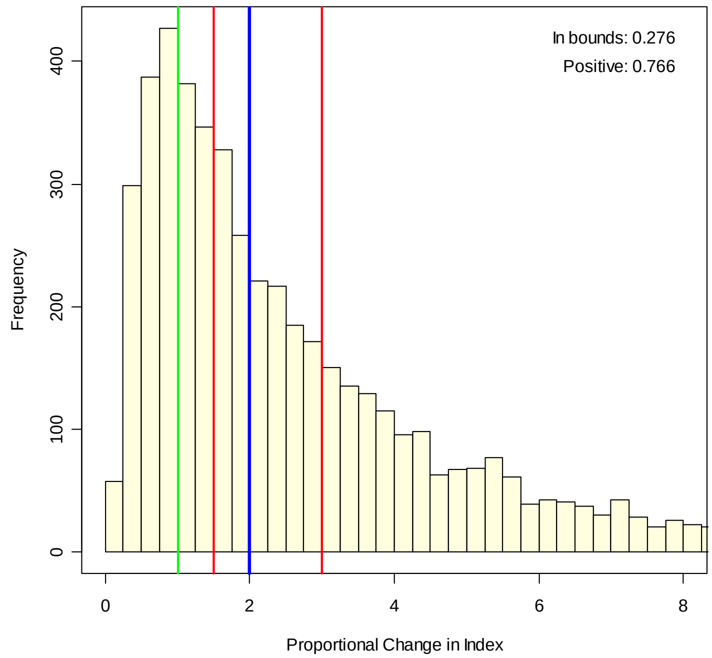


Figure 20. Simulation results for bocaccio under the 2X increase scenario. "In bounds" indicates the proportion of the simulation runs which indicated an increase from 1.5 times and 3.0 times the original biomass (within the red vertical lines). "Positive" indicates the proportion of runs which indicated a positive change in biomass (to the right of the vertical green line).

Using the doubling over 10 years scenario, the results appear congruent with our crude standard of using the survey RE's shown below to characterize the adequacy of the biennial survey, although we recommend using the $RE_{OE,s,Pooled}$.

- excellent = < 0.20
- good = 0.20-30
- adequate = 0.30-0.40
- poor = 0.40-0.60
- very poor = > 0.60

A biennial density of 240 tows is probably over-sampling for species like Dover sole, while providing poor indexing of canary rockfish and bocaccio. However, it would not be cost-effective to improve the indexing accuracy for these poor survey candidates by increasing the tow number.

It should be noted that these tables exaggerate the cost of improving the survey for any one population. The indexing of one population, especially one which tends to be confined to one depth stratum, could be improved by a relatively modest re-allocation of a few tows to a specific stratum. The intent of Table 10 is to show what would be required to simultaneously raise the precision of the survey for all of the poorly surveyed populations.

In the second set of scenarios, we examined the same populations given a 70% decline over 10 years with detection tolerance limits of 50 and 80% declines (Table 10,

Figure 21 and Figure 22). We again used $RE_{OE,s,Pooled}$. The last column of Tables 10 and 11 were derived by re-running the simulator with different tow numbers until the desired accuracy was achieved.

Table 10. Summary of results in testing how well the GF-QCSd survey can track a 70% decline over 10 years using $RE_{OE,s,Pooled}$.

Species	$RE_{OE,s,Pooled}$	$RE_{OEs,2005}$	% correct within 0.2 and 0.5 times	% positive	Approx. tows required to be correct 80%
Dover sole	0.11	0.11	100	0	35
Arrowtooth flounder	0.18	0.15	100	0	80
Rougheye rockfish	0.31	0.26	79	0	250
Southern rock sole	0.39	0.31	67	0.5	425
Canary rockfish	0.51	0.43	54	2.8	550
Bocaccio	0.82	0.65	37	10	> 1000

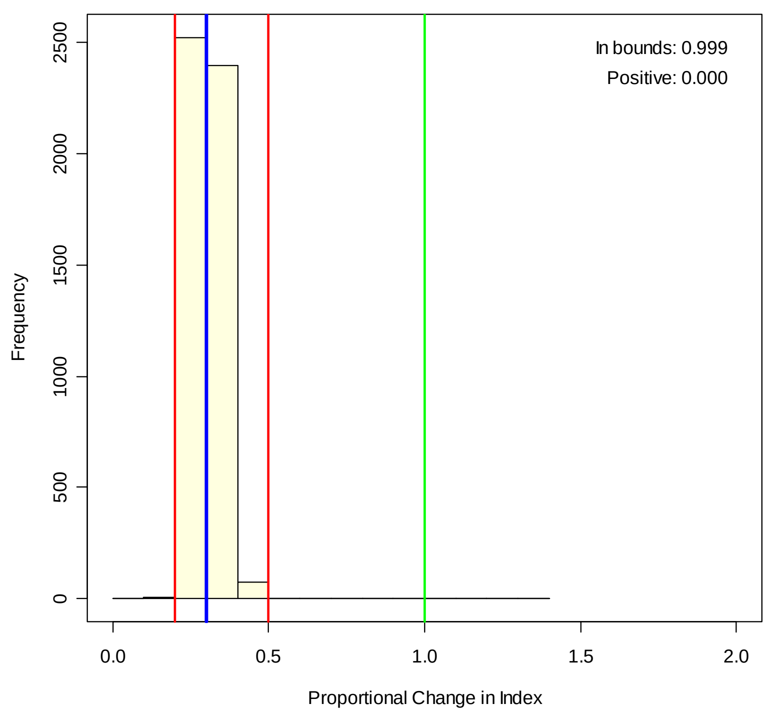


Figure 21. Simulation results for Dover sole under the 70% decrease scenario. "In bounds" indicates the proportion of the simulation runs which indicated a decrease from 20% to 50% (within the red vertical lines). "Positive" indicates the proportion of runs which indicated a positive change in biomass (to the right of the vertical green line).

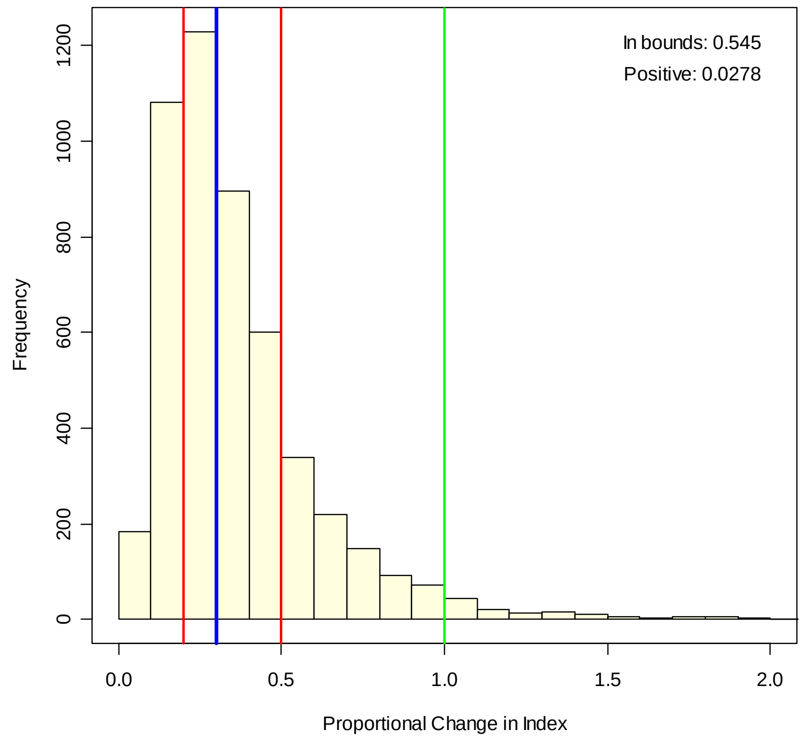


Figure 22. Simulation results for canary rockfish under the 70% decrease scenario. "In bounds" indicates the proportion of the simulation runs which indicated a decrease from 20% to 50% (within the red vertical lines). "Positive" indicates the proportion of runs which indicated a positive change in biomass (to the right of the vertical green line).

We have created more contrast in the population change so the survey appears to perform better. For canary rockfish, the survey will almost always note the decline and even lead to estimating the correct amount of decline most of the time. Even for bocaccio, it noted a decline 90% of the time; although only a third of the time did it estimate the degree of decline correctly. Nevertheless, it continues to indicate that the adequacy of the survey for tracking a given species is represented by the simple qualitative classification of the RE_{Pooled}'s above, under the assumption of a biennial frequency. This in turn indicates that, while the accuracy of the survey will be disappointing for many species, it still provides adequate to excellent tracking for most of the species that are common in the catch, which includes most of the commercial species. Exceptions only include relatively rare animals and some of the rockfish, such as bocaccio and widow rockfish which have a very patchy distribution and low catchability to bottom trawl gear.

While the lack of precision for many species captured in the GF-QCSd survey is disappointing, we emphasize that one time series from this survey does not reflect the sum of the information that will be available at the time of assessment. These decisions will always be made with the knowledge that the index will be updated within two years. The survey data will also be only one component of the information available. Additional information will include age and size composition information from the survey and commercial fishery, commercial catch rates, as well as other surveys, both in BC and in US waters to the north and south.

SURVEY COST OPTIMIZATION

Analysis of Tow Number

It is appropriate after three years to re-examine whether the survey would be more cost-effective with a different number of tows. Table 11 shows the effect on the estimated RE_{Pooled} of the 40 most precisely indexed populations of the survey. The number of tows is shown in 30-tow increments. Adding 30 tows would add about $45K to the cost of the survey.

Table 11. Estimated $RE_{OE,s,Pooled}$ for the 40 most precisely indexed populations at different tow densities. Net change is the average change in $RE_{OE,s,Pooled}$ across all species from the 240 tow configuration. Values are colour coded to correspond to levels of "accuracy" presented above.

Net change	-22%	-14%	-7%	0	5%	7%
Species	N=150	N=180	N=210	N=240	N=270	N=300
Dover sole	0.135	0.121	0.117	0.107	0.099	0.099
Shortspine thornyhead	0.136	0.127	0.120	0.113	0.106	0.100
Rex sole	0.148	0.133	0.119	0.119	0.108	0.101
Longnose skate	0.179	0.151	0.149	0.141	0.129	0.126
Pacific ocean perch	0.188	0.175	0.165	0.150	0.146	0.143
Slender sole	0.208	0.184	0.164	0.156	0.149	0.147
Sablefish	0.206	0.184	0.181	0.159	0.151	0.143
Arrowtooth flounder	0.221	0.202	0.184	0.179	0.161	0.163
Silvergray rockfish	0.227	0.210	0.203	0.180	0.180	0.163
Redbanded rockfish	0.236	0.216	0.190	0.182	0.173	0.166
Pacific halibut	0.240	0.224	0.206	0.202	0.181	0.180
English sole	0.280	0.276	0.237	0.216	0.212	0.207
Greenstriped rockfish	0.275	0.255	0.238	0.224	0.209	0.199
Lingcod	0.294	0.275	0.259	0.234	0.213	0.209
Walleye pollock	0.312	0.276	0.265	0.237	0.224	0.225
Pacific hake	0.338	0.309	0.286	0.264	0.252	0.235
Petrale sole	0.351	0.313	0.290	0.269	0.255	0.246
Sandpaper skate	0.393	0.370	0.328	0.302	0.309	0.281
Rougheye rockfish	0.360	0.344	0.306	0.309	0.302	0.265
Pacific cod	0.389	0.363	0.333	0.309	0.292	0.273
Rosethorn rockfish	0.429	0.388	0.341	0.323	0.334	0.299
Pacific sanddab	0.443	0.415	0.369	0.345	0.329	0.337
Pacific herring	0.428	0.412	0.373	0.347	0.324	0.302
Southern rock sole	0.477	0.444	0.421	0.383	0.370	0.359
Flathead sole	0.524	0.453	0.430	0.391	0.384	0.373
Yellowtail rockfish	0.526	0.450	0.425	0.401	0.382	0.368
Blackbelly eelpout	0.516	0.496	0.431	0.403	0.379	0.381
Yelloweye rockfish	0.533	0.490	0.456	0.409	0.425	0.361
Blackfin sculpin	0.537	0.457	0.463	0.412	0.403	0.370
Bigfin eelpout	0.532	0.494	0.436	0.414	0.374	0.374
Curlfin sole	0.532	0.503	0.421	0.422	0.385	0.344
Shortraker rockfish	0.580	0.509	0.470	0.451	0.421	0.402
Redstripe rockfish	0.536	0.492	0.474	0.454	0.428	0.386
Canary rockfish	0.622	0.585	0.523	0.482	0.476	0.451
Yellowmouth rockfish	0.623	0.527	0.507	0.488	0.462	0.435
Darkblotched rockfish	0.633	0.564	0.539	0.515	0.473	0.423
Big skate	0.673	0.607	0.565	0.515	0.493	0.476
Wolf eel	0.626	0.608	0.560	0.521	0.468	0.459
Quillback rockfish	0.718	0.628	0.578	0.549	0.527	0.512
Widow rockfish	0.845	0.721	0.668	0.600	0.591	0.546

We recommend continuing with 240 tows as the target. The marginal gain in precision by increasing to 270 and 300 appears negligible given the incremental costs of $45K and $90K, respectively, while decreasing the tow number to 150 leads to an unacceptably large loss of 22% in precision.

