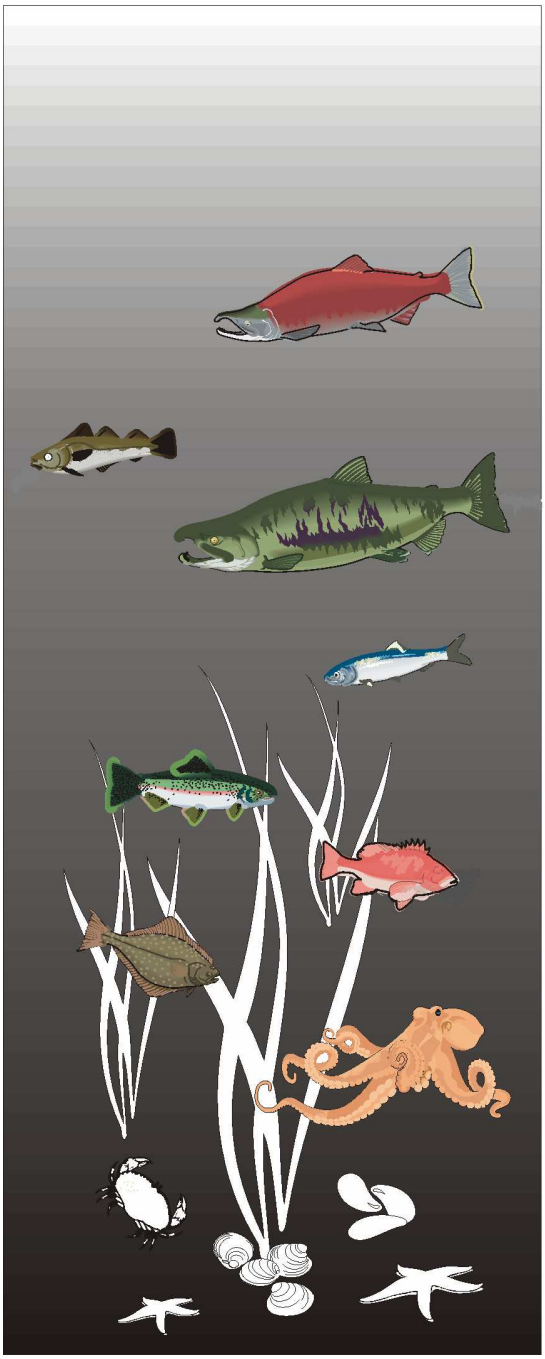
Northwest Fishery Resource Bulletin



The Effect of Decreasing Sample Size on the Precision of GSI Stock Composition Estimates for Chinook Salmon (*Oncorhynchus tshawytscha*) Using Data from the Washington Coastal and Strait of Juan de Fuca Troll Fisheries in 1989-90

By

Christopher Marlowe and Craig Busack

Washington Department of Fish and Wildlife

Project Report Series No. 2

Northwest Fishery Resource Bulletin

Project Report Series

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March 1995

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ABSTRACT

Bootstrap resampling of previously analyzed fishery samples was conducted to examine the effects of sample size on the precision of stock composition estimates from a genetic stock identification analysis. The relationship between estimates of stock group contributions and the precision of these estimates, as measured by the coefficient of variation, was used to compare the effects of different sample sizes on the precision of the estimates for specific fishery strata. The samples sizes required for a coefficient of variation of 50% were compared to demonstrate the relationship between the precision of the stock grouping contribution estimates and sample size. Sample sizes of 200 fish were sufficient for stock groupings which contributed at rates of five percent or greater to the fishery samples. Stock groupings which contributed two percent or less to the fishery samples required sample sizes of 800 fish or more to demonstrate their contribution to the mixture. The problems of estimating the contribution rates of all but the higher contributing stocks to a fishery sample composed of a mixture of stocks are discussed with respect to the precision of the estimates.

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INTRODUCTION

The Washington Department of Fish and Wildlife (WDFW) samples the following fisheries directed at chinook salmon (*Oncorhynchus tshawytscha*): the winter, treaty-troll fishery in catch areas 4B, 5, and 6C; the spring, treaty-troll fishery in areas 4 and 4B; and the spring, non-treaty troll fishery in areas 3 and 4. Sampling of these fisheries includes tissue samples for genetic stock identification (GSI) as well as sex-length data and scales for age determination. Estimates of the stock composition of these fisheries are made using GSI techniques to provide fishery managers information on fishery impacts on specific stocks or stock groupings (Marshall et al. 1990).

Currently the desired sample size for each fishery stratum (time/area combination) sampled is 500 fish. Because of the time and expense of both the collection of the samples and the lab analysis of the tissue samples, it is desirable to determine if fewer fish can be sampled in each stratum while retaining acceptable precision of the stock composition estimates. This report describes an analysis that evaluates the effects of decreasing the sample size below 500 fish.

Initially two approaches were considered for this work, simulations of hypothetical fishery mixtures and bootstrap resampling of existing fishery samples. The bootstrap method (Efron and Tibshirani 1986) was selected because it uses genotypes of actual fish and because of the complexity of the mixtures of stocks found in these fisheries. A comparable analysis using simulations would have required an excessive number of simulations.

METHODS

The analysis method used was a modification of the bootstrap procedure in that different sample sizes were selected from the original sample. For these analyses, existing fishery samples were repeatedly resampled with replacement to create new samples of the desired sample size. Each new sample was then analyzed using standard GSI methods to estimate the contributions of the major stock groups. One hundred of these new samples were constructed for each fishery sample/sample size combination and analyzed. The mean, standard deviation, and coefficient of variation (CV)[1] of the stock contribution estimates were then computed from the 100 estimates for each stock grouping. The regional groupings (six groups) and stock groupings (25 stock groups) reported by Marshall et al. (1990) were used in this study (Appendix A).

Fishery samples for this analysis were selected from the 1989-1990 treaty-troll and the 1990 May-June Washington ocean-troll fisheries. Original fishery stratum samples that had a minimum of 500 fish were selected so that sample sizes of 100, 200, 300, 400, and 500 fish could be evaluated. From the 1989-1990 fishery collections, four fishery samples were selected: three from the treaty-troll fisheries (samples labeled TT995DJ, TT89DJ5, and TT89MJ4) and one from the all citizens fishery (sample MT90A12). Sample TT995DJ was from catch area 5 in December 1988-January 1989. Sample TT89DJ5 was from the same time stratum but from catch area 4. Sample TT89MJ4 was taken in during May and June, 1989 in catch area 4. Sample MT90A12 was taken in May and June, 1990 in catch areas 1 and 2. The results of the original GSI analysis of these fishery samples are reported in Marshall et al. (1990).

