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Sampling for Estimation of Catch Composition in Bering Sea Trawl Fisheries

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M. E. Conners, J. Cahalan, S. Gaichas, W. A. Karp, T. Loomis, and J. Watson

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Executive Summary

Management of groundfish fisheries in Alaska is based on annual, seasonal, or fishery- and vessel-specific catch limits. Limits include both total allowable catch quotas for major species and incidental catch limits for many non-target species, including prohibited species such as Pacific halibut (*Hippoglossus stenolepis*). Fisheries are managed in near-real time based on industry reports and data collected by at-sea observers. Estimates of both the total catch for sampled hauls and the species composition of individual hauls are based on randomly selected samples collected by observers. The precision and accuracy of observer sampling are, therefore, of considerable importance to both industry and regulators of these fisheries. Accuracy of sample composition estimates is particularly critical where total catch is estimated for individual vessels or small fleet sectors; variability in estimates can have large effects on catch accounting.

We present results of two studies conducted in the eastern Bering Sea aboard commercial trawl catcher/processors. These two studies had three common goals:

1) To evaluate alternatives for selection of catch composition samples,

2) To check for possible biases associated with sample selection, and

3) To estimate the precision of catch composition estimates based on selected samples.

The first study, conducted in 1999 aboard the FV *American No. 1*, used modified standard observer sample collection methods and looked for evidence of mechanical sorting or stratification of species during net retrieval and catch handling aboard the vessel. Samples for this study were selected systematically throughout the haul. These sample-based catch estimates were compared to catch estimates based on processed catch product for targeted species, and to censuses of catch for non-target species. For this study, target species included walleye pollock (*Theragra chalcogramma*), Pacific cod (*Gadus macrocephalus*), yellowfin sole *(Limanda*

aspera), flathead sole (*Hippoglossoides elassodon*), and Alaska plaice (*Pleuronectes quadrituberculatus*). Non-target species included in the study were Pacific halibut, skates (*Raja* sp. and *Bathyraja* sp.), Tanner crab (*Chinoecetes bairdi*), snow crab (*Chinoecetes opilio*), and red king crab (*Paralithodes camtschaticus*).

The second study, aboard the FV *Seafisher* in 2005, tested an automated catch sampling and monitoring system as a means to limit mechanical sorting and to remove potential bias from the sample selection process. The automated sample selection system used a factory-based computer to determine when the sample should be selected, and then diverted catch from the processing line to the observer sample station. Samples were collected from the haul using a simple random sampling design. Catch estimates based on sampling results (sample-based catch estimates) were compared to censuses of catch for selected non-target species and to the difference between the total haul weight (flow scale) and censused non-target catch weight for the target species (yellowfin sole). Non-target species included in this study were Pacific halibut, arrowtooth flounder (*Atheresthes stomias*), Kamchatka flounder (*Atheresthes evermanni*), Pacific halibut, and eelpout species (Family Zoarcidae, all species). Both studies provided information on the variability of catch composition estimates between hauls and within multiple samples of each haul.

A simulation study was conducted based on data collected during the *Seafisher* research to examine the effects of sampling fraction on estimates of species composition. A simulated haul (28 metric tons) was constructed consisting of six species of fish, essentially mimicking the five major species encountered in the *Seafisher* data set, and a last species that represented all other species. Fish were randomly assigned to a sample until the sample achieved the target weight of fish. Since only whole fish are included in the sample, the weight of fish in the sample varied. Estimates of catch based on the simulated samples were compared with the true catch (simulated haul total for the species). Bias and variance of the estimates was evaluated.

Results

- Measurements of codend volume provided a reasonable approximation of total catch weight in both studies. When the volume of the codend was measured, the volumetric estimate was generally within 15% of the weight measured by the vessel's flow scale.
- The automatic sample collection and electronic monitoring (EM) systems tested on the FV *Seafisher* performed well, but two concerns were identified. First, since the total catch size was unknown prior to sampling, selection of a fixed number of random samples was difficult. When the initial volumetric estimate of total catch was an overestimate, sometimes a smaller number of samples were collected than was desired. When total catch was initially underestimated, the final portion of the catch was not included in the random selection. Secondly, random selection of samples sometimes led to samples that were too close together to be efficiently processed by the observers. Both of these concerns could be addressed by systematic sampling with a random start point. Actual weight of samples diverted by the system varied somewhat from the target 100 kg, primarily due to accumulation of fish at the inclined conveyor belt. The use of EM, in particular, appears to have the potential to increase compliance with catch-sorting protocols and smooth the sampling process.
- While both studies fished with bottom trawl gear on the central Bering Sea shelf, fishing methods and the overall composition of catch differed between the two studies. Catch in the *American No. 1* study was a mixture of yellowfin and flathead

sole, walleye pollock, and Pacific cod. Catch in the *Seafisher* study was dominated by the targeted species, yellowfin sole. These differences produced differences in the variability of the catch composition between hauls in each study. The coefficients of variation (CVs) of product or census-based catch proportions for the *Seafisher* study were 7% for yellowfin sole and 49-63% for the three rare species. For the *American No. 1* experiment, the four dominant species had CVs of 55-95%, while CVs for crabs and Alaska plaice were on the order of 100-200%.

- Estimates of species composition in both studies were calculated for sample sizes of 100, 300, and 600 kg. While the overall means of species proportions estimated from the samples tended to be very close to the product or census-based means, the range and variability of the sample estimates differed substantially between studies and between species. Overall CVs of sample-based estimates of species proportion for the *American No. 1* study were high; in the range of 60-80% for the dominant species and over 100% for the rare groups. Species proportion estimates from the *Seafisher* study showed similar patterns. The single dominant species in the *Seafisher* study was well represented even at 100 kg sample sizes; the overall CVs for this species were 8-11%. The three rare species groups in this study, however, showed wide ranges in estimates of sample proportion and had overall CVs of over 100% at even the largest sampling fraction, with CVs for 100 kg samples of 300-600%. For all species, increasing the size of the sample had little effect on the overall mean of the sample estimates but markedly reduced the range of individual estimates of the species composition. Overall CVs for each species group decreased with increasing sampling fraction.

This effect was slight for the predominant species, but pronounced for the less common species, especially Pacific halibut.

- For each haul, the difference between census-based estimates and sample-based estimates was calculated; the frequency distribution of these differences was examined to check for any sampling bias. In general, these distributions fall into three distinct groups depending on the overall abundance of the species being sampled. For dominant species in both studies (e.g., yellowfin sole, walleye pollock), the distribution of the differences was symmetric around zero for all sample fractions. Rare species groups in both studies (Pacific halibut, skates, and Kamchatka flounder) show a distinctive, strongly asymmetrical pattern in the differences between sample and census-based estimates. The strong skewness in the distribution caused the majority of samples to underestimate the proportion of these species as zero (when none of the rare species appear in the sample), but a few samples to overestimate the proportion by a large extent (when one or few of the rare species is present in the sample). This skewed distribution can be expected to occur when the overall average proportion for a species or species group is very small.
- Results of the simulation study were consistent with the two field studies. Means of the sample-estimated haul weight for each species were close to the true values and did not change substantially with sampling fraction. The precision of the sample estimates did, however, change substantially with sampling fraction. The variability of the sample estimates decreased with increasing sample fraction for all of the studied species; the rate of decrease was fastest at the lowest sampling fractions and for rare species. Frequency distributions for rare species were strongly right-skewed

at low sampling fractions but became progressively less skewed at increasing sampling fractions. Distributions for rare species did not become symmetric, however, until the sampling fraction exceeded 37% of the total haul weight.

- Comparison of variability between product and census-based estimates and within-haul sample estimates indicate that between-haul variability is the dominant variance component for target species in these studies. For rare species, however, variability of sample estimates was much higher than variance of product and census-based estimates, indicating substantial within-haul variability due to sample selection.

Conclusions

Results of these field studies indicate that existing observer sampling protocols based on 300 kg standard samples provide good estimation of catch composition for target and common groundfish species. While there was evidence of slight stratification of species composition within the trawl net, sample estimates of proportion were generally in good agreement with production and census-based species proportion estimates. Even small samples (100 kg) provided estimates of catch composition for predominant species that were close to production and census-based species proportion estimates.

The most important observation from both studies was the pattern revealed in estimation for rare species, including Pacific halibut. Where management of a fishery includes catch limits on prohibited or non-target species, the poor precision of the estimates for rare species has potentially serious consequences. If precise estimation of catch of rare species is desired, large sampling fractions are needed to provide haul-specific estimates with small variance. Where large sampling fractions cannot be achieved, then combined estimates over a number of hauls are needed to obtain precise estimates of catch for the combined hauls. The relative importance of competing management goals and the eventual use of observer data in management will need to be explicitly considered in structuring of observer data collection programs.

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Introduction

Recent revisions to the Magnuson-Stevens Fishery Conservation and Management Act require use of annual catch limits for fisheries management in the United States, including catch limits for both target and non-target species. Groundfish fisheries management in federal waters off Alaska is based on real-time (in-season) monitoring of catch against catch quotas. Groundfish fisheries in Alaska are among the largest in the United States, with annual harvests of over two million metric tons (t) and ex-vessel value of $740 million in 2005 (Hiatt 2007). Fisheries in the U.S. Exclusive Economic Zone (EEZ) are managed by the National Marine Fisheries Service (NMFS). Annual or biannual stock assessments are prepared at the Alaska Fisheries Science Center (AFSC) for major commercial groundfish species in Alaska and some minor species groups; these assessments include recommendations for overfishing levels and acceptable biological catches for each group. Pacific halibut (*Hippoglossus stenolepis*) are assessed independently by the International Pacific Halibut Commission which also determines the total allowable catch level of halibut. The North Pacific Fishery Management Council (NPFMC) establishes total allowable catch levels for all managed groundfish species or species-groups based on the stock assessments and other factors. Fisheries are managed in-season by NMFS' Alaska Regional Office, based on industry reports and data collected by at-sea observers. Cumulative totals of catch for all species groups are monitored; fisheries may be closed when either the directed catch of the commercial target species or incidental catch of non-target species approach catch limits. Non-target species usually represent only a small fraction of the total catch, but the existence of catch limits makes monitoring these groups an important component of in-season management. As regulation and management of the fishery becomes more sophisticated, there are increasing needs for timely and accurate estimation of both target and non-target species.

The AFSC's Fisheries Monitoring and Analysis Division (FMA) is responsible for monitoring of domestic commercial groundfish fisheries and collection of catch data. Fisheries observers have a wide variety of responsibilities and prioritized tasks that include sampling catch, monitoring incidental catch of endangered species and documenting vessel compliance with fisheries regulations (AFSC 2006). One of their main responsibilities is the collection of data used for estimation of the total catch (inclusive of discards) and species composition of each sampled fishing event (AFSC 2006). These data are used to monitor total catch in relation to catch limits. The precision and accuracy of observer sampling are, therefore, of considerable importance to both industry and regulators of these fisheries. Observer data also form a critical part of the information base for stock assessment modeling used to set catch quotas and provide important data on the spatial and temporal distributions of catch of various species.

Observers reported apparent sorting or stratification of catch by species within the codend of the trawl net in some fisheries. The movement of the trawl net through the water or the methods used in processing fish though the vessel's factory may have caused this sorting (stratification) of the fish available to the observer for sampling by either size or species. This may result in higher sample variance on the estimated species composition relative to that associated with variances estimated from well-mixed catch. In this situation, sample data from a systematic random sample will produce better estimates of species composition than data from a simple random sample

Observer data are collected over a wide variety of vessels and fisheries. In most cases, significant between-haul variability in catch composition is expected due to vessel and gear differences as well as spatial and temporal differences in fish distribution. Overall estimates of catch composition for a fishery will include both this between-haul variability as well as within-haul variability due to sampling. Since these two experiments were each conducted with a single vessel in one region, they will have less between-haul variability than a larger fleet sector. Additionally, the captain and crew of the FV *Seafisher* were requested to use fishing methods that minimized the between-haul variability of catch in terms of both size of catch and species composition of catch. It is useful, however, to compare the relative magnitude of between-haul and within-haul components of variance for the two studies. Both studies provided information on the variability of catch composition estimates between hauls and between multiple samples taken from each haul.

Electronic monitoring equipment was installed during the *Seafisher* study to allow the observer to monitor crew activities on deck and in the fish tanks (bins) and the flow of fish through the factory to the point of discard. Electronic monitoring can provide useful information to those working at the sampling station. By glancing at the video display, it was possible to see if a haul is being landed and to observe the deck crew emptying a haul into the holding tank. It is also possible to view crew activities prior to the sample collection point. This monitoring makes it possible to observe both crew handling of the catch and any mechanical sorting or blocks in the system. Video observation of the base of the incline belt would allow samplers to determine exactly when to start and stop sample collection, which would improve efficiency.

The AFSC conducts evaluations of observer sampling methodologies and investigates potential improvements to these methods. This paper reports the results of two field studies concerning sample selection methods and estimation of catch composition. The first study, conducted in 1999 on the FV *American No. 1*, used standard observer sample collection methods and looked for evidence of mechanical sorting and stratification of species during catch processing. The second study, conducted in 2005 on the FV *Seafisher*, tested an automated catch sampling and monitoring system as a means to limit mechanical sorting and to remove potential bias from the sample selection process. In both studies, the weight of the entire catch was determined for each species to allow evaluation of the accuracy of sample-based estimates.

These studies had three goals: 1) evaluate methods for selection of samples for estimation of species composition of the catch, 2) to estimate the precision of catch composition estimates based on selected samples, and 3) to look for possible bias associated with sample selection.

Methods

Experiment 1 - *American No. 1*, September 1999

This experiment was initiated by industry to evaluate sampling accuracy. The study was conducted aboard the 50 m commercial factory trawler *American No. 1* from 6 – 19 September, 1999, under an exempted fishing permit (EFP). Sixty-two non-pelagic trawl tows were made on the central Bering Sea shelf between St. Paul Island and Bristol Bay in waters 50-70 m deep (Fig. 1). The target fishery for all tows was flathead sole (mixed flatfish and roundfish) and the target weight for each haul was 10 t. Species and species groups included in this study were target species flathead sole (*Hippoglossoides elassodon*), yellowfin sole (*Limanda aspera*), Alaska plaice (*Pleuronectes quadrituberculatus*), walleye pollock (*Theragra chalcogramma*), Pacific cod (*Gadus macrocephalus*), and non-target species Pacific halibut, Tanner crab (*Chionoecetes bairdi)*, snow crab *(Chionoecetes opilio*), red king crab (*Paralithoides camtschaticus*), and skates (*Raja* sp. and *Bathyraja* sp.). Both flatfish and roundfish target species were included to determine how catches of these mixed species might be physically and mechanically sorted, producing potentially "stratified" units of catch, and creating sampling challenges. In addition to the five target species, skates were included as a moderately abundant non-target species group.

After each haul was landed, the codend of the trawl net was measured and the volume of the catch was calculated. A density of 1.0 t/m^3 was applied to the volume to provide a preliminary estimate of the total catch weight. The actual total haul weight was later determined by the vessel's flow scale (scale built into the factory conveyor belt system that measures the total weight of catch flowing over the scale). Regression analysis (through the origin) was used to evaluate the relationship between haul volumes and catch weight.

The codend was emptied into a holding tank and crew members facilitated the transfer of catch from the tank to sampling and processing stations through a conveyor belt system. The layout of the holding tank permitted the catch to be stored so that any stratification or structuring of fish within the codend of the trawl net would be preserved, and samples could be taken from the catch in sequential order. All catch was weighed using a Marel model 2000-X01 flow scale.

Observers used a computer with a pre-programmed spreadsheet that generated random weights within the haul (sampling start points) and subsequent weights for a systematic sample of the haul, with the goal of collecting six 100-kg samples from each haul. The preliminary estimated catch total weight (catch volume) was entered into the spreadsheet which was programmed to automatically designate systematic sample weight intervals where observers would collect samples by monitoring the cumulative weight of the haul on the flow scale. While this process resulted in the targeted number of six samples being collected from a majority of hauls, error in estimation of haul weights based on codend volumes led to under- or overestimates of actual haul weight measured on the flow scale, so a range of three to eight samples per haul were collected during the study.

For each of the samples the study species were counted and weighed in the aggregate, with the remaining catch recorded as a combined weight. A laptop computer displayed information on upcoming sampling intervals and was used to review sampling histories for each haul. From the sampling station, the catch was visible as it proceeded along the factory's conveyor belt system. Any fish that accumulated at the base of an inclined belt were manually cleared before and after sample collection.

Haul composition for each of the five target species (flathead sole, yellowfin sole, Alaska plaice, walleye pollock, and Pacific cod) was determined by adding the total retained weight to the discarded weight of each species (retained temporarily and then run over the flow scale prior to discard). The retained total weight of target species was estimated by multiplying the number of cases of fish product (fillets, surimi, etc.) and the average case-weight of each product type, and then dividing by the product recovery rate (PRR) estimated on board for each species and product type. The product recovery rate is the ratio of whole fish weight to finished product weight. Variability in case weights and PRR were examined by collecting direct measurements of 261 case weights and 5 to 10 replicate PRR measurements for each target species, selected at random intervals throughout the study. It was not feasible, however, to measure variability in daily case counts, so the overall variability of the estimated catch totals for these species cannot be calculated.

For skates, Pacific halibut, and the three crab species, species composition of the entire haul was determined by sorting the sampled and unsampled portion of the catch for these species and recording aggregated weights for these individual species.

Round weight of non-study species groups was estimated by subtracting total (flow scale plus production-estimated) weights of study species from total haul (flow scale) weights.

Experiment 2 – *Seafisher*, October 2005

Data for this experiment were collected aboard the 70 m commercial factory trawler *Seafisher* (Cascade Fishing Inc.) between 14 and 22 October 2005. Thirty non-pelagic trawl tows were made on the central Bering Sea shelf between St. Paul Island and Bristol Bay in waters 56-66 m deep (Fig. 1). The study design required a total of six 100-kg random samples to be selected from each haul. The target species for all tows was yellowfin sole and the target weight for each haul was 30 t. Tow locations and durations were selected to minimize between-tow variance in total catch weight and species composition.

Species and species groups included in this study were target species yellowfin sole, non-target species arrowtooth flounder (*Atheresthes stomias*), Kamchatka flounder (*Atheresthes evermanni*), Pacific halibut, and eelpout (Family Zoarcidae, all species). In addition to the target species, arrowtooth flounder was included in the analysis as a moderately abundant species, and Kamchatka flounder and eelpouts were included as examples of rare species. Pacific halibut were included as an important non-target species.

The Seafisher study was primarily designed to evaluate an automated sample selection system that was used to select and collect samples as the catch was being processed. Details of the system and system performance were presented at the ICES 2006 Annual Science Conference. The system consisted of a Scanvaegt Model 4674 flow scale and Scanvaegt 8564 MKIII Scale Computer Indicator (control unit). A diverter board, activated by the computer, diverted fish from the factory conveyor belts to the observer sampling station.

After each haul was landed, the codend of the trawl was measured and the volume of the catch was estimated. The codend was emptied into a holding tank and crew members facilitated the transfer of catch from the tank to sampling and processing stations through a conveyor belt system. The haul volume was used as an initial estimate of the total catch weight by measuring or visually estimating the volume of the codend and applying a density of 1.0 t/m^3. When flow scale weights are not available, routine observer sampling methods call for direct measurement of density of the catch, and use this density to estimate total catch weight. Regression analysis (through the origin) was used to evaluate the relationship between haul volumes and catch weight.

The estimated catch total volume (weight) and sample specifications were entered into the control unit, which worked in conjunction with the flow scale. Based on the estimated total weight, the system selected sample weights (times for sample collection) based on a simple random sampling design for six samples of approximately 100 kg. As catch passed over the flow scale, the control unit displayed both the total amount of catch weighed for that haul and the cumulative total for the sample being collected. At predetermined intervals, the conveyor belt system was stopped by the control unit allowing the sampler to remove fish from the belts (especially the base of the incline belt) prior to starting sample collection. A pneumatic diverter board automatically directed catch for samples to the observer workstation.

The belt system was then restarted, allowing fish to flow through the factory to the observer station. When a pre-determined amount of fish (50 or 70 kg) had been diverted the system again turned off the belt from the holding tank, but the diverter board continued to direct fish to the sampling station until all the fish that had accumulated at the base of the incline conveyor had reached this location. Target sample weight was 100 kg. At the conclusion of sample collection, the operator pressed another function key on the control unit and this closed the diverter board and restarted the conveyor belt from the holding tank. Since the volume estimate of catch was imprecise, between four and six samples were collected from each haul. A laptop computer connected to the system displayed information on upcoming sampling intervals and was used to review sampling histories for each haul.

For one randomly selected sample in each haul, all species present were counted and weighed in the aggregate. For the remaining samples, the study species were counted and weighed in the aggregate, with remaining catch recorded as a combined weight. The unsampled portion of the catch was sorted for non-target study species; the total weight and number of these species in each haul was recorded. The total haul weight of the target species yellowfin sole was assumed to be the total haul weight less the measured weight of study species and other bycatch.

Electronic monitoring (EM) equipment (video cameras) monitored catch and crew activities from the point of landing to the point of discard. Three NMFS scientists, two observers, an EM technician, and a representative of the fishing company served as the survey's scientific staff. Nine closed circuit television cameras were installed to monitor catch and crew activities. Monitored areas included the trawl deck, fish holding tank, flat conveyor belt, incline conveyor belt, sorting belt, and locations within the factory where fish were discarded. Digital video records were stored on hard drives. A waterproof monitor was located above the observer sampling station to allow observers to monitor activities at multiple locations; the system was designed to allow observers to select among the operational cameras and display up to nine images simultaneously.

Data Analysis

One of the main objectives of both studies was to assess the variability associated with sampling the catch; that is, the within-haul variance. For both studies, we looked at the performance and sampling variability of species proportion estimates based on 1) single samples of approximately 100 kg; 2) combined results from three 100 kg samples, which is the current minimal level of sampling for observers; 3) combined results of six 100 kg samples for those hauls where at least six samples were taken; and 4) all samples combined for each haul. Despite the fact that actual sample weight was variable, these are nominally referred to as the 100 kg, 300 kg, 600 kg, and "all–sample" estimates.

Species weights from individual samples in both studies were divided by the total sample weight to obtain proportion estimates for each sample. For each haul with at least five samples, samples 1, 3, and 5 were pooled to generate a 300 kg sample. For hauls with at least six samples, samples 2, 4, and 6 were pooled to estimate a proportion based on an approximate 300 kg sample (sum of species sample weights divided by sum of sample weights). In cases where exactly six samples were collected for a haul, all species and sample weights were pooled to calculate a 600 kg sample estimate of species proportion for the haul. Estimates for each haul were also generated by combining all samples collected in that haul. The precision of each of these types of estimators (100 kg, 300 kg, 600 kg, and all samples) was examined.