The range of 180-240 appears adequate in the short term; however, we recommend over-sampling in anticipation of attrition in the sampling frame. As time passes, we expect more areas will become off-limits to the survey. Since we initiated the survey, the boundaries of the sponge reef closures have been altered, removing a few blocks that we fished in previous surveys. We can expect further attrition as closures are implemented to protect coral and/or other sensitive habitats. Analysts 20 years from now will probably choose to ignore the earlier tow data from blocks that were subsequently deleted from the sampling frame. Thus, we might expect that in the future, trend analyses may only be able to use 80-90% of the 2003-2005 data. If we wish future analysts to retain over 200 usable tows from present surveys, then we should continue to strive for 240.

Finally, the examples above treat all the species as one population in QCSd. Some of these species have been assessed as two populations within this area, for example Pacific ocean perch, canary rockfish, and silvergray rockfish. Assuming future assessments will continue this practice, the resulting indices will be based on half the tows. The precision of these indices will degrade more rapidly under lower overall survey densities.

Analysis of Survey Frequency

Given the current cost structure and in today's dollars, we project that that the 240-tow survey conducted biennially will have a 10-y cost of $1,950K (five surveys @ $390K). The simulator can be used to compare the effectiveness of the survey under different configurations for the same budget. In particular, we examined whether the survey would be more effective if done every year at a lower tow density under the same budget.

Based on our estimates of the fixed costs (cost to mobilize and demobilize for each survey) and the variable cost/tow of a lower density survey, we could conduct an annual survey of 95 tows for the same price as the current 240-tow biennial configuration. Moving to an annual configuration is not cost neutral (120 tows/survey) because of the fixed costs of mounting a survey (@ $30K/survey) and the fact that the cost/tow increases from (≈ $1.5K to $1.7K) as travel time between tows increases with the lower density (Figure 23).

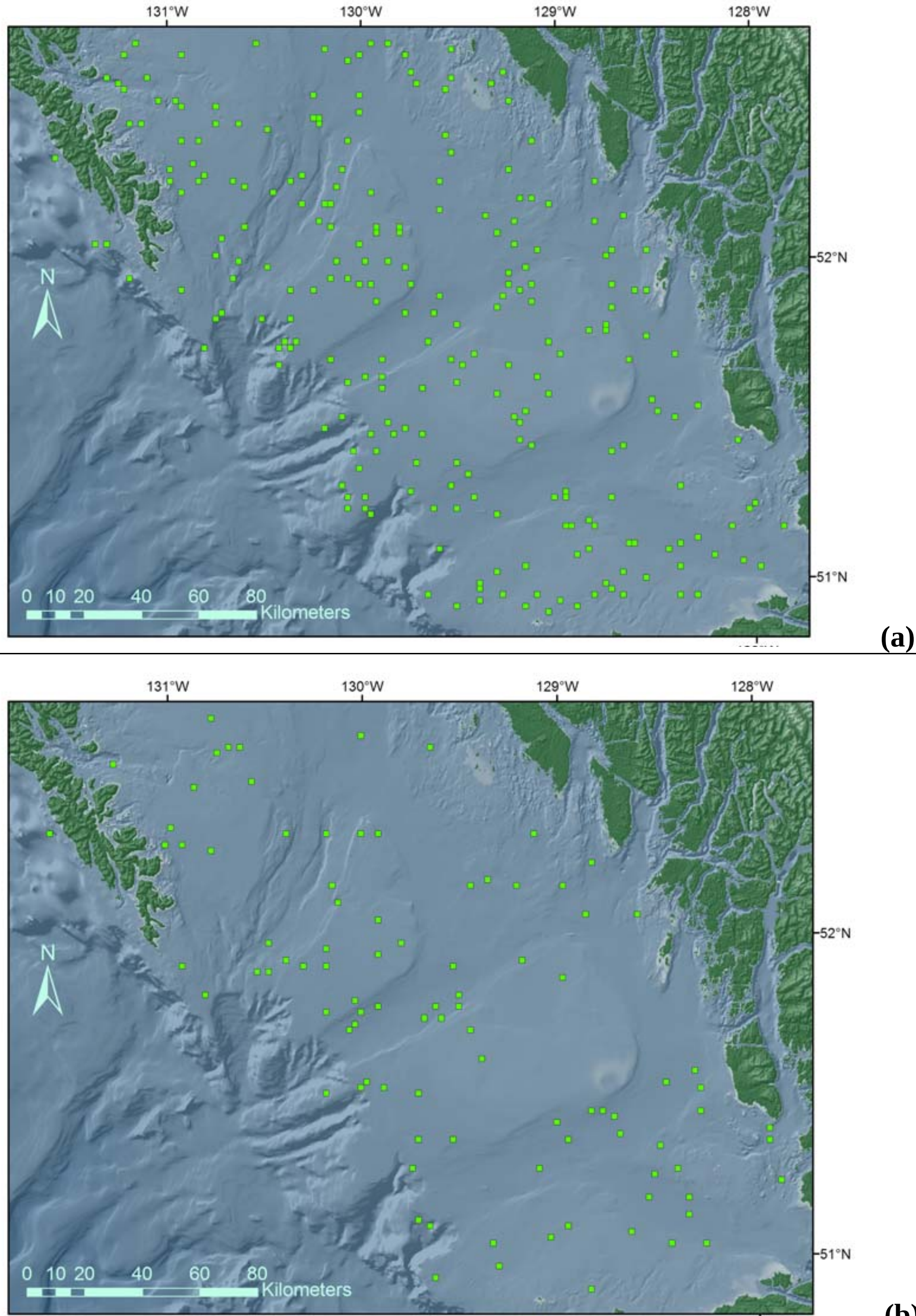


Figure 23. Comparison of a 240 block allocation (a) and a 95 block allocation (b).

Table 12. Comparison of survey performance between 95-tow annual and 240-tow biennial surveys when abundance doubles over 10 years.

Species	$RE_{OE', s,Pooled}$	% Correct within 1.5 and 3.0 times		Tows required in annual survey to match 240-tow bi-ennial performance
		Biennial (240)	Annual (95)	
Dover sole	0.11	99	95	180
Arrowtooth flounder	0.18	89	79	160
Rougheye rockfish	0.31	65	65	65
Southern rock sole	0.39	54	40	170
Canary rockfish	0.51	42	34	150
Bocaccio	0.82	28	24	140

From Table 12, it appears that, under a fixed budget, the biennial survey outperforms the annual configuration. This result, however, is conditional on whether *PE-C* is included. The performance of the biennial survey degrades more rapidly than the annual survey as *PE-C* is increased (Figure 24). For arrowtooth flounder, the annual survey performs better if *PE-C* is set at > 0.2. For canary rockfish, the performances of the two configurations starts to converge at a *PE-C* > 0.4. For Dover sole, they converge with a *PE-C* = 0.14. This level of *PE-C* appears to be greater than implied in Table 9. The average value of *PE-C* across all species would have to be much larger than the generic value of 0.2 suggested by Francis *et al*. (2003).

Given our current understanding of the magnitude of *PE-C* for this survey and our cost analysis, it appears that the biennial configuration is more cost-effective than an annual approach.

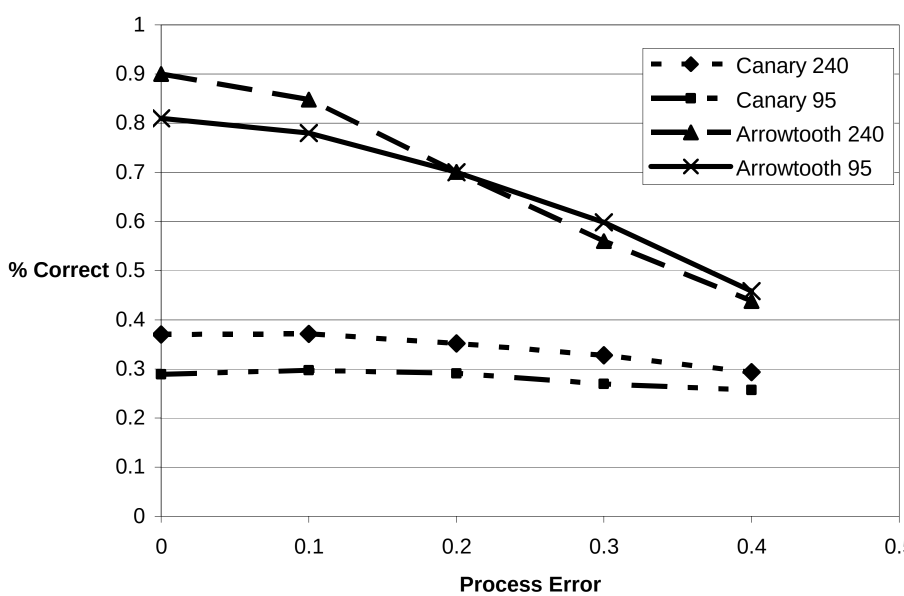


Figure 24. Comparison of performance between 95-tow annual and 240-tow biennial surveys with increasing process error. Performance is determined as the % of runs which indicate between a 1.5X and 3.0 increase given an actual population doubling over 10 years.

We also examined whether a triennial survey would be more cost-effective (Table 13 and Figure 25). In this case we ran the doubling scenario over 12 years. Unlike the change from annual to biennial however, there is little reduction in cost/tow with a triennial survey. The density is already optimal with 240 tows, thus we expect little or no gain from reduced travel time. Furthermore, cumulative fixed costs only decline by one third as opposed to one half when changing from annual to biennial. Therefore, for the same price, we assume a gain of only about 10 tows/survey in the triennial configuration.

Table 13. Comparison of performance between 240 tow biennial and 370 tow triennial surveys when abundance doubles over 12 years.

Species	$RE_{OE,s,Pooled}$	% Correct within 1.5 and 3.0 times	
		Biennial 240	Triennial 370
Dover sole	0.11	100	100
Arrowtooth flounder	0.18	90	93
Rougheye rockfish	0.31	68	74
Southern rock sole	0.39	55	61
Canary rockfish	0.51	45	49
Bocaccio	0.82	29	33

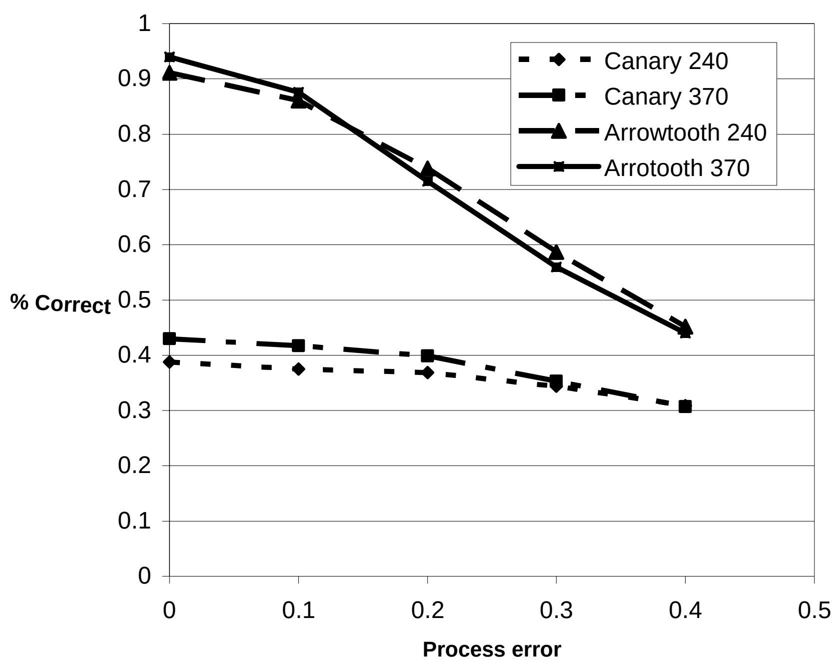


Figure 25. Comparison of performance between 240-tow biennial and 370-tow triennial surveys with increasing PE. Performance is determined as the % of runs which indicate between a 1.5X and 3.0 increase given an actual doubling over 10 years.

The triennial survey performs modestly better, but is significantly more sensitive to *PE-C* (Figure 25). While it requires a *PE-C* of about 0.14 for Dover sole to render the annual and biennial configurations equally cost-effective, a *PE-C* of 0.10 renders the biennial and triennial surveys equally cost-effective. Similarly the "break even" *PE-C* for arrowtooth flounder declines from just over 0.2 to about 0.15. These "break-even" values of *PE-C* are approaching the implied values of Table 9 and, averaged over all species, the generic value of 0.2 of Francis *et al.* (2003).

Although the survey performance appears to improve modestly with a triennial frequency, we recommend continuing with the biennial design. The triennial survey is more sensitive to *PE-C* which may be revealed to be larger than we currently estimate. A 3-year frequency would also seem inadequate for managing dynamic species such as Pacific cod. It also means that biological samples will only be obtained every three years.

ABUNDANCE TRENDS

With only three years of observations, limited use can be made of the survey results (Figure 26) although they have proved useful for inferring minimum biomass estimates for canary rockfish in a COSEWIC document (Stanley *et al.* 2005).