The analyses of the fishery samples were conducted on the WDFW Prime computer. From each fishery sample (e.g., TT995DJ), 100 bootstrap resampled files at each specified sample size were created. For all four fishery samples, 100 bootstrapped samples of 500, 400, 300, 200, and 100 fish each were created and analyzed. Fishery collection TT89DJ5 had a sample size of 788 fish and an additional bootstrap sample size of 788 fish was analyzed to examine the effects of samples larger than 500 on the precision of the stock composition estimates.

Maximum likelihood estimates (MLE) of stock grouping contributions were produced using the methods of Millar (Millar 1987). The same coast-wide GSI baseline that Marshall et al. (1990) used for the original analysis of these fishery samples was used for these analyses. The mean, standard deviation, and coefficient of variation of the 100 estimates of contribution for each of the six regional and 25 area stock groupings were calculated. These estimates were then used in a regression analysis and graphed for visual interpretation.

Scatter plots of the mean stock contribution estimates and their coefficients of variation, at all of the sample sizes, were created. Simple linear regression analysis of the logarithms of the mean estimates and the logarithms of their coefficients of variation were calculated and plotted. Using these regressions, contribution levels for predetermined levels of precision as defined by the CV could be estimated and compared for the various sample sizes and fishery samples.

---

[1] The coefficient of variation is the standard deviation of the 100 sample estimates divided by the mean of the 100 sample estimates and is usually expressed as a percentage.

The stock group contributions required for a CV of 50% at each sample size were estimated from the regressions and plotted for each of the fishery samples. These plots were examined for generalizations regarding the sample sizes needed to achieve a specified level of precision for the estimated stock contribution rates.

RESULTS

Table 1 presents the means, standard deviations, and coefficients of variation for the four fishery samples at each of the sample sizes examined for the six regional stock groupings. Appendix Table 1 presents the same information for the 25 stock groupings.

Effects of sample size on the precision of stock grouping contribution estimates and their standard deviations

Examination of Table 1 and Appendix Table 1 reveals that for all sample sizes examined, for all of the analyzed fishery samples, there are not large differences in the mean estimated contributions by stock group among the different sample sizes.

In almost all cases, standard deviations of the stock group estimates decreased as sample sizes increased. For stock contribution levels above 7-10% (in both the six stock and the 25 stock groupings), standard deviations of stock group estimates decreased as sample size increased. For stock group contributions below 2-3%, the standard deviations were erratically related to sample size and were not consistent. We attribute this lack of a relationship to sample errors, i.e., "rare sample" problems.

Effects of sample size on the coefficients of variation

Table 1 and Appendix Table 1 demonstrate that by using the coefficient of variation as the measure of precision, the effect of the magnitude of the mean values of the contribution estimates on the measure of precision is removed and that stock groups with relatively high levels of contribution (e.g., above 10%) show high levels of precision (i.e., they have low CVs). Increasing sample size has a decreasing effect on the CV of any stock group contribution estimate except for stock groups which contribute at low levels (2% or less) where, as discussed above, the standard deviation estimates become unpredictable and therefore so does the CV of the contribution estimates.

Relationship of stock contribution estimates and coefficients of variation

Figures 1 and 2 show scatter plots for sample TT995DJ of the mean stock contribution estimate versus the coefficient of variation for the six and 25 stock groupings with a sample size of 400. These figures demonstrate the basic relationship between these parameters which exists for all of the sample sizes for all of the fishery samples. The shape of these scatter plots strongly suggests a logarithmic relationship. Figures 3 and 4 show the same data plotted after both variables have been transformed to the natural logarithms of their values. The strong linear relationship between the natural logarithm of the stock contribution estimates and the natural logarithm of the associated coefficient of variation is evident. This relationship exists for all of the fishery samples and sample sizes examined.

Table 1. Estimated mean contributions, with standard deviations (SD) and coefficients of variation (CV), for the six stock groupings with sample sizes of 100, 200, 300, 400, and 500 fish. Sample analyzed: TT89MJ4.

SAMPLE:	100 FISH SAMPLE			200 FISH SAMPLE			300 FISH SAMPLE			400 FISH SAMPLE			500 FISH SAMPLE		
TT89MJ4	MEAN	SD	CV	MEAN	SD	CV	MEAN	SD	CV	MEAN	SD	CV	MEAN	SD	CV
STOCK GROUP															
CALIFORNIA/OREGON	12.6%	5.6%	44.7%	12.5%	3.8%	30.7%	12.6%	3.5%	27.8%	12.5%	2.8%	22.1%	11.8%	2.7%	22.7%
COLUMBIA RIVER	33.5%	6.8%	20.3%	32.2%	4.6%	14.4%	32.4%	4.5%	13.9%	31.5%	3.7%	11.6%	32.5%	3.1%	9.7%
WASHINGTON COAST	0.6%	2.0%	356.4%	0.2%	1.0%	468.3%	0.1%	0.6%	570.3%	0.1%	0.9%	614.9%	0.1%	0.3%	610.9%
PUGET SOUND	39.6%	6.9%	17.4%	41.0%	5.2%	12.7%	40.7%	3.9%	9.5%	41.6%	3.6%	8.5%	41.8%	3.4%	8.2%
FRASER RIVER	11.3%	4.6%	40.9%	12.2%	3.0%	24.9%	12.4%	2.7%	21.5%	13.0%	2.6%	20.4%	12.7%	2.0%	15.5%
NON-FRASER RIVER	2.5%	3.0%	120.1%	1.9%	1.8%	98.3%	1.7%	1.9%	108.9%	1.3%	1.4%	109.1%	1.1%	1.1%	98.6%

- continued -

Table 1. Estimated mean contributions, with standard deviations (SD) and coefficients of variation (CV), for the six stock groupings with sample sizes of 100, 200, 300, 400, and 500 fish (continued). Sample analyzed: MT90A12.