Both experiments included measures of the catch composition for the selected species groups for the entire haul ("actual" product or census-based species composition). For the rarer species groups in each study (Pacific halibut, skates, crabs, Kamchatka flounder, eelpouts), the entire study haul was processed and actual species weights per haul were measured. For the dominant species in the *Seafisher* hauls (yellowfin sole), species weight was calculated as the difference between total catch and the combined catch weight of measured species and other bycatch. Estimates of product or census-based weight for target species in the *American No. 1* study (yellowfin and flathead sole, Alaska plaice, walleye pollock, and Pacific cod) were based on production estimates plus measured weight of discards, as described above.

We looked at potential sampling biases by comparing estimates of species composition derived from the sample data with the proportion or census-based species compositions based on measurements or production estimates. For both experiments, we calculated differences as the species proportion measurement (or estimate) based on production or census data for the entire haul minus the corresponding sample estimate of species proportion. The frequency distribution and statistical properties of these differences over all of the study hauls was examined for systematic biases. If the sampling procedure has no bias, then the mean of the differences should be equal to zero.

To evaluate the extent of sorting or stratification of the catch by species within the codend of the trawl net, 100 kg sample estimates from the *American No. 1* experiment were examined in a sequential fashion. The holding tank of the *American No. 1* was fitted with a set of baffles intended to prevent the catch from mixing in the hold and preserve the relative position of fish within the trawl net. Species weights were evaluated using linear models; based on initial examination of the data, an arcsine transformation was used prior to analysis. The species proportion from each sample was regressed against its sequential position within the haul; the significance and sign of regression slopes was examined as an indication of stratification effects. In addition, sequential sample numbers were classified into three categories (early, middle, and late portions of the haul), and ANOVA methods were used to evaluate whether effects of sequencing on species proportion were significant. Since catch from each haul aboard the

FV *Seafisher* was mixed in a holding tank prior to being processed, the relative position of fish coming from the holding tank to the factory was not expected to reflect the relative position of fish within the trawl net. Hence, this analysis was conducted only on data from the *American No. 1* experiment.

For both experiments, the difference between the product- or census-based species proportion (determined as described above) and the sample-based estimates of species proportion (based on 100 kg, 300 kg, 600 kg, and all-samples) were computed for each haul. The frequency distribution of these differences (pooled over all study hauls) was examined to look for any evidence of systematic sampling bias (differences consistently greater or less than zero). The Wilcoxon rank-sum test was used to test whether the mean difference was significantly different from zero (SPlus 2000, MathSoft Inc., Seattle, WA). For both experiments, the variance of the sample estimates around the whole-haul proportion (within-haul sampling variability) was compared to the overall variance of whole-haul proportions around a mean proportion for the entire trip (between-haul variability).

Simulation studies were conducted to further examine the sampling distribution of the *Seafisher* data. A simulated haul was constructed consisting of six species of fish. The species composition that essentially mimicked the five major species encountered in the *Seafisher* data set plus one species to encompass all other catch. The total simulated haul comprised 83,211 fish (28,205.66 kg) to mimic the target haul size in the *Seafisher* experiment. For each fish within the simulated haul, a weight was assigned from either a normal or lognormal distribution based on average weights and weight distributions observed in the current study (Table 1). Fish were randomly assigned to a sample until the sample achieved the target sample weight. Since only whole fish were included in the sample, the total weight of the simulated sample varied slightly.

Target weight of the samples ranged from 100 kg (0.35% of the total haul weight) to 10,500 kg (37.23% of the total haul weight). Simulated sampling was conducted 1,000 times for each size of sample.

In order to estimate the haul weight of catch for each species in the simulation work, we estimated the species composition the simulated samples by weight and applied that species composition to the total weight of the haul. The frequency distribution and variance of the simulated results was examined for each sampling fraction.

Results

Electronic Monitoring

Electronic monitoring (EM) equipment installed on the FV *Seafisher* performed well throughout the study. Observers were able to monitor the flow of fish from the holding tanks (and within the holding tanks) through the factory to the point of final processing or discard. The deck monitors allowed observers to know when to expect the next haul and prepare to sample. Crew activities were easily monitored and observers were aware of any sorting activities. Details of the electronic monitoring experiment are also reported in McElderry et al. (2008).

Volumetric Estimation of Total Catch

For both studies, there was a close relationship between volumetric estimates and flow scale measurement of total catch weight (Fig. 2). Regression of scale weight on measured codend volume (through the origin) showed good fits to a linear relationship. The regression coefficient for the *American No. 1* over 62 hauls was 0.94, with an r^2 value of 86%. Flow scale catch weights for this experiment ranged from 3.88 to 21.26 t, with an average haul weight of 10.87 t.

Estimated catch ranged from 3.95 to 21.76 t, with an average of 10.80 t (Table 2). The hauls were evenly divided between those where estimated weights exceeded the scale weight and those where the estimate was less than scale weight. The majority of the hauls showed differences between the estimated and scale weights of 15% or less. The largest differences, both positive and negative, were 28% of the scale weight (Fig. 3).

On the FV *Seafisher*, initial estimates of the catch weight were made for all hauls based on either measurement of the codend volume or a visual estimate of total haul size. The total catch size estimate was not recorded for the second haul of the study. When poor weather prevented measuring the codend on three hauls, visual estimates of the catch weight were made. The regression coefficient for flow scale weight as a linear function of volumetric estimates was 0.98, with an r^2 value of 91% (Fig. 2). The average estimated catch weight for 29 hauls was 27.94 t and ranged from 10.47 to 52.20 t. Flow scale catch weights ranged from 10.48 to 48.50 t and averaged 27.76 t (Table 2). For 17 of 29 hauls the catch weight was overestimated by 0.20 – 8.33 t (0.9-36%); for the remaining 12 hauls the catch weight was underestimated by 0.07 – 5.35 t (0.1-17%). The volumetric catch estimate differed from the flow scale weight by more than 15% for only 4 out of 29 hauls (Fig. 3).

Selection of Catch Composition Samples

On the FV *American No. 1*, samples were selected and removed from the conveyor belt at systematic intervals selected using a laptop computer and customized spreadsheet. This system performed well, enforcing the systematic random selection of samples. Systematic sampling provided an even work flow for the observer. Additionally, the system allowed for continued sampling of the haul beyond the initial estimate of haul size in cases where the original size of the haul was underestimated.

The study on the FV *Seafisher* tested an automated catch sampling system that both determined the points for random sample selection and operated pneumatic diverter boards to collect the sample. The system generally performed well; however, on two occasions it failed to collect the first sample. On the first occasion, the system was reset and the haul and sampling information was re-entered. This generated a new set of random samples and processing and sampling of the haul was restarted. On the second occasion, the control unit was used to manually initiate collection of the first sample indicated by the random sample generator, and the system worked properly for the remainder of the haul.

The process of estimating the preliminary catch volume and entering the sampling parameters into the control unit took approximately 10 minutes per haul. While initial total catch estimates based on volumetric approximations were usually close to actual catch weight, over- or under-estimation of catch occasionally resulted in an incorrect determination of the number of 100 kg portions available for sampling. For two hauls only four of six samples were collected and for two hauls only five samples were collected before all of the catch was processed (i.e., the catch was overestimated). Conversely, for hauls where the catch weight was underestimated, sampling ceased once the scale weight reached the initially estimated weight. For example, if the estimated catch weight was 15 t, but the haul was actually 20 t, fish in the last 5 t would not be available for sampling by the automated system.

The target sample weight for the automated catch sampling system was 100 kg, but actual sample weights ranged from 63 to 217 kg with an average of 105 kg (Fig. 4). Through trial and error, it was determined that a programmed sample weight of between 50 and 70 kg resulted in actual sample weights close to the target of 100 kg. To a large extent, sample size variation was the result of the flow scale being located after an incline conveyor belt where catch that was part of the sample tended to accumulate. As the scientists and observers became familiar with the system and worked with the crew to provide a uniform flow of catch onto the conveyor belt, individual sample weights were less variable and closer to the 100 kg target (Fig. 4). Cumulative sample weights for individual hauls ranged from 387 to 874 kg with a mean of 609 kg. Similar to individual sample weights, as the cruise progressed total sample weights came closer to the target of 600 kg (Fig. 4).

Whole-Haul Catch Composition (Census or Product Estimates)

The two experiments were conducted with similar vessels in the same general region, but used different target species and different fishing methods. The overall species composition of the catch and the variability between hauls differed substantially between the two studies. In the *American No. 1* study (September 1999), the majority of the catch was a mixture of yellowfin and flathead sole, walleye pollock, and Pacific cod (Table 2). Based on estimated product- or census-based catch weights, flathead sole accounted for an average of 18% of the catch, yellowfin sole 18%, pollock 16%, and cod 10%. These four species combined made up between 33% and 88% of each haul. The species composition of individual hauls, however, varied greatly. The four dominant species varied from less than 1% to over 50% of individual hauls, with different species dominating different hauls. Catch of Alaska plaice was also highly variable between hauls, ranging from zero to 25% of individual hauls, with an overall average of 3.6%. Catches of halibut and skates contributed averages of 0.9% and 2.5%, respectively, but varied from less than 0.5% to 11.9% of individual hauls. Tanner and snow crabs were present in nearly all of the hauls, but each made up only 0.4% of the catch weight on average. Red king crabs were present in only 44 out of 60 hauls; it never made up more than 0.14% of the catch weight, with an overall average of 0.04%.

For the *Seafisher* study (October 2005), yellowfin sole was the dominant component of the catch for all hauls. Yellowfin sole made up between 61% and 91% of the catch in each haul, with an overall mean catch proportion of 82% (Table 2). Arrowtooth flounder made up 1-4% of the catch in each haul, with an overall mean of 2.4%. All of the other species groups in the study were uncommon, making up less than 1% of the catch. Pacific halibut were present in every haul, making up from 0.16% to 1.56% of the catch of each haul and an overall average of 0.64% of the catch. Kamchatka flounder consistently made up 0.1% or less of the haul by weight, with an overall average of 0.05%. Eelpout was an extremely rare and small-bodied species group. There was at least one eelpout in each of the 30 study hauls, but the total weight of eelpout in a haul never exceeded 5 kg and was often less than 2 kg. On a percentage basis, eelpout never made up more than 0.02% of the haul weight, with an average catch proportion of 0.006%.

Variability between hauls for each species over the 2-week period of each study is summarized in Table 2. This table shows the distribution of production and census-based species composition measurements, without the within-haul sampling component. The *Seafisher* experiment was designed to minimize between-haul variability and census-based estimates showed remarkable consistency between hauls, even for the rare species groups. The coefficients of variation (CVs) of census-based catch proportions over the 30 tows in the experiment were 7% for yellowfin sole and 49-63% for the three rare species (eelpout, Pacific halibut, and Kamchatka flounder). The *American No. 1* experiment, with the more diverse catch, showed much greater between–haul variability. For this experiment, even the four dominant species had

CVs of 55-95% between hauls, while CVs for crabs and Alaska plaice were on the order of 100-200%. Pacific halibut and skates were small but consistent components of the catch in this study, with between-haul CVs of 70% and 83%, respectively

Sample-estimated Catch Composition

While the overall means of species proportions estimated from the samples tended to be very close to the proportion or census-based means, the range and variability of the sample estimates differed substantially between studies and between species (Tables 3 and 4). The *American No. 1* study, which had a greater variability in production or census-based species composition, showed wide ranges in sample estimates for even the dominant groundfish species (Table 3). All of the species groups in this study were occasionally absent from individual 100 kg samples. At the larger sampling fractions, the four dominant species were always detected but rarer species (skates and Pacific halibut) were still absent from many of the samples (Tables 3 and 4). Overall CVs of the sample estimates for this study were high; in the range of 60-80% for the dominant species and over 100% for the rare groups. For all species, increasing the sample fraction had little effect on the overall mean of the sample estimates, but it markedly reduced the range of individual estimates. Overall CVs for each species group decreased with increasing sampling fraction, even though the number of samples increased. This effect was slight for the dominant species, but pronounced for the less common species, especially Pacific halibut.

Species proportion estimates from the *Seafisher* study showed similar patterns (Table 4). Overall means of sample estimates were unaffected by sample size and, for the most part, were very close census-based means for the haul (Table 4). The exception in this study was Pacific halibut, with an average percent difference from the haul species proportion of 17% to 22%.

The single dominant species (yellowfin sole) in the *Seafisher* study was well represented at all sample sizes; the overall CVs of estimated species composition for this species were 8-11%. The three rare species groups in this study, however, showed wide ranges in estimates of sample proportion and had overall CVs of over 100% at even the largest sampling fraction, with CVs for 100 kg samples of 300-600%. As in the *American No. 1* study, all species groups showed reduced range and decreasing CVs at larger sampling fractions. This effect was especially pronounced for the rare species.

Effects of sample size (differences in CV for 100 kg vs. 300 kg samples) were especially pronounced for large-bodied species such as Pacific halibut. In both studies, a few 100 kg samples contained large individuals and therefore had very high halibut percent composition estimates. These estimates contribute heavily to the overall variance in sampling estimates for this species. Combining samples into 300 kg and 600 kg estimates reduced the effect of these large individuals on the estimated proportion, and reduced the variance of the sampling estimates by eliminating large outliers.

Stratification

All of the dominant groundfish species in the *American No. 1* study showed some stratification within the net and holding tanks (Table 5, Fig. 5). The proportion of pollock and cod tended to be higher and the proportion of flatfish species tended to be lower deeper into the net (Fig. 5). Linear regressions showed that all five of the relatively common groundfish species had species proportion trends significantly different from zero (Table 5a). The slopes of all of the regressions were, however, small. When the regression slopes are converted back to change in proportion, the effect is minor; even for pollock the mean effect is less than 2% change across the haul. No trend was detected in regressions for Tanner and snow crab. There were not enough data to perform regressions for the rarer species groups (skates, halibut, and king crab).

Each sample position (*American No. 1*) was classified as part of the early, middle, or late third of each haul. ANOVA tests using this classified variable also showed significant effects of sample order for the five groundfish species, but none for Tanner and snow crab (Table 5b). Mean squared errors (MSE) of the ANOVA table indicated that while present, the effect of sample position accounted for only a fraction of the overall variance in the data. The greatest effect was for walleye pollock, where the sample position variable was associated with approximately 20% of the overall variability.

Accuracy of Sample-based Estimates

The *American No. 1* dataset did not show consistent results in testing of differences (Table 6). The difference in species composition (sample-based estimates minus production-based estimates) for the four predominant species were significantly different from zero based on a Wilcoxon rank-sum test, with the single exception of the 600 kg samples of Pacific cod (P-value = 0.0543). However, for Alaska plaice, the other species with sample-based species composition compared to production-based species composition, the difference in species composition was significantly different from zero in only two of four sampling scenarios tested.

All four of the dominant species from this study (flathead and yellowfin sole, walleye pollock, and Pacific cod) had mean differences significantly different from zero at all sample sizes (Table 6), and all of the mean differences were positive, indicating that sample estimates were higher than production or census-based estimates. For these target species, we used production estimates of census-based catch weights instead of sorting the entire haul for these species. These estimates were computed from production and discard data supplied by the vessel. Production estimates are subject to error resulting from incorrect case counts, variance in the estimated PRR rates, variance in the estimated weight per case, recording errors, and other sources. Thus, the differences between census-based and sample-based estimates for these species include effects of both sampling and production estimation.

For two hauls in the *American No. 1* study, the amount of fish estimated for the haul was less than the weight of fish retained in samples. In one haul, 9.1 kg of pollock were contained in three samples, giving a total catch estimate for the haul of approximately 138 kg. The production plus discard estimate for that haul, however, was less than 1 kg. Similarly, in another haul the production plus discard estimate for Alaska plaice was zero, but 1.17 kg were retained in one of three samples, which would give a total catch weight of approximately 13 kg.

There was no clearly discernable pattern in the species composition differences for species where sample-based estimates were compared to census-based estimates. For one species only, Pacific halibut, the species composition difference was significantly different from zero in three of the four sample fractions tests. The only non-significant difference was for the case where only hauls with six samples (600 kg samples) were used in the analysis; the scenario where the species composition difference was positive (sample-based estimates were larger than production-based). For three of the other species, the species composition difference was significantly different from zero only at the smallest sample fraction.

The more common species (yellowfin sole and arrowtooth flounder) in the *Seafisher* data had mean differences not significantly different from zero at all four sample sizes (Table 7) based on a Wilcoxon rank-sum test. These species tended to be slightly under-represented in sample estimates (differences less than zero). Kamchatka flounder and eelpouts had relatively small mean differences due to their small overall proportion. In this study, the average proportion of Pacific halibut in samples was higher than census-based proportions, unlike the result in the *American No. 1* study. Mean differences for Pacific halibut and Kamchatka flounder were significantly different from zero for the 100 kg sample size, but not significant at larger sampling fractions. This is most likely a result of the large positive values in sample species composition for these species; at 100 kg, the weight of a single fish makes up a large proportion of the sample. Because larger samples have a greater total sample size but the same mean species weight per fish, the estimated proportion of these species is smaller at the larger sample sizes and the effect of the high values is removed. The extreme rarity of eelpouts (only a few fish per haul) causes almost all of the sample estimates to be zero for this species and results in mean differences that are significantly different from zero at all sample sizes.

Examples of the frequency distribution of differences from the *Seafisher* study are shown in Figure 6. In general, these distributions fall into three distinct groups depending on the overall abundance of the species being sampled. For dominant species in both studies (e.g., yellowfin sole, Fig. 6A), the distribution of the differences was more symmetric around zero for all sample fractions than was the case for the less common species. For the less common species (arrowtooth flounder), differences between sample-based proportion estimates and actual catch proportions had a greater variance and a symmetric to slightly right-skewed distribution, with sample estimates occasionally substantially higher than actual catch proportions. Rare species groups in both studies (Pacific halibut and Kamchatka flounder in Fig. 6C and 6D) show a distinctive, strongly asymmetrical pattern in the differences between sample and census-based estimates.

Simulation Study

We used a simulation study to examine the effects of sampling fraction on the distribution of sample-based estimates of species composition. Results of the simulation study are presented in Table 8 as the mean of the percentage differences between 1,000 simulated sample estimates and the "true" values for the species proportion. This mean difference is converted to a weight based on a total haul weight of 30 t (*Seafisher* haul size) for comparative purposes.

The overall mean percent differences between the true haul weight and the estimated haul weight were relatively small (Table 8) for the more common species and were larger for rare species, e.g., Pacific halibut and eelpouts. There was no pattern of mean sample-estimated weight being larger or smaller than the true haul weight as a function of sampling fraction; all 95% (empirical) intervals contained zero.

The precision of the sample estimates changed substantially with sampling fraction size. The coefficient of variation of the estimates decreased with increasing sample fraction for all of the studied species (Table 9; Fig. 7). The rate of decrease was fastest at the lowest sampling fractions and for rare species. The rate of change in precision with increasing sample fraction slowed above a sample fraction of 6.2%. For the dominant species in the simulated catches, the CV was below 15% at the lowest sampling fraction and was less than 5% at all sampling fractions over 4%. For the rare species, in contrast, the CV was over 300% at the smallest sampling fraction and remained above 30% even at the highest sampling fraction. For Pacific halibut and Kamchatka flounder, sampling fractions of 6.2% or higher were needed to obtain CVs under 100% (Table 9).

At small sampling fractions, the distributions of estimated species weights (Fig. 8) for simulated samples were similar to those seen in the *Seafisher* data. Distributions for rare species were strongly right-skewed at low sampling fractions but became progressively less skewed (smaller positive errors) at increasing sampling fractions. As illustrated in Figure 8D, however, distributions for Pacific halibut did not approach symmetry until the very largest sampling fraction (37.2%).

For all species, the percentage of simulated sample values greater than the true value was generally equal to or less than 50%. In other words, for a single outcome of a sampling event, the chances of overestimating the catch is equal to or less than the chances of underestimating the catch (Table 10). For the rare species, the probability of estimates greater than the true value was less than 20% at the smallest sampling fractions, but 50-100% of the estimates at these fractions were more than double the true value (Table 11). Increasing sample fraction increased the frequency of estimates slightly greater than the true value, but decreased the frequency of large overestimates. Notice that for the largest sampling fraction, the probability of overestimation is approximately equal to the probability of underestimation for all species.

Components of Variation

The mean and CV (standard deviation of the estimates / mean) for estimated species proportions based on a 300 kg sample of each haul is shown in Table 12. These values are compared to the mean and CV of the production or census-based proportions for each study.

Discussion

Alternatives for Selection of Catch Composition Samples

Overall, the initial catch estimates (volume of net) were strongly correlated with the final flow scale weights of the total catch. The use of flow scales has been recommended for Alaskan fleet, since they provide a more accurate measurement both of total catch weight and of sample weight and increase the precision of catch composition estimates (Dorn et al. 1997, Dorn et al. 1999). In both these studies, using the volume of the net as an index of catch tended to overestimate the size of the haul. For this reason, the AFSC observer program currently uses flow scales to determine total haul weight in lieu of volume-based estimates (AFSC 2006)

On the FV *American No. 1*, the samples were taken systematically (random) throughout the entire haul while on the FV *Seafisher* samples were selected from the estimated weight of the haul based on a simple random sample design. Use of the computer systems and initial estimates of haul size to determine sample selection points resulted in a variable number of samples collected per haul (3 to 8). Where the initial estimated weight was too high, fewer samples than desired could be collected. On the FV *Seafisher*, where the initial estimate of haul weight was too low, the last portion of the haul was not included in the random selection of samples from total catch. In the presence of stratification in the catch, this could introduce a small sampling bias. In addition, selection of true random samples was problematic when the samples were closely spaced. On several occasions, samplers were overwhelmed when back-to-back samples had to be collected. To alleviate these effects, the AFSC observer program currently advocates selection of a random start point (weight) and collection of systematic samples thereafter.

A second component of the prototype sample selection system used on the FV *Seafisher* was the use of electronic monitoring (EM), which enabled samplers to monitor multiple locations in the catch processing system. Automated catch sampling systems with EM enabled observers to expend less effort and collect higher quality data. Such systems both facilitate the sampling process and may act as a deterrent against any pre-sorting of catch.

In both of these studies, the catch composition for all species was based on a fixed sample weight. In some situations, however, it may be desirable to estimate proportions for common and rare species separately, using different sample sizes. Based on the results of the studies presented here a large sampling fraction is critical for precise estimation of rare species composition, but smaller fractions may be adequate for predominant target species. Where the catch is dominated by one or two species (as on the FV *Seafisher*), different sampling fractions are sometimes implemented by estimating the proportion for the common species from a sample, and processing the entire haul for a census of all remaining species. Different sample sizes can also be obtained by splitting a large initial sample (into halves, quarters, etc); the entire sample is processed for rare species, but only one of the smaller splits is processed for common species. Where the catch is a complex mixture of several dominant species, however (as on the FV *American No. 1*), complex sampling approaches are usually not feasible. In Alaska, observers maintain a single sample size within a haul, however, that sample size is the maximum the observer is able to collect given the vessel's configuration and the diversity of the haul.

Precision of Sample Estimates

One of the major goals of both of these studies was to quantify the precision of sample estimates. The differences in overall composition of the catch in the two studies allowed us to look at precision over a wide range of relative proportion in the catch. Not surprisingly, precision of catch estimation was greatest for species that made up the largest proportions of the catch, and became progressively poorer for less common species. General results were quite different for the two studies, reflecting the different nature of the catches.