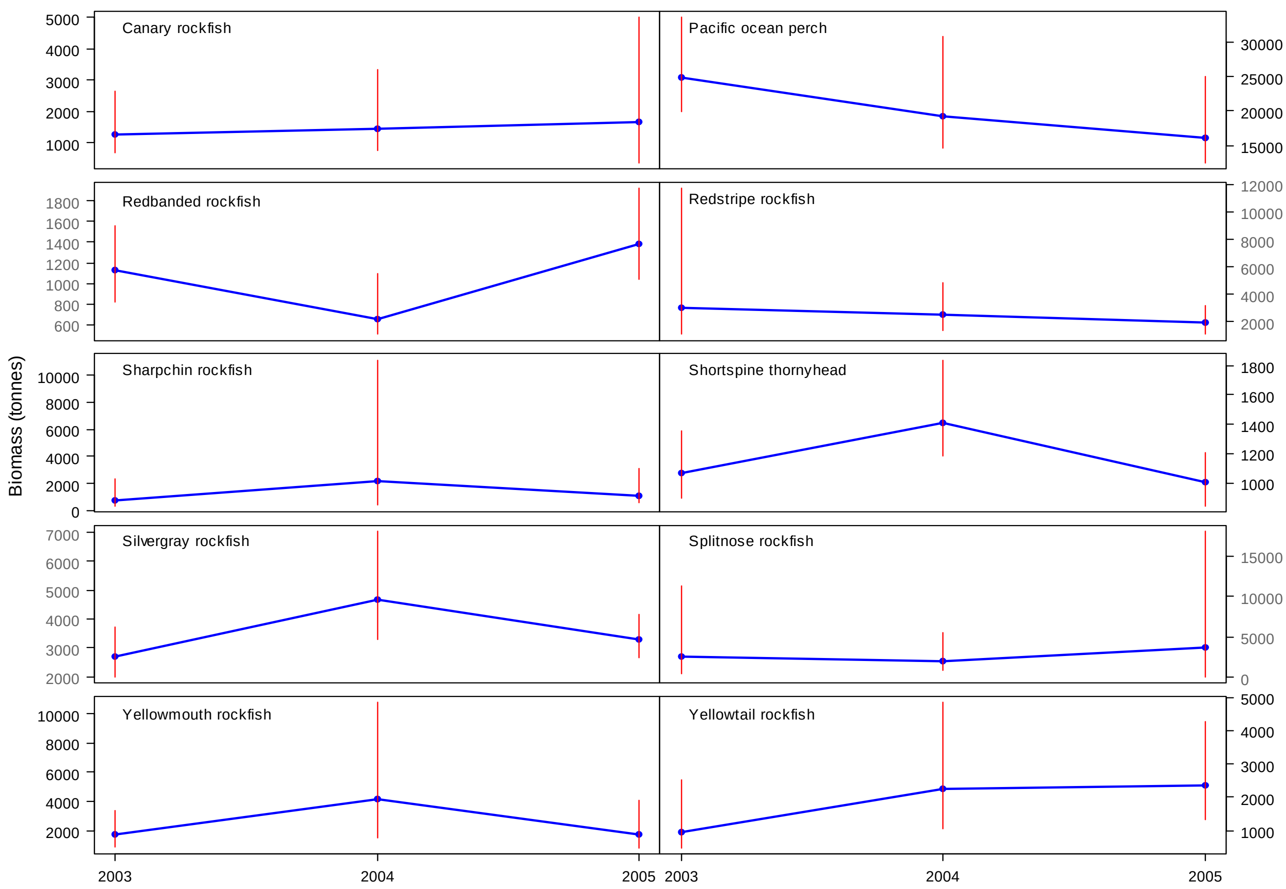


Figure 26. Estimated relative biomass from the 2003-2005 surveys of QCSd for selected rockfish species, 95% confidence limits are shown as red bars. Note: these values should be treated as **minimum** biomass estimates.

BIOLOGICAL SAMPLING

The sampling target was to collect L/S samples for each species in each tow but we took two shortcuts to reduce the workload. First, we did not sample unless there were a minimum number of pieces per species (Appendix 2). Second, we choose to sample only some of the tows for those species which were present in most of the tows. For example, since arrowtooth flounder are caught in 88% of the tows, we felt that sampling this species every third tow would yield a sufficient number of samples. Thus, our goal is to rationalize our sampling efforts in order to achieve adequate sample sizes for as many species as possible (Table 14).

To examine whether we were attaining our sampling protocol, we created a simulator that calculated from the catches in the survey how many samples we should have obtained if the protocol were followed perfectly (Table 15 to Table 17).

The simulator first converts species weights in each tow to numbers using a mean weight by species table. The catch in numbers for each species in each tow is then compared against the sampling protocol to predict the species whether the species would have been sampled in that tow, given perfect decision-making by the deck boss. The sum of these opportunities over all tows represents the predicted number of samples. The predicted piece count obtained from each of the predicted samples was determined as the number of pieces in the catch up to the maximum piece count per sample specified in the protocol.

The results indicate that the sampling protocol has been followed and that the number of samples obtained is meeting our expectations. We suggest that sampling effort does not have to be increased and the survey can forgo the additional 15K in cost for one more sampler, but we could not achieve the protocol with any fewer staff.

Table 14. Numbers of samples (n) and specimens (N) by sample type and species from the 2005 QCSd survey.

	LS		LSW		LSWA		Total	
Species	**n**	**N**	**n**	**N**	**n**	**N**	**n**	**N**
Alaska skate	0	0	3	3	0	0	3	3
Aleutian skate	0	0	3	3	0	0	3	3
Arrowtooth flounder	60	2,503	10	491	16	612	86	3,606
Big skate	2	25	10	33	0	0	12	58
Bigmouth sculpin	0	0	1	1	0	0	1	1
Black eelpout	3	69	0	0	0	0	3	69
Blackbelly eelpout	22	1,513	0	0	0	0	22	1,513
Blackfin sculpin	4	38	0	0	0	0	4	38
Bocaccio	0	0	0	0	19	68	19	68
Brown cat shark	1	2	0	0	0	0	1	2
Canary rockfish	12	162	2	10	2	101	16	273
China rockfish	0	0	0	0	1	2	1	2
Chum salmon	0	0	3	3	0	0	3	3
Curlfin sole	3	13	7	9	6	45	16	67
Darkblotched rockfish	3	34	6	9	0	0	9	43
Dover sole	51	1,382	11	437	7	275	69	2,094
English sole	29	1,011	6	300	11	536	46	1,847
Eulachon	11	627	0	0	0	0	11	627
Flathead sole	51	2,063	3	149	3	149	57	2,361
Greenstriped rockfish	16	191	3	28	9	176	28	395
Harlequin rockfish	0	0	1	14	0	0	1	14
Kelp greenling	2	9	3	8	0	0	5	17
Lingcod	10	29	47	54	6	68	63	151
Longnose skate	18	65	71	87	0	0	89	152
Longspine thornyhead	1	44	1	21	0	0	2	65
Pacific cod	1	13	125	1,186	0	0	126	1,199
Pacific hake	91	3,460	14	777	10	434	115	4,671
Pacific halibut	26	146	54	61	0	0	80	207
Pacific herring	3	39	0	0	0	0	3	39
Pacific ocean perch	54	2,347	7	267	30	1,458	91	4,072
Pacific sand lance	1	9	0	0	0	0	1	9
Pacific sanddab	17	824	1	82	2	100	20	1,006
Pacific sardine	1	31	0	0	0	0	1	31
Petrale sole	12	110	3	18	9	226	24	354
Pygmy rockfish	3	116	0	0	0	0	3	116
Quillback rockfish	4	18	4	4	7	142	15	164
Redbanded rockfish	30	286	36	126	51	654	118	1,067
Redstripe rockfish	30	1,038	3	174	8	424	41	1,636
Rex sole	69	3,117	15	912	8	442	92	4,471
Rosethorn rockfish	6	199	0	0	3	54	9	253
Roughback sculpin	2	10	0	0	0	0	2	10
Rougheye rockfish	31	386	16	88	10	328	57	802
Roughtail skate	0	0	1	1	0	0	1	1
Sablefish	22	280	4	23	13	288	39	592
Sandpaper skate	4	8	15	17	0	0	19	25
Sharpchin rockfish	26	939	5	293	3	157	34	1,389
Shortbelly rockfish	1	2	0	0	0	0	1	2
Shortraker rockfish	0	0	0	0	2	14	2	14
Shortspine thornyhead	47	1,798	20	972	8	430	75	3,200
Silvergray rockfish	49	911	13	324	10	352	72	1,587
Slender sole	34	673	0	0	0	0	34	673
Southern rock sole	11	204	4	39	11	517	26	760
Spiny dogfish	68	821	58	179	0	0	126	1,000
Splitnose rockfish	5	103	3	80	4	177	12	360
Spotted ratfish	41	1,068	3	165	0	0	44	1,233
Threadfin sculpin	1	91	0	0	0	0	1	91
Vermilion rockfish	0	0	0	0	2	2	2	2
Walleye pollock	62	1,499	11	320	0	0	73	1,819
Widow rockfish	7	115	1	50	1	58	9	223
Yelloweye rockfish	9	42	27	45	4	25	40	112
Yellowmouth rockfish	10	213	3	117	9	409	22	739
Yellowtail rockfish	18	379	4	169	6	275	28	823
Total	**1,095**	**31,075**	**641**	**8,149**	**291**	**8,998**	**2,028**	**48,224**

Table 15. Summary of actual LS samples in comparison with the number of samples we should have obtained based on the catches in the tows and the design of the sampling protocol.

	Actual		Predicted			Actual		Predicted	
Species	**n**	**N**	**n**	**N**	**Species**	**n**	**N**	**n**	**N**
Alaska skate	3	3	3	3	Pacific sanddab	20	1,006	19	709
Aleutian skate	3	3	3	3	Pacific sardine	1	31	2	44
Arrowtooth flounder	86	3,606	81	4,391	Pacific tomcod			1	7
Big skate	12	58	10	57	Pacific viperfish			1	5
Bigmouth sculpin	1	1			Petrale sole	24	354	22	314
Black eelpout	3	69			Puget sound rockfish			1	4
Blackbelly eelpout	22	1,513	23	1,046	Pygmy rockfish	3	116	6	100
Blackfin sculpin	4	38	6	51	Quillback rockfish	15	164	6	112
Bocaccio	19	68	19	65	Redbanded rockfish	117	1,067	67	1,020
Brown cat shark	1	2			Redstripe rockfish	41	1,636	39	1,746
Cabezon			1	1	Rex sole	92	4,471	62	3,299
California headlightfish			2	17	Rosethorn rockfish	9	253	8	183
Canary rockfish	16	273	16	252	Roughback sculpin	2	10	2	10
China rockfish	1	2	1	2	Rougheye rockfish	57	802	65	592
Chum salmon	3	3	4	4	Roughtail skate	1	1	1	1
Curlfin sole	16	67	11	46	Sablefish	39	592	22	377
Darkblotched rockfish	9	43	21	59	Sandpaper skate	19	25	19	25
Dover sole	69	2,094	59	1,902	Sharpchin rockfish	34	1,389	28	1,207
English sole	46	1,847	46	2,115	Shortbelly rockfish	1	2		
Eulachon	11	627	13	685	Shortraker rockfish	2	14	2	10
Flathead sole	57	2,361	64	2,770	Shortspine thornyhead	75	3,200	87	3,518
Greenstriped rockfish	28	395	28	402	Silvergray rockfish	72	1,587	73	1,668
Harlequin rockfish	1	14	1	8	Slender sole	34	673	35	751
Kelp greenling	5	17	6	19	Sockeye salmon			1	1
Lingcod	63	151	5	75	Southern rock sole	26	760	23	617
Longnose skate	89	152	90	154	Spiny dogfish	126	1,000	126	1,222
Longspine thornyhead	2	65	2	56	Splitnose rockfish	12	360	12	299
Northern lampfish			2	18	Spotted ratfish	44	1,233	20	758
Pacific cod	126	1,199	125	2,154	Threadfin sculpin	1	91	1	50
Pacific hagfish			2	2	Vermilion rockfish	2	2	2	2
Pacific hake	115	4,671	122	5,821	Walleye pollock	73	1,819	69	1,407
Pacific halibut	80	207	80	210	Widow rockfish	9	223	8	128
Pacific herring	3	39			Wolf eel			6	6
Pacific lamprey			2	2	Yelloweye rockfish	40	112	41	105
Pacific ocean perch	91	4,072	67	4,147	Yellowmouth rockfish	22	739	21	623
Pacific sand lance	1	9	1	6	Yellowtail rockfish	28	823	29	859
					Total	**2,027**	**48,224**	**1,843**	**48,322**

Table 16. Summary of actual LW samples actually obtained in comparison with the number of samples we should have obtained based on the catches in the tows and the design of the sampling protocol.