SAMPLE:	100 FISH SAMPLE			200 FISH SAMPLE			300 FISH SAMPLE			400 FISH SAMPLE			500 FISH SAMPLE		
MT90A12	MEAN	SD	CV	MEAN	SD	CV	MEAN	SD	CV	MEAN	SD	CV	MEAN	SD	CV
STOCK GROUP															
CALIFORNIA/OREGON	15.6%	6.3%	40.0%	15.0%	4.0%	26.5%	15.2%	3.3%	21.5%	14.6%	3.0%	20.5%	14.7%	2.4%	16.5%
COLUMBIA RIVER	68.2%	7.7%	11.2%	69.1%	5.4%	7.8%	69.1%	3.8%	5.6%	69.4%	3.4%	4.8%	69.8%	3.1%	4.5%
WASHINGTON COAST	0.2%	0.7%	355.9%	0.1%	0.3%	457.9%	0.0%	0.1%	766.7%	0.0%	0.0%		0.0%	0.0%	
PUGET SOUND	12.5%	5.9%	47.3%	12.6%	3.6%	28.6%	12.8%	3.0%	23.3%	13.4%	2.4%	17.6%	13.0%	2.3%	17.5%
FRASER RIVER	1.7%	1.8%	105.4%	1.7%	1.3%	77.5%	1.4%	0.9%	66.4%	1.3%	0.8%	64.4%	1.0%	0.6%	61.6%
NON-FRASER RIVER	1.8%	1.9%	110.3%	1.5%	1.4%	97.2%	1.5%	1.2%	81.2%	1.3%	1.1%	79.2%	1.4%	1.1%	73.8%

- continued -

Table 1. Estimated mean contributions, with standard deviations (SD) and coefficients of variation (CV), for the six stock groupings with sample sizes of 100, 200, 300, 400, 500, and 788 fish (continued). Sample analyzed: TT89DJ5.

SAMPLE:	100 FISH SAMPLE			200 FISH SAMPLE			300 FISH SAMPLE			400 FISH SAMPLE			500 FISH SAMPLE		
TT89DJ5	MEAN	SD	CV	MEAN	SD	CV	MEAN	SD	CV	MEAN	SD	CV	MEAN	SD	CV
STOCK GROUP															
CALIFORNIA/OREGON	2.1%	2.2%	103.5%	1.8%	1.5%	85.1%	1.8%	1.5%	80.9%	1.7%	1.2%	68.7%	1.7%	1.0%	58.0%
COLUMBIA RIVER	15.7%	4.4%	28.2%	16.4%	3.4%	20.7%	16.0%	3.0%	18.8%	16.5%	2.7%	16.2%	16.4%	2.6%	16.2%
WASHINGTON COAST	0.7%	1.9%	263.5%	0.8%	1.5%	193.8%	0.4%	0.8%	183.3%	0.6%	1.2%	192.8%	0.6%	0.8%	150.6%
PUGET SOUND	52.9%	7.3%	13.7%	53.1%	4.6%	8.7%	53.9%	3.9%	7.1%	53.5%	4.1%	7.7%	53.3%	3.3%	6.2%
FRASER RIVER	26.1%	5.6%	21.2%	25.5%	3.8%	15.0%	25.9%	3.6%	14.0%	26.1%	3.2%	12.1%	26.7%	2.9%	10.8%
NON-FRASER RIVER	2.5%	2.5%	97.2%	2.4%	2.1%	89.5%	2.0%	1.6%	81.8%	1.6%	1.5%	91.5%	1.5%	1.1%	72.9%

SAMPLE:	788 FISH SAMPLE		
TT89DJ5	MEAN	SD	CV
STOCK GROUP			
CALIFORNIA/OREGON	1.5%	0.7%	48.6%
COLUMBIA RIVER	15.9%	1.7%	10.6%
WASHINGTON COAST	0.5%	0.7%	155.9%
PUGET SOUND	54.3%	2.4%	4.4%
FRASER RIVER	26.6%	2.0%	7.6%
NON-FRASER RIVER	1.2%	0.9%	75.8%

- continued -

Table 1. Estimated mean contributions, with standard deviations (SD) and coefficients of variation (CV), for the six stock groupings with sample sizes of 100, 200, 300, 400, and 500 fish (continued). Sample analyzed: TT995DJ.

SAMPLE:	100 FISH SAMPLE			200 FISH SAMPLE			300 FISH SAMPLE			400 FISH SAMPLE			500 FISH SAMPLE		
TT995DJ	MEAN	SD	CV	MEAN	SD	CV	MEAN	SD	CV	MEAN	SD	CV	MEAN	SD	CV
STOCK GROUP															
CALIFORNIA/OREGON	3.6%	3.1%	87.6%	2.9%	2.4%	81.4%	2.2%	1.8%	84.1%	2.7%	1.9%	71.9%	2.3%	1.4%	63.9%
COLUMBIA RIVER	13.5%	5.4%	40.2%	13.8%	3.9%	28.0%	12.4%	3.0%	24.2%	12.8%	2.6%	20.5%	13.1%	2.6%	20.0%
WASHINGTON COAST	0.4%	1.2%	263.9%	0.3%	1.2%	463.9%	0.1%	0.4%	541.1%	0.1%	0.9%	608.1%	0.0%	0.1%	999.9%
PUGET SOUND	76.3%	6.4%	8.4%	76.9%	4.9%	6.3%	79.3%	3.6%	4.6%	78.4%	2.8%	3.6%	78.8%	2.8%	3.5%
FRASER RIVER	2.4%	2.2%	89.9%	2.7%	1.6%	57.8%	2.3%	1.5%	63.3%	2.5%	1.2%	47.7%	2.5%	1.4%	55.5%
NON-FRASER RIVER	3.7%	2.6%	70.9%	3.5%	2.1%	60.1%	3.7%	1.7%	44.3%	3.5%	1.7%	49.3%	3.3%	1.4%	43.4%