The *American No. 1* study had a much more diverse catch and a much higher variability between hauls. This was in part due to instructions given to the vessel prior to study implementation and was part of the study design. The sample fractions used in this study varied from 1% (100 kg samples) to 6% (600 kg samples), while the sample fractions for the *Seafisher* study ranged from 0.3% (100 kg samples) to 2% (600 kg samples). Given the larger sampling fraction, we may have expected the *American No. 1* results to be less variable than the *Seafisher* results. Catches in the *Seafisher* study were highly consistent among hauls, in part due to the design of the study, with very low variability in the census-based proportions, even for the rare species. While the majority of the variability in the *American No. 1* data is a reflection of variability in species composition, some of this variability may also come from estimating target species haul weights from production data. In either case, the two data sets serve to illustrate the differing conditions that may occur in these types of fisheries.

In both studies, increasing the sample size from 100 kg to 300 kg or 600 kg had little effect on the precision of estimates for dominant species, but substantially increased the precision for rarer species. This change in the variability for rare species is related to the sampling fraction used. Both study data and simulations indicated that the greatest increases in precision with increasing sample fraction occurred for rare species groups.

The frequency distribution of differences between sample- and census-based estimates from both studies show that for species making up less than 1% of the catch, catch estimates are less precise and have a highly skewed distribution. We feel that this is one of the most important finding of these studies. While differences for dominant species tended to be symmetric about zero, those for rare species were consistently strongly right-skewed, with a high frequency of small negative differences (small underestimates), and a low frequency of positive differences (large overestimates).

The fact that observers sample the catch in discrete units limits the possible sample outcomes for very rare species (either an individual fish is included in the sample or not). In cases where the rare species is present in the haul but not included in the sample, the sample-based estimate of zero will be lower in the sample-based species proportion than the true census-based proportion. In samples where even one individual of the rare species is included in the sample, the weight of that one individual makes up a larger fraction of the sample weight than the true census-based proportion, so the sample-based estimate of the species proportion is much larger than the census-based proportion. The smaller the total sample weight and the larger the individual fish, the more the sample fraction of the rare species is exaggerated. The effect is especially problematic for species such as Pacific halibut where individual fish may be very large. In our studies, increasing the sampling fraction from 100 kg to 600 kg reduced the highest positive sampling outcomes but did not eliminate the skewness in the distribution of sample estimates.

The effects of the skewness of the catch estimate distributions may be of concern to fishery managers. Fisheries science has a tendency to rely heavily on arithmetic means because they are both easily computed and unbiased in the statistical sense. Where the underlying distribution from which a sample is drawn is strongly skewed, at small sample sizes the distribution of the sample mean will also be skewed (Conners and Schwager 2002). Where highly precise estimates of rare species catch are needed, large fractions of the haul must be examined to determine species composition of the haul. This is only practical where belt systems and flow scales make large portions of the catch accessible to the observer and where the catch is relatively "clean" (consisting primarily of one or two target species). The additional time and effort required for the observer to sort a large catch fraction is likely to limit the feasibility of this sampling approach.

Stratification

A long-standing concern with sampling catch on trawl vessels is that mechanical sorting and stratification of fish in mixed catches might result in bias of catch composition estimates. The *American No. 1* experiment showed that such stratification can occur, with all four of the major target species showing some trend in species proportion with sample order. The strongest effect was for walleye pollock, which tended to increase significantly toward the bottom portion of the codend. The effect of this sorting accounted for less than 20% of the overall variability in estimated sample proportion. Observers are made aware of the possibility of stratification and advised to mitigate for it by taking samples throughout the haul. On vessels where fish holds and conveyor belt systems are used, stratification effects can be neutralized by using a systematic, rather than random, sampling scheme because this ensures sampling throughout any given haul. In addition, since most vessels do not have baffles or other devices that prevent mixing of fish in the hold, the results observed on the FV *American No. 1* are likely to be more pronounced than in many other fishing situations where the catch is allowed to mix in the hold or on deck prior to sorting and processing. We expect that in most cases, species sorting or stratification produces only a slight increase in the variance of the observer catch composition estimates, and that over a combination of hauls and vessels, its effects will be minimal. Further, vessels with different processing protocols will have different stratification effects, so attempting to adjust for every situation would be difficult.

Accuracy of Sample Estimates

Systematic biases as a result of sample selection would have shown up in our analysis of the differences between sample estimates and their corresponding production or census-based estimates and in tests of whether the means of these differences were zero. The four dominant groundfish from the *American No. 1* study had small but consistently positive differences from zero at all sample sizes. This could indicate a positive bias in the sample estimates (overestimation) or it could indicate that the haul weight of these species was underestimated. Production estimates of target species weight are subject to variability in case counts, PRRs, and case weights. Based on at-sea experience, we believe that the small bias we saw may be a result of underestimating the discard portion of the "production plus discard" estimates, rather than a mechanical bias in sample selection. It is not, however, possible to verify this with the available data.

Sample-based species composition estimates that compared with census-based data (rare species in the *American No. 1* study and all species on the *Seafisher* study), showed no consistent pattern in the data or test results indicating no sampling bias except for very rare species (eelpouts) and at very low sampling fractions (100 kg). Sample estimates for Pacific halibut tended to be lower than census-based estimates for the *American No. 1* study but higher than census-based estimates for the *Seafisher* study. Differences between sample and census-based estimates for halibut were significant in both studies at the lowest sampling fraction, but not at larger sample sizes. The direction of the mean error for yellowfin sole was also not consistent between the two studies. The mean difference in species proportion was significantly different from zero only in the *American No. 1* study where the sample-based catch estimates were compared to production estimates. The extreme rarity of eelpouts in the *Seafisher* study led to a significant tendency to underestimate the true census-based proportion, since eelpouts were usually completely absent from samples while present in small numbers in the census-based census. The difference in estimated catch weight due to this bias is small.

In both studies, the significance (P-value) of the differences between sample and census-based estimates does not appear to be a function of the sampling fraction. This may be a result of decreasing replication as the sampling fraction increases. For example, in the *Seafisher* study there were 174, 100 kg samples, but only 26, 600 kg samples. The smaller population of differences at the larger sample sizes may mask small changes in the average difference.

Simulation Study

Based on the simulation results, there was no evidence of systematic bias in the estimation of species composition. There was, however, an asymmetric pattern in sample estimates for rare species and a decreasing trend in the coefficients of variation of the estimates (increasing precision) with increasing sampling fraction. The CVs of sample estimates decreased progressively with increasing sampling fraction for all species. While the overall difference in precision increasing with sample fraction was small for the dominant target species, gains in accuracy for rare species were substantial.

The simulation analysis was used to assess the performance of sample-based estimators for a population similar to that seen in the *Seafisher* study, but over a wider range of sampling fractions than could be processed in the field. For rare species at the lowest sampling fractions, the probability of a sample estimate being higher than the true catch rate was less than 20% (Table 12). There was, however, a small probability (less than 15%) of a sample estimate of more than double the true value (Table 13). When used in haul-based accounting systems, such as that currently used by the Alaska Regional Office, this distribution means that most of the time the catch of rare species would be under-reported, but an occasional high sample estimate may trigger management actions based on non-target catch quotas. At higher sampling fractions the distribution of errors for rare species more closely resembled those for common species, with the probability of small overestimation generally equal to or less than the probability of underestimation.

Variance Components

Our results suggest that optimal allocation of observer effort may depend on the relative importance of different management goals, and that it may not be possible to design a single sampling plan that will address all goals equally. One of the components of managing and designing observer programs is determining the frequency of sampling and the standard sample size. For the dominant groundfish species in each study, standard deviations of the 300 kg sample estimates are roughly the same magnitude as the standard deviation of the census-based estimates, suggesting that most of the variability comes from the between-haul component. For these species, where sample-based haul level estimates of catch composition are fairly precise, collection of samples from a large number of hauls would give the greatest information on spatial and temporal variability in catch.

For rare species, in contrast, the deviation among sample estimates within a haul is larger than the deviation among census-based measurements, indicating additional within-haul sampling variance. This is especially true for the *Seafisher* study, where census-based species composition was highly consistent over the study, and the CVs for sample estimates of rare species are several times larger than those for census-based measurements. For these rare species, sample-based haul-level estimates are likely to be highly variable unless a large sampling fraction is used. In the case of rare species, within-haul sampling variance was much larger than between-haul sample variance in these studies. If the most important management goal is precise catch composition estimates for rare species (e.g., for regulation of prohibited species catch), then the high sampling variance must be reduced either by using as large a sampling fraction as possible for these groups, or by aggregating data over multiple hauls to make total catch calculations. Depending on management goals, design of an observer sampling program may need to balance data needs for common and rare species.

Conclusions

Observer sample data, reported on a haul-specific basis, provide the basis for real-time management of catch quotas for a wide variety of fisheries. The increased use of flow scales in the Alaskan fleet has increased the accuracy of catch estimation, and the experimental catch sampling system tested here has the potential to further automate and streamline the system. The use of electronic monitoring, in particular, appears to have the potential to increase compliance with catch-sorting protocols and further smooth the sampling process.

Results of these field studies indicate that existing observer sampling protocols based on 300 kg standard samples provide accurate estimates of catch composition for abundant and common components of the catch. While there was evidence of small effects from stratification, sample estimates of proportion were in agreement with production or census-based estimates.

Even small samples (100 kg) provided low-CV estimates of catch composition for target species. There was an apparent small positive sampling bias when compared with production-plus-discard estimates, but we suspect this bias is due to difficulty in accurately measuring discards during processing. When sample estimates were compared to census-based proportions, there was no significant sampling bias.

Estimation for rare species, however, is problematic. Where management of a fishery includes catch limits on rare non-target species, poor precision of estimation of catch for these species has potentially serious consequences. The strongly asymmetric distribution of estimates, in particular, shows that these groups need to be treated with special caution. If precise estimation of catch of rare species is desired, large sampling fractions are needed to provide estimates on a per-haul basis. Where large sampling fractions cannot be achieved, then combined estimates over a number of hauls are needed to smooth the zero-one effect of whether the species is represented in the sample. A fishery regulated on a haul-specific basis for rare species catch is likely to underestimate the true catch for most hauls but drastically overestimate the total catch for a few hauls. This type of variability can be difficult to incorporate into fisheries management based on small, sometimes vessel-specific quotas.

As the demands placed on observer data increase, conflicting management goals will demand more attention to allocation of observer sampling effort. Our results suggest that, for dominant or target species in Alaska, the current minimum sampling level of 300 kg per haul is adequate. For precise estimation of rare species, however, larger sampling fractions may be required. Where larger sampling fractions cannot be used, the high variance and skewed distribution of sample estimates for rare species proportion must be recognized.

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Table 1. -- Population characteristics for sampling simulations. Haul size, composition, and mean and variance of weight per fish are based on *Seafisher* data; weight per fish distributions are assumed.

	Arrowtooth	Eelpout	Halibut	Kamchatka	Yellowfin	Other
Percentage of Study Haul	2.42%	0.006%	0.64%	0.046%	82%	14.4%
True Percentage of Simulated Haul	2.4257%	0.0067%	0.6563%	0.0454%	80.9645%	15.9013%
Total Weight of Species in Simulated Haul	684.18 kgs	1.9 kgs	185.12 kgs	12.82 kgs	22836.57 kgs	4485.08 kgs
Weight per Fish Distribution	Normal	Normal	Lognormal	Normal	Normal	Normal
Mean Weight per Fish	0.610	0.330	4.340	0.601	0.280	5.200
Variance of Weight per Fish	0.044	0.370	4.140	0.200	0.016	8.600

Table 2. -- Catch composition by species based on assessment of the entire haul for experiments aboard the *American No.1* and the *Seafisher.* Source of species composition is based on production plus discard estimates (P&D), total enumeration of all individuals in the haul (Census) or total haul weight minus the census weight of all other species (Difference).

	Number Zero	Minimum	Maximum	Mean	Standard deviation	CV (SD/ mean)	Source
American Number 1							
Flathead sole	0	0.0036	0.5160	0.1837	0.1116	61%	P&D
Yellowfin sole	0	0.0015	0.5359	0.1805	0.1515	84%	P&D
Walleye pollock	0	0.0001	0.5880	0.1561	0.1462	94%	P&D
Pacific cod	0	0.0137	0.2267	0.0938	0.0517	55%	P&D
Alaska plaice	1	0.0000	0.2506	0.0356	0.0554	156%	P&D
Skate	0	0.0044	0.1194	0.0253	0.0210	83%	Census
Pacific halibut	0	0.0012	0.0364	0.0094	0.0065	70%	Census
Opilio (snow) crab	0	0.0007	0.0249	0.0043	0.0046	109%	Census
Bairdi (Tanner) crab	0	0.0001	0.0325	0.0022	0.0044	198%	Census
Red king crab	44	0.0000	0.0014	0.0002	0.0004	200%	Census
Seafisher							
Yellowfin sole	0	0.696	0.911	0.8225	0.0553	7%	Difference
Arrowtooth flounder	0	0.014	0.042	0.0242	0.0065	27%	Census
Pacific halibut	0	0.002	0.017	0.0064	0.0031	49%	Census
Kamchatka flounder	0	0.0002	0.001	0.0005	0.0002	45%	Census
Eelpout (all species)	0	0.000004	0.0002	0.00006	0.00004	63%	Census

Table 3. -- Summary of sample estimates of species proportion for the *American No.1* study. Summary statistics over all sample estimates based on sample sizes of 100 kg, 300 kg, 600 kg , and all samples in haul (300-800 kg).

Species	Size of sample kg	Number of estimates	Number Zero estimates	Minimum	Maximum	Mean	Standard deviation	CV (SD/ mean)
Yellowfin sole	100	347	7	0.00%	83.76%	21.05%	0.1729	82%
Yellowfin sole	300	91	1	0.00%	70.02%	20.37%	0.1659	81%
Yellowfin sole	600	29	0	0.81%	69.63%	20.08%	0.1741	87%
Yellowfin sole	ALL	62	0	0.60%	69.63%	21.24%	0.1647	78%
Flathead sole	100	347	3	0.00%	69.83%	20.93%	0.1332	64%
Flathead sole	300	91	0	1.05%	5.91%	21.21%	0.1229	58%
Flathead sole	600	29	0	1.39%	47.60%	1.99%	0.1138	57%
Flathead sole	ALL	62	0	1.39%	55.23%	20.15%	0.1163	58%
Walleye pollock	100	347	17	0.00%	77.99%	17.22%	0.1657	96%
Walleye pollock	300	91	0	0.13%	66.85%	17.74%	0.1562	88%
Walleye pollock	600	29	0	10.83%	59.02%	18.04%	0.159	88%
Walleye pollock	ALL	62	0	1.08%	6.59%	17.01%	0.1569	92%
Pacific cod	100	347	24	0.00%	42.09%	10.60%	0.089	84%
Pacific cod	300	91	0	0.70%	31.79%	10.41%	0.0685	66%
Pacific cod	600	29	0	2.17%	26.01%	10.54%	0.0723	69%
Pacific cod	ALL	62	0	2.17%	26.01%	10.73%	0.0623	58%
Alaska plaice	100	347	121	0.00%	43.50%	4.10%	0.0716	175%
Alaska plaice	300	91	12	0.00%	31.73%	4.24%	0.0705	166%
Alaska plaice	600	29	1	0.00%	28.96%	0.90%	0.0817	160%
Alaska plaice	ALL	62	2	0.00%	28.96%	4.14%	0.0652	157%
Skate	100	347	214	0.00%	33.35%	2.54%	0.0506	199%
Skate	300	91	29	0.00%	22.10%	2.46%	0.0351	143%
Skate	600	29	5	0.00%	18.27%	2.62%	0.3592	137%
Skate	ALL	62	9	0.00%	18.27%	2.75%	0.1579	115%
Pacific halibut	100	347	292	0.00%	19.57%	0.78%	0.0249	317%
Pacific halibut	300	91	55	0.00%	7.29%	0.79%	0.0145	183%
Pacific halibut	600	29	10	0.00%	5.25%	0.98%	0.0133	136%
Pacific halibut	ALL	62	29	0.00%	6.01%	0.85%	0.013	152%
Opilio crab	100	347	156	0.00%	11.61%	0.53%	0.011	207%
Opilio crab	300	91	15	0.00%	4.15%	0.48%	0.0066	138%
Opilio crab	600	29	1	0.00%	2.24%	0.50%	0.0052	104%
Opilio crab	ALL	62	3	0.00%	2.70%	0.54%	0.0056	104%
Bairdi crab	100	347	194	0.00%	70.16%	0.25%	0.006	246%
Bairdi crab	300	91	21	0.00%	1.12%	0.20%	0.0025	123%
Bairdi crab	600	29	2	0.00%	0.95%	0.21%	0.0022	102%
Bairdi crab	ALL	62	6	0.00%	4.52%	0.27%	0.006	222%
Red King crab	100	347	346	0.00%	1.98%	0.01%	0.0011	1863%
Red King crab	300	91	91	0.00%	0.00%	0.00%	0	
Red King crab	600	29	29	0.00%	0.00%	0.00%	0	
Red King crab	ALL	62	61	0.00%	0.90%	0.01%	0.0011	787%

Table 4. -- Summary of sample estimates of species proportion for the *Seafisher* study. Summary statistics over all sample estimates based on sample sizes of 100 kg, 300 kg, 600 kg , and all samples in haul (300-600 kg).

Species	Size of sample	Number of estimates	Number Zero estimates	Minimum	Maximum	Mean	Standard deviation	CV (SD/ mean)
Yellowfin sole	300	54	0	58.38%	92.93%	81.41%	0.0683	8%
Yellowfin sole	600	26	0	64.87%	91.65%	81.39%	0.0623	8%
Yellowfin sole	ALL	30	0	64.87%	91.65%	81.80%	0.0611	7%
Arrowtooth flounder	100	174	3	0.00%	7.55%	2.39%	0.0148	62%
Arrowtooth flounder	300	54	0	0.77%	6.06%	2.41%	0.0113	47%
Arrowtooth flounder	600	26	0	1.01%	4.23%	2.45%	0.0088	36%
Arrowtooth flounder	ALL	30	0	1.01%	4.24%	2.38%	0.0085	36%
Pacific halibut	100	174	143	0.000%	24.250%	0.890%	0.0298	336%
Pacific halibut	300	54	29	0.000%	80.460%	0.880%	0.0164	185%
Pacific halibut	600	26	10	0.000%	5.710%	0.890%	0.0132	149%
Pacific halibut	ALL	30	12	0.000%	5.710%	0.860%	0.1263	147%
Kamchatka flounder	100	174	158	0.000%	0.890%	0.050%	0.0017	339%
Kamchatka flounder	300	54	41	0.000%	0.530%	0.050%	0.0011	213%
Kamchatka flounder	600	26	14	0.000%	0.230%	0.050%	0.0007	130%
Kamchatka flounder	ALL	30	18	0.000%	0.230%	0.050%	0.0007	145%
Eelpout	100	174	168	0.000%	0.290%	0.005%	0.0003	599%
Eelpout	300	54	50	0.000%	0.120%	0.005%	0.0002	409%
Eelpout	600	26	22	0.000%	0.060%	0.006%	0.0002	280%
Eelpout	ALL	30	25	0.000%	0.060%	0.006%	0.0002	275%

Table 5. -- Results of testing for stratification effects from the *American No. 1* study: a) linear regression tests of species proportion versus relative position in the haul; b) ANOVA testing significance of sample position as first, middle, or last third of the haul. Sample proportions were arcsine transformed prior to testing.

a) Linear Regression Analysis: Slope of species proportion versus sample position

Species	Parameter estimate	Standard error	T-statistic	P-value
Flathead sole	-0.033273	0.01554674	-2.140	**0.0330**
Alaska plaice	-0.033402	0.01205449	-2.771	**0.0059**
Yellowfin sole	-0.063835	0.01267762	-5.035	**0.0001**
Walleye pollock	0.139139	0.01480773	9.396	**0.0001**
Pacific cod	0.082011	0.02177592	3.766	**0.0002**
Opilio crab	-0.009021	0.00858211	-1.051	0.2939
Bairdi crab	0.008681	0.00535697	1.621	0.1060

b) ANOVA anaysis, with position in haul classified as first, middle, or last third of haul (df = 2 for all species).

Species	Mean square error	F-statistic	P-value
Flathead sole	0.02065530	3.05	**0.0485**
Alaska plaice	0.01411044	3.45	**0.0329**
Yellowfin sole	0.08268896	18.93	**0.0001**
Walleye pollock	0.23610570	37.07	**0.0001**
Pacific cod	0.15780787	12.18	**0.0001**
Opilio crab	0.00089297	0.43	0.6502
Bairdi crab	0.00067982	0.84	0.4324

Table 6. -- Results of significance testing on differences between sample estimates and whole-haul species proportion for the *Seafisher* study. For each sample size, differences were calculated between sample estimates and whole-haul proportions for that haul. Tests are over all differences against the null hypothesis that the mean is equal to zero. The true species percent is the mean of whole-haul percentages for those hauls included in the analysis.

Sample size	No. of samples	Species	Source of WH est.	True species percent	Mean difference	Mean percent difference	Wilcoxon test P-value
100	174	Yellowfin sole	Subtraction	82.25%	-0.57%	-0.66%	0.5833
300	54	Yellowfin sole	Subtraction	82.10%	-0.68%	-0.77%	0.5875
600	26	Yellowfin sole	Subtraction	82.25%	-0.69%	-0.80%	0.3740
ALL	30	Yellowfin sole	Subtraction	82.25%	-0.46%	-0.52%	0.5647
100	174	Arrowtooth flounder	Census	2.42%	-0.03%	-1.71%	0.1895
300	54	Arrowtooth flounder	Census	2.43%	-0.01%	-0.01%	0.3845
600	26	Arrowtooth flounder	Census	2.42%	0.00%	-0.52%	0.4461
ALL	30	Arrowtooth flounder	Census	2.42%	-0.04%	-2.08%	0.2410
100	174	Pacific halibut	Census	0.640%	0.252%	21.55%	**0.0000**
300	54	Pacific halibut	Census	0.630%	0.251%	21.04%	0.7895
600	26	Pacific halibut	Census	0.640%	0.245%	19.73%	0.9797
ALL	30	Pacific halibut	Census	0.640%	0.224%	17.74%	0.8050
100	174	Kamchatka flounder	Census	0.050%	0.006%	0.11%	**0.0000**
300	54	Kamchatka flounder	Census	0.050%	0.006%	-1.74%	0.1074
600	26	Kamchatka flounder	Census	0.050%	-0.008%	2.66%	0.7605
ALL	30	Kamchatka flounder	Census	0.050%	0.000%	-11.03%	0.7112
100	174	Eelpout	Census	0.0100%	-0.0010%	-12.62%	**0.0000**
300	54	Eelpout	Census	0.0010%	-0.0014%	-10.10%	**0.0000**
600	26	Eelpout	Census	0.0100%	-0.0010%	-5.30%	**0.0111**
ALL	30	Eelpout	Census	0.0100%	0.00%	-12.38%	**0.0075**

Table 7. -- Results of significance testing on differences between sample estimates and whole-haul species proportion for the *American No. 1* study. For each sample size, differences were calculated between sample estimates and whole-haul proportions for that haul. Tests are over all differences against the null hypothesis that the mean is equal to zero. The true species percent is the mean of whole-haul percentages for those hauls included in the analysis.