	Actual		Predicted	
Species	**n**	**N**	**n**	**N**
Alaska skate	2	3	2	3
Aleutian skate	3	3	3	3
Arrowtooth flounder	11	1,103	12	1,150
Big skate	3	33	3	58
Bocaccio	9	68	9	65
Canary rockfish	3	111	2	100
China rockfish	1	2	1	2
Chum salmon	3	3	0	0
Curlfin sole	5	54	4	46
Darkblotched rockfish	4	9	0	0
Dover sole	7	712	8	650
English sole	8	836	8	700
Flathead sole	4	298	8	650
Greenstriped rockfish	7	204	8	130
Harlequin rockfish	1	14	1	8
Kelp greenling	2	8	0	0
Lingcod	12	122	4	75
Longnose skate	16	87	16	154
Longspine thornyhead	1	21	0	0
Pacific cod	13	1,186	13	2,155
Pacific hake	11	1,211	15	1,100
Pacific halibut	14	61	0	0
Pacific ocean perch	12	1,725	13	1,550
Pacific sanddab	3	182	3	350
Petrale sole	7	244	10	314
Pygmy rockfish	0	0	5	100
Quillback rockfish	4	146	3	112
Redbanded rockfish	14	770	12	1,020
Redstripe rockfish	6	598	6	550
Rex sole	9	1,354	12	850
Rosethorn rockfish	3	54	0	0
Rougheye rockfish	10	416	2	200
Roughtail skate	1	1	1	1
Sablefish	11	312	3	150
Sandpaper skate	9	17	11	25
Sharpchin rockfish	6	450	5	400
Shortraker rockfish	2	14	2	10
Shortspine thornyhead	12	1,402	7	650
Silvergray rockfish	7	676	3	400
Slender sole	0	0	2	100
Southern rock sole	6	556	5	617
Spiny dogfish	11	179	2	100
Splitnose rockfish	5	257	3	150
Spotted ratfish	3	165	6	300
Vermilion rockfish	2	2	2	2
Walleye pollock	6	320	4	300
Widow rockfish	2	108	1	50
Yelloweye rockfish	9	70	9	105
Yellowmouth rockfish	7	526	5	300
Yellowtail rockfish	6	444	5	500
Total	**313**	**17,137**	**259**	**16,255**

Table 17. Summary of actual ageing samples obtained in comparison with the number of samples we should have obtained based on the catches in the tows and the design of the sampling protocol

	Actual		Predicted	
Species	**n**	**N**	**n**	**N**
Arrowtooth flounder	16	612	11	300
Bocaccio	19	68	19	65
Canary rockfish	2	101	2	100
China rockfish	1	2	1	2
Curlfin sole	6	45	11	46
Dover sole	7	275	6	300
English sole	11	536	6	300
Flathead sole	3	149	6	300
Greenstriped rockfish	9	176	1	50
Harlequin rockfish	0	0	1	8
Lingcod	6	68	5	75
Pacific hake	10	434	7	300
Pacific ocean perch	30	1,458	18	600
Pacific sanddab	2	100	6	300
Petrale sole	9	226	2	100
Pygmy rockfish	0	0	6	100
Quillback rockfish	7	142	6	112
Redbanded rockfish	51	654	67	300
Redstripe rockfish	8	424	6	300
Rex sole	8	442	6	300
Rosethorn rockfish	3	54	0	0
Rougheye rockfish	10	328	4	200
Sablefish	13	288	3	150
Sharpchin rockfish	3	157	6	300
Shortraker rockfish	2	14	2	10
Shortspine thornyhead	8	430	6	300
Silvergray rockfish	10	352	6	300
Slender sole	0	0	2	100
Southern rock sole	11	517	8	300
Splitnose rockfish	4	177	2	100
Vermilion rockfish	2	2	2	2
Walleye pollock	0	0	3	150
Widow rockfish	1	58	0	0
Yelloweye rockfish	4	25	41	105
Yellowmouth rockfish	9	409	4	200
Yellowtail rockfish	6	275	6	300
Total	**291**	**8,998**	**288**	**6,475**

RECOMMENDATIONS

1. The survey should be continued.
2. The survey should continue with a target of 240 tows and a biennial frequency. The next RFP will be jointly developed with CGRCS in the spring of 2007.
3. The current stratification is acceptable but should be re-examined prior to the 2009 survey given the declining cost/risk of shallow tows.
4. Previously rejected blocks should be permanently eliminated from the sampling frame.
5. Prior to the next survey, trawl skippers should be consulted to identify any additional blocks which are sure to be untrawlable. These should be permanently removed from the sampling frame.
6. A scientific crew of five is adequate to meet the biological sampling needs.
7. The survey simulator will be used to examine the power of the other groundfish indexing surveys. We will assume that a biennial frequency is optimal for the major bottom trawl surveys.
8. The tow densities of the other surveys will be tailored to meet the RE standards accepted for the GF-QCSd survey.
9. We will use the simulator to see if the West Coast Vancouver Island thornyhead survey can be merged into the biennial WCVI shelf survey on the CCGS W.E. Ricker.
10. The general operational procedures for the GF-QCSd survey, such as requiring only a single rejection to delete a block, should be adopted for the other major bottom trawl surveys.
11. The current sampling protocol is acceptable, notwithstanding minor modifications or re-prioritizing among sampled populations.

LITERATURE CITED

Efron, B. 1982. The jackknife, the bootstrap, and other resampling plans. Society for Industrial and Applied Mathematics, Philadelphia.

Francis, R.I., Hurst, R.J., and Renwick, J.A. 2003. Quantifying annual variability in catchability for commercial and research fishing. Fish. Bull. 101(2):293:304.

Pennington, M. 1985. Estimating the relative abundance of fish from a series of trawl surveys. Biometrics 41, 197-202.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 191. 382 p.

Schnute, J.T., and Haigh, R. 2003. A simulation model for designing groundfish trawl surveys. Can. J. Fish Aquat. Sci. 60: 640-656

Sinclair, A., Schnute, J., Haigh, R., Starr, P., Stanley, R.D., Fargo, J., and Workman, G. 2003. Feasibility of multispecies groundfish bottom trawl surveys on the BC coast. Can. Stock Assess. Sec. Res. Doc. 2003/049.

Stanley, R.D., Starr, P., Olsen, N., Haigh, R. 2004. Summary of results of the 2003 Queen Charlotte Sound Bottom trawl survey. Can. Sci. Adv. Sec. 2004/028.

Stanley, R.D., Starr, P., Olsen, N., Rutherford, K., and Wallace, S.S. 2005. Status report on canary rockfish (*Sebastes pinniger*). Can. Sci. Adv. Sec. 2005/089.

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APPENDIX 1. LIST OF CURRENT INDEXING SURVEYS[2]

GF-WCQCI-SH/SL-BT	Shelf/Slope species	Trawl Charter	DFO-GF	CGRCS	Comm. GFish BT	2	2006
GF-HS/DE-SH/SL-BT	Shelf/Slope species	W.E. Ricker	DFO-GF	CGRCS	Comm. GFish BT	2	2003
GF-QCSd-SH-BT	Shelf/Slope species	Trawl Charter	DFO-GF	CGRCS	Comm. GFish BT	2	2003
GF-WCVI-SH-BT	Shelf/Slope species	W.E. Ricker	DFO-GF	CGRCS	Comm. GFish BT	2	2004
GF-WCVI-SL-BT	Deep slope species	Trawl Charter	DFO-GF	CGRCS	Comm. GFish BT	?	2001
GF-NC-Inshore-LL	Inshore rockfish	LL Charter	DFO-GF	PHMA	Comm. Longline	2	2006
GF-SC-Inshore-LL	Inshore rockfish	LL Charter	DFO-GF	PHMA	Comm. Longline	2	2007
GF-Coast-Hake-AC/MW	Hake	W.E. Ricker	DFO-AT	NMFS-CGRCS	Acoust. and Comm. MWT	2	1989
GF-Coast-SH/SL-Trap	Sablefish	Trap Charter	DFO-GF	CSA	Comm. Korean Traps	1	1988
INV-WCVI/QCSd-SH-ST	Shrimp	W.E. Ricker	DFO-INV	none	Comm. Shrimp BT	1	1975
IPHC-Coast-SH-LL	Pacific halibut	LL Charter	IPHC	none	Comm. Longline	1	1995
GF-4BN-Inshore-LL	Inshore rockfish	Neocaligus	DFO-GF	none	Comm. Longline	3	2003
GF-4BS-Inshore-LL	Inshore rockfish	Neocaligus	DFO-GF	none	Comm. Longline	3	2005
GF-4BS-Inshore-HL	Lingcod	Neocaligus	DFO-GF	none	Handline	2	1985
GF-4BS-Shallow-BT	YOY Lingcod	Neocaligus	DFO-GF	none	Bottom trawl	3	2003
GF-4BS-SubTidal-Scuba	Lingcod nests	Launch	DFO-GF	none	Visual	1	2001
GF-4BS-Offshore-LL	Dogfish	LL Charter	DFO-GF	none	Comm. Longline	3	2004
GF-4BS-Hake-AC/MW	Hake/Pollock	W.E. Ricker	DFO-AT	none	Acoust. and Comm. MWT	?	1981

Acronyms

1. GF: DFO-Groundfish Section; INV: DFO-Invertebrates Section; AT: DFO-Applied Technology Section; IPHC: International Pacific Halibut Commission
2. WCQCI: West Coast Queen Charlotte Islands, HS/DE: Hecate Strait/Dixon Entrance; WCVI: West Coast Vancouver Islands, NC: Outside-North Coast; SC: Outside-South Coast; 4BN: Area 4B North (Johnstone Strait); 4BS: Area 4B South (Strait of Georgia).
3. SH: Continental Shelf; SL: Continental Slope
4. BT: Bottom trawl; LL: Longline; Acoust: Acoustics; MW: Midwater trawl; ST: Shrimp trawl; HL: Handline.
5. CGRCS: Canadian Groundfish Research and Conservation Society; NMFS: National Marine Fisheries Service (USA); PHMA: Pacific Halibut Management Association; CSA: Canadian Sablefish Association

[2] Note: "First year" indicates first year of relatively frequent series of surveys

APPENDIX 2. BIOLOGICAL SAMPLING PROTOCOL

Fishing and sampling follow the prioritization of:

1. do not let sampling get in the way of fishing and sorting the catches;
2. do not let otolith samples get in the way of L/S and L/S/W samples;
3. obtain at least two L/S/W samples per species/stratum for dominant species.

The objective of biological sampling during these surveys is to develop relative indices of species numbers (abundance), numbers at length, numbers by sex (when required), and numbers at age. These indices will complement the index of species biomass already described. We therefore collect length by sex data from all species caught in every tow, with two exceptions. First, the number of specimens caught must meet the minimum criterion for that species (Appendix 2: Table 1). Second, some species occur so frequently that we will collect a length/sex sample every second or third tow. In addition, one length/sex/weight (LSW) and one length/sex/weight/maturity/age (LSWMA) sample is collected per tow with the objectives of collecting two LSW samples per species per depth strata and 300 LSWMA specimens from each of the major commercial species. LSWMA samples are by default LSW samples in the overall scheme. For each set, the commercial species with the largest catch, if greater than 40 pieces, is sampled, to a target of 300 age structures per stock. In addition, the following species are sampled for age structures on every tow if minimum sample size requirement is met:

Species	Minimum Sample Size
Pacific cod	10
Rock sole	10
Petrale sole	10
Lingcod	10
Redbanded rockfish	5
Bocaccio	1
Copper rockfish	1
Darkblotched rockfish	1
Quillback rockfish	1
Shortraker rockfish	1
Yelloweye rockfish	1

Age structure sampling was based on random collections. There was no attempt to stratify by sex or size.

Appendix 2: Table 1. A partial list of the minimum specimen criteria and sampling frequency which sets a maximum of 60 L/S samples per survey per species.

Species	Occurrences in 2003	Sampling frequency per tow	Minimum number of specimens in catch
Arrowtooth flounder	213	3	10
Rex sole	201	3	10
Pacific ocean perch	181	2	10
Dover sole	172	2	10
Spotted ratfish	151	2	10
Sablefish	135	2	5
Redbanded rockfish	129	1	1
Silvergrey rockfish	127	1	5
Spiny dogfish	126	1	1
Shortspine thornyhead	106	1	1
Pacific cod	105	1	5
Slender sole	95	1	10
Walleye pollock	92	1	5
Pacific hake	87	1	10
Flathead sole	82	1	5
Longnose skate	81	1	1
Rougheye rockfish	78	1	1
English sole	75	1	5
Petrale sole	67	1	5
Lingcod	56	1	1
Greenstriped rockfish	51	1	5
Pacific halibut	47	1	5
Redstripe rockfish	47	1	10
Sharpchin rockfish	43	1	10
Eulachon	40	1	5
Yellowmouth rockfish	40	1	5
Canary rockfish	37	1	5
Rosethorn rockfish	36	1	5
Rock sole	35	1	1
Pacific sanddab	33	1	10
Yellowtail rockfish	32	1	5
Splitnose rockfish	28	1	5
Sandpaper skate	26	1	1
Darkblotched rockfish	25	1	1

APPENDIX 3. CALCULATION OF RELATIVE CATCH RATE AND RELATIVE ERROR

The area covered by each tow (swept area) was calculated as the mean doorspread (the distance between the trawl doors) multiplied by the distance that the vessel traveled during the tow. Doorspread measures were obtained electronically from sensors and were recorded throughout each tow at one second intervals. The distance traveled during each tow was determined by multiplying the mean vessel speed during the tow by the duration of the tow. The tow duration is defined as the interval between the net-on-bottom start time and the net-on-bottom end time, as determined by a bottom contact sensor.