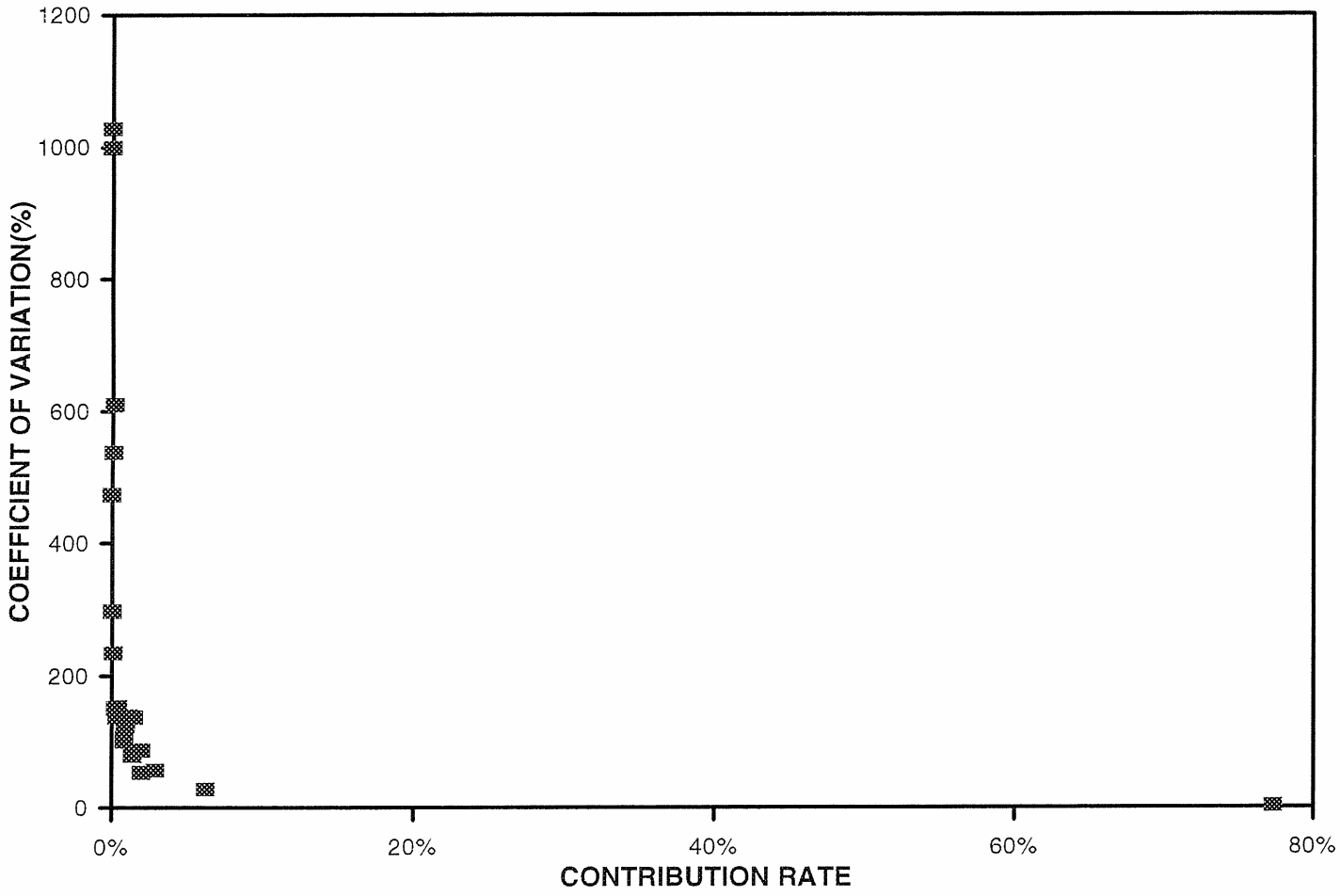

Figure 1. Plot of estimated stock contribution versus coefficient of variation of the estimate from the analysis of sample TT995DJ using 25 stocks groups and a 400 fish sample size.

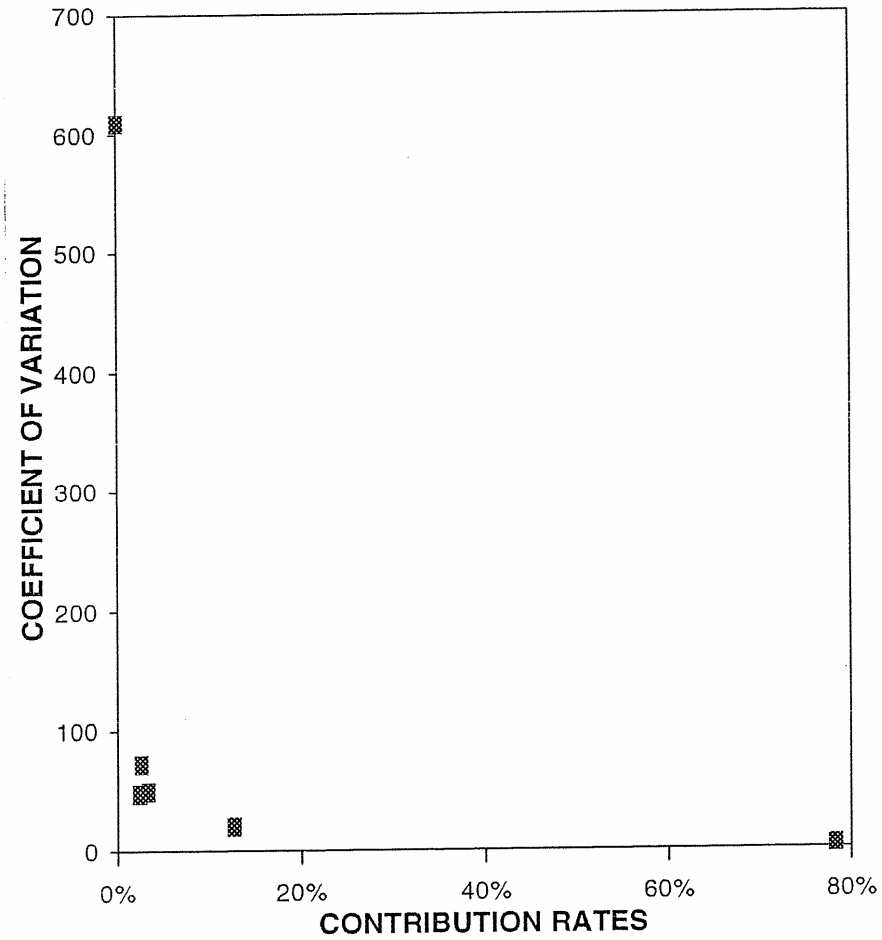

Figure 2. Plot of estimated stock contribution versus coefficient of variation of the estimate from the analysis of sample TT995DJ using six regional stocks groups and a 400 fish sample size.