Sample size	No. of samples	Species	Source of WH est.	True species percent	Mean difference	Mean percent difference	Wilcoxon test P-value
100	347	Flathead sole	P&D	19.02%	1.91%	31.31%	**0.0000**
300	91	Flathead sole	P&D	19.38%	1.83%	11.84%	**0.0000**
600	29	Flathead sole	P&D	17.92%	1.95%	13.83%	**0.0002**
ALL	62	Flathead sole	P&D	18.37%	1.78%	31.17%	**0.0000**
100	347	Yellowfin sole	P&D	17.85%	3.20%	80.33%	**0.0000**
300	91	Yellowfin sole	P&D	17.59%	2.78%	76.08%	**0.0000**
600	29	Yellowfin sole	P&D	16.46%	3.62%	106.20%	**0.0001**
ALL	62	Yellowfin sole	P&D	18.05%	3.19%	81.67%	**0.0000**
100	347	Walleye pollock	P&D	15.77%	1.45%	352.09%	**0.0129**
300	91	Walleye pollock	P&D	16.26%	1.48%	307.72%	**0.0097**
600	29	Walleye pollock	P&D	16.54%	1.50%	13.57%	**0.0164**
ALL	62	Walleye pollock	P&D	15.61%	1.40%	366.49%	**0.0055**
100	347	Pacific cod	P&D	9.35%	1.24%	15.11%	**0.0284**
300	91	Pacific cod	P&D	9.27%	1.15%	12.39%	**0.0223**
600	29	Pacific cod	P&D	9.45%	1.10%	10.81%	0.0543
ALL	62	Pacific cod	P&D	9.38%	1.35%	17.15%	**0.0001**
100	347	Alaska plaice	P&D	3.54%	0.56%		0.2674
300	91	Alaska plaice	P&D	3.72%	0.52%	44.11%	**0.0386**
600	29	Alaska plaice	P&D	4.45%	0.64%	41.98%	0.2701
ALL	62	Alaska plaice	P&D	3.56%	0.58%	NA	**0.0076**
100	347	Skate	Census	2.47%	0.07%	3.07%	**0.0000**
300	91	Skate	Census	2.42%	0.05%	8.11%	0.6996
600	29	Skate	Census	2.70%	-0.07%	-5.10%	0.6654
ALL	62	Skate	Census	2.53%	0.23%	9.12%	0.5941
100	347	Pacific halibut	Census	0.92%	-0.36%	-10.02%	**0.0000**
300	91	Pacific halibut	Census	0.90%	-0.10%	0.80%	**0.0045**
600	29	Pacific halibut	Census	0.90%	0.08%	-62.99%	0.7294
ALL	62	Pacific halibut	Census	0.75%	-0.08%	-3.74%	**0.0249**
100	347	Opilio (snow) crab	Census	0.41%	0.12%	58.30%	0.0912
300	91	Opilio (snow) crab	Census	0.40%	0.08%	60.51%	0.6194
600	29	Opilio (snow) crab	Census	0.43%	0.06%	26.86%	0.1474
ALL	62	Opilio (snow) crab	Census	0.43%	0.11%	52.77%	**0.0087**
100	347	Bairdi (Tanner) crab	Census	0.20%	0.05%	33.39%	**0.0044**
300	91	Bairdi (Tanner) crab	Census	0.17%	0.04%	46.47%	0.5383
600	29	Bairdi (Tanner) crab	Census	0.17%	0.05%	66.64%	**0.0876**
ALL	62	Bairdi (Tanner) crab	Census	0.22%	0.05%	26.67%	0.2803

Table 8. -- Comparison of variability of whole-haul and sample-based estimates of catch composition for *the American No.1* and *Seafisher* studies.

	Whole-haul estimates			Sample estimates (300 kg)		
	Mean	Standard deviation	CV (SD/ mean)	Mean	Standard deviation	CV (SD/ mean)
American No. 1						
Flathead sole	18.4%	0.1116	61%	21.21%	0.1229	58%
Yellowfin sole	18.1%	0.1515	84%	20.37%	0.1659	81%
Walleye pollock	15.6%	0.1462	94%	17.74%	0.1562	88%
Pacific cod	9.38%	0.0517	55%	10.41%	0.0685	66%
Alaska plaice	3.56%	0.0554	156%	4.24%	0.0705	166%
Skate	2.53%	0.0210	83%	2.46%	0.0351	143%
Pacific halibut	0.94%	0.0065	70%	0.79%	0.0145	183%
Opilio (snow) crab	0.43%	0.0046	109%	0.48%	0.0066	138%
Bairdi (Tanner) crab	0.22%	0.0044	198%	0.20%	0.0024	123%
Seafisher						
Yellowfin sole	82.3%	0.0553	7%	81.41%	0.0683	8%
Arrowtooth flounder	2.42%	0.0065	27%	2.41%	0.0113	47%
Pacific halibut	0.64%	0.0031	49%	0.88%	0.0164	185%
Kamchatka flounder	0.050%	0.00020	45%	0.052%	0.00110	213%
Eelpout	0.006%	0.00004	63%	0.005%	0.00022	409%

Table 9. -- Estimated mean percent difference between species true haul weight and estimated haul weight (95% interval) for 1,000 simulated hauls.

Sampling fraction (size)	**Parameter**	**Yellowfin sole**	**Arrowtooth flounder**	**Pacific halibut**	**Kamchatka flounder**	**Eelpout**
	True species percent	80.96%	2.43%	0.63%	0.05%	0.007%
	Species weight in 30 t haul	24,288 kg	729 kg	189 kg	15 kg	2.1 kg
0.0035 (100kg)	Mean % difference (95% CI)	2.96% (-24.5, 21.3)	3.8% (-77.2, 124.4)	-18.09% (-100.0, 1188.2)	3.15% (-100.0, 1527.1)	16.66% (-100.0, -100.0)
	Difference in 30 t haul	718 kg	28 kg	-34 kg	< 1 kg	< 1 kg
0.0106 (300kg)	Mean % difference (95% CI)	0.99% (-16.0, 15.9)	1.01% (-50.8, 59.7)	-7.49% (-100.0, 593.1)	-3.20% (-100.0, 569.8)	-20.09% (-100.0, 747.9)
	Difference in 30 t haul	240 kg	7 kg	-14 kg	< -1 kg	< -1 kg
0.0213 (600 kg)	Mean % difference (95% CI)	0.28% (-11.3, 11.3)	-0.2% (-37.4, 42.6)	4.40% (-100.0, 516.8)	1.07% (-100.0, 448.3)	4.75% (-100.0, 1353.8)
	Difference in 30 t haul	68 kg	-2 kg	8 kg	< 1 kg	< 1 kg
0.0425 (1,200kg)	Mean % difference (95% CI)	0.19% (-8.6, 8.5)	0.04% (-26.2, 31.6)	4.31% (-100.0, 332.4)	-2.12% (-100.0, 267.9)	0.49% (-100.0, 795.0)
	Difference in 30 t haul	46 kg	< 1 kg	8 kg	< -1 kg	< 1 kg
0.0620 (1,750kg)	Mean % difference (95% CI)	-0.07% (-6.6, 6.6)	-0.01% (-23.6, 23.6)	0.65% (-100.0, 244.7)	-0.47% (-100.0, 219.7)	6.71% (-100.0, 517.0)
	Difference in 30 t haul	-17 kg	< -1 kg	1 kg	< -1 kg	< 1 kg
0.1240 (3,500kg)	Mean % difference (95% CI)	-0.03% (-4.9, 4.4)	0.07% (-14.6, 16.2)	0.56% (-93.2, 137.1)	1.06% (-100.0, 144.4)	-4.24% (-100.0, 317.8)
	Difference in 30 t haul	-7 kg	< 1 kg	1 kg	< 1 kg	< -1 kg
0.3723 (10,500 kg)	Mean % difference (95% CI)	-0.01% (-2.4, 2.3)	-0.18% (-7.8, 7.7)	-0.21% (-59.0, 64.4)	0.051% (-57.4, 64.0)	-3.34% (-100.0, 136.6)
	Difference in 30 t haul	-2.4 kg	-1.3 kg	< -1 kg	< 1 kg	< -1 kg

Table 10. -- Coefficients of variation (CVs) of weight estimates for each species and sampling fraction in the simulation study.

Nominal sampling fraction	Total sample size	Yellowfin sole	Arrowtooth flounder	Pacific halibut	Kamchatka flounder	Eelpout
0.0035	100 kg	12.70%	50.98%	447.07%	398.76%	834.64%
0.0106	300 kg	8.28%	29.01%	231.71%	228.66%	569.77%
0.0213	600 kg	5.90%	20.50%	170.31%	158.96%	339.43%
0.0425	1,200 kg	4.35%	14.91%	115.19%	110.43%	238.90%
0.0620	1,750 kg	3.50%	12.01%	94.55%	92.27%	191.47%
0.1240	3,500 kg	2.45%	7.97%	62.46%	63.84%	139.79%
0.3720	10,500 kg	1.18%	4.03%	32.38%	30.66%	68.67%

Table 11. -- Percentage of simulation estimates greater than the true value.

Nominal sampling fraction	Total sample size	Yellowfin sole	Arrowtooth flounder	Pacific halibut	Kamchatka flounder	Eelpout
0.0035	100 kg	64.8%	50.4%	9.3%	6.5%	2.1%
0.0106	300 kg	57.8%	50.9%	19.2%	19.2%	4.7%
0.0213	600 kg	53.1%	47.5%	27.7%	33.7%	12.6%
0.0425	1,200 kg	52.5%	49.6%	40.8%	48.5%	23.4%
0.0620	1,750 kg	51.3%	50.0%	41.9%	40.8%	22.5%
0.1240	3,500 kg	50.8%	48.3%	44.3%	45.1%	27.0%
0.3720	10,500 kg	50.3%	47.7%	48.3%	48.8%	49.7%

Table 12. -- Percentage of simulation estimates greater than twice true value (+100% error).

Nominal sampling fraction	Total sample size	Yellowfin sole	Arrowtooth flounder	Pacific halibut	Kamchatka flounder	Eelpout
0.0035	100 kg	0%	0.1%	5.5%	6.5%	2.1%
0.0106	300 kg	0%	0%	12.1%	17.0%	4.7%
0.0213	600 kg	0%	0%	11.4%	10.6%	9.0%
0.0425	1,200 kg	0%	0%	8.0%	6.0%	9.1%
0.0620	1,750 kg	0%	0%	3.8%	3.5%	14.5%
0.1240	3,500 kg	0%	0%	0.6%	0.4%	14.0%
0.3720	10,500 kg	0%	0%	0%	0%	0.0%

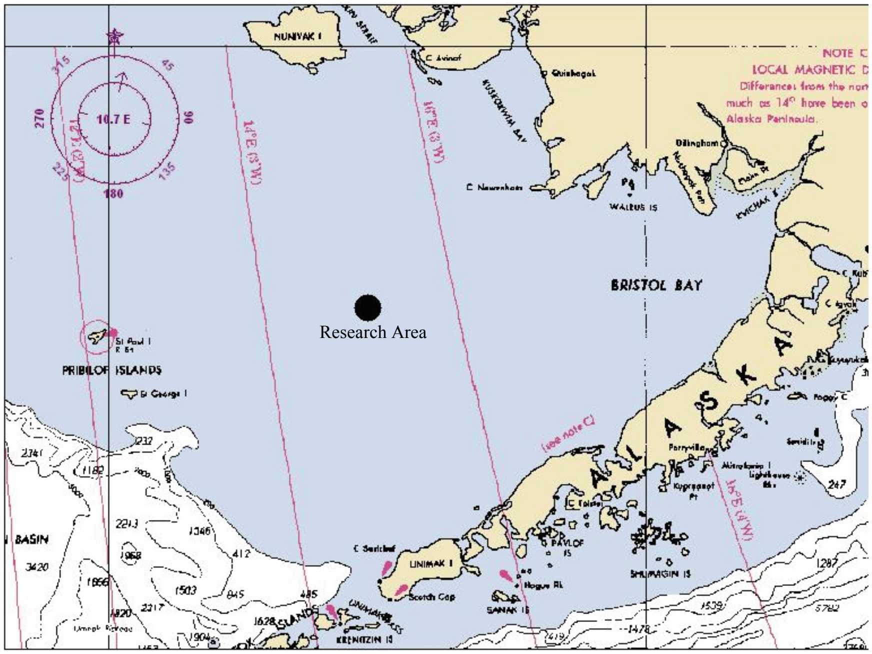


Figure 1. -- Location of research area in the eastern Bering Sea.

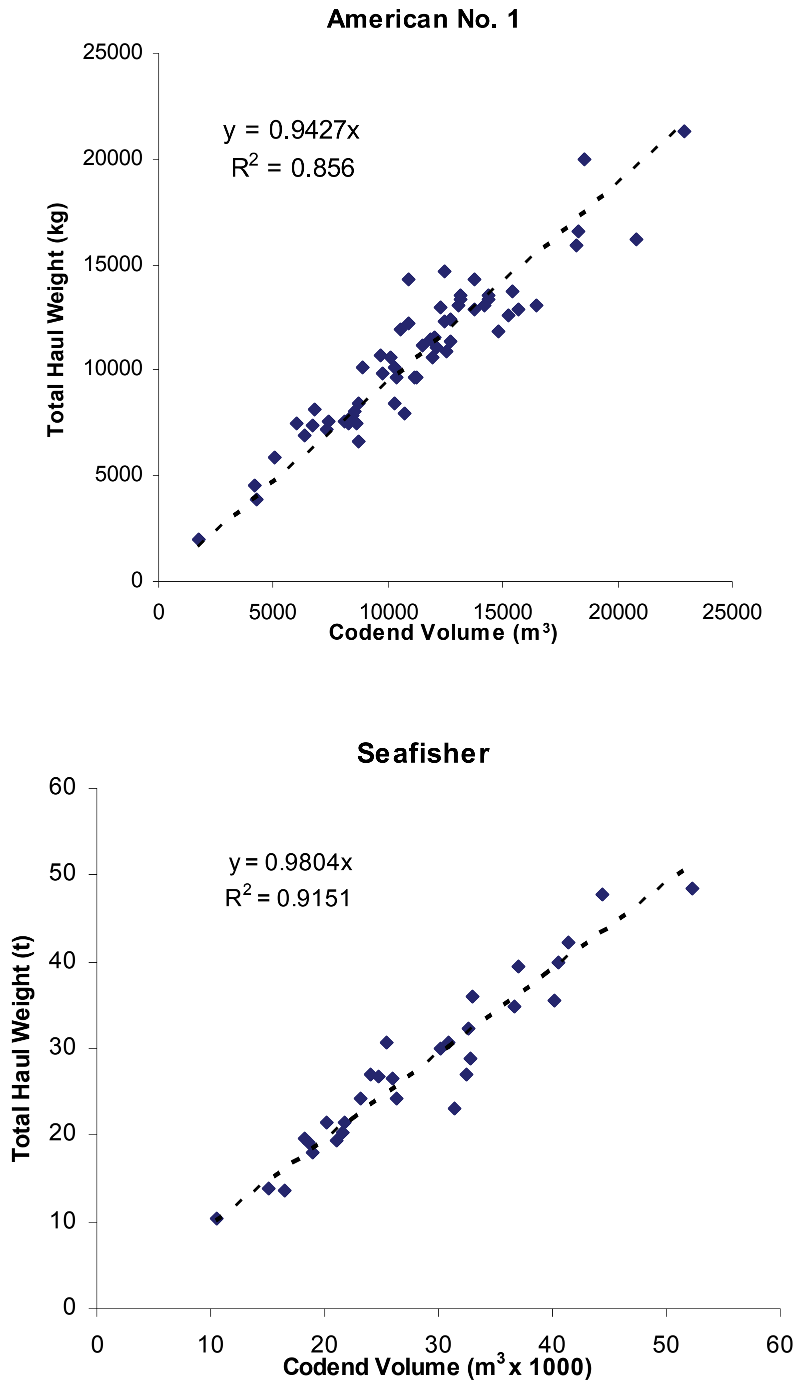
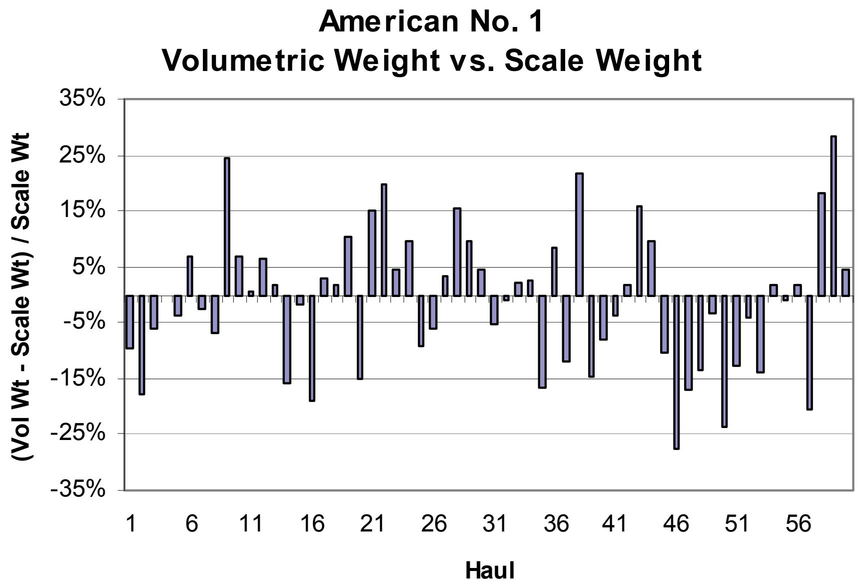


Figure 2. -- Regression of codend volume to measured flow scale weight for hauls: a) *American No. 1*, b) *Seafisher.*



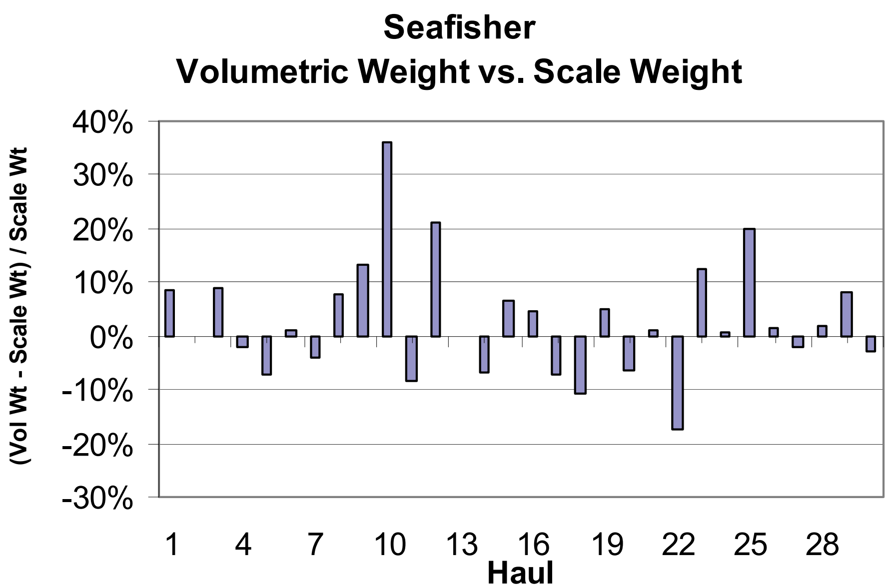


Figure 3. -- Percent difference between volumetric estimates and measured flow scale weights for a) *American No.1* and b) *Seafisher* experiments.

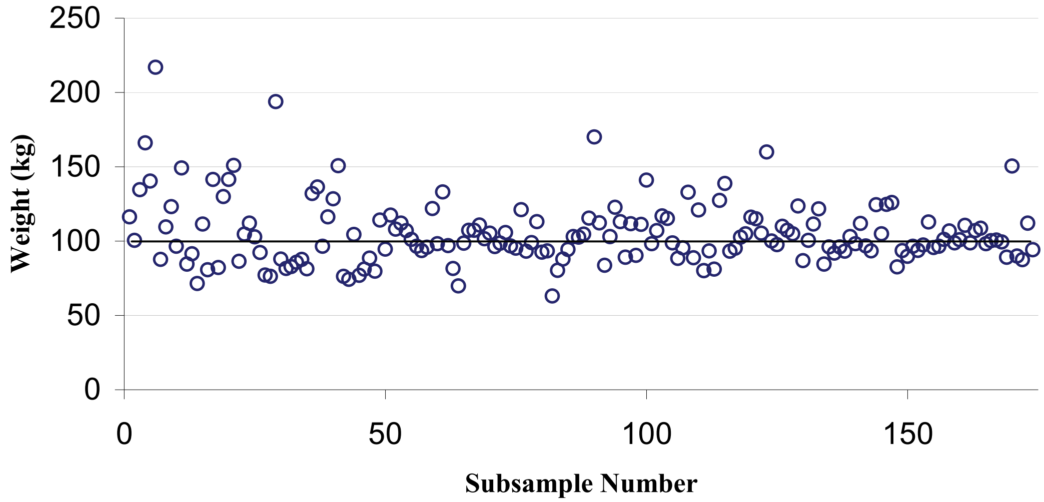


Figure 4. -- Individual sample weights collected by the automated catch sampling system over 30 hauls. The target sample weight was 100 kg.