The expanded swept area catch rates were obtained by summing the product of the CPUE and the area surveyed across the surveyed strata *i* for each species *s* as before (Appendix 1 of Stanley *et al.* 2004) for each year separately.

$$B_s = \sum_i C_{s_i} A_i = \sum_i B_{s_i} \qquad \text{Eq. 1}$$

where C_{s_i} = mean CPUE density (kg/km^2) for species *s* in stratum *i*

A_i = area of stratum *i* (km^2), and

B_{s_i} = estimated biomass of species *s* in stratum *i*.

The variance of the survey biomass estimate V_{B_s} for species *s* is calculated in kg^2 as follows:

$$V_{B_s} = \sum_i \sigma_{s_i}^2 A_i^2 / n_i \qquad \text{Eq. 2}$$

where $\sigma_{s_i}^2$ = variance of CPUE (kg^2/km^4) for species *s* in stratum *i*

n_i = number of tows in stratum *i*

CPUE $\left(C_{s_i}\right)$ was calculated as a density in kg/km^2 by

$$C_{s_i} = \frac{\sum_{j=1}^{n_i} \left(W_{s_i j} / D_{ij} w_{ij} \right)}{n_i} \qquad \text{Eq. 3}$$

where $W_{s_i j}$ = catch weight (kg) for species *s* in stratum *i* and tow *j*

D_{ij} = distance travelled (km; average speed multiplied by tow duration) by tow j in stratum I

w_{ij} = doorspread width (km) for tow j in stratum i

n_i = number of tows for stratum i

The relative error (RE) for each species s was calculated as follows:

$$RE_s = \frac{\sqrt{V_{B_s}}}{B_s} \qquad \text{Eq. 4}$$

One thousand bootstrap replicates with replacement were made on the survey data to estimate bias corrected 95% confidence regions for each survey species (Efron 1982). In the document we refer to this estimate of the variance at the RE based on observational error for population *s* and year *y* ($RE_{OE,s,y}$).

We also calculated a "Pooled" estimate ($RE_{OE,s,Pooled}$) using the first three years of the data. The calculation was as above, except we combined all three years of data as if it were one survey. The intent of this estimate of the variance is to implicitly incorporate the among year Process Error (*PE-C*) owing to changes in catchability over the three years to provide a more realistic estimate the precision of the survey, since this is underestimated by using only Observation Error. The weakness of this approach is that it also implicitly includes the Process Error (*PE-A*) owing to real changes in abundance, thus possibly overestimating the true survey variance.

APPENDIX 4. THE SURVEY SIMULATOR

The survey simulator is based on a simulation model developed by Schnute and Haigh (2003) to assist in the planning and design of groundfish surveys. We extend their model to simulate the trend in future abundance, provide options for specifying the variance of positive tows, and provide a convenient graphical front-end for controlling the simulation (Appendix 4: Figure 1).

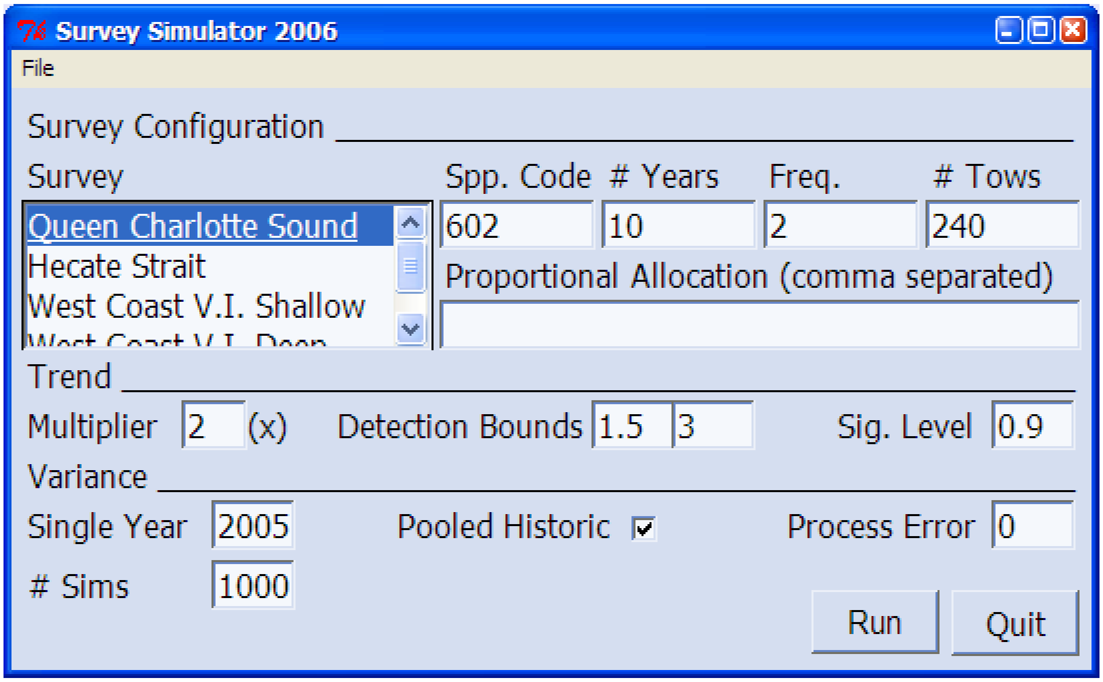

Figure 1. Graphical front-end for the simulator.

Annual stock growth is simulated using a compound annual growth rate given as:

$$\left[\frac{B_t}{B_{t_0}}\right]^{\frac{1}{t-t_0}} - 1$$

where B_{t_0} is the starting biomass and B_t is the biomass after *t* years.

We provide three options for specifying the variance of positive tows, which is used as a parameter for the gamma distribution (see Schnute and Haigh, 2003). These are:

1. Use the observed variance from a single year of the survey (2003 - 2005).
2. Use the observed variance from all three survey years pooled.
3. Use (1) or (2) above, plus a specified amount of additional process error.

In general terms, the catch for each stratum for a given species is estimated from the observed data in terms of the mean and variance of non-zero tows and the proportion of zero catches (μ , v , p). These parameters define a theoretical distribution of catches from each stratum of the survey. For the starting year, the simulator draws n=240 results, for example, (with specified allocation by stratum) from the theoretical distributions to generate one survey result for year 0. This is converted to one survey index point for year 0 as described above. This process is repeated 5,000 times to create an observed set of possible survey results for year 0. The same process is repeated for the subsequent survey (+2 years) after incrementing the population according to the specified growth rate. [Note: for this report, the population change was mediated by increasing the catch in non-zero tows; we did not vary the proportion of zero tows].

Option 2 above simply combines all 720 tows into the initial data set, prior to calculation of the variance parameters. For most species, it increased the estimates of variance owing to the addition of *PE* over the three surveys.

Option 3, is similar to Option 1 and uses the variance calculated from only one survey year. Process error is added by “jittering” (multiplying) each of the 5000 survey results by a random normal deviate with a mean of 0 and standard deviation specified in the simulator front end (Appendix 4: Figure 2). One simulated time period of surveys is simply the result of pulling one index value from each of the simulated survey years.

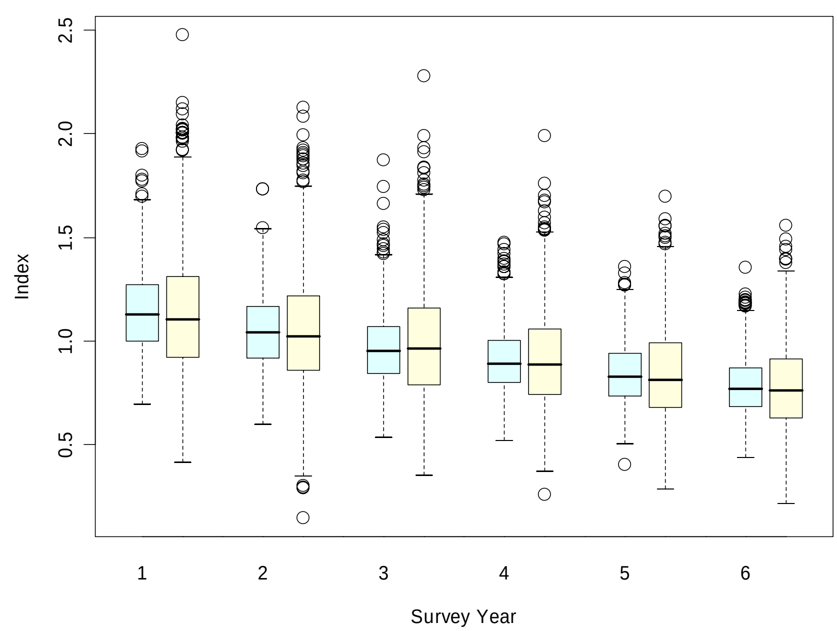

Figure 2. Comparison of simulated survey indices before (blue boxplots) and after (yellow boxplots) the addition of a user-specified process error. The upper and lower edge of each box define the first and third quartiles of the data, respectively, with the central bar representing the median. The "whiskers" extending from each box are drawn to the most extreme data point that lies within 1.5 times the inter-quartile range; any points outside this limit are shown as individual points and are considered as outliers.

APPENDIX 5. LIST OF RE'S FOR ALL FISH SPECIES IN THE GF-QCSD SURVEY[3].

Species	2003	2004	2005	Average	Pooled
Shortspine thornyhead	0.10	0.11	0.09	0.10	0.11
Rex sole	0.10	0.12	0.08	0.10	0.12
Dover sole	0.12	0.12	0.10	0.11	0.11
Pacific ocean perch (south)	0.17	0.12	0.15	0.15	0.17
Arrowtooth flounder	0.11	0.18	0.17	0.15	0.18
Longnose skate	0.21	0.14	0.11	0.15	0.14
Silvergray rockfish	0.15	0.19	0.12	0.15	0.19
Redbanded rockfish	0.16	0.18	0.16	0.17	0.18
Pacific ocean perch	0.13	0.20	0.17	0.17	0.16
Sablefish	0.12	0.23	0.15	0.17	0.16
Slender sole	0.27	0.16	0.13	0.19	0.16
Silvergray rockfish (north)	0.20	0.23	0.14	0.19	0.19
Walleye pollock	0.18	0.19	0.21	0.19	0.24
Pacific halibut	0.24	0.16	0.20	0.20	0.19
Pacific hake	0.14	0.32	0.14	0.20	0.27
English sole	0.24	0.21	0.19	0.21	0.23
Greenstriped rockfish	0.27	0.19	0.23	0.23	0.23
Lingcod	0.27	0.20	0.23	0.23	0.23
Pacific cod	0.16	0.26	0.33	0.25	0.31
Petrale sole	0.18	0.21	0.36	0.25	0.27
Rougheye rockfish	0.40	0.23	0.15	0.26	0.31
Pacific herring	0.28	0.32	0.19	0.26	0.35
Silvergray rockfish (south)	0.27	0.39	0.19	0.28	0.30
Flathead sole	0.19	0.47	0.21	0.29	0.42
Pacific ocean perch (north)	0.20	0.34	0.35	0.29	0.27
Southern rock sole	0.25	0.37	0.31	0.31	0.39
Pacific sanddab	0.28	0.30	0.38	0.32	0.35
Sandpaper skate	0.33	0.40	0.25	0.33	0.32
Blackfin sculpin	0.29	0.47	0.26	0.34	0.41
Rosethorn rockfish	0.25	0.32	0.45	0.34	0.33
Bigeye poacher			0.35	0.35	0.63
Curlfin sole	0.31	0.29	0.47	0.35	0.42
Bigfin eelpout	0.52	0.27	0.27	0.36	0.42
Yelloweye rockfish	0.38	0.47	0.22	0.36	0.43
Yellowtail rockfish	0.42	0.38	0.28	0.36	0.40
Blackbelly eelpout	0.36	0.37	0.37	0.37	0.41
Redstripe rockfish	0.56	0.32	0.26	0.38	0.43
Blacktip poacher			0.39	0.39	0.69
Yellowmouth rockfish	0.34	0.46	0.40	0.40	0.49
Canary rockfish	0.33	0.37	0.59	0.43	0.51
Canary rockfish (south)	0.44	0.56	0.31	0.44	0.48
Eulachon	0.37	0.67	0.29	0.44	1.00
Redstripe rockfish (north)	0.44	0.45	0.45	0.45	0.43
Yellowmouth rockfish (south)	0.42	0.55	0.42	0.47	0.54
Threadfin sculpin	0.37	0.32	0.71	0.47	0.74
Redstripe rockfish (south)	0.79	0.35	0.28	0.48	0.72
Wattled eelpout	0.58	0.51	0.35	0.48	0.74
Pink salmon	0.49			0.49	0.83
Shortraker rockfish	0.39	0.34	0.77	0.50	0.45
Darkblotched rockfish	0.51	0.39	0.62	0.51	0.48
Big skate	0.73	0.29	0.52	0.51	0.52
Pygmy rockfish	0.83	0.37	0.34	0.51	0.68
Canary rockfish (north)	0.45	0.46	0.66	0.52	0.53
Spotted ratfish	0.74	0.24	0.61	0.53	0.64
Quillback rockfish	0.62	0.51	0.47	0.53	0.54
Spiny dogfish	0.40	0.72	0.48	0.53	0.81
Widow rockfish	0.56	0.59	0.46	0.54	0.66
Wolf eel	0.71	0.53	0.39	0.54	0.50
Aleutian skate		0.51	0.58	0.55	0.64