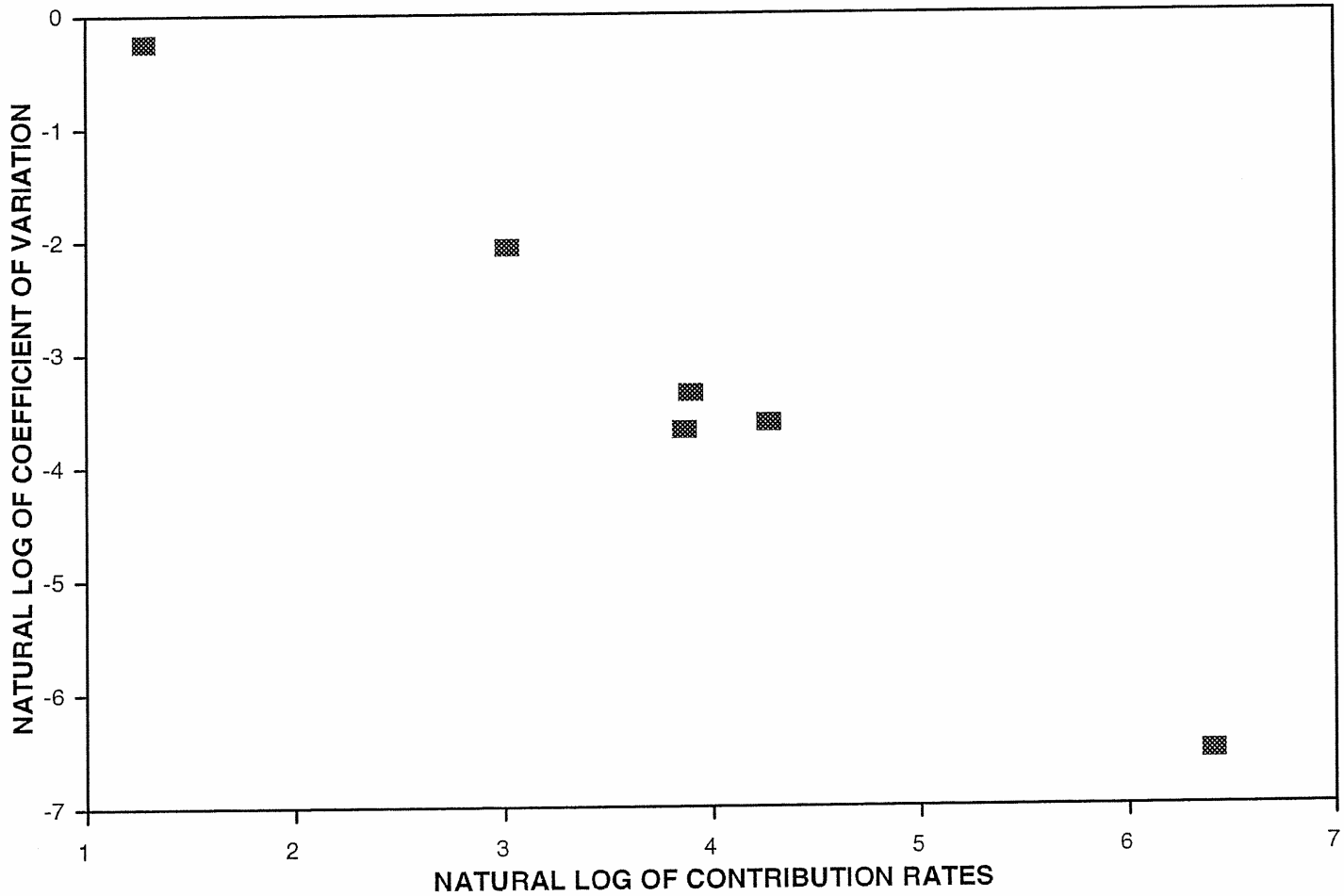

Figure 3. Plot of the natural log of the estimated stock contribution versus the natural log of the coefficient of variation of the estimate from the analysis of sample TT995DJ using six regional stocks groups and a 400 fish sample size.

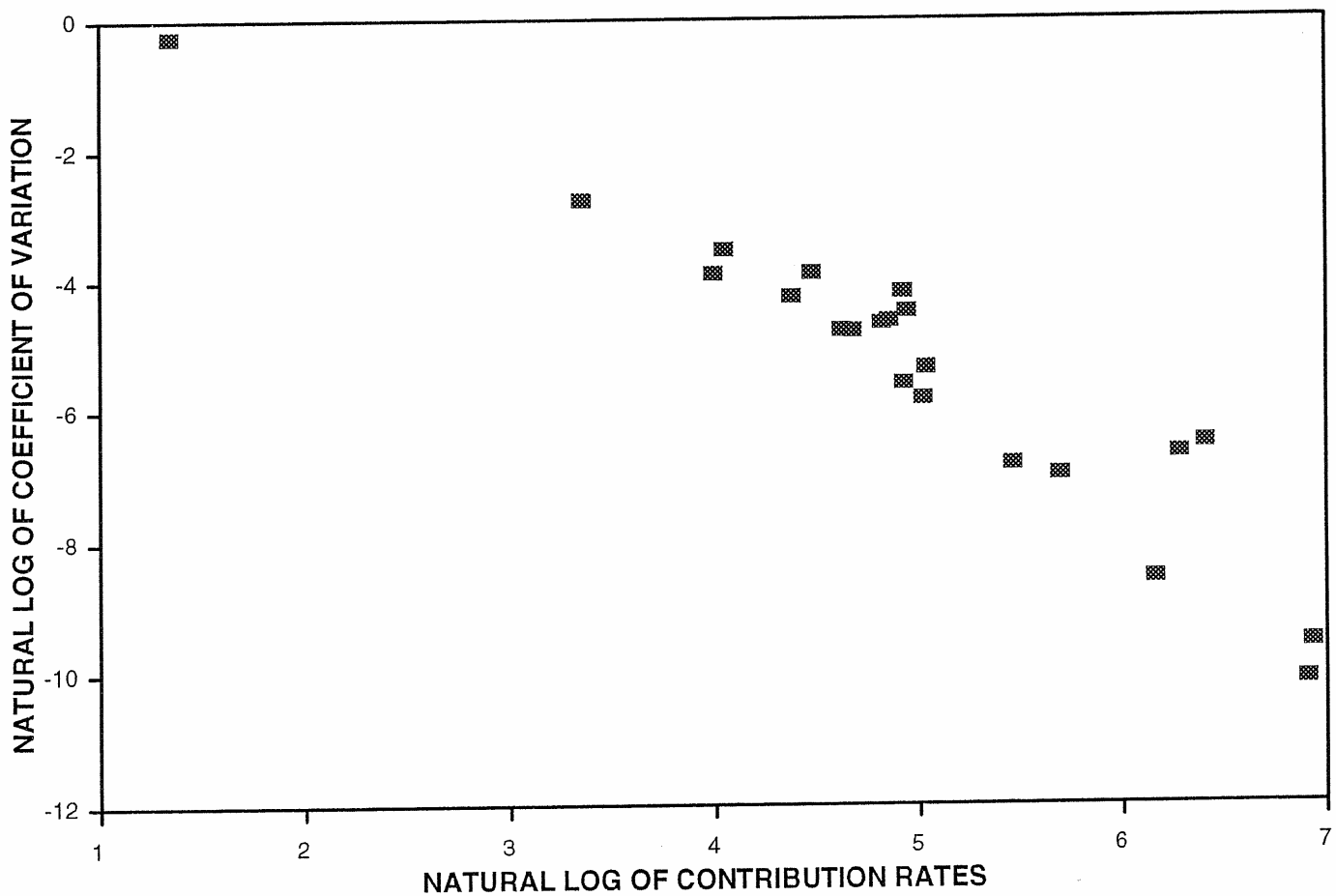

Figure 4. Plot of the natural log of the estimated stock contribution versus the natural log of the coefficient of variation of the estimate from the analysis of sample TT995DJ using 25 stocks groups and a 400 fish sample size.