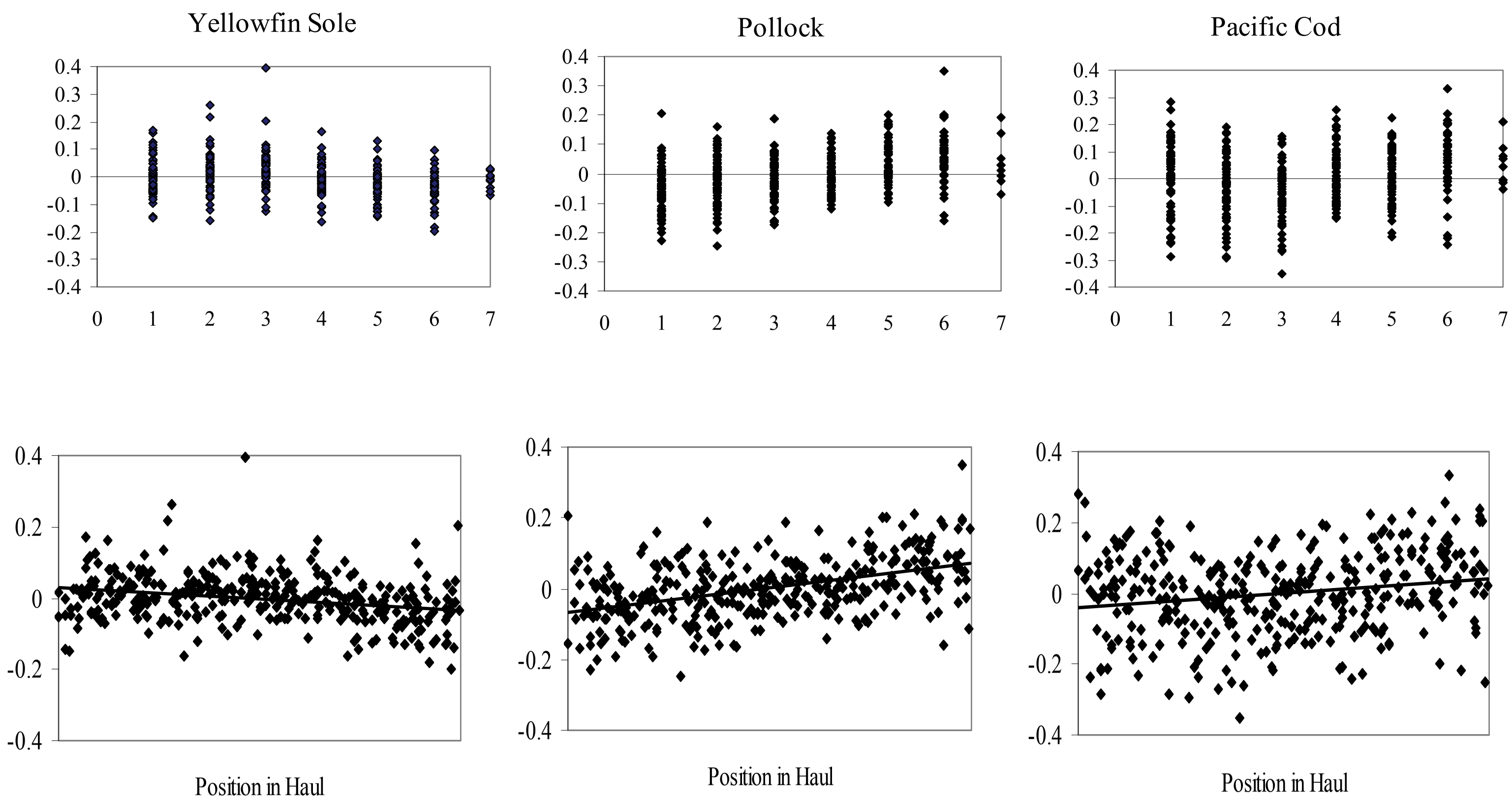


Figure 5. -- Examples of sample proportion estimates (difference between sample and overall mean proportions, arcsin transformed) as a function of relative position of sample in the haul from the *American No. 1* study. The y-axis units are deviance from the mean proportion. Trend lines in lower row are best linear fit model.

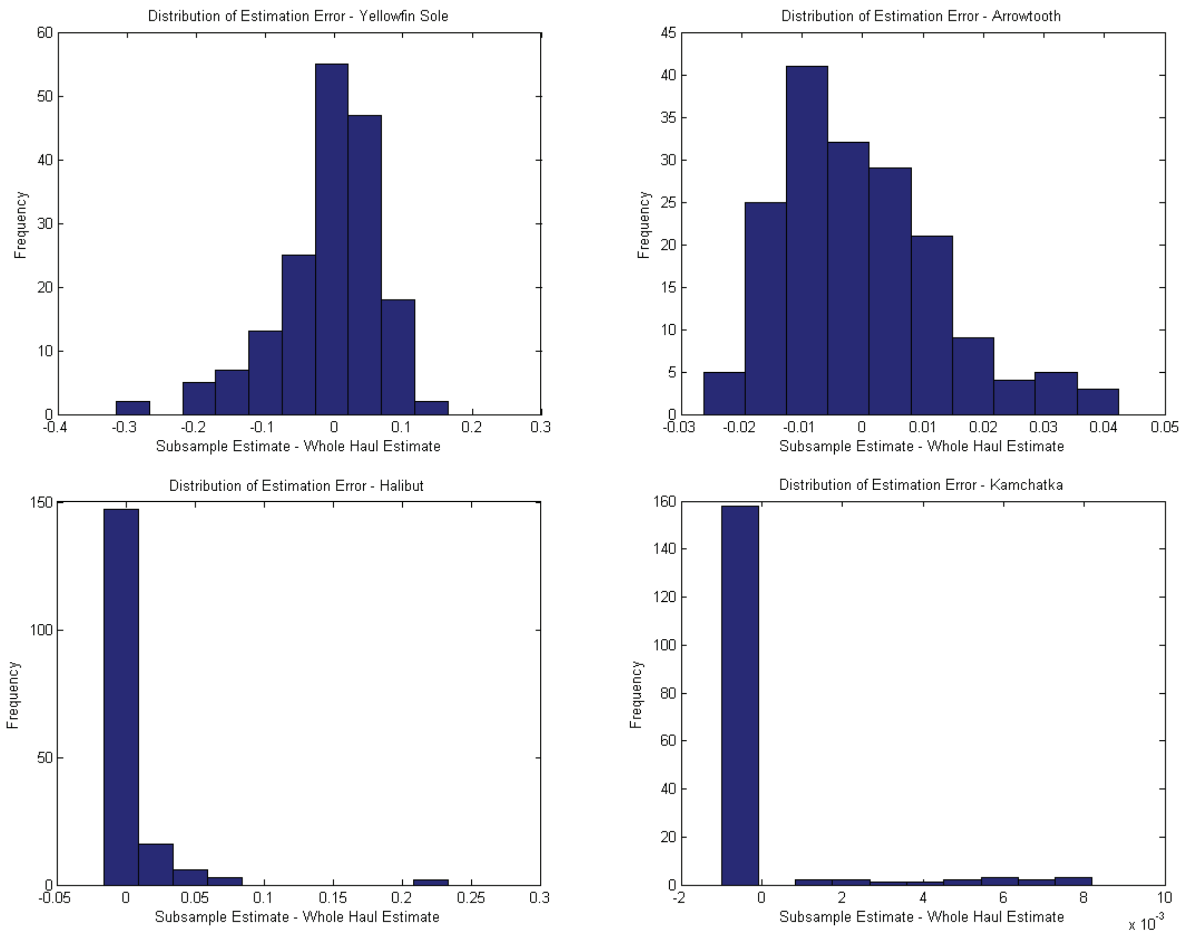
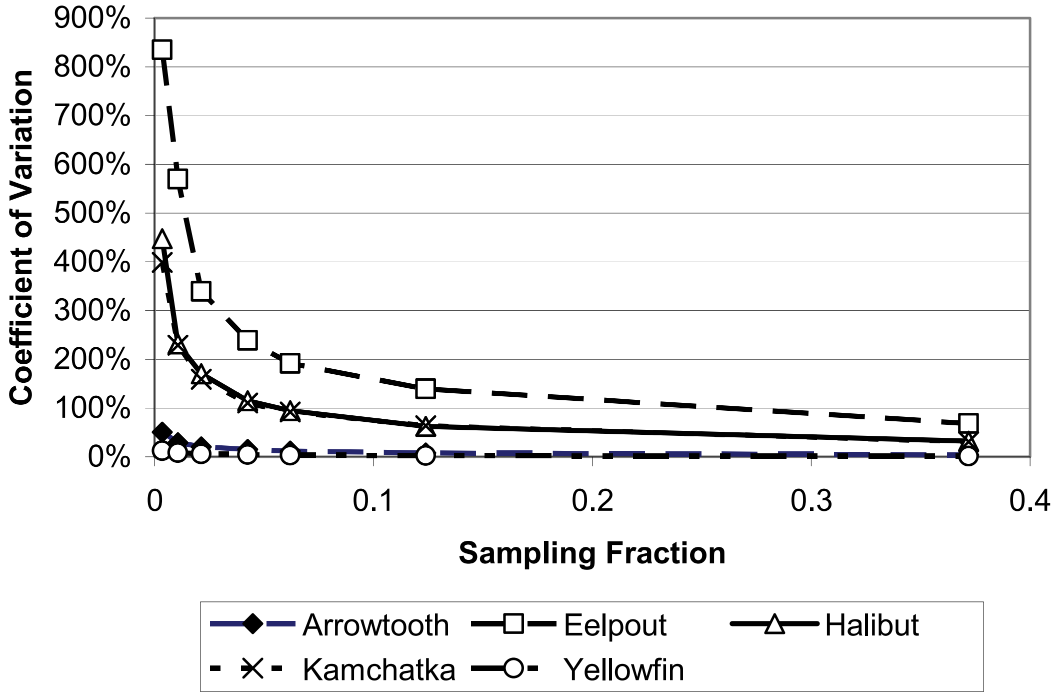


Figure 6. -- Examples from the Seafisher study of frequency distribution of differences between species proportion estimates based on 100 kg samples and whole-haul census.



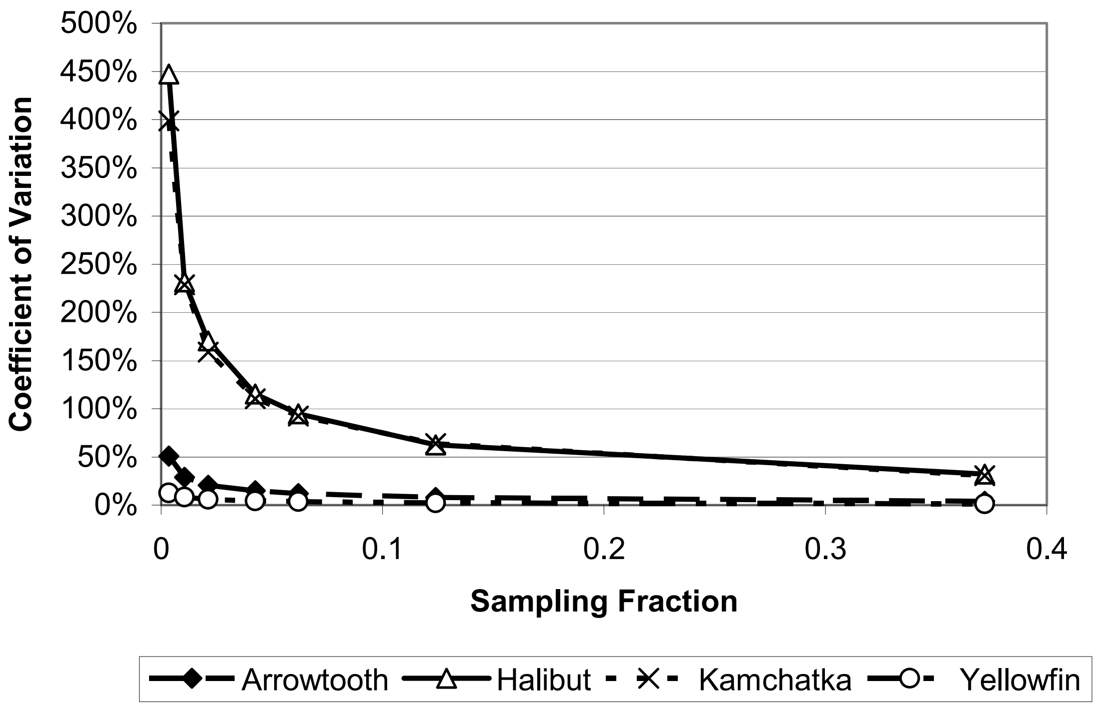


Figure 7. -- Coefficient of variance (CV) of weight estimates as a function of sampling fraction for each species (left) and omitting eelpouts (right).

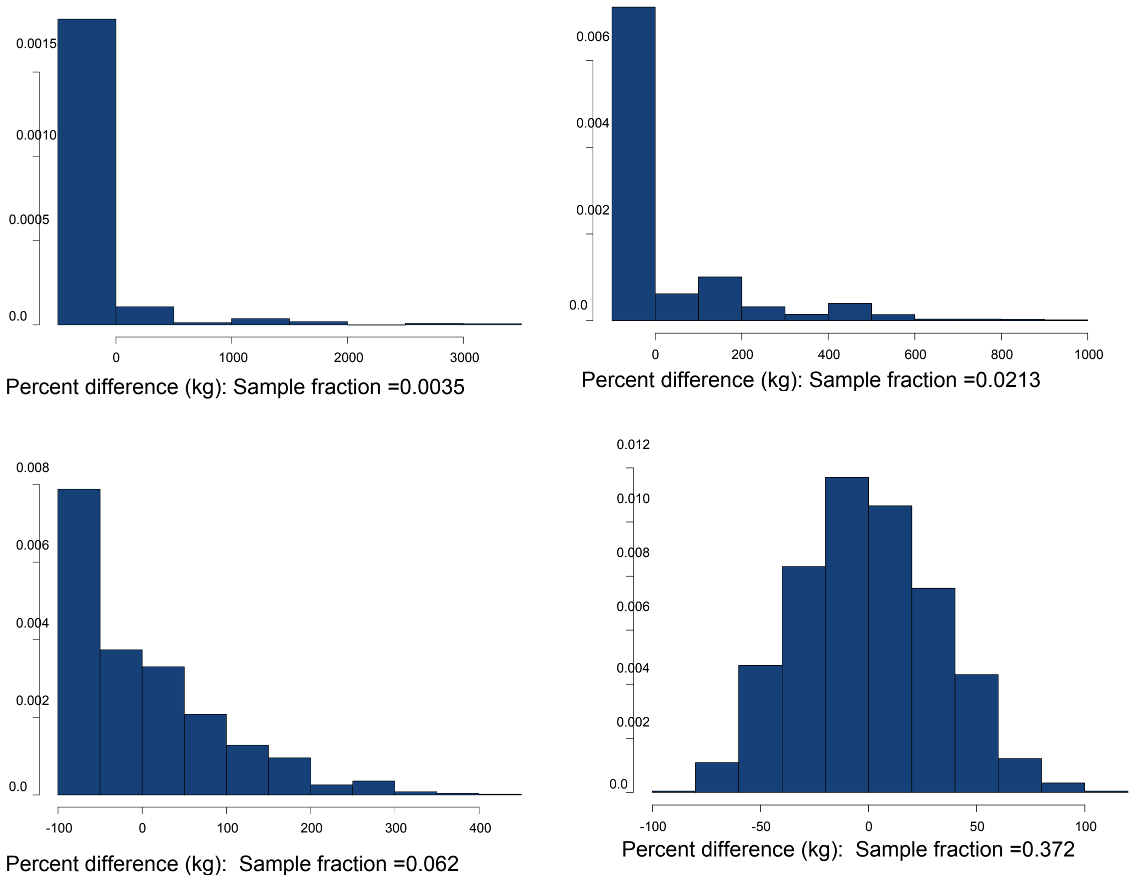


Figure 8. -- Frequency distribution of 1,000 simulated sample estimates for Pacific halibut at sampling fractions of 0.35%, 2.13%, 6.2%, and 37.2% of haul weight.

Appendix Table 1. -- Estimates of catch composition based on 100 kg samples for the *American No. 1* .

			Walleye Pollock										
	TotWt	Whole	Proportion from Sample								Stats Within Haul		
Haul	(kg)	Haul	1	2	3	4	5	6	7	8	Mean	Stdev	CV
1	10,587	0.483	0.560	0.496	0.527	0.575	0.705	0.723			0.598	0.094	15.8%
2	5,878	0.244	0.197	0.160	0.341	0.347	0.329				0.275	0.089	32.5%
3	9,238	0.015	0.002	0.027	0.011	0.007	0.009	0.017			0.012	0.009	73.5%
4	9,918	0.079	0.047	0.014	0.046	0.075	0.074	0.071	0.088	0.213	0.078	0.059	75.7%
5	10,124	0.133	0.100	0.109	0.128	0.149	0.135	0.190			0.135	0.032	23.9%
6	10,622	0.104	0.086	0.113	0.073	0.099	0.130	0.173			0.112	0.036	31.8%
7	11,200	0.204	0.213	0.189	0.219	0.173	0.297	0.311			0.234	0.057	24.4%
8	7,529	0.066	0.083	0.057	0.027	0.113	0.096	0.009	0.060	0.042	0.061	0.035	57.7%
9	6,653	0.039	0.064	0.037	0.045	0.016	0.080				0.048	0.025	51.3%
10	13,723	0.024	0.045	0.029	-	0.034	0.056				0.033	0.021	64.2%
11	13,571	0.036	-	-	0.021	0.035	0.030	0.095	0.127		0.044	0.049	109.9%
12	11,375	0.025	0.029	0.009	-	0.039	0.098	0.030			0.034	0.035	101.0%
13	12,852	0.142	0.103	0.043	0.229	0.208	0.133	0.258			0.162	0.083	51.0%
14	1,963	0.027	0.030	0.028	-						0.019	0.017	86.7%
15	11,483	0.018	0.009	-	0.017	0.024	0.061	0.126			0.039	0.047	119.6%
16	14,642	0.041	0.062	0.057	-	0.084	0.008	0.028			0.040	0.033	82.8%
17	13,065	0.131	0.114	0.233	0.108	0.222	0.108	0.175			0.160	0.058	36.3%
18	13,365	0.138	0.128	0.129	0.303	0.277	0.280				0.223	0.087	39.1%
19	9,674	0.058	0.269	0.196	0.092	0.088	0.058	0.031			0.122	0.091	74.3%
20	12,215	0.051	0.023	0.112	0.100	0.155	0.065				0.091	0.050	54.4%
21	12,602	0.223	0.055	0.253	0.166	0.184	0.282				0.188	0.089	47.0%
22	13,066	0.332	0.354	0.133	0.274	0.277	0.515	0.530			0.347	0.153	44.2%
23	16,617	0.559	0.533	0.627	0.687	0.665	0.780				0.658	0.090	13.7%
24	9,688	0.014	0.006	0.035	-	-	0.040				0.016	0.020	120.4%
25	14,331	0.027	0.038	0.046	0.009	0.045	0.029	0.075			0.040	0.022	53.7%
26	13,307	0.158	0.103	0.096	0.075	0.207					0.121	0.059	49.0%
27	11,095	0.071	0.077	0.193	0.075	0.088	0.120	0.146			0.117	0.046	39.8%
28	12,926	0.050	0.088	0.037	0.050	0.060					0.059	0.022	36.8%
29	7,453	0.000	-	-	0.034	0.024	0.041				0.020	0.019	96.3%
30	7,527	0.099	0.075	0.082	0.071	0.131					0.090	0.028	31.0%
31	13,094	0.223	0.196	0.164	0.233	0.240	0.389	0.398			0.270	0.100	36.9%

Appendix Table 1. -- Estimates of catch composition based on 100 kg samples for the *American No. 1* .

			Walleye Pollock										
	TotWt	Whole	Proportion from Sample								Stats Within Haul		
Haul	(kg)	Haul	1	2	3	4	5	6	7	8	Mean	Stdev	CV
32	8,386	0.067	0.029	0.064	0.080	0.093					0.066	0.028	41.7%
33	7,889	0.543	0.260	0.508	0.399	0.545	0.361	0.383			0.409	0.103	25.2%
34	21,260	0.250	0.086	0.116	0.084	0.161	0.309	0.522			0.213	0.173	81.3%
35	11,976	0.365	0.198	0.159	0.218	0.205	0.204	0.298	0.152		0.205	0.048	23.4%
36	15,944	0.349	0.397	0.332	0.507	0.468	0.539				0.449	0.084	18.8%
37	19,948	0.349	0.121	0.216	0.486	0.305	0.243	0.499			0.312	0.152	48.9%
38	16,237	0.482	0.379	0.365	0.500	0.459	0.648				0.470	0.114	24.2%
39	10,748	0.253	0.164	0.269	0.301	0.239	0.285	0.378	0.324		0.280	0.067	24.0%
40	13,576	0.198	0.100	0.325	0.182	0.173	0.174	0.164	0.210		0.190	0.068	36.0%
41	6,930	0.132	0.189	0.213	0.234	0.224	0.223	0.274			0.226	0.028	12.3%
42	8,015	0.045	0.020	0.052	0.037	0.017	0.034	0.014			0.029	0.015	50.2%
43	8,386	0.341	0.277	0.322	0.318	0.411	0.444	0.374			0.357	0.063	17.7%
44	10,876	0.349	0.370	0.400	0.465	0.550					0.446	0.080	17.9%
45	12,991	0.311	0.339	0.312	0.292	0.355	0.318	0.365			0.330	0.028	8.4%
46	14,258	0.476	0.420	0.509	0.501	0.629	0.556	0.638			0.542	0.083	15.3%
47	10,152	0.017	-	0.004	0.015	-	0.054	-			0.012	0.021	174.9%
48	4,560	0.013	0.021	0.020	0.065						0.035	0.026	73.0%
49	12,449	0.032	-	0.054	0.051	0.006	0.040	0.039			0.032	0.023	72.6%
50	7,490	0.064	0.076	0.063	0.089	0.039	0.036	0.029	0.148		0.069	0.041	60.4%
51	6,890	0.075	0.096	0.049	0.114	0.070	0.121	0.136	0.079		0.095	0.031	32.4%
52	12,325	0.109	0.184	0.092	0.074	0.072	0.125	0.205			0.125	0.057	45.8%
53	7,379	0.029	0.016	0.009	-	0.019	0.036	0.043			0.020	0.016	78.7%
54	7,554	0.011	0.043	0.028	0.003	0.019					0.023	0.017	71.6%
55	11,526	0.056	0.034	0.060	0.046	0.069	0.050	0.065			0.054	0.013	24.4%
56	9,689	0.217	0.035	0.135	0.065	0.181	0.298	0.173			0.148	0.094	63.4%
57	8,162	0.055	0.137	0.186	0.249	0.108	0.214	0.292	0.188		0.196	0.063	32.0%
58	11,867	0.228	0.133	0.185	0.314	0.231	0.407				0.254	0.108	42.5%
59	7,919	0.190	0.162	0.168	0.178	0.225	0.368				0.220	0.086	39.2%
60	3,851	0.019	0.026	-	0.019						0.015	0.014	90.5%
A	9,455	0.077	0.043	0.076	0.173	0.019	0.026				0.067	0.063	93.6%
B	10,895	0.228	0.181	0.262	0.176	0.219	0.347				0.237	0.071	29.8%

Appendix Table 1. -- (Continued).