Species	2003	2004	2005	Average	Pooled
Chum salmon	0.73	0.41	0.54	0.56	0.67
Sharpchin rockfish	0.48	0.78	0.44	0.57	0.74
Black eelpout	0.85	0.62	0.23	0.57	0.62
Bigmouth sculpin	0.57	0.60	0.57	0.58	0.63
Longspine thornyhead		0.48	0.69	0.58	0.78
Brown rockfish	0.62			0.62	1.02
Northern lampfish	0.68		0.61	0.64	1.03
Aurora rockfish	0.96	0.34		0.65	0.78
Bocaccio	0.59	0.71	0.65	0.65	0.82
Butter sole	0.65			0.65	1.22
Roughback sculpin		0.73	0.60	0.67	0.85
California headlightfish			0.68	0.68	1.27
Kelp greenling	0.88	0.71	0.45	0.68	0.78
Vermilion rockfish			0.69	0.69	1.17
Pacific lamprey			0.70	0.70	1.21
Sturgeon poacher	0.70			0.70	1.19
Splitnose rockfish	0.74	0.47	0.91	0.71	0.85
Shortbelly rockfish	0.67	0.90	0.58	0.72	1.29
Pacific sardine			0.72	0.72	1.40
Roughtail skate	0.52		0.93	0.72	0.84
Yellowmouth rockfish (north)	0.56	0.92	0.70	0.73	0.84
Northern ronquil			0.76	0.76	1.51
Alaska skate		1.02	0.57	0.79	0.93
Pacific sand lance	0.82	0.66	0.94	0.80	1.09
Pacific tomcod	0.67	0.80	0.94	0.80	1.43
Whitespotted greenling		0.81		0.81	1.61
Shortfin eelpout	0.69	0.95		0.82	1.07
Harlequin rockfish	0.80	0.99	0.71	0.83	1.97
Pacific hagfish		1.01	0.67	0.84	1.04
Spotfin sculpin	0.79		0.90	0.85	1.14
American shad		0.85		0.85	1.36
Bluespotted poacher		1.02	0.70	0.86	1.00
Longfin dragonfish			0.87	0.87	1.71
Blacktail snailfish	0.99	0.79		0.89	1.28
Blackfin poacher	0.92			0.92	1.70
Prowfish		0.87	1.00	0.94	1.19
Ribbon barracudina	0.95			0.95	1.61
Brown cat shark		0.95	0.94	0.95	1.26
Northern clingfish		0.95		0.95	1.81
China rockfish			0.95	0.95	1.69
Spinyhead sculpin		0.96		0.96	1.74
Pearly prickleback	0.94		0.98	0.96	1.18
Pallid slipskin			0.98	0.98	1.89
Smootheye poacher		0.98		0.98	1.73
Slim sculpin	0.98			0.98	1.69
Chilipepper	0.98			0.98	1.68
Black rockfish	0.99	0.98		0.98	1.36
Sockeye salmon			0.99	0.99	1.67
Stripetail rockfish		0.99		0.99	1.60
Chub mackerel	0.95	1.04		1.00	1.67
Sand sole		1.00		1.00	1.65
Pacific viperfish			1.00	1.00	1.84
Chinook salmon		1.00		1.00	1.78
Brown irish lord	1.00			1.00	1.69
Dusky rockfish	1.04		0.98	1.01	1.21
Pygmy poacher	1.01			1.01	1.73
Jack mackerel	1.03	1.02		1.02	1.49
Blackgill rockfish	1.04		1.01	1.03	1.23
Puget sound rockfish			1.05	1.05	1.75
Cabezon			1.06	1.06	1.70

[3] Relative errors are colour coded corresponding to qualitative classes of accuracy shown above.

APPENDIX 6. RE'S FOR ALL SPECIES CAPTURED IN ALL GROUNDFISH SURVEYS

Table 1. RE's by species/population and survey (see Table for survey acronyms)

Species	Stock	QCSBT	QCSBTN	QCSBTS	WCVIBT	HSBT	WCQCIBT	WCVISH	QCSSH	WCVITH	IPHCLL	IPHCVN	IPHCGJ	IPHCCH	JSLL	LCYOY	PHMALL
Abyssal skate	Coastwide						0.70			0.31							
Alaska skate	Coastwide	0.79					1.00				0.99						
Aleutian skate	Coastwide	0.55					0.69										
American shad	Coastwide	0.85			0.53			0.33	0.57								
Arrowtooth flounder	Area 3CD				0.20			0.32		0.49		0.30					
Arrowtooth flounder	Area 5A to 5E	0.15				0.23	0.21		0.39								
Arrowtooth flounder	Coastwide	0.15			0.20	0.23	0.21	0.32	0.39	0.49	0.12				0.84		
Aurora rockfish	Coastwide	0.65			0.61		0.57			0.56							
Big skate	Coastwide	0.51			0.38	0.34	0.99	0.98	0.55		0.21				0.52	0.73	
Bigeye poacher	Coastwide	0.35			1.01		0.57		0.46	0.86							
Bigeye thresher	Coastwide										0.69						
Bigfin eelpout	Coastwide	0.36			0.34	0.39	0.44		0.95	0.50							
Bigmouth sculpin	Coastwide	0.58							0.86								
Black eelpout	Coastwide	0.57			0.51	0.56	0.48			0.16							
Black hagfish	Coastwide				0.92												
Black rockfish	Coastwide	0.98			0.99										0.98		
Blackbelly eelpout	Coastwide	0.37			0.31	0.34	0.59	0.33	0.45							0.33	
Blackfin poacher	Coastwide	0.92					1.03			0.65							
Blackfin sculpin	Coastwide	0.34			1.04		0.30		0.63						0.96		
Blackgill rockfish	Coastwide	1.03					0.75										
Blacktail snailfish	Coastwide	0.89			0.90	0.90	0.73			0.41							
Blacktip poacher	Coastwide	0.39						0.51	0.38								
Blue rockfish	Coastwide														1.03		
Blue shark	Coastwide										0.25						
Bluespotted poacher	Coastwide	0.86						1.00									
Bocaccio	Coastwide	0.65			0.65	0.67	0.36	0.74	0.74		0.34						
Brown cat shark	Coastwide	0.95			0.56	0.45	0.65			0.20							
Brown irish lord	Coastwide	1.00													0.70		
Brown rockfish	Coastwide	0.62															
Buffalo sculpin	Coastwide															0.83	
Butter sole	Coastwide	0.65			0.99						0.99					0.52	
C-o sole	Coastwide															0.35	
Cabezon	Coastwide	1.06					1.01								0.69	0.69	
California headlightfish	Coastwide	0.68															
Canary rockfish	Area 3CD				0.42			0.46				0.55					

Species	Stock	QCSBT	QCSBTN	QCSBTS	WCVIBT	HSBT	WCQCIBT	WCVISH	QCSSH	WCVITH	IPHCLL	IPHCVN	IPHCGJ	IPHCCH	JSLL	LCYOY	PHMALL
Canary rockfish	Area 5AB	0.43							0.51				0.46				
Canary rockfish	Area 5CD					0.30								0.59			
Canary rockfish	Coastwide	0.43			0.42	0.30	0.52	0.46	0.51		0.35				0.47		
Chilipepper	Coastwide	0.98															
China rockfish	Coastwide	0.95			0.69						0.75				0.75		
Chinook salmon	Coastwide	1.00			0.63	0.57		0.71									
Chub mackerel	Coastwide	1.00															
Chum salmon	Coastwide	0.56			0.95		0.35										
Coho salmon	Coastwide										1.00						
Copper rockfish	Area 3C to 5E				1.00	0.95					0.65						
Copper rockfish	Area 4B															0.77	
Copper rockfish	Coastwide				1.00	0.95					0.65				0.62	0.77	
Crested bigscale	Coastwide						0.89			0.43							
Curlfin sole	Coastwide	0.35			0.34	0.35										0.75	
Darkblotched rockfish	Coastwide	0.51			0.43	0.57	0.78	0.53	0.33								
Deepsea sole	Coastwide				1.02		0.26			0.18							
Dover sole	Area 3CD				0.12			0.20		0.13		0.97					
Dover sole	Area 5AB	0.11							0.20				0.75				
Dover sole	Area 5C to 5E					0.14	0.11										
Dover sole	Coastwide	0.11			0.12	0.14	0.11	0.20	0.20	0.13	0.63					0.52	
Dusky rockfish	Coastwide	1.01					0.94										
Dwarf wrymouth	Coastwide							1.01	0.55							1.01	
English sole	Area 3CD				0.20			0.38									
English sole	Area 4B															0.20	
English sole	Area 5AB	0.21							0.36								
English sole	Area 5CD					0.26											
English sole	Coastwide	0.21			0.20	0.26	0.44	0.38	0.36							0.20	
Eulachon	Coastwide	0.44			0.65	0.93		0.25	0.25								
Flathead sole	Coastwide	0.29			0.33	0.36		0.29	0.18		1.01					0.38	
Giant blobsculpin	Coastwide									0.59							
Giant grenadier	Coastwide				0.64		0.12			0.10							
Giant wrymouth	Coastwide								1.02		0.67						
Graveldiver	Coastwide									0.72							
Great sculpin	Coastwide														0.98	0.46	
Green sturgeon	Coastwide				0.99												

Species	Stock	QCSBT	QCSBTN	QCSBTS	WCVIBT	HSBT	WCQCIBT	WCVISH	QCSSH	WCVITH	IPHCLL	IPHCVN	IPHCGJ	IPHCCH	JSLL	LCYOY	PHMALL
Greenstriped rockfish	Coastwide	0.23			0.27	0.32	0.46	0.42	0.90		0.56				0.25	0.63	
Harlequin rockfish	Coastwide	0.83			1.01		0.25		0.97						1.04		
Jack mackerel	Coastwide	1.02															
Kelp greenling	Coastwide	0.68			0.57	0.64									0.65	0.51	
Lingcod	Area 3CD				0.31			0.79				0.37					
Lingcod	Area 4B															0.26	
Lingcod	Area 5AB	0.23							0.34				0.23				
Lingcod	Area 5CD					0.49								0.30			
Lingcod	Coastwide	0.23			0.31	0.49	0.24	0.79	0.34		0.16				0.24	0.26	
Longfin dragonfish	Coastwide	0.87					0.65			0.26							
Longnose skate	Coastwide	0.15			0.14	0.16	0.19	0.27	0.22	0.29	0.08				0.24	0.68	
Longsnout prickleback	Coastwide								0.73								
Longspine thornyhead	Area 3CD				0.49					0.08							
Longspine thornyhead	Area 5E						0.15										
Longspine thornyhead	Coastwide	0.58			0.49		0.15			0.08							
Manacled sculpin	Coastwide									0.72							
Northern clingfish	Coastwide	0.95															
Northern lampfish	Coastwide	0.64					0.39			0.23							
Northern ronquil	Coastwide	0.76			0.74	0.97		0.98	0.97								
Pacific cod	Area 3CD				0.22			0.38		0.63		0.43					
Pacific cod	Area 4B															0.37	
Pacific cod	Area 5AB	0.25							0.44				0.23				
Pacific cod	Area 5CD					0.19								0.25			
Pacific cod	Coastwide	0.25			0.22	0.19	0.24	0.38	0.44	0.63	0.18				0.37	0.37	
Pacific flatnose	Coastwide				0.55		0.17			0.10							
Pacific grenadier	Coastwide				0.95		0.38			0.11	1.01						
Pacific hagfish	Coastwide	0.84							0.96	0.44	0.96						
Pacific hake	Area 3C to 5E	0.20			0.25	0.31	0.22	0.46	0.46	0.42	0.46						
Pacific hake	Area 4B															0.70	
Pacific hake	Coastwide	0.20			0.25	0.31	0.22	0.46	0.46	0.42	0.46					0.70	
Pacific halibut	Coastwide	0.20			0.28	0.35	0.20	0.22	0.38		0.06				0.33		
Pacific herring	Coastwide	0.26			0.35	0.32		0.46	0.30							0.42	
Pacific lamprey	Coastwide	0.70						1.00									
Pacific ocean perch	Area 3CD				0.25			0.53		0.84							
Pacific ocean perch	Area 5AB			0.15					0.39								