Linear regression using these data proved to be highly significant for all stock groupings and bootstrap sample size combinations (Table 2). R-squared values ranged between 0.89 and 0.99 and the slopes of the regressions were significant ($P \leq 0.001$ in all cases). Table 2 also reports the Y-intercept and the standard error associated with the intercept for each regression as well as the regression slope and its significance.

Comparison of stock group contributions among different sample sizes for a coefficient of variation of 50%

The strong relationship between the coefficients of variation and the stock group contribution estimates allows comparisons among samples at equivalent levels of the CV. The regression equations defined above can be used to estimate the stock contribution at different sample sizes for a specified coefficient of variation (i.e., the stock contribution rate for each of the different sample sizes when the coefficient of variation is equal to a specified percentage).

A 50% CV was chosen as significant because, with the assumption that the estimates from the bootstrapped samples are normally distributed, any estimate with a CV greater than 50% can not be shown with 95% confidence to have contributed to the fishery collection (the estimated contribution is not significantly different than zero). A 50% CV is a close approximation to 1.96 standard deviations for a normal distribution. Plots of the 50% CV level versus sample size were then interpreted to indicate the smallest estimated contribution level of a stock that was detectable using fishery samples of various sizes for the stock mixtures encountered.

Figures 5 and 6 show the plots of the 50% CV levels for each of the fishery samples and bootstrap sample size combinations for the six regional stock groups and the 25 stock groupings. It is evident that an increase in the sample size decreases the estimated contribution of a stock required to attain a 50% CV. This increases the number of stock groups that could be shown to contribute to a given mixture. This decrease was most dramatic in the increase from a 100 to 200 fish sample size and continued to decrease with increasing sample size.

Figure 5 shows that for the six regional stock group aggregations with a 100 fish sample, stock contributions required for a 50% CV are between six and nine percent. With a 500 fish sample size, the stock contribution required for a 50% CV has decreased to two or three percent for all of the fishery samples examined. Figure 6 shows that for the 25 stock group aggregations with a 100 fish sample size, the stock contribution required for a 50% CV is between eight and 14 percent. With a 500 fish sample size, the stock contribution required for a 50% CV decreased to between three and four percent for all of the fishery samples examined.

In the one fishery collection (TT89DJ5) with a sample size of 788 fish, the stock contribution required for a 50% CV has decreased to less than two percent for both the six group and 25 group stock aggregations (Figures 5 and 6).

Table 2. Results of the regressions of the natural logs of stock contribution estimates and the natural logs of the coefficients of variation for each fishery sample analyzed.

Sample Size:	100	200	300	400	500	100	200	300	400	500
Number of Stocks:	6	6	6	6	6.	25	25	25	25	25
SAMPLE: TT89MJ4										
Constant	2.24	1.90	1.80	1.52	1.55	2.82	2.55	2.43	2.24	2.07
Stand. Error of Y Est.	0.07	0.08	0.15	0.06	0.13	0.28	0.33	0.32	0.35	0.32
R Squared	1.00	1.00	0.99	1.00	0.99	0.90	0.91	0.92	0.93	0.92
Slope[1]	-0.70	-0.68	-0.67	-0.74	-0.65	-0.50	-0.50	-0.50	-0.53	-0.54
Stand. Error of Slope	0.02	0.02	0.03	0.01	0.02	0.04	0.03	0.03	0.03	0.04

Sample Size:	100	200	300	400	500	100	200	300	400	500
Number of Stocks:	6	6	6	6	6.	25	25	25	25	25
SAMPLE: MT90A12										
Constant	2.48	2.09	1.85	1.53	1.44	2.98	2.61	2.45	2.35	2.31
Stand. Error of Y Est.	0.21	0.18	0.24	0.21	0.22	0.21	0.19	0.24	0.30	0.29
R Squared	0.98	0.99	0.98	0.97	0.97	0.95	0.96	0.96	0.94	0.95
Slope[1]	-0.55	-0.56	-0.56	-0.64	-0.64	-0.46	-0.48	-0.48	-0.47	-0.47
Stand. Error of Slope	0.04	0.03	0.04	0.06	0.06	0.02	0.02	0.02	0.03	0.02

[1] All slopes are significant with $P \leq 0.001$.

- continued -

Table 2. Results of the regressions of the natural logs of stock contribution estimates and the natural logs of the coefficients of variation for each fishery sample analyzed (continued).

Sample Size:	100	200	300	400	500	788	100	200	300	400	500	788
Number of Stocks:	6	6	6	6	6.	6	25	25	25	25	25	25
SAMPLE: TT89DJ5												
Constant	2.13	1.72	1.66	1.54	1.47	1.02	2.54	2.42	2.36	2.15	1.90	1.69
Stand. Error of Y Est.	0.08	0.10	0.10	0.11	0.10	0.12	0.22	0.25	0.37	0.29	0.24	0.37
R Squared	1.00	0.99	1.00	0.99	0.99	0.99	0.95	0.94	0.90	0.93	0.96	0.93
Slope[1]	-0.67	-0.72	-0.67	-0.71	-0.67	-0.73	-0.54	-0.50	-0.48	-0.51	-0.54	-0.54
Stand. Error of Slope	0.02	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.04

Sample Size:	100	200	300	400	500	100	200	300	400	500
Number of Stocks:	6	6	6	6	6.	25	25	25	25	25
SAMPLE: TT995DJ										
Constant	2.14	1.69	1.61	1.57	1.57	2.90	2.43	2.30	2.17	2.16
Stand. Error of Y Est.	0.18	0.19	0.21	0.31	0.31	0.32	0.30	0.31	0.42	0.35
R Squared	0.98	0.99	0.99	0.98	0.98	0.89	0.92	0.92	0.89	0.93
Slope[1]	-0.66	-0.73	-0.67	-0.62	-0.62	-0.46	-0.52	-0.50	-0.52	-0.50
Stand. Error of Slope	0.05	0.04	0.04	0.05	0.05	0.03	0.04	0.03	0.04	0.03

[1] All slopes are significant with $P \leq 0.001$.