			Pacific Cod										
	TotWt	Whole	Proportion from Sample								Stats Within Haul		
Haul	(kg)	Haul	1	2	3	4	5	6	7	8	Mean	Stdev	CV
1	10,587	0.135	0.222	0.028	0.054	0.318	0.187	0.224			0.172	0.111	64.3%
2	5,878	0.196	0.318	0.246	0.254	0.100	0.128				0.209	0.092	43.9%
3	9,238	0.032	-	0.009	0.104	0.032	0.054	0.068			0.045	0.039	87.2%
4	9,918	0.061	0.012	0.071	0.052	0.033	0.035	0.065	0.038	0.068	0.047	0.021	44.2%
5	10,124	0.162	0.072	0.164	0.020	0.272	0.255	0.235			0.170	0.104	61.3%
6	10,622	0.095	0.145	0.140	0.085	0.132	0.055	0.156			0.119	0.040	33.3%
7	11,200	0.149	0.127	0.140	0.040	0.064	0.083	0.180			0.106	0.053	49.7%
8	7,529	0.074	0.086	0.090	0.078	0.070	0.213	0.011	0.250	0.062	0.108	0.081	75.3%
9	6,653	0.045	0.137	0.025	0.033	0.017	0.123				0.067	0.058	86.4%
10	13,723	0.095	0.272	-	0.133	0.190	0.009				0.121	0.117	97.1%
11	13,571	0.067	-	0.008	0.055	0.060	0.041	0.292	0.099		0.079	0.100	125.5%
12	11,375	0.064	0.084	0.027	0.015	0.016	0.093	0.051			0.048	0.034	72.5%
13	12,852	0.058	0.051	0.027	0.074	0.066	0.017	0.120			0.059	0.037	62.9%
14	1,963	0.148	0.105	0.164	-						0.090	0.083	92.6%
15	11,483	0.031	0.026	-	-	0.018	0.067	0.132			0.040	0.051	126.5%
16	14,642	0.030	0.059	0.030	0.068	0.016	0.005	0.059			0.040	0.026	66.3%
17	13,065	0.042	0.041	0.072	-	0.024	0.019	0.053			0.035	0.026	73.9%
18	13,365	0.041	0.006	0.032	0.056	0.191	0.041				0.065	0.073	111.2%
19	9,674	0.047	0.232	0.146	0.028	0.018	0.015	-			0.073	0.094	128.7%
20	12,215	0.043	0.030	-	0.042	0.129	0.036				0.047	0.048	101.8%
21	12,602	0.064	-	0.153	0.020	0.044	0.092				0.062	0.061	99.3%
22	13,066	0.052	0.108	0.013	0.192	0.148	0.079	0.117			0.110	0.061	55.4%
23	16,617	0.101	0.019	0.071	0.079	0.145	0.122				0.087	0.049	55.6%
24	9,688	0.052	0.050	0.058	0.083	0.030	0.167				0.078	0.054	69.2%
25	14,331	0.056	0.049	0.015	0.054	0.011	0.021	0.159			0.052	0.056	108.2%
26	13,307	0.057	0.040	0.005	0.016	0.210					0.068	0.096	140.9%
27	11,095	0.131	0.061	0.217	0.032	0.097	0.233	0.312			0.159	0.111	69.9%
28	12,926	0.157	0.232	0.101	0.155	0.066					0.139	0.072	52.2%
29	7,453	0.083	0.166	-	0.039	0.092	0.105				0.080	0.064	79.2%
30	7,527	0.210	0.421	0.154	0.075	0.347					0.249	0.162	64.8%
31	13,094	0.187	0.236	0.277	0.143	0.296	0.239	0.240			0.239	0.053	22.1%

Appendix Table 1. -- (Continued).

			Pacific Cod										
	TotWt	Whole	Proportion from Sample								Stats Within Haul		
Haul	(kg)	Haul	1	2	3	4	5	6	7	8	Mean	Stdev	CV
32	8,386	0.157	0.184	0.321	0.204	0.210					0.230	0.062	26.9%
33	7,889	0.214	0.305	0.111	0.305	0.255	0.307	0.225			0.251	0.076	30.4%
34	21,260	0.097	-	-	0.074	0.212	0.185	0.251			0.120	0.110	91.6%
35	11,976	0.082	0.151	0.052	0.016	0.032	0.062	0.170	0.241		0.103	0.084	81.5%
36	15,944	0.116	0.020	0.126	0.232	0.171	0.189				0.148	0.081	54.7%
37	19,948	0.099	-	0.107	0.082	0.080	-	0.136			0.068	0.056	83.0%
38	16,237	0.126	0.049	0.035	0.126	0.170	0.181				0.112	0.068	60.2%
39	10,748	0.167	0.038	0.279	0.088	0.227	0.199	0.157	0.222		0.173	0.084	48.9%
40	13,576	0.054	0.055	0.137	0.056	0.147	0.027	-	0.080		0.072	0.054	75.6%
41	6,930	0.244	0.416	0.259	0.209	0.174	0.301	0.187			0.258	0.091	35.2%
42	8,015	0.049	0.042	-	0.051	-	0.030	0.054			0.030	0.024	82.3%
43	8,386	0.182	0.362	0.159	0.018	0.295	0.329	0.269			0.239	0.128	53.8%
44	10,876	0.151	0.246	0.072	0.138	0.182					0.159	0.073	46.0%
45	12,991	0.130	0.074	0.116	-	0.035	0.128	0.183			0.089	0.066	74.4%
46	14,258	0.133	0.083	0.073	0.147	0.110	0.330	0.160			0.151	0.094	62.7%
47	10,152	0.034	-	0.021	0.010	0.008	0.012	0.081			0.022	0.030	135.2%
48	4,560	0.060	0.084	0.064	0.075						0.074	0.010	13.6%
49	12,449	0.072	0.010	0.048	0.062	0.073	0.065	0.134			0.066	0.040	61.3%
50	7,490	0.101	0.248	0.122	0.107	0.175	0.087	0.105	0.108		0.136	0.057	41.7%
51	6,890	0.123	0.264	0.069	0.182	0.054	0.078	0.233	0.134		0.145	0.084	57.9%
52	12,325	0.085	0.141	0.111	0.050	0.043	0.125	0.083			0.092	0.040	43.6%
53	7,379	0.039	0.087	0.017	0.008	0.042	0.033	0.033			0.037	0.028	75.8%
54	7,554	0.036	0.029	-	0.135	0.104					0.067	0.063	94.2%
55	11,526	0.038	-	0.036	0.047	0.050	-	0.086			0.036	0.033	90.1%
56	9,689	0.096	0.092	0.113	0.063	0.079	0.129	0.276			0.125	0.078	61.8%
57	8,162	0.117	0.165	0.181	0.133	0.095	0.043	0.040	0.197		0.122	0.064	52.5%
58	11,867	0.044	0.067	0.062	0.078	0.099	0.020				0.065	0.029	44.7%
59	7,919	0.091	0.146	0.114	0.024	0.073	0.097				0.091	0.046	50.2%
60	3,851	0.013	0.067	0.010	-						0.026	0.036	140.0%
A	9,455	0.100	0.118	0.015	0.055	0.227	0.231				0.129	0.098	75.9%
B	10,895	0.085	0.111	0.044	0.074	0.105	0.074				0.081	0.027	33.0%

Appendix Table 1. -- (Continued).

	TotWt	Whole	Yellowfin Sole										
			Proportion from Sample								Stats Within Haul		
Haul	(kg)	Haul	1	2	3	4	5	6	7	8	Mean	Stdev	CV
1	10,587	0.002	0.013	0.016	0.056	0.007	0.014	0.004			0.018	0.019	104.9%
2	5,878	0.027	0.018	0.050	0.025	0.051	0.034				0.035	0.014	40.9%
3	9,238	0.391	0.393	0.410	0.409	0.410	0.356	0.510			0.415	0.051	12.3%
4	9,918	0.216	0.326	0.382	0.372	0.250	0.400	0.251	0.267	0.191	0.305	0.076	24.9%
5	10,124	0.109	0.181	0.136	0.122	0.096	0.082	0.073			0.115	0.040	34.9%
6	10,622	0.219	0.199	0.226	0.202	0.180	0.212	0.177			0.199	0.019	9.4%
7	11,200	0.130	0.206	0.216	0.231	0.128	0.129	0.077			0.165	0.062	37.5%
8	7,529	0.240	0.274	0.407	0.340	0.322	0.273	0.276	0.267	0.476	0.329	0.076	23.1%
9	6,653	0.355	0.343	0.423	0.482	0.476	0.308				0.407	0.078	19.2%
10	13,723	0.215	0.200	0.538	0.333	0.301	0.272				0.329	0.127	38.6%
11	13,571	0.206	0.228	0.310	0.286	0.282	0.225	0.182	0.273		0.255	0.045	17.6%
12	11,375	0.124	0.249	0.276	0.288	0.218	0.130	0.293			0.242	0.062	25.5%
13	12,852	0.094	0.173	0.218	0.140	0.118	0.204	0.094			0.158	0.049	30.9%
14	1,963	0.245	0.272	0.239	0.546						0.352	0.169	47.8%
15	11,483	0.432	0.513	0.348	0.556	0.667	0.486	0.466			0.506	0.105	20.8%
16	14,642	0.255	0.108	0.321	0.195	0.205	0.254	0.232			0.219	0.071	32.2%
17	13,065	0.071	0.067	0.091	0.130	0.099	0.080	0.128			0.099	0.025	25.7%
18	13,365	0.090	0.117	0.122	0.094	0.080	0.124				0.107	0.020	18.2%
19	9,674	0.400	0.390	0.406	0.505	0.503	0.444	0.403			0.442	0.052	11.7%
20	12,215	0.497	0.657	0.512	0.497	0.422	0.570				0.532	0.088	16.5%
21	12,602	0.234	0.411	0.249	0.324	0.371	0.197				0.310	0.087	28.1%
22	13,066	0.182	0.174	0.397	0.167	0.178	0.092	0.056			0.177	0.119	66.9%
23	16,617	0.012	0.027	0.030	0.040	0.030	0.006				0.027	0.013	47.5%
24	9,688	0.335	0.526	0.403	0.365	0.219	0.338				0.370	0.111	30.0%
25	14,331	0.184	0.234	0.197	0.154	0.261	0.178	0.147			0.195	0.045	23.1%
26	13,307	0.204	0.409	0.515	0.422	0.284					0.407	0.095	23.3%
27	11,095	0.177	0.264	0.138	0.244	0.266	0.189	0.097			0.200	0.071	35.4%
28	12,926	0.014	0.121	0.214	0.246	0.192					0.193	0.053	27.5%
29	7,453	0.246	0.129	0.145	0.152	0.134	0.130				0.138	0.010	7.3%
30	7,527	0.065	0.057	0.097	0.134	0.065					0.088	0.035	39.9%
31	13,094	0.003	0.040	0.070	0.067	0.041	0.019	0.018			0.043	0.022	52.5%
32	8,386	0.010	0.010	-	0.044	0.010					0.016	0.019	119.6%
33	7,889	0.015	0.014	0.019	0.012	-	0.016	0.017			0.013	0.007	51.8%
34	21,260	0.011	0.009	0.004	0.028	0.003	-	0.003			0.008	0.010	126.5%

Appendix Table 1. -- (Continued).

			Yellowfin Sole										
	TotWt	Whole	Proportion from Sample								Stats Within Haul		
Haul	(kg)	Haul	1	2	3	4	5	6	7	8	Mean	Stdev	CV
35	11,976	0.003	0.004	-	0.023	-	0.013	-	0.003		0.006	0.009	140.5%
36	15,944	0.019	0.033	0.017	0.015	0.023	-				0.018	0.012	68.5%
37	19,948	0.050	0.047	0.078	0.006	0.047	0.106	0.008			0.049	0.039	80.1%
38	16,237	0.050	0.060	0.088	0.071	0.042	0.010				0.054	0.030	55.2%
39	10,748	0.009	0.017	0.004	0.023	0.013	0.010	0.005	0.008		0.011	0.007	59.0%
40	13,576	0.020	0.010	0.039	0.026	0.022	0.024	0.028	0.009		0.023	0.011	46.4%
41	6,930	0.031	0.068	0.066	0.083	0.060	0.041	0.031			0.058	0.019	32.4%
42	8,015	0.080	0.106	0.053	0.106	0.112	0.076	0.087			0.090	0.023	25.4%
43	8,386	0.031	0.025	0.074	0.062	0.061	0.020	0.023			0.044	0.024	55.1%
44	10,876	0.014	0.023	0.024	0.015	0.007					0.017	0.008	45.0%
45	12,991	0.030	0.019	0.048	0.041	0.048	0.026	0.029			0.035	0.012	35.0%
46	14,258	0.021	0.038	0.012	0.036	0.028	0.012	0.014			0.023	0.012	52.3%
47	10,152	0.515	0.838	0.678	0.651	0.742	0.590	0.653			0.692	0.087	12.5%
48	4,560	0.507	0.608	0.489	0.384						0.494	0.112	22.7%
49	12,449	0.225	0.214	0.242	0.343	0.197	0.250	0.240			0.248	0.050	20.4%
50	7,490	0.315	0.306	0.384	0.366	0.288	0.340	0.357	0.375		0.345	0.036	10.4%
51	6,890	0.527	0.272	0.471	0.261	0.443	0.346	0.258	0.326		0.340	0.087	25.7%
52	12,325	0.227	0.268	0.386	0.403	0.378	0.310	0.323			0.344	0.053	15.3%
53	7,379	0.389	0.560	0.427	0.436	0.489	0.465	0.482			0.476	0.048	10.0%
54	7,554	0.354	0.372	0.543	0.417	0.358					0.422	0.084	19.9%
55	11,526	0.188	0.358	0.350	0.270	0.347	0.324	0.235			0.314	0.050	16.0%
56	9,689	0.177	0.217	0.192	0.610	0.217	0.135	0.089			0.243	0.187	76.6%
57	8,162	0.179	0.244	0.224	0.175	0.248	0.174	0.244	0.222		0.219	0.032	14.6%
58	11,867	0.254	0.245	0.290	0.252	0.352	0.157				0.259	0.071	27.4%
59	7,919	0.254	0.233	0.298	0.340	0.268	0.246				0.277	0.043	15.6%
60	3,851	0.255	0.281	0.330	0.332						0.315	0.029	9.2%
A	9,455	0.305	0.422	0.410	0.348	0.306	0.215				0.340	0.084	24.8%
B	10,895	0.087	0.086	0.092	0.119	0.113	0.101				0.102	0.014	13.3%

Appendix Table 1. -- (Continued).

			Flathead Sole										
	TotWt	Whole	Proportion from Sample								Stats Within Haul		
Haul	(kg)	Haul	1	2	3	4	5	6	7	8	Mean	Stdev	CV
1	10,587	0.020	0.003	0.025	0.024	0.005	0.030	-			0.015	0.013	90.7%
2	5,878	0.149	0.121	0.148	0.137	0.167	0.220				0.159	0.038	24.1%
3	9,238	0.164	0.246	0.187	0.107	0.201	0.154	0.132			0.171	0.050	29.4%
4	9,918	0.314	0.296	0.289	0.290	0.371	0.228	0.286	0.406	0.349	0.314	0.057	18.1%
5	10,124	0.318	0.451	0.294	0.447	0.251	0.293	0.225			0.327	0.098	30.0%
6	10,622	0.324	0.315	0.373	0.370	0.442	0.336	0.321			0.360	0.047	13.2%
7	11,200	0.285	0.324	0.285	0.194	0.368	0.301	0.284			0.293	0.057	19.6%
8	7,529	0.180	0.292	0.154	0.265	0.139	0.192	0.231	0.123	0.319	0.214	0.074	34.3%
9	6,653	0.134	0.094	0.178	0.108	0.100	0.133				0.123	0.034	28.1%
10	13,723	0.142	0.099	0.196	0.083	0.156	0.268				0.160	0.075	46.9%
11	13,571	0.193	0.128	0.298	0.303	0.242	0.207	0.156	0.171		0.215	0.069	32.1%
12	11,375	0.192	0.415	0.191	0.278	0.224	0.208	0.214			0.255	0.084	32.8%
13	12,852	0.202	0.181	0.173	0.172	0.163	0.220	0.203			0.185	0.022	11.6%
14	1,963	0.004	0.031	0.009	0.210						0.084	0.110	131.8%
15	11,483	0.031	0.038	0.039	0.050	0.095	0.087	0.023			0.055	0.029	52.3%
16	14,642	0.159	0.171	0.301	0.239	0.175	0.207	0.235			0.221	0.049	22.0%
17	13,065	0.305	0.270	0.290	0.302	0.215	0.292	0.312			0.280	0.035	12.4%
18	13,365	0.174	0.194	0.242	0.152	0.161	0.196				0.189	0.036	18.8%
19	9,674	0.056	-	0.047	0.030	0.064	0.091	0.147			0.063	0.051	81.2%
20	12,215	0.022	0.017	0.020	0.023	0.009	0.009				0.016	0.006	41.0%
21	12,602	0.137	0.161	0.122	0.152	0.188	0.136				0.152	0.025	16.6%
22	13,066	0.084	0.140	0.213	0.107	0.074	0.044	0.036			0.102	0.067	65.1%
23	16,617	0.031	0.066	0.023	0.042	0.058	0.031				0.044	0.018	40.5%
24	9,688	0.100	0.063	0.156	0.114	0.099	0.109				0.108	0.034	31.0%
25	14,331	0.227	0.180	0.265	0.287	0.280	0.280	0.278			0.261	0.040	15.5%
26	13,307	0.081	0.077	0.081	0.131	0.100					0.097	0.024	25.1%
27	11,095	0.198	0.308	0.208	0.269	0.245	0.187	0.173			0.232	0.052	22.4%
28	12,926	0.261	0.223	0.268	0.300	0.288					0.270	0.034	12.5%
29	7,453	0.369	0.280	0.240	0.418	0.358	0.430				0.345	0.084	24.2%
30	7,527	0.309	0.254	0.363	0.469	0.325					0.353	0.090	25.5%
31	13,094	0.234	0.200	0.344	0.285	0.291	0.082	0.205			0.234	0.093	39.6%

Appendix Table 1. -- (Continued).

			Flathead Sole										
	TotWt	Whole	Proportion from Sample								Stats Within Haul		
Haul	(kg)	Haul	1	2	3	4	5	6	7	8	Mean	Stdev	CV
32	8,386	0.365	0.287	0.314	0.258	0.481					0.335	0.100	29.8%
33	7,889	0.026	0.009	0.055	0.028	0.005	0.037	0.040			0.029	0.019	66.2%
34	21,260	0.429	0.698	0.685	0.614	0.379	0.270	0.151			0.466	0.232	49.7%
35	11,976	0.420	0.450	0.444	0.494	0.637	0.542	0.398	0.362		0.475	0.093	19.5%
36	15,944	0.206	0.274	0.327	0.091	0.259	0.111				0.213	0.105	49.4%
37	19,948	0.215	0.538	0.481	0.139	0.193	0.308	0.095			0.292	0.184	62.9%
38	16,237	0.109	0.222	0.201	0.169	0.129	0.093				0.163	0.052	32.1%
39	10,748	0.266	0.354	0.332	0.419	0.309	0.209	0.388	0.177		0.313	0.090	28.6%
40	13,576	0.486	0.645	0.388	0.520	0.459	0.608	0.639	0.627		0.555	0.101	18.2%
41	6,930	0.094	0.101	0.111	0.133	0.120	0.150	0.067			0.114	0.029	25.1%
42	8,015	0.159	0.155	0.230	0.280	0.128	0.183	0.157			0.189	0.056	29.8%
43	8,386	0.068	0.040	0.083	0.083	0.031	0.022	0.022			0.047	0.029	61.1%
44	10,876	0.134	0.106	0.231	0.154	0.110					0.150	0.058	38.6%
45	12,991	0.199	0.289	0.230	0.222	0.290	0.203	0.169			0.234	0.048	20.5%
46	14,258	0.069	0.086	0.146	0.145	0.048	0.026	0.057			0.085	0.051	60.0%
47	10,152	0.028	0.018	0.050	0.038	0.043	0.050	0.083			0.047	0.021	45.0%
48	4,560	0.035	0.012	0.043	0.045						0.033	0.019	55.5%
49	12,449	0.153	0.094	0.150	0.158	0.134	0.261	0.163			0.160	0.055	34.5%
50	7,490	0.199	0.193	0.250	0.194	0.131	0.227	0.209	0.177		0.197	0.038	19.1%
51	6,890	0.164	0.170	0.212	0.205	0.222	0.214	0.130	0.202		0.194	0.033	16.9%
52	12,325	0.159	0.226	0.209	0.191	0.192	0.228	0.187			0.206	0.018	8.8%
53	7,379	0.215	0.157	0.306	0.205	0.259	0.235	0.214			0.229	0.051	22.1%
54	7,554	0.145	0.263	0.315	0.175	0.282					0.259	0.060	23.1%
55	11,526	0.311	0.354	0.262	0.358	0.343	0.363	0.409			0.348	0.048	13.7%
56	9,689	0.283	0.442	0.273	-	0.335	0.296	0.314			0.277	0.148	53.4%
57	8,162	0.185	0.242	0.207	0.137	0.266	0.162	0.216	0.118		0.193	0.055	28.5%
58	11,867	0.214	0.300	0.237	0.226	0.175	0.305				0.249	0.055	22.0%
59	7,919	0.209	0.119	0.158	0.139	0.236	0.118				0.154	0.049	31.5%
60	3,851	0.102	0.069	0.117	0.083						0.090	0.025	27.7%
A	9,455	0.127	0.108	0.167	0.147	0.115	0.147				0.137	0.024	17.9%
B	10,895	0.168	0.284	0.292	0.266	0.206	0.168				0.243	0.054	22.2%

Appendix Table 1. -- (Continued).

			Alaska Plaice										
	TotWt	Whole	Proportion from Sample								Stats Within Haul		
Haul	(kg)	Haul	1	2	3	4	5	6	7	8	Mean	Stdev	CV
1	10,587	0.002	-	-	-	-	-	-			-		
2	5,878	0.029	-	0.046	-	0.014	0.007				0.013	0.019	142.3%
3	9,238	0.004	-	-	0.013	-	0.009	-			0.004	0.006	158.4%
4	9,918	0.011	0.007	0.014	-	-	0.040	0.038	-	-	0.012	0.017	138.5%
5	10,124	0.006	-	0.009	0.012	-	-	-			0.003	0.006	157.6%
6	10,622	0.008	0.021	-	-	-	-	-			0.004	0.009	244.9%
7	11,200	0.004	-	-	-	0.128	-	-			0.021	0.052	244.9%
8	7,529	0.014	0.020	0.005	0.029	0.024	0.009	0.022	0.025	0.021	0.019	0.008	41.8%
9	6,653	0.022	0.020	-	0.047	0.046	0.021				0.027	0.020	74.3%
10	13,723	0.022	0.042	0.099	0.015	0.010	0.024				0.038	0.036	95.4%
11	13,571	0.041	0.033	0.053	0.067	0.061	0.021	0.053	-		0.041	0.024	59.1%
12	11,375	0.046	0.075	0.056	0.036	0.032	0.044	0.022			0.044	0.019	43.2%
13	12,852	0.160	0.234	0.120	0.157	0.146	0.122	0.158			0.156	0.042	26.7%
14	1,963	-	-	0.016	-						0.005	0.009	173.2%
15	11,483	0.051	0.049	0.016	0.057	0.020	0.043	0.095			0.047	0.029	61.7%
16	14,642	0.194	0.435	0.121	0.170	0.215	0.163	0.208			0.219	0.111	50.9%
17	13,065	0.130	0.261	0.135	0.247	0.176	0.165	0.053			0.173	0.076	44.1%
18	13,365	0.156	0.187	0.211	0.209	0.148	0.092				0.169	0.050	29.6%
19	9,674	0.023	0.050	0.020	0.022	0.059	0.049	0.042			0.041	0.016	39.2%
20	12,215	0.057	0.038	0.091	0.056	0.046	0.051				0.056	0.021	36.5%
21	12,602	0.094	0.185	0.071	0.137	0.107	0.048				0.110	0.054	49.7%
22	13,066	0.048	0.051	0.056	0.047	0.028	0.027	0.051			0.043	0.013	29.3%
23	16,617	0.015	0.011	0.033	0.025	0.009	-				0.016	0.013	84.5%
24	9,688	0.115	0.119	0.109	0.106	0.425	0.092				0.170	0.143	83.8%
25	14,331	0.251	0.296	0.292	0.298	0.263	0.353	0.230			0.289	0.041	14.1%
26	13,307	0.104	0.092	0.112	0.132	0.048					0.096	0.036	37.4%
27	11,095	0.014	0.016	0.038	0.031	0.021	0.031	0.006			0.024	0.012	49.2%
28	12,926	0.013	-	0.010	0.018	-					0.007	0.009	124.0%
29	7,453	0.004	-	-	0.005	-	-				0.001	0.002	223.6%
30	7,527	0.011	0.007	-	0.011	-					0.004	0.005	122.8%
31	13,094	0.015	0.008	0.008	0.007	-	-	0.009			0.005	0.004	79.1%

Appendix Table 1. -- (Continued).