Species	Stock	QCSBT	QCSBTN	QCSBTS	WCVIBT	HSBT	WCQCIBT	WCVISH	QCSSH	WCVITH	IPHCLL	IPHCVN	IPHCGJ	IPHCCH	JSLL	LCYOY	PHMALL
Pacific ocean perch	Area 5CD		0.29														
Pacific ocean perch	Area 5E						0.24										
Pacific ocean perch	Coastwide	0.17			0.25	0.34	0.24	0.53	0.39	0.84							
Pacific sand lance	Coastwide	0.80			0.78	1.00											
Pacific sanddab	Coastwide	0.32			0.22	0.25	0.92	0.40	0.80		0.89				0.53	0.32	
Pacific sardine	Coastwide	0.72			0.56			0.54									
Pacific sleeper shark	Coastwide						0.93			0.72	0.45						
Pacific staghorn sculpin	Coastwide										0.98				0.69	0.49	
Pacific tomcod	Coastwide	0.80			0.44	0.45		0.89	0.98							0.41	
Pacific viperfish	Coastwide	1.00			0.99		0.46			0.13							
Pearly prickleback	Coastwide	0.96					0.64										
Petrale sole	Area 3CD				0.23			0.31				0.63					
Petrale sole	Area 5AB	0.25							0.42				0.57				
Petrale sole	Area 5C to 5E					0.30	0.17										
Petrale sole	Coastwide	0.25			0.23	0.30	0.17	0.31	0.42		0.35						
Pile perch	Coastwide				0.89												
Pink salmon	Coastwide	0.49															
Pinpoint lampfish	Coastwide				0.96		0.41			0.64							
Prowfish	Coastwide	0.94					0.75										
Puget sound rockfish	Coastwide	1.05			0.70	0.70										0.98	
Pygmy poacher	Coastwide	1.01															
Pygmy rockfish	Coastwide	0.51			0.56	0.59	0.81	0.97	0.94								
Quillback rockfish	Area 3C to 5E	0.53			0.50	0.48					0.28						0.10
Quillback rockfish	Coastwide	0.53			0.50	0.48					0.28				0.14	0.72	0.10
Quillback rockfish	Minor 12 and 13														0.14		
Ragfish	Coastwide									0.90							
Red irish lord	Coastwide														0.72		
Redbanded rockfish	Coastwide	0.17			0.25	0.33	0.19	0.86	0.37	0.79	0.16						
Redstripe rockfish	Area 3CD				0.55			0.60									
Redstripe rockfish	Area 5AB	0.38							0.66				0.98				
Redstripe rockfish	Area 5CD					0.54											
Redstripe rockfish	Area 5E						0.37										
Redstripe rockfish	Coastwide	0.38			0.55	0.54	0.37	0.60	0.66		1.00				0.77		
Rex sole	Coastwide	0.10			0.12	0.11	0.15	0.16	0.20	0.51						0.45	
Ribbon barracudina	Coastwide	0.95															

Species	Stock	QCSBT	QCSBTN	QCSBTS	WCVIBT	HSBT	WCQCIBT	WCVISH	QCSSH	WCVITH	IPHCLL	IPHCVN	IPHCGJ	IPHCCH	JSLL	LCYOY	PHMALL
Rockweed gunnel	Coastwide									0.86							
Rosethorn rockfish	Coastwide	0.34			0.42		0.21		0.97		0.51				0.99		
Roughback sculpin	Coastwide	0.67														0.30	
Rougheye rockfish	Coastwide	0.26			0.40	0.45	0.24	0.61	0.31	0.34	0.37						
Roughtail skate	Coastwide	0.72					0.30			0.19							
Sablefish	Area 3CD				0.22			0.38		0.12		0.24					
Sablefish	Area 5A to 5E	0.17				0.29	0.40		0.20								
Sablefish	Coastwide	0.17			0.22	0.29	0.40	0.38	0.20	0.12	0.11				0.50		
Sailfin sculpin	Coastwide							0.99								1.00	
Salmon shark	Coastwide										0.86						
Sand sole	Coastwide	1.00			0.59	0.58		0.97								0.38	
Sandpaper skate	Coastwide	0.33			0.31	0.38	0.34	0.37	0.28	0.39	0.37				0.69		
Sharpchin rockfish	Coastwide	0.57			0.34	0.32	0.25	0.56	0.60						1.00		
Shiner perch	Coastwide				0.66	0.63		0.97	0.87							0.26	
Shortbelly rockfish	Coastwide	0.72			0.73			0.98									
Shortfin eelpout	Coastwide	0.82							0.11								
Shortraker rockfish	Coastwide	0.50			0.42	0.39	0.49			0.36	0.52						
Shortspine thornyhead	Area 3CD				0.18			0.99		0.09		0.81					
Shortspine thornyhead	Area 5E						0.08										
Shortspine thornyhead	Coastwide	0.10			0.18	0.18	0.08	0.99	0.35	0.09	0.27						
Silvergray rockfish	Area 3CD				0.31			0.56				0.48					
Silvergray rockfish	Area 5AB			0.28					0.39				0.36				
Silvergray rockfish	Area 5CD		0.19											0.47			
Silvergray rockfish	Area 5E						0.54										
Silvergray rockfish	Coastwide	0.15			0.31	0.37	0.54	0.56	0.39		0.32				1.01		
Sixgill shark	Coastwide										0.85						
Slender barracudina	Coastwide									0.52							
Slender blacksmelt	Coastwide									0.57							
Slender codling	Coastwide						0.96			0.84							
Slender sole	Coastwide	0.19			0.28	0.17	0.22	0.14	0.14	0.89					0.98	0.52	
Slim sculpin	Coastwide	0.98					0.97									1.01	
Smootheye poacher	Coastwide	0.98			0.98		1.01										
Snake prickleback	Coastwide				0.98	1.01										0.45	
Sockeye salmon	Coastwide	0.99															
Soupfin shark	Coastwide										0.51						

Species	Stock	QCSBT	QCSBTN	QCSBTS	WCVIBT	HSBT	WCQCIBT	WCVISH	QCSSH	WCVITH	IPHCLL	IPHCVN	IPHCGJ	IPHCCH	JSLL	LCYOY	PHMALL
Southern rock sole	Area 3CD				0.24			0.99				1.00					
Southern rock sole	Area 5AB	0.31							0.71				0.85				
Southern rock sole	Area 5CD					0.24								0.98			
Southern rock sole	Coastwide	0.31			0.24	0.24	0.97	0.99	0.71		0.69				0.97	0.16	
Spiny dogfish	Area 3C to 5E	0.53			0.42	0.38	0.24	0.26	0.59		0.09						
Spiny dogfish	Area 4B															0.17	
Spiny dogfish	Coastwide	0.53			0.42	0.38	0.24	0.26	0.59		0.09				0.10	0.17	
Spinyhead sculpin	Coastwide	0.96														0.97	
Splitnose rockfish	Coastwide	0.71			0.45	0.60	0.61	0.62	0.60	0.73							
Spotfin sculpin	Coastwide	0.85															
Spotted ratfish	Coastwide	0.53			0.21	0.26	0.21	0.29	0.11	0.87	0.24				0.16	0.51	
Starry flounder	Coastwide				0.95	0.99										0.26	
Stout blacksmelt	Coastwide						0.61			0.90							
Stripetail rockfish	Coastwide	0.99			0.68												
Sturgeon poacher	Coastwide	0.70			1.00	0.96		0.79								0.57	
Thornback sculpin	Coastwide							0.67	0.86								
Threadfin grenadier	Coastwide						0.96			0.22							
Threadfin sculpin	Coastwide	0.47			0.34	0.37		0.60	0.95							0.53	
Threadfin slickhead	Coastwide									0.85							
Tiger rockfish	Coastwide														0.80		
Twoline eelpout	Coastwide				0.96		0.45			0.19							
Vermilion rockfish	Coastwide	0.69															
Walleye pollock	Area 4B															0.53	
Walleye pollock	Area 5AB + 12	0.19															
Walleye pollock	Area 5C to 5E					0.70	0.21										
Walleye pollock	Coastwide	0.19			0.59	0.70	0.21	0.36	0.34		0.69					0.53	
Wattled eelpout	Coastwide	0.48					1.05		0.32								
Whitebait smelt	Coastwide				0.81			0.68									
Whitebarred prickleback	Coastwide							0.81	0.81								
Whitespotted greenling	Coastwide	0.81														0.31	
Widow rockfish	Coastwide	0.54			0.84	0.96	0.80	0.97	0.80						0.97		
Wolf eel	Coastwide	0.54			0.55	0.56			0.94		0.71						
Yelloweye rockfish	Area 3C to 5E	0.36			0.34	0.43		1.02	0.66		0.19						0.10
Yelloweye rockfish	Area 4B															0.85	
Yelloweye rockfish	Coastwide	0.36			0.34	0.43		1.02	0.66		0.19				0.21	0.85	
Yellowmouth rockfish	Area 3CD				0.55												
Yellowmouth rockfish	Area 5AB	0.40							0.62				0.66				
Yellowmouth rockfish	Area 5CD													0.76			
Yellowmouth rockfish	Area 5E						0.41										
Yellowmouth rockfish	Coastwide	0.40			0.55		0.41		0.62		0.63						
Yellowtail rockfish	Area 3C to 5E	0.36			0.48	0.23	0.61	0.36	0.40		0.66						

Table 2. List of Survey acronyms used in Appendix 1. Table 1

Survey Name	Surveys (survey number from Appendix 1)
QCSBT	Queen Charlotte Sound bottom trawl survey (3)
QCSBTN	Queen Charlotte Sound bottom trawl survey (3) - north stratum
QCSBTS	Queen Charlotte Sound bottom trawl survey (3) - south stratum
WCVIBT	West coast Vancouver Island bottom trawl survey (4)
HSBT	Hecate Strait bottom trawl survey(2)
WCQCIBT	West coast Queen Charlotte Islands bottom trawl survey (1)
WCVISH	West coast Vancouver Island shrimp bottom trawl survey (10)
QCSSH	Queen Charlotte Sound shrimp bottom trawl survey (10)
WCVITH	West coast Vancouver Island thornyhead bottom trawl survey (5)
IPHCLL	IPHC longline survey (11)
JSLL	Johnstone Strait longline survey (12-13)
LCYOY	Strait of Georgia lingcod young-of-year bottom trawl survey (15)
PHMALL	PHMA near-shore longline survey (6 and 7)
IPHCVN	IPHC longline survey - Vancouver Island station (11)
IPHCGJ	IPHC longline survey - Goose Island and Cape St. James stations (11)
IPHCCH	IPHC longline survey – Queen Charlotte Islands Stations (11)

Table 3. Ranked list of all available groundfish survey RE's for each species/population.

Species	**Stock**									
Abyssal skate	Coastwide	0.31	0.70							
Alaska skate	Coastwide	0.79	0.99	1.00						
Aleutian skate	Coastwide	0.55	0.69							
American shad	Coastwide	0.33	0.53	0.57	0.85					
Arrowtooth flounder	Area 3CD	0.20	0.30	0.32	0.49					
Arrowtooth flounder	Area 5A to 5E	0.15	0.21	0.23	0.39					
Arrowtooth flounder	Coastwide	0.12	0.15	0.20	0.21	0.23	0.32	0.39	0.49	0.84
Aurora rockfish	Coastwide	0.56	0.57	0.61	0.65					
Big skate	Coastwide	0.21	0.34	0.38	0.51	0.52	0.55	0.73	0.98	0.99
Bigeye poacher	Coastwide	0.35	0.46	0.57	0.86	1.01				
Bigeye thresher	Coastwide	0.69								
Bigfin eelpout	Coastwide	0.34	0.36	0.39	0.44	0.50	0.95			
Bigmouth sculpin	Coastwide	0.58	0.86							
Black eelpout	Coastwide	0.16	0.48	0.51	0.56	0.57				
Black hagfish	Coastwide	0.92								
Black rockfish	Coastwide	0.98	0.98	0.99						
Blackbelly eelpout	Coastwide	0.31	0.33	0.33	0.34	0.37	0.45	0.59		
Blackfin poacher	Coastwide	0.65	0.92	1.03						
Blackfin sculpin	Coastwide	0.30	0.34	0.63	0.96	1.04				
Blackgill rockfish	Coastwide	0.75	1.03							
Blacktail snailfish	Coastwide	0.41	0.73	0.89	0.90	0.90				
Blacktip poacher	Coastwide	0.38	0.39	0.51						
Blue rockfish	Coastwide	1.03								