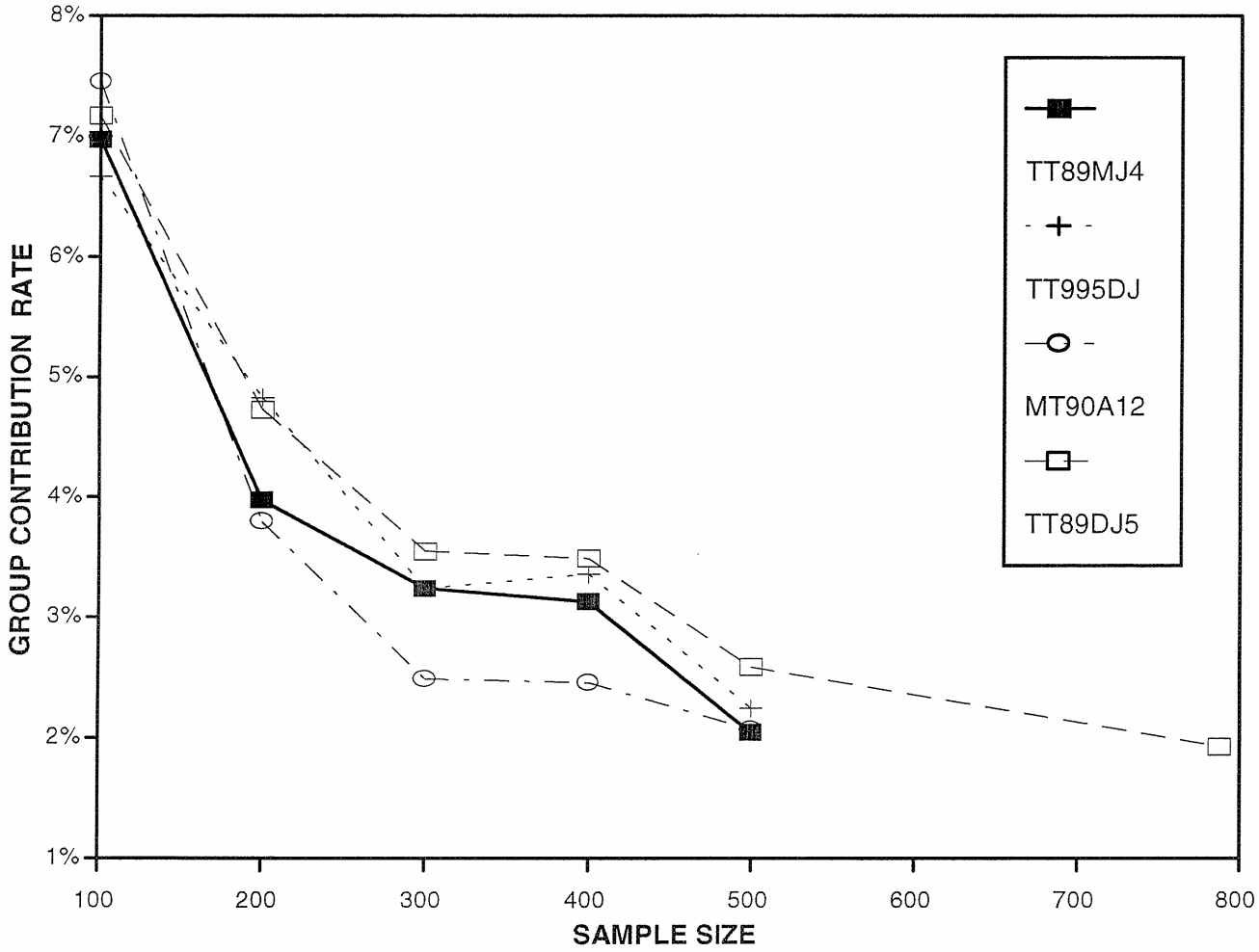

Figure 5. Plot of the sample sizes needed for a 50% coefficient of variation at various stock contribution rates for the four fishery samples analyzed using six regional stocks groups.