			Alaska Plaice										
	TotWt	Whole	Proportion from Sample								Stats Within Haul		
Haul	(kg)	Haul	1	2	3	4	5	6	7	8	Mean	Stdev	CV
32	8,386	0.009	0.011	0.007	0.012	0.032					0.015	0.011	74.4%
33	7,889	0.011	0.005	0.009	0.020	-	-	0.013			0.008	0.008	98.6%
34	21,260	0.005	-	0.010	-	-	-	-			0.002	0.004	244.9%
35	11,976	0.001	0.013	-	-	-	-	-	-		0.002	0.005	264.6%
36	15,944	0.011	0.010	0.009	-	-	0.023				0.009	0.010	112.2%
37	19,948	0.005	-	0.027	0.015	0.016	-	0.022			0.013	0.011	83.9%
38	16,237	0.001	-	0.017	0.020	0.008	-				0.009	0.009	102.6%
39	10,748	0.004	0.022	0.015	0.006	-	-	-	0.015		0.008	0.009	108.6%
40	13,576	0.005	-	-	-	-	0.011	-	0.010		0.003	0.005	171.5%
41	6,930	0.006	0.021	0.034	0.044	0.019	-	-			0.020	0.018	90.8%
42	8,015	0.012	0.022	-	0.025	-	0.022	0.034			0.017	0.014	81.4%
43	8,386	0.001	-	0.022	-	-	-	-			0.004	0.009	244.9%
44	10,876	0.007	-	-	0.011	-					0.003	0.006	200.0%
45	12,991	0.019	0.026	-	-	-	0.053	0.019			0.016	0.021	129.2%
46	14,258	0.014	-	0.031	0.008	0.020	0.022	-			0.013	0.013	94.2%
47	10,152	0.027	0.040	0.016	0.032	0.027	0.033	-			0.025	0.014	58.9%
48	4,560	0.080	0.150	0.071	0.114						0.112	0.040	35.3%
49	12,449	0.200	0.264	0.305	0.230	0.325	0.186	0.213			0.254	0.054	21.3%
50	7,490	0.009	-	-	0.011	0.013	0.028	0.004	-		0.008	0.010	129.0%
51	6,890	0.022	0.025	0.030	0.028	0.017	0.049	0.036	0.076		0.037	0.020	53.2%
52	12,325	0.015	0.022	0.015	0.011	0.022	0.031	0.014			0.019	0.007	38.3%
53	7,379	0.012	0.007	-	-	0.009	-	0.012			0.005	0.005	114.8%
54	7,554	0.001	0.014	0.022	-	-					0.009	0.011	120.7%
55	11,526	0.002	-	-	0.018	-	-	-			0.003	0.007	244.9%
56	9,689	0.008	-	-	0.006	-	0.002	-			0.001	0.003	194.7%
57	8,162	0.004	0.004	-	0.004	-	-	0.027	-		0.005	0.010	197.2%
58	11,867	0.001	-	-	-	-	-				-		
59	7,919	0.005	0.035	-	-	0.011	-				0.009	0.015	165.3%
60	3,851	0.004	-	-	0.037						0.012	0.022	173.2%
A	9,455	0.012	0.028	0.014	0.012	0.012	0.036				0.020	0.011	55.6%
B	10,895	0.038	0.067	0.067	0.059	0.020	0.019				0.047	0.025	52.7%

Appendix Table 1. -- (Continued).

	TotWt	Whole	Pacific Halibut										
			Proportion from Sample								Stats Within Haul		
Haul	(kg)	Haul	1	2	3	4	5	6	7	8	Mean	Stdev	CV
1	10,587	0.004	-	-	-	-	-	-			-		
2	5,878	0.012	-	-	0.040	-	-				0.008	0.018	224%
3	9,238	0.009	0.021	-	-	-	-	0.012			0.005	0.009	163%
4	9,918	0.004	-	-	-	-	-	-	-	-	-		
5	10,124	0.015	-	0.082	0.010	-	0.030	-			0.020	0.032	159%
6	10,622	0.004	-	-	-	-	-	-			-	-	
7	11,200	0.005	0.013	-	0.029	-	-	-			0.007	0.012	172%
8	7,529	0.009	-	-	-	-	-	-	-	-	-	-	
9	6,653	0.008	-	-	-	-	0.113				0.023	0.050	224%
10	13,723	0.005	-	-	-	-	-				-	-	
11	13,571	0.021	-	-	-	0.012	0.050	-	0.031		0.013	0.020	150%
12	11,375	0.019	-	0.013	0.026	-	-	-			0.006	0.011	168%
13	12,852	0.019	0.007	-	0.008	-	-	-			0.003	0.004	155%
14	1,963	0.005	-	-	-						-		
15	11,483	0.021	-	0.097	-	-	0.122	-			0.037	0.057	156%
16	14,642	0.010	-	-	-	0.043	-	-			0.007	0.018	245%
17	13,065	0.003	0.066	-	-	-	-	-			0.011	0.027	245%
18	13,365	0.013	-	-	-	-	-				-		
19	9,674	0.001	-	-	-	-	-	-			-		
20	12,215	0.011	-	-	-	-	-				-		
21	12,602	0.006	-	-	-	-	-				-		
22	13,066	0.009	-	-	-	0.196	-	-			0.033	0.080	245%
23	16,617	0.019	-	-	-	-	-				-		
24	9,688	0.036	0.031	-	-	0.078	0.014				0.024	0.032	132%
25	14,331	0.015	-	-	-	0.020	-	-			0.003	0.008	245%
26	13,307	0.009	-	-	0.019	-					0.005	0.009	200%
27	11,095	0.005	-	-	-	-	-	-			-		
28	12,926	0.011	0.020	0.084	-	-					0.026	0.040	154%
29	7,453	0.014	-	0.067	-	-	-				0.013	0.030	224%
30	7,527	0.009	-	-	-	-					-		
31	13,094	0.003	-	-	-	-	0.165	-			0.027	0.067	245%

Appendix Table 1. -- (Continued).

			Pacific Halibut										
	TotWt	Whole	Proportion from Sample								Stats Within Haul		
Haul	(kg)	Haul	1	2	3	4	5	6	7	8	Mean	Stdev	CV
32	8,386	0.010	0.183	-	0.016	-					0.050	0.089	179%
33	7,889	0.008	-	-	-	-	-	-			-		
34	21,260	0.004	0.030	-	-	0.037	-	-			0.011	0.017	156%
35	11,976	0.005	-	-	-	-	-	-	-		-		
36	15,944	0.005	-	-	-	-	-				-		
37	19,948	0.014	-	-	-	-	-	0.055			0.009	0.022	245%
38	16,237	0.006	-	-	-	-	-				-		
39	10,748	0.001	-	-	-	-	-	-	-		-		
40	13,576	0.005	-	-	-	0.055	-	-	-		0.008	0.021	265%
41	6,930	0.008	-	-	-	-	0.017	0.060			0.013	0.024	187%
42	8,015	0.015	-	0.041	-	-	0.060	-			0.017	0.027	159%
43	8,386	0.005	-	-	-	-	-	-			-		
44	10,876	0.004	-	-	-	-					-		
45	12,991	0.004	-	-	-	-	-	-			-		
46	14,258	0.011	-	-	-	-	-	-			-		
47	10,152	0.009	-	0.017	-	-	-	-			0.003	0.007	245%
48	4,560	0.023	0.016	0.021	0.026						0.021	0.005	23%
49	12,449	0.020	0.106	-	-	0.059	0.055	0.085			0.051	0.043	86%
50	7,490	0.005	-	-	-	-	-	-	-		-		
51	6,890	0.006	-	-	-	-	-	-	-		-		
52	12,325	0.005	-	-	-	-	-	-			-		
53	7,379	0.004	-	-	0.051	-	-	-			0.008	0.021	245%
54	7,554	0.014	-	0.062	-	0.011					0.018	0.030	163%
55	11,526	0.003	-	-	-	-	-	-			-		
56	9,689	0.007	-	-	-	-	-	0.016			0.003	0.007	245%
57	8,162	0.007	0.014	-	-	-	-	-	-		0.002	0.005	265%
58	11,867	0.004	-	-	0.043	-	-				0.009	0.019	224%
59	7,919	0.006	-	-	-	-	-				-		
60	3,851	0.004	-	-	-						-		
A	9,455	0.017	-	-	-	-	0.066				0.013	0.030	224%
B	10,895	0.009	-	-	-	-	-				-		

Appendix Table 1. -- (Continued).

			Skates (all species)										
	TotWt	Whole	Proportion from Sample								Stats Within Haul		
Haul	(kg)	Haul	1	2	3	4	5	6	7	8	Mean	Stdev	CV
1	10,587	0.013	-	0.083	-	-	-	-			0.014	0.034	244.9%
2	5,878	0.004	-	-	-	-	-				-		
3	9,238	0.033	0.126	0.158	-	0.087	-	-			0.062	0.071	115.4%
4	9,918	0.019	-	0.015	0.004	0.003	-	0.001	-	-	0.003	0.005	179.2%
5	10,124	0.007	-	-	0.054	-	-	-			0.009	0.022	244.9%
6	10,622	0.014	0.056	-	-	-	0.110	-			0.028	0.046	166.7%
7	11,200	0.009	-	-	-	-	-	-			-		
8	7,529	0.032	0.075	0.005	0.001	0.003	0.003	0.127	-	-	0.027	0.048	179.5%
9	6,653	0.032	-	0.003	-	0.059	-				0.012	0.026	212.0%
10	13,723	0.021	0.021	0.058	0.072	0.014	0.033				0.040	0.025	62.1%
11	13,571	0.011	0.099	-	0.092	0.002	0.021	-	-		0.031	0.045	147.5%
12	11,375	0.007	-	0.033	-	0.029	-	-			0.010	0.016	155.3%
13	12,852	0.024	-	0.001	-	0.017	0.030	-			0.008	0.013	158.3%
14	1,963	0.033	0.040	0.135	-						0.058	0.069	119.2%
15	11,483	0.033	0.081	0.195	-	0.033	-	-			0.051	0.077	150.0%
16	14,642	0.022	-	-	0.074	0.074	0.016	-			0.027	0.037	134.1%
17	13,065	0.010	-	-	-	0.091	-	0.002			0.016	0.037	237.8%
18	13,365	0.017	0.088	0.087	-	-	0.002				0.035	0.048	134.7%
19	9,674	0.019	-	0.015	0.029	0.042	-	0.107			0.032	0.040	125.0%
20	12,215	0.009	-	0.006	-	-	0.002				0.002	0.002	156.9%
21	12,602	0.006	0.003	-	-	-	0.106				0.022	0.047	215.4%
22	13,066	0.007	-	-	-	-	-	-			-		
23	16,617	0.026	0.069	0.074	0.002	0.002	-				0.029	0.039	131.8%
24	9,688	0.023	0.054	0.021	0.145	-	-				0.044	0.061	137.5%
25	14,331	0.015	-	-	-	-	-	-			-		
26	13,307	0.027	0.084	0.043	-	-					0.032	0.040	126.6%
27	11,095	0.012	-	-	-	0.002	0.071	0.092			0.028	0.043	154.2%
28	12,926	0.016	0.042	0.019	-	-					0.015	0.020	130.5%
29	7,453	0.089	0.208	0.224	-	0.149	-				0.116	0.110	94.4%
30	7,527	0.052	0.080	0.102	-	-					0.045	0.053	117.2%
31	13,094	0.066	0.083	-	0.078	-	-	0.003			0.027	0.041	150.4%

Appendix Table 1. -- (Continued).

			Skates (all species)										
	TotWt	Whole	Proportion from Sample								Stats Within Haul		
Haul	(kg)	Haul	1	2	3	4	5	6	7	8	Mean	Stdev	CV
32	8,386	0.062	0.074	0.094	-	0.003					0.043	0.049	113.6%
33	7,889	0.053	0.101	-	-	-	-	-			0.017	0.041	244.9%
34	21,260	0.014	0.082	-	-	-	-	-			0.014	0.033	244.9%
35	11,976	0.014	-	0.110	0.087	-	-	-	-		0.028	0.049	172.3%
36	15,944	0.020	-	-	-	-	-				-		
37	19,948	0.034	-	-	0.111	0.162	0.130	-			0.067	0.075	112.3%
38	16,237	0.041	0.151	0.142	-	0.117	-				0.082	0.076	92.6%
39	10,748	0.024	0.070	-	-	0.085	-	-	-		0.022	0.038	171.9%
40	13,576	0.022	-	-	-	-	-	0.001	-		0.000	0.000	264.6%
41	6,930	0.059	0.019	0.042	-	0.144	-	0.067			0.045	0.055	120.9%
42	8,015	0.119	0.265	0.060	0.107	0.334	0.071	0.264			0.183	0.118	64.1%
43	8,386	0.045	-	0.147	0.174	-	-	-			0.054	0.083	155.7%
44	10,876	0.040	0.155	0.001	-	-					0.039	0.077	197.8%
45	12,991	0.046	-	-	-	-	-	-			-		
46	14,258	0.035	0.092	0.001	-	-	-	-			0.015	0.037	241.3%
47	10,152	0.027	-	-	0.102	-	-	0.001			0.017	0.041	240.7%
48	4,560	0.022	-	0.132	-						0.044	0.076	173.2%
49	12,449	0.023	-	-	0.017	-	0.001	0.023			0.007	0.010	150.3%
50	7,490	0.008	-	-	-	-	-	-	-		-		
51	6,890	0.014	-	-	-	-	-	-	-		-		
52	12,325	0.010	-	-	0.068	-	-	0.003			0.012	0.027	232.7%
53	7,379	0.011	-	0.018	-	-	-	0.002			0.003	0.007	218.1%
54	7,554	0.017	0.056	-	0.001	-					0.014	0.028	194.5%
55	11,526	0.012	-	-	-	0.028	0.001	-			0.005	0.011	233.0%
56	9,689	0.006	-	-	-	-	-	-			-		
57	8,162	0.011	-	-	0.098	-	0.149	-	-		0.035	0.062	175.8%
58	11,867	0.009	0.006	-	-	-	-				0.001	0.003	223.6%
59	7,919	0.005	-	-	-	0.001	-				0.000	0.001	223.6%
60	3,851	0.036	0.001	0.047	0.092						0.047	0.045	96.6%
A	9,455	0.008	-	0.002	-	0.001	0.065				0.014	0.029	211.2%
B	10,895	0.012	-	-	-	0.079	-				0.016	0.035	223.6%

Appendix Table 1. -- (Continued).

			Tanner Crab (*C. bairdi*)										
	TotWt	Whole	Proportion from Sample								Stats Within Haul		
Haul	(kg)	Haul	1	2	3	4	5	6	7	8	Mean	Stdev	CV
1	10,587	0.0006	-	-	-	0.0024	-	-			0.0004	0.0010	244.9%
2	5,878	0.0003	-	0.0012	-	-	-				0.0002	0.0006	223.6%
3	9,238	0.0034	0.0017	0.0038	0.0156	-	0.0153	0.0032			0.0066	0.0070	106.2%
4	9,918	0.0012	0.0083	0.0087	0.0028	-	-	0.0072	-	-	0.0034	0.0040	119.1%
5	10,124	0.0005	-	-	-	-	0.0007	-			0.0001	0.0003	244.9%
6	10,622	0.0003	-	-	0.0064	-	-	-			0.0011	0.0026	244.9%
7	11,200	0.0002	-	-	0.0047	-	0.0074	-			0.0020	0.0032	160.4%
8	7,529	0.0018	-	-	-	0.0071	0.0082	-	0.0027	-	0.0022	0.0035	154.4%
9	6,653	0.0031	0.0041	0.0128	0.0027	0.0058	0.0035				0.0058	0.0041	70.9%
10	13,723	0.0016	-	-	-	0.0017	-				0.0003	0.0007	223.6%
11	13,571	0.0003	-	-	-	-	-	-	-		-		
12	11,375	0.0003	-	-	-	-	-	-			-		
13	12,852	0.0018	0.0038	0.0039	-	-	0.0048	-			0.0021	0.0023	110.8%
14	1,963	0.0325	0.0426	0.0387	0.0716						0.0510	0.0180	35.2%
15	11,483	0.0038	0.0088	0.0065	0.0013	0.0172	0.0042	0.0016			0.0066	0.0059	89.6%
16	14,642	0.0016	-	-	0.0040	-	0.0097	-			0.0023	0.0040	173.4%
17	13,065	0.0017	-	0.0006	0.0008	0.0010	0.0141	0.0042			0.0035	0.0054	156.9%
18	13,365	0.0024	-	-	0.0057	0.0004	-				0.0012	0.0025	205.5%
19	9,674	0.0100	-	0.0092	0.0249	-	0.0106	0.0138			0.0098	0.0094	95.9%
20	12,215	0.0082	0.0029	0.0196	0.0116	0.0023	0.0023				0.0077	0.0077	99.9%
21	12,602	0.0032	0.0051	0.0017	0.0038	0.0012	0.0133				0.0050	0.0049	97.3%
22	13,066	0.0033	0.0015	0.0049	-	-	0.0077	-			0.0023	0.0032	137.7%
23	16,617	0.0005	0.0009	-	-	-	-				0.0002	0.0004	223.6%
24	9,688	0.0017	0.0009	0.0023	-	0.0015	0.0009				0.0011	0.0008	74.7%
25	14,331	0.0005	-	-	-	-	0.0078	0.0016			0.0016	0.0031	198.1%
26	13,307	0.0009	-	0.0016	-	-					0.0004	0.0008	200.0%
27	11,095	0.0008	-	-	0.0050	-	-	-			0.0008	0.0020	244.9%
28	12,926	0.0009	-	-	-	0.0051					0.0013	0.0026	200.0%
29	7,453	0.0013	-	-	-	0.0009	0.0036				0.0009	0.0016	171.8%
30	7,527	0.0013	0.0014	-	-	-					0.0003	0.0007	200.0%
31	13,094	0.0025	0.0055	-	-	0.0012	-	0.0027			0.0016	0.0022	139.7%

Appendix Table 1. -- (Continued).

			Tanner Crab (*C. bairdi*)										
	TotWt	Whole	Proportion from Sample								Stats Within Haul		
Haul	(kg)	Haul	1	2	3	4	5	6	7	8	Mean	Stdev	CV
32	8,386	0.0032	0.0033	0.0023	0.0075	0.0107					0.0060	0.0039	65.4%
33	7,889	0.0024	-	0.0089	0.0057	0.0053	-	0.0052			0.0042	0.0035	84.0%
34	21,260	0.0004	-	-	0.0060	-	-	-			0.0010	0.0024	244.9%
35	11,976	0.0007	0.0006	-	-	0.0019	-	-	-		0.0004	0.0007	202.6%
36	15,944	0.0001	-	-	-	-	-				-		
37	19,948	0.0003	-	-	-	-	-	-			-		
38	16,237	0.0004	-	0.0003	-	-	-				0.0001	0.0001	223.6%
39	10,748	0.0009	-	0.0003	0.0055	-	-	-	0.0029		0.0012	0.0022	173.2%
40	13,576	0.0006	0.0024	0.0006	0.0003	0.0002	-	-	-		0.0005	0.0009	173.3%
41	6,930	0.0011	-	0.0008	0.0030	-	-	-			0.0006	0.0012	190.1%
42	8,015	0.0032	-	-	-	0.0029	0.0027	0.0169			0.0038	0.0066	175.1%
43	8,386	0.0020	0.0017	-	0.0092	-	-	0.0022			0.0022	0.0036	162.9%
44	10,876	0.0014	-	-	-	-					-		
45	12,991	0.0010	-	0.0120	0.0014	0.0011	0.0014	0.0021			0.0030	0.0045	148.0%
46	14,258	0.0004	-	0.0008	-	0.0014	-	-			0.0004	0.0006	164.4%
47	10,152	0.0011	-	-	-	0.0065	0.0011	-			0.0013	0.0026	206.1%
48	4,560	0.0014	-	-	0.0021						0.0007	0.0012	173.2%
49	12,449	0.0019	-	-	0.0008	0.0013	-	0.0049			0.0012	0.0019	163.8%
50	7,490	0.0010	0.0044	0.0017	-	-	-	-	-		0.0009	0.0017	191.7%
51	6,890	0.0013	-	-	-	-	0.0073	0.0025	0.0006		0.0015	0.0027	183.7%
52	12,325	0.0008	0.0009	-	-	0.0025	-	0.0068			0.0017	0.0027	158.5%
53	7,379	0.0007	-	0.0037	-	-	-	0.0022			0.0010	0.0016	162.9%
54	7,554	0.0010	-	0.0031	0.0020	0.0007					0.0014	0.0014	96.5%
55	11,526	0.0008	-	-	-	0.0016	-	0.0008			0.0004	0.0007	166.9%
56	9,689	-	-	-	0.0019	0.0082	0.0017	-			0.0020	0.0032	161.6%
57	8,162	0.0007	-	0.0006	-	0.0099	0.0012	-	-		0.0017	0.0036	217.1%
58	11,867	0.0004	-	-	-	-	-				-		
59	7,919	0.0013	0.0030	-	0.0008	-	0.0068				0.0021	0.0029	135.9%
60	3,851	0.0010	-	0.0022	-						0.0007	0.0013	173.2%
A	9,455	0.0095	0.0104	0.0080	0.0083	0.0197	0.0081				0.0109	0.0050	46.0%
B	10,895	0.0022	0.0045	0.0015	0.0017	0.0008	0.0019				0.0021	0.0014	68.9%

Appendix Table 1. -- (Continued).