Species	Stock									
Blue shark	Coastwide	0.25								
Bluespotted poacher	Coastwide	0.86	1.00							
Bocaccio	Coastwide	0.34	0.36	0.65	0.65	0.67	0.74	0.74		
Brown cat shark	Coastwide	0.20	0.45	0.56	0.65	0.95				
Brown irish lord	Coastwide	0.70	1.00							
Brown rockfish	Coastwide	0.62								
Buffalo sculpin	Coastwide	0.83								
Butter sole	Coastwide	0.52	0.65	0.99	0.99					
C-o sole	Coastwide	0.35								
Cabezon	Coastwide	0.69	0.69	1.01	1.06					
California headlightfish	Coastwide	0.68								
Canary rockfish	Area 3CD	0.42	0.46	0.55						
Canary rockfish	Area 5AB	0.43	0.46	0.51						
Canary rockfish	Area 5CD	0.30	0.59							
Canary rockfish	Coastwide	0.30	0.35	0.42	0.43	0.46	0.47	0.51	0.52	
Chili pepper	Coastwide	0.98								
China rockfish	Coastwide	0.69	0.75	0.75	0.95					
Chinook salmon	Coastwide	0.57	0.63	0.71	1.00					
Chub mackerel	Coastwide	1.00								
Chum salmon	Coastwide	0.35	0.56	0.95						
Coho salmon	Coastwide	1.00								
Copper rockfish	Area 3C to 5E	0.65	0.95	1.00						
Copper rockfish	Area 4B	0.77								
Copper rockfish	Coastwide	0.62	0.65	0.77	0.95	1.00				
Crested bigscale	Coastwide	0.43	0.89							
Curlfin sole	Coastwide	0.34	0.35	0.35	0.75					
Darkblotched rockfish	Coastwide	0.33	0.43	0.51	0.53	0.57	0.78			
Deepsea sole	Coastwide	0.18	0.26	1.02						
Dover sole	Area 3CD	0.12	0.13	0.20	0.97					
Dover sole	Area 5AB	0.11	0.20	0.75						
Dover sole	Area 5C to 5E	0.11	0.14							
Dover sole	Coastwide	0.11	0.11	0.12	0.13	0.14	0.20	0.20	0.52	0.63
Dusky rockfish	Coastwide	0.94	1.01							
Dwarf wrymouth	Coastwide	0.55	1.01	1.01						
English sole	Area 3CD	0.20	0.38							
English sole	Area 4B	0.20								
English sole	Area 5AB	0.21	0.36							
English sole	Area 5CD	0.26								
English sole	Coastwide	0.20	0.20	0.21	0.26	0.36	0.38	0.44		
Eulachon	Coastwide	0.25	0.25	0.44	0.65	0.93				
Flathead sole	Coastwide	0.18	0.29	0.29	0.33	0.36	0.38	1.01		
Giant blobsculpin	Coastwide	0.59								
Giant grenadier	Coastwide	0.10	0.12	0.64						
Giant wrymouth	Coastwide	0.67	1.02							
Graveldiver	Coastwide	0.72								
Great sculpin	Coastwide	0.46	0.98							
Green sturgeon	Coastwide	0.99								
Greenstriped rockfish	Coastwide	0.23	0.25	0.27	0.32	0.42	0.46	0.56	0.63	0.90
Harlequin rockfish	Coastwide	0.25	0.83	0.97	1.01	1.04				

Species	Stock										
Jack mackerel	Coastwide	1.02									
Kelp greenling	Coastwide	0.51	0.57	0.64	0.65	0.68					
Lingcod	Area 3CD	0.31	0.37	0.79							
Lingcod	Area 4B	0.26									
Lingcod	Area 5AB	0.23	0.23	0.34							
Lingcod	Area 5CD	0.30	0.49								
Lingcod	Coastwide	0.16	0.23	0.24	0.24	0.26	0.31	0.34	0.49	0.79	
Longfin dragonfish	Coastwide	0.26	0.65	0.87							
Longnose skate	Coastwide	0.08	0.14	0.15	0.16	0.19	0.22	0.24	0.27	0.29	0.68
Longsnout prickleback	Coastwide	0.73									
Longspine thornyhead	Area 3CD	0.08	0.49								
Longspine thornyhead	Area 5E	0.15									
Longspine thornyhead	Coastwide	0.08	0.15	0.49	0.58						
Manacled sculpin	Coastwide	0.72									
Northern clingfish	Coastwide	0.95									
Northern lampfish	Coastwide	0.23	0.39	0.64							
Northern ronquil	Coastwide	0.74	0.76	0.97	0.97	0.98					
Pacific cod	Area 3CD	0.22	0.38	0.43	0.63						
Pacific cod	Area 4B	0.37									
Pacific cod	Area 5AB	0.23	0.25	0.44							
Pacific cod	Area 5CD	0.19	0.25								
Pacific cod	Coastwide	0.18	0.19	0.22	0.24	0.25	0.37	0.37	0.38	0.44	0.63
Pacific flatnose	Coastwide	0.10	0.17	0.55							
Pacific grenadier	Coastwide	0.11	0.38	0.95	1.01						
Pacific hagfish	Coastwide	0.44	0.84	0.96	0.96						
Pacific hake	Area 3C to 5E	0.20	0.22	0.25	0.31	0.42	0.46	0.46	0.46		
Pacific hake	Area 4B	0.70									
Pacific hake	Coastwide	0.20	0.22	0.25	0.31	0.42	0.46	0.46	0.46	0.70	
Pacific halibut	Coastwide	0.06	0.20	0.20	0.22	0.28	0.33	0.35	0.38		
Pacific herring	Coastwide	0.26	0.30	0.32	0.35	0.42	0.46				
Pacific lamprey	Coastwide	0.70	1.00								
Pacific ocean perch	Area 3CD	0.25	0.53	0.84							
Pacific ocean perch	Area 5AB	0.15	0.39								
Pacific ocean perch	Area 5CD	0.29									
Pacific ocean perch	Area 5E	0.24									
Pacific ocean perch	Coastwide	0.17	0.24	0.25	0.34	0.39	0.53	0.84			
Pacific sand lance	Coastwide	0.78	0.80	1.00							
Pacific sanddab	Coastwide	0.22	0.25	0.32	0.32	0.40	0.53	0.80	0.89	0.92	
Pacific sardine	Coastwide	0.54	0.56	0.72							
Pacific sleeper shark	Coastwide	0.45	0.72	0.93							
Pacific staghorn sculpin	Coastwide	0.49	0.69	0.98							
Pacific tomcod	Coastwide	0.41	0.44	0.45	0.80	0.89	0.98				
Pacific viperfish	Coastwide	0.13	0.46	0.99	1.00						
Pearly prickleback	Coastwide	0.64	0.96								
Petrale sole	Area 3CD	0.23	0.31	0.63							
Petrale sole	Area 5AB	0.25	0.42	0.57							
Petrale sole	Area 5C to 5E	0.17	0.30								
Petrale sole	Coastwide	0.17	0.23	0.25	0.30	0.31	0.35	0.42			
Pile perch	Coastwide	0.89									

Species	Stock									
Pink salmon	Coastwide	0.49								
Pinpoint lampfish	Coastwide	0.41	0.64	0.96						
Prowfish	Coastwide	0.75	0.94							
Puget sound rockfish	Coastwide	0.70	0.70	0.98	1.05					
Pygmy poacher	Coastwide	1.01								
Pygmy rockfish	Coastwide	0.51	0.56	0.59	0.81	0.94	0.97			
Quillback rockfish	Area 3C to 5E	0.10	0.28	0.48	0.50	0.53				
Quillback rockfish	Coastwide	0.10	0.14	0.28	0.48	0.50	0.53	0.72		
Quillback rockfish	Minor 12 and 13	0.14								
Ragfish	Coastwide	0.90								
Red irish lord	Coastwide	0.72								
Redbanded rockfish	Coastwide	0.16	0.17	0.19	0.25	0.33	0.37	0.79	0.86	
Redstripe rockfish	Area 3CD	0.55	0.60							
Redstripe rockfish	Area 5AB	0.38	0.66	0.98						
Redstripe rockfish	Area 5CD	0.54								
Redstripe rockfish	Area 5E	0.37								
Redstripe rockfish	Coastwide	0.37	0.38	0.54	0.55	0.60	0.66	0.77	1.00	
Rex sole	Coastwide	0.10	0.11	0.12	0.15	0.16	0.20	0.45	0.51	
Ribbon barracudina	Coastwide	0.95								
Rockweed gunnel	Coastwide	0.86								
Rosethorn rockfish	Coastwide	0.21	0.34	0.42	0.51	0.97	0.99			
Roughback sculpin	Coastwide	0.30	0.67							
Rougheye rockfish	Coastwide	0.24	0.26	0.31	0.34	0.37	0.40	0.45	0.61	
Roughtail skate	Coastwide	0.19	0.30	0.72						
Sablefish	Area 3CD	0.12	0.22	0.24	0.38					
Sablefish	Area 5A to 5E	0.17	0.20	0.29	0.40					
Sablefish	Coastwide	0.11	0.12	0.17	0.20	0.22	0.29	0.38	0.40	0.50
Sailfin sculpin	Coastwide	0.99	1.00							
Salmon shark	Coastwide	0.86								
Sand sole	Coastwide	0.38	0.58	0.59	0.97	1.00				
Sandpaper skate	Coastwide	0.28	0.31	0.33	0.34	0.37	0.37	0.38	0.39	0.69
Sharpchin rockfish	Coastwide	0.25	0.32	0.34	0.56	0.57	0.60	1.00		
Shiner perch	Coastwide	0.26	0.63	0.66	0.87	0.97				
Shortbelly rockfish	Coastwide	0.72	0.73	0.98						
Shortfin eelpout	Coastwide	0.11	0.82							
Shortraker rockfish	Coastwide	0.36	0.39	0.42	0.49	0.50	0.52			
Shortspine thornyhead	Area 3CD	0.09	0.18	0.81	0.99					
Shortspine thornyhead	Area 5E	0.08								
Shortspine thornyhead	Coastwide	0.08	0.09	0.10	0.18	0.18	0.27	0.35	0.99	
Silvergray rockfish	Area 3CD	0.31	0.48	0.56						
Silvergray rockfish	Area 5AB	0.28	0.36	0.39						
Silvergray rockfish	Area 5CD	0.19	0.47							
Silvergray rockfish	Area 5E	0.54								
Silvergray rockfish	Coastwide	0.15	0.31	0.32	0.37	0.39	0.54	0.56	1.01	
Sixgill shark	Coastwide	0.85								
Slender barracudina	Coastwide	0.52								
Slender blacksmelt	Coastwide	0.57								
Slender codling	Coastwide	0.84	0.96							
Slender sole	Coastwide	0.14	0.14	0.17	0.19	0.22	0.28	0.52	0.89	0.98

Species	**Stock**										
Slim sculpin	Coastwide	0.97	0.98	1.01							
Smootheye poacher	Coastwide	0.98	0.98	1.01							
Snake prickleback	Coastwide	0.45	0.98	1.01							
Sockeye salmon	Coastwide	0.99									
Soupfin shark	Coastwide	0.51									
Southern rock sole	Area 3CD	0.24	0.99	1.00							
Southern rock sole	Area 5AB	0.31	0.71	0.85							
Southern rock sole	Area 5CD	0.24	0.98								
Southern rock sole	Coastwide	0.16	0.24	0.24	0.31	0.69	0.71	0.97	0.97	0.99	
Spiny dogfish	Area 3C to 5E	0.09	0.24	0.26	0.38	0.42	0.53	0.59			
Spiny dogfish	Area 4B	0.17									
Spiny dogfish	Coastwide	0.09	0.10	0.17	0.24	0.26	0.38	0.42	0.53	0.59	
Spinyhead sculpin	Coastwide	0.96	0.97								
Splitnose rockfish	Coastwide	0.45	0.60	0.60	0.61	0.62	0.71	0.73			
Spotfin sculpin	Coastwide	0.85									
Spotted ratfish	Coastwide	0.11	0.16	0.21	0.21	0.24	0.26	0.29	0.51	0.53	0.87
Starry flounder	Coastwide	0.26	0.95	0.99							
Stout blacksmelt	Coastwide	0.61	0.90								
Stripetail rockfish	Coastwide	0.68	0.99								
Sturgeon poacher	Coastwide	0.57	0.70	0.79	0.96	1.00					
Thornback sculpin	Coastwide	0.67	0.86								
Threadfin grenadier	Coastwide	0.22	0.96								
Threadfin sculpin	Coastwide	0.34	0.37	0.47	0.53	0.60	0.95				
Threadfin slickhead	Coastwide	0.85									
Tiger rockfish	Coastwide	0.80									
Twoline eelpout	Coastwide	0.19	0.45	0.96							
Vermilion rockfish	Coastwide	0.69									
Walleye pollock	Area 4B	0.53									
Walleye pollock	Area 5AB + 12	0.19									
Walleye pollock	Area 5C to 5E	0.21	0.70								
Walleye pollock	Coastwide	0.19	0.21	0.34	0.36	0.53	0.59	0.69	0.70		
Wattled eelpout	Coastwide	0.32	0.48	1.05							
Whitebait smelt	Coastwide	0.68	0.81								
Whitebarred prickleback	Coastwide	0.81	0.81								
Whitespotted greenling	Coastwide	0.31	0.81								
Widow rockfish	Coastwide	0.54	0.80	0.80	0.84	0.96	0.97	0.97			
Wolf eel	Coastwide	0.54	0.55	0.56	0.71	0.94					
Yelloweye rockfish	Area 3C to 5E	0.10	0.19	0.34	0.36	0.43	0.66	1.02			
Yelloweye rockfish	Area 4B	0.85									
Yelloweye rockfish	Coastwide	0.19	0.21	0.34	0.36	0.43	0.66	0.85	1.02		
Yellowmouth rockfish	Area 3CD	0.55									
Yellowmouth rockfish	Area 5AB	0.40	0.62	0.66							
Yellowmouth rockfish	Area 5CD	0.76									
Yellowmouth rockfish	Area 5E	0.41									
Yellowmouth rockfish	Coastwide	0.40	0.41	0.55	0.62	0.63					
Yellowtail rockfish	Area 3C to 5E	0.23	0.36	0.36	0.40	0.48	0.61	0.66			