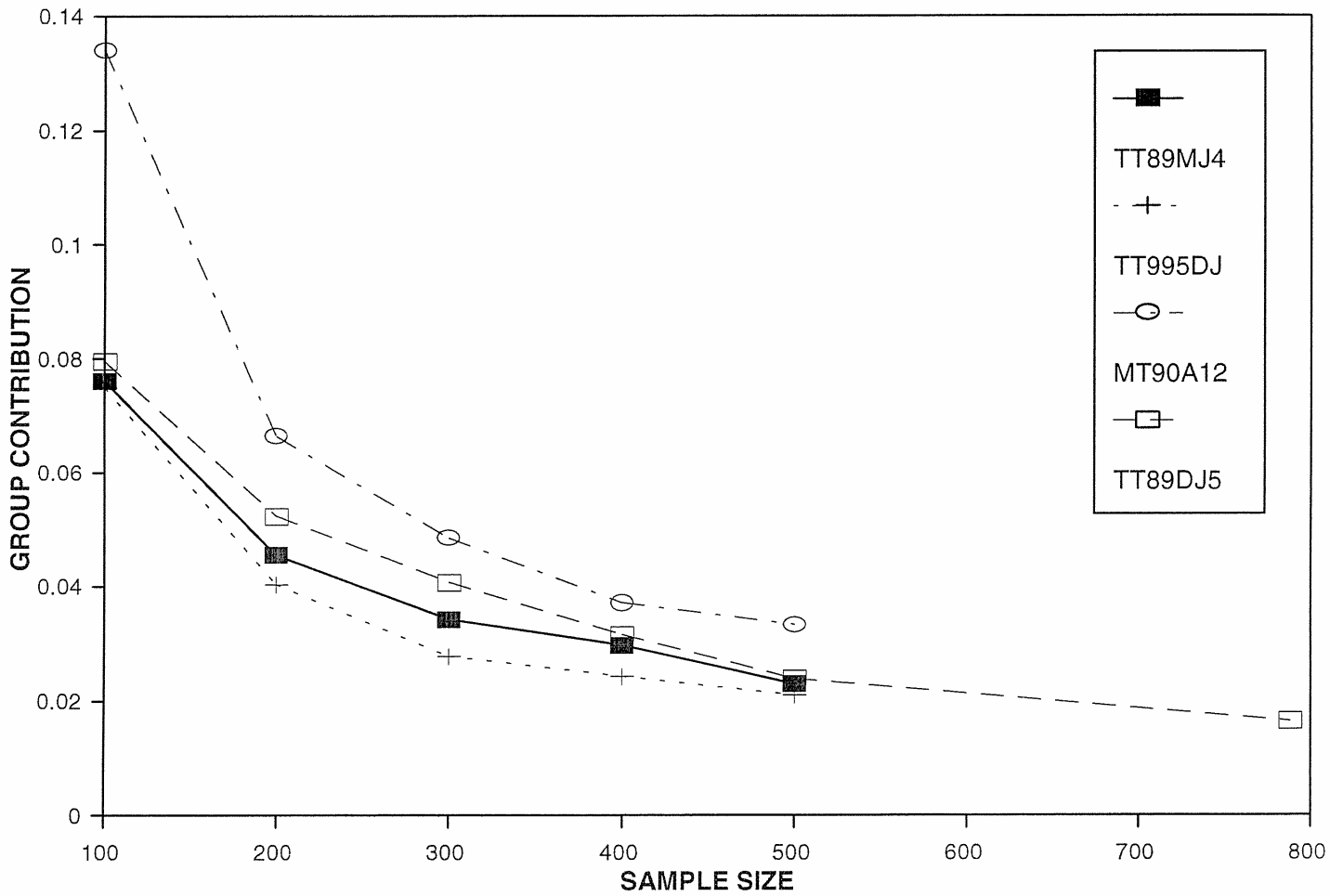

Figure 6. Plot of the sample sizes needed for a 50% coefficient of variation at various stock contribution rates for the four fishery samples analyzed using 25 stocks groups.

In all cases, the largest decrease in the stock contribution needed to attain a 50% CV occurred between the 100 and 200 fish sample sizes with a consistently decreasing rate of change as sample size increases. Only in the six group aggregation from 400 to 500 fish sample sizes does the rate of decrease rise slightly for three of the four fishery samples examined.

CONCLUSIONS AND SUGGESTIONS

The fishery samples examined represent a wide range of stock group mixtures, from mixtures with a single dominant stock (e.g., an 80% contribution of a single stock in sample TT995DJ) to samples with a number of substantial contributors (e.g., in sample TT89MJ4 with six regional stock groupings there are contribution estimates of 38%, 31%, 12%, 12%, 1%, and 0%). We would expect similar results for other GSI stock composition problems with baselines and stock mixtures of similar complexity. The exact decreases in the precision of the stock contribution estimates (increases in the standard deviation and coefficient of variation) due to decreasing the sample size could vary, however. Further bootstrap sample size analyses similar to this study for other mixed stock fishery analyses which use MLE to estimate stock composition are recommended so that the results can be compared with those reported here.

This study demonstrated a relationship between the estimated stock group contribution levels of a fishery sample estimated with GSI techniques and the precision of those estimates as measured by the coefficient of variation. It indicates that estimates of contribution for stocks which are present at low levels, especially when the estimates are made with smaller sample sizes (e.g., 100 or 200 fish) should be used with caution. With smaller sample sizes, the probability increases of having stock groups which cannot with high levels of confidence (e.g., 95%) be shown to have contributed to the fishery. Increasing the sample size for GSI stock composition estimates decreases the smallest level of contribution which can be determined to be present in the mixture. This assumes no bias in the assignment of fish genotypes to baseline stock groupings. These results also show that for the stocks which contribute at rates of 5-6% or greater fishery samples of 200 fish are probably sufficient for most analyses. It is therefore a matter of the level of contribution and the precision of the estimates which fishery managers need which must be defined before sample size requirements can be decided. These results suggest that smaller fishery samples (< 500 fish) would be sufficient to determine the presence of stocks with relatively large contributions to the fishery (e.g., those with estimated contributions of approximately 6% or greater). The corollary of this appears true (i.e., to determine the presence of stock groupings which contribute 2% or less to the fishery requires sample sizes of 800 fish or more).

The large decreases in the estimated stock contribution required for a 50% CV between sample sizes of 100 and 200 fish in the four fishery samples analyzed (Figures 5 and 6), suggests that 200 fish samples may be a reasonable minimum sample size for mixtures of this type where only the estimates for stocks contributing 6% or more to the fishery are required with high precision.

These results illuminate one of the limitations of GSI data analyzed using MLE methodology to estimate stock contributions to fishery mixtures. Even at the largest sample sizes, stocks aggregations which contribute less than 2% to a fishery sample cannot, with 95% confidence, be determined to be present in the sample. At the lowest levels of sample size (i.e., 100 fish), stock groups which contribute less than 6-9% to the fishery sample for six stock groupings and 8-13% for 25 stock groupings are similarly uncertain as to their presence in the sample.

These conclusions are based on the assumption that the contribution estimates at all contribution levels are normally distributed. This assumption allowed the use of the 50% CV to represent the

95% confidence level that a stock's contribution was greater than zero and therefore conclude that the stock was present in the mixture. A brief examination of the shapes of the distributions of the bootstrap estimates suggests that at small contribution levels the normality assumption may not be true. Further study of the empirical distributions of small estimates is needed. Until this is done, we recommend that the results of this work not be used for sample designs intended to detect stocks or stock groups expected to contribute five percent or less to a fishery sample.

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APPENDICES

APPENDIX A

SIX REGIONAL STOCK GROUPS
California-Oregon
Columbia River
Washington Coast
Puget Sound
BC: Fraser River
BC: Non-Fraser

25 STOCK GROUPS
Sacramento (Spring, Fall, Winter)
California Eel and Coastal (Fall)
Klamath (Spring and Fall)
Smith (Fall)
South Oregon Coastal (Spring and Fall)
North Oregon Coastal (Spring and fall)
Lower Columbia (Spring)
Lower Columbia and Bonneville Pool (Fall)
Upper Columbia (Spring)
Snake (Spring)
Upper Columbia and Snake (Summer)
Upper Columbia and Snake (Fall)
North Washington Coastal (Spring and Summer)
Washington Coastal (Fall)
North Puget Sound (Spring)
Puget Sound (Summer and Fall)
Lower Fraser (Spring and Summer)
Lower Fraser (Fall)
Thompson (Summer)
Mid-Fraser (Spring and