			Snow Crab (*C. opilio*)										
	TotWt	Whole	Proportion from Sample								Stats Within Haul		
Haul	(kg)	Haul	1	2	3	4	5	6	7	8	Mean	Stdev	CV
1	10,587	0.0018	-	0.0086	-	0.0049	-	0.0024			0.0026	0.0035	132.6%
2	5,878	0.0034	0.0105	-	-	-	0.0030				0.0027	0.0045	168.2%
3	9,238	0.0129	0.0075	0.0092	0.0220	0.0038	0.0253	0.0323			0.0167	0.0114	68.6%
4	9,918	0.0042	0.0027	0.0063	0.0056	0.0083	-	0.0096	-	0.0018	0.0043	0.0037	85.8%
5	10,124	0.0021	0.0023	0.0014	-	-	0.0011	0.0051			0.0016	0.0019	115.6%
6	10,622	0.0033	-	-	0.0013	-	-	-			0.0002	0.0005	244.9%
7	11,200	0.0019	-	-	0.0025	-	-	-			0.0004	0.0010	244.9%
8	7,529	0.0095	0.0067	0.0069	-	0.0011	0.0110	0.0040	-	0.0806	0.0138	0.0273	197.5%
9	6,653	0.0155	0.0163	0.0202	0.0022	0.0152	0.0129				0.0133	0.0068	50.8%
10	13,723	0.0054	-	0.0227	0.0013	0.0109	0.0049				0.0080	0.0092	116.0%
11	13,571	0.0009	0.0028	0.0004	-	0.0064	-	-	-		0.0014	0.0024	176.6%
12	11,375	0.0009	0.0034	0.0021	-	0.0059	0.0027	-			0.0024	0.0022	94.8%
13	12,852	0.0024	-	-	-	0.0026	0.0058	-			0.0014	0.0024	170.8%
14	1,963	0.0210	0.0184	0.0463	-						0.0216	0.0233	108.1%
15	11,483	0.0078	0.0076	-	0.0164	0.0064	0.0102	-			0.0067	0.0063	93.0%
16	14,642	0.0038	-	-	-	0.0010	0.0571	-			0.0097	0.0232	239.8%
17	13,065	0.0024	-	0.0040	-	-	0.0109	0.0156			0.0051	0.0067	131.3%
18	13,365	0.0050	0.0072	0.0007	0.0065	-	0.0066				0.0042	0.0035	83.7%
19	9,674	0.0249	0.0009	0.0242	0.0512	0.0189	0.0277	0.0154			0.0231	0.0166	72.2%
20	12,215	0.0054	0.0067	0.0358	0.0094	0.0022	-				0.0108	0.0144	133.5%
21	12,602	0.0015	0.0021	0.0043	0.0076	-	0.0012				0.0031	0.0030	97.5%
22	13,066	0.0016	-	0.0190	0.0014	-	0.0023	-			0.0038	0.0075	198.7%
23	16,617	0.0008	-	-	-	0.0074	-				0.0015	0.0033	223.6%
24	9,688	0.0036	0.0059	0.0021	0.0053	0.0199	0.0018				0.0070	0.0074	106.2%
25	14,331	0.0011	0.0054	0.0031	0.0101	-	0.0027	0.0012			0.0038	0.0036	96.1%
26	13,307	0.0026	0.0092	0.0046	-	-					0.0034	0.0044	128.0%
27	11,095	0.0026	0.0025	0.0081	-	-	-	-			0.0018	0.0033	183.8%
28	12,926	0.0026	0.0061	0.0059	0.0033	0.0171					0.0081	0.0062	76.0%
29	7,453	0.0123	0.0244	0.0205	0.0187	0.0181	0.0079				0.0179	0.0061	34.1%
30	7,527	0.0030	0.0060	0.0123	0.0070	-					0.0063	0.0050	79.6%
31	13,094	0.0020	0.0071	-	-	0.0033	0.0069	-			0.0029	0.0034	119.4%

Appendix Table 1. -- (Continued).

			Snow Crab (*C. opilio*)										
	TotWt	Whole	Proportion from Sample								Stats Within Haul		
Haul	(kg)	Haul	1	2	3	4	5	6	7	8	Mean	Stdev	CV
32	8,386	0.0037	0.0172	0.0047	-	-					0.0055	0.0081	148.5%
33	7,889	0.0045	-	0.0043	-	-	0.0032	-			0.0012	0.0020	157.1%
34	21,260	0.0008	-	-	-	-	-	-			-	-	#DIV/0!
35	11,976	0.0008	-	-	-	-	-	-	-		-	-	#DIV/0!
36	15,944	0.0007	-	-	-	-	-				-	-	#DIV/0!
37	19,948	0.0030	-	-	-	0.0057	0.0164	-			0.0037	0.0067	180.0%
38	16,237	0.0009	0.0045	0.0023	-	-	-				0.0014	0.0020	148.0%
39	10,748	0.0008	-	-	-	0.0087	-	-	-		0.0012	0.0033	264.6%
40	13,576	0.0010	0.1161	-	-	-	-	-	-		0.0166	0.0439	264.6%
41	6,930	0.0060	0.0056	0.0084	0.0069	0.0259	-	-			0.0078	0.0096	122.4%
42	8,015	0.0124	-	0.0098	0.0020	0.0572	0.0071	0.0031			0.0132	0.0218	165.6%
43	8,386	0.0050	-	0.0014	0.0178	0.0307	-	-			0.0083	0.0130	156.3%
44	10,876	0.0021	-	0.0069	0.0057	-					0.0031	0.0037	116.4%
45	12,991	0.0022	-	0.0118	0.0183	-	-	0.0074			0.0062	0.0077	122.7%
46	14,258	0.0009	0.0008	-	-	-	-	-			0.0001	0.0003	244.9%
47	10,152	0.0041	0.0024	0.0021	-	0.0104	0.0049	0.0074			0.0045	0.0038	84.9%
48	4,560	0.0043	0.0016	0.0024	-						0.0013	0.0012	92.4%
49	12,449	0.0022	-	-	-	-	0.0016	-			0.0003	0.0007	244.9%
50	7,490	0.0028	0.0021	-	-	0.0012	0.0041	0.0062	0.0069		0.0029	0.0029	97.7%
51	6,890	0.0034	-	0.0048	0.0043	0.0140	0.0056	0.0015	0.0080		0.0055	0.0046	84.0%
52	12,325	0.0019	-	-	-	0.0044	0.0054	-			0.0016	0.0026	156.1%
53	7,379	0.0047	0.0060	0.0036	0.0098	-	0.0064	0.0078			0.0056	0.0034	61.1%
54	7,554	0.0042	0.0034	0.0269	0.0103	-					0.0102	0.0120	117.8%
55	11,526	0.0025	0.0023	0.0187	-	0.0012	0.0224	-			0.0074	0.0103	138.3%
56	9,689	0.0032	0.0084	-	0.0051	0.0053	-	0.0052			0.0040	0.0033	83.3%
57	8,162	0.0024	0.0019	0.0024	-	-	-	-	0.0040		0.0012	0.0016	135.1%
58	11,867	0.0014	-	0.0010	-	-	-				0.0002	0.0005	223.6%
59	7,919	0.0029	-	0.0011	-	-	-				0.0002	0.0005	223.6%
60	3,851	0.0054	0.0043	0.0140	0.0041						0.0075	0.0057	75.9%
A	9,455	0.0046	-	0.0024	0.0038	0.0038	0.0034				0.0027	0.0016	59.7%
B	10,895	0.0015	0.0026	0.0021	0.0056	0.0022	0.0028				0.0031	0.0014	47.0%

Appendix Table 2. -- *Seafisher* catch composition based on whole-haul sampling and on 100 kg samples.

Yellowfin Sole

			Whole	Proportion from Subsample						All Samples for Haul		
Haul #	TotWt	#Samp	Haul	1	2	3	4	5	6	Avg	StDev	CV
1	13,820	6	0.829	0.836	0.840	0.869	0.801	0.885	0.877	0.851	0.0318	3.7%
2	39,359	6	0.811	0.883	0.676	0.755	0.772	0.811	0.679	0.763	0.0793	10.4%
3	24,142	6	0.758	0.923	0.841	0.743	0.689	0.825	0.829	0.808	0.0815	10.1%
4	42,300	6	0.887	0.882	0.908	0.887	0.904	0.917	0.887	0.897	0.0139	1.5%
5	47,834	6	0.911	0.916	0.949	0.935	0.920	0.892	0.916	0.921	0.0193	2.1%
6	30,582	6	0.831	0.778	0.632	0.831	0.697	0.782	0.915	0.773	0.0992	12.8%
7	24,213	6	0.841	0.850	0.526	0.899	0.817	0.836	0.882	0.802	0.1385	17.3%
8	48,497	6	0.838	0.662	0.830	0.905	0.893	0.892	0.758	0.824	0.0968	11.7%
9	28,878	6	0.721	0.430	0.560	0.506	0.834	0.823	0.749	0.650	0.1737	26.7%
10	23,099	4	0.821	0.839	0.812	0.888	0.856			0.849	0.0318	3.7%
11	35,938	6	0.868	0.884	0.801	0.916	0.884	0.929	0.837	0.875	0.0484	5.5%
12	13,611	5	0.774	0.834	0.696	0.842	0.771	0.718		0.772	0.0657	8.5%
13	10,477	6	0.724	0.609	0.835	0.741	0.788	0.748	0.781	0.750	0.0768	10.2%
14	19,586	6	0.810	0.899	0.800	0.898	0.829	0.834	0.828	0.848	0.0408	4.8%
15	20,276	6	0.777	0.672	0.710	0.750	0.765	0.823	0.817	0.756	0.0591	7.8%
16	18,020	6	0.696	0.633	0.851	0.710	0.711	0.784	0.788	0.746	0.0769	10.3%
17	26,701	6	0.728	0.800	0.712	0.777	0.742	0.675	0.755	0.744	0.0450	6.1%
18	26,890	6	0.806	0.841	0.814	0.697	0.641	0.718	0.807	0.753	0.0792	10.5%
19	34,954	6	0.841	0.737	0.768	0.828	0.800	0.910	0.937	0.830	0.0790	9.5%
20	21,549	6	0.795	0.724	0.765	0.702	0.789	0.721	0.669	0.728	0.0433	5.9%
21	32,338	6	0.878	0.817	0.912	0.885	0.798	0.948	0.737	0.850	0.0789	9.3%
22	30,750	6	0.866	0.906	0.880	0.765	0.884	0.892	0.878	0.868	0.0513	5.9%
23	35,586	5	0.869	0.804	0.863	0.875	0.872	0.890		0.861	0.0331	3.8%
24	29,911	6	0.832	0.805	0.892	0.859	0.920	0.874	0.889	0.873	0.0388	4.4%
25	27,017	4	0.870	0.882	0.877	0.927	0.896			0.895	0.0228	2.6%
26	39,987	6	0.886	0.850	0.829	0.887	0.895	0.893	0.789	0.857	0.0427	5.0%
27	26,603	6	0.821	0.894	0.818	0.736	0.621	0.898	0.896	0.810	0.1125	13.9%
28	21,354	6	0.872	0.789	0.920	0.897	0.877	0.686	0.891	0.843	0.0894	10.6%
29	19,388	6	0.858	0.874	0.897	0.815	0.790	0.903	0.926	0.867	0.0536	6.2%
30	19,234	6	0.857	0.844	0.824	0.918	0.879	0.847	0.922	0.872	0.0408	4.7%

Appendix Table 2. -- (Continued).

Arrowtooth Flounder

			Whole	Proportion from Sample						All Samples for Haul		
Haul #	TotWt	#Samp	Haul	1	2	3	4	5	6	Avg	StDev	CV
1	13,820	6	0.035	0.013	0.044	0.037	0.057	0.021	0.030	0.034	0.0159	47.1%
2	39,359	6	0.027	0.011	0.025	0.060	0.021	0.016	0.011	0.024	0.0186	77.1%
3	24,142	6	0.035	0.032	0.009	0.022	0.020	0.042	0.053	0.030	0.0161	54.5%
4	42,300	6	0.020	0.001	0.012	0.011	0.037	0.014	0.020	0.016	0.0120	76.3%
5	47,834	6	0.019	0.020	0.013	0.008	0.008	0.007	0.008	0.010	0.0050	48.1%
6	30,582	6	0.033	0.049	0.038	0.029	0.022	0.047	0.008	0.032	0.0155	48.4%
7	24,213	6	0.032	0.031	0.038	0.035	0.035	0.048	0.017	0.034	0.0098	29.0%
8	48,497	6	0.022	0.040	0.012	0.012	0.024	0.015	0.040	0.024	0.0131	55.3%
9	28,878	6	0.042	0.037	0.039	0.035	0.051	0.036	0.047	0.041	0.0067	16.5%
10	23,099	4	0.023	0.024	0.032	0.010	-			0.017	0.0144	86.9%
11	35,938	6	0.018	0.009	-	0.034	0.031	0.033	0.026	0.022	0.0144	64.8%
12	13,611	5	0.018	0.015	0.027	0.006	0.017	0.004		0.014	0.0094	67.4%
13	10,477	6	0.016	0.020	0.005	0.023	0.017	0.023	0.014	0.017	0.0068	40.0%
14	19,586	6	0.014	0.014	0.009	0.013		0.010	0.016	0.012	0.0030	24.8%
15	20,276	6	0.022	0.014	0.015	0.013	0.017	0.023	0.044	0.021	0.0120	57.2%
16	18,020	6	0.027	0.048	0.014	0.030	0.031	0.008	0.019	0.025	0.0143	57.6%
17	26,701	6	0.022	0.032	0.018	0.014	0.014	0.008	0.022	0.018	0.0084	47.1%
18	26,890	6	0.023	0.016	0.022	0.024	0.033	0.032	0.014	0.024	0.0077	32.7%
19	34,954	6	0.020	0.044	0.016	0.004	0.003	0.023	0.012	0.017	0.0151	89.7%
20	21,549	6	0.026	0.014	0.030	0.012	0.031	0.026	0.015	0.021	0.0087	40.3%
21	32,338	6	0.019	0.018	0.030	0.015	0.026	0.006	0.043	0.023	0.0128	56.0%
22	30,750	6	0.023	0.017	0.003	0.029	0.028	0.005	0.019	0.017	0.0109	64.6%
23	35,586	5	0.019	0.026	0.032	0.024	0.005	0.032		0.024	0.0113	47.7%
24	29,911	6	0.033	0.063	0.025	0.043	0.014	0.075	0.024	0.041	0.0244	60.1%
25	27,017	4	0.029	0.021	0.038	0.026	0.012			0.024	0.0106	43.5%
26	39,987	6	0.024	0.058	0.063	0.017	0.054	0.031	0.032	0.042	0.0184	43.2%
27	26,603	6	0.025	0.017	0.006	0.056	0.018	0.016	0.037	0.025	0.0182	73.1%
28	21,354	6	0.019	0.004	0.032	0.010	0.028	0.017	0.024	0.019	0.0107	56.0%
29	19,388	6	0.020	0.017	0.020	0.037	0.013	0.024	0.004	0.019	0.0113	58.5%
30	19,234	6	0.020	0.022	0.013	0.032	0.028	0.061	0.011	0.028	0.0181	64.9%

Appendix Table 2. -- (Continued).

Kamchatka Flounder

			Whole	Proportion from Subsample						All Samples for Haul		
Haul #	TotWt	#Samp	Haul	1	2	3	4	5	6	Avg	StDev	CV
1	13,820	6	0.0004	-	0.0080	-	-	-	-	0.0013	0.0033	245%
2	39,359	6	0.0002	-	-	-	-	-	-	-	0.0000	
3	24,142	6	0.0004	-	-	-	-	-	-	-	0.0000	
4	42,300	6	0.0003	-	-	-	-	-	-	-	0.0000	
5	47,834	6	0.0002	0.0027	-	-	-	-	-	0.0005	0.0011	245%
6	30,582	6	0.0006	-	-	-	-	-	-	-	0.0000	
7	24,213	6	0.0007	-	-	-	0.0072	-	0.0089	0.0027	0.0042	156%
8	48,497	6	0.0002	-	-	-	-	-	-	-	0.0000	
9	28,878	6	0.0005	-	0.0085	-	-	-	-	0.0014	0.0035	245%
10	23,099	4	0.0004	-	-	-	-			-	0.0000	
11	35,938	6	0.0005	0.0059	-	0.0036	-	-	-	0.0016	0.0026	162%
12	13,611	5	0.0009	-	-	-	-	-		-	0.0000	
13	10,477	6	0.0010	-	-	-	0.0049	-	0.0027	0.0013	0.0021	164%
14	19,586	6	0.0004	-	-	-	-	-	0.0056	0.0009	0.0023	245%
15	20,276	6	0.0004	-	-	-	-	-	-	-	0.0000	
16	18,020	6	0.0005	-	-	-	-	-	0.0062	0.0010	0.0025	245%
17	26,701	6	0.0005	-	-	-	-	-	-	-	0.0000	
18	26,890	6	0.0004	-	0.0073	-	-	0.0021	-	0.0016	0.0029	188%
19	34,954	6	0.0002	-	-	-	-	-	-	-	0.0000	
20	21,549	6	0.0006	-	-	-	-	-	-	-	0.0000	
21	32,338	6	0.0002	-	-	-	-	-	-	-	0.0000	
22	30,750	6	0.0002	-	-	-	-	-	-	-	0.0000	
23	35,586	5	0.0003	-	-	-	-	-		-	0.0000	
24	29,911	6	0.0004	-	-	-	-	-	-	-	0.0000	
25	27,017	4	0.0004	-	-	-	-			-	0.0000	
26	39,987	6	0.0003	-	-	-	-	-	-	-	0.0000	
27	26,603	6	0.0006	-	-	-	-	-	-	-	0.0000	
28	21,354	6	0.0007	-	-	-	0.0031	-	-	0.0005	0.0013	245%
29	19,388	6	0.0006	-	-	0.0065	-	-	-	0.0011	0.0027	245%
30	19,234	6	0.0005	-	-	-	0.0061	-	-	0.0010	0.0025	245%

Appendix Table 2. -- (Continued).

Pacific Halibut

			Whole	Proportion from Subsample						All Samples for Haul		
Haul #	TotWt	#Samp	Haul	1	2	3	4	5	6	Avg	StDev	CV
1	13,820	6	0.0079	-	-	-	0.024	-	-	0.004	0.0098	245%
2	39,359	6	0.0048	-	0.064	-	-	-	-	0.011	0.0263	245%
3	24,142	6	0.0166	-	-	0.026	0.097	-	-	0.021	0.0391	190%
4	42,300	6	0.0071	-	-	0.034	-	-	-	0.006	0.0137	245%
5	47,834	6	0.0049	-	-	-	-	-	-	-	0.0000	
6	30,582	6	0.0058	-	0.059	0.063	-	-	-	0.020	0.0315	155%
7	24,213	6	0.0069	-	0.240	-	-	0.029	-	0.045	0.0961	215%
8	48,497	6	0.0060	-	-	-	-	-	-	-	0.0000	
9	28,878	6	0.0156	0.242	0.031	-	-	-	0.063	0.056	0.0947	169%
10	23,099	4	0.0101	-	-	-	0.074			0.018	0.0369	200%
11	35,938	6	0.0016	-	-	-	-	-	-	-	0.0000	
12	13,611	5	0.0042	-	-	0.021	0.027	-		0.010	0.0134	139%
13	10,477	6	0.0036	-	-	-	-	-	-	-	0.0000	
14	19,586	6	0.0070	-	-	-	-	-	-	-	0.0000	
15	20,276	6	0.0095	-	-	-	-	-	-	-	0.0000	
16	18,020	6	0.0068	-	-	0.013	0.037	0.029	-	0.013	0.0163	124%
17	26,701	6	0.0054	-	-	-	0.038	-	-	0.006	0.0154	245%
18	26,890	6	0.0050	-	-	-	-	-	-	-	0.0000	
19	34,954	6	0.0056	0.047	0.012	-	-	-	-	0.010	0.0187	191%
20	21,549	6	0.0064	0.024	-	-	-	-	-	0.004	0.0099	245%
21	32,338	6	0.0048	-	-	-	-	-	0.011	0.002	0.0043	245%
22	30,750	6	0.0046	-	-	-	-	-	-	-	0.0000	
23	35,586	5	0.0049	-	-	-	-	-		-	0.0000	
24	29,911	6	0.0059	0.022	-	0.027	-	-	-	0.008	0.0129	156%
25	27,017	4	0.0054	-	-	-	-			-	0.0000	
26	39,987	6	0.0035	-	-	-	-	-	-	-	0.0000	
27	26,603	6	0.0054	-	0.038	-	0.039	-	-	0.013	0.0199	155%
28	21,354	6	0.0045	0.056	-	-	-	-	0.026	0.014	0.0231	169%
29	19,388	6	0.0047	-	0.010	0.021	-	-	-	0.005	0.0088	168%
30	19,234	6	0.0063	-	-	-	-	-	-	-	0.0000	

Appendix Table 2. -- (Continued).

Eelpouts

			Whole	Proportion from Subsample						All Samples for Haul		
Haul #	TotWt	#Samp	Haul	1	2	3	4	5	6	Avg	StDev	CV
1	13,820	6	0.00011	-	-	-	0.0016	-	0.0014	0.0005	0.0008	155%
2	39,359	6	0.00011	-	-	-	-	-	-	-	0.0000	
3	24,142	6	0.00011	-	-	-	-	-	-	-	0.0000	
4	42,300	6	0.00005	-	-	-	-	-	-	-	0.0000	
5	47,834	6	0.00006	-	-	-	-	-	-	-	0.0000	
6	30,582	6	0.00005	-	-	-	-	-	-	-	0.0000	
7	24,213	6	0.00019	-	-	0.0005	-	-	-	0.0001	0.0002	245%
8	48,497	6	0.00008	-	-	-	-	-	-	-	0.0000	
9	28,878	6	0.00004	-	-	-	-	-	-	-	0.0000	
10	23,099	4	0.00001	-	-	-	-			-	0.0000	
11	35,938	6	0.00001	-	-	-	-	-	-	-	0.0000	
12	13,611	5	0.00004	-	-	-	-	-		-	0.0000	
13	10,477	6	0.00004	-	0.0029	-	-	-	-	0.0005	0.0012	245%
14	19,586	6	0.00002	-	-	-	-	-	-	-	0.0000	
15	20,276	6	0.00001	-	-	-	-	-	-	-	0.0000	
16	18,020	6	0.00010	-	-	-	-	-	-	-	0.0000	
17	26,701	6	0.00009	-	-	-	-	-	-	-	0.0000	
18	26,890	6	0.00007	-	-	-	-	-	-	-	0.0000	
19	34,954	6	0.00004	-	-	-	-	-	-	-	0.0000	
20	21,549	6	0.00007	-	-	-	-	-	-	-	0.0000	
21	32,338	6	0.00009	-	-	-	-	-	-	-	0.0000	
22	30,750	6	0.00004	-	-	-	-	-	-	-	0.0000	
23	35,586	5	0.00010	-	0.0008	-	-	-		0.0002	0.0004	224%
24	29,911	6	0.00013	-	-	-	-	-	-	-	0.0000	
25	27,017	4	0.00005	-	-	-	-			-	0.0000	
26	39,987	6	0.00005	-	-	-	-	-	-	-	0.0000	
27	26,603	6	0.00004	-	-	-	-	0.0018	-	0.0003	0.0007	245%
28	21,354	6	0.00006	-	-	-	-	-	-	-	0.0000	
29	19,388	6	0.00000	-	-	-	-	-	-	-	0.0000	
30	19,234	6	0.00007	-	-	-	-	-	-	-	0.0000	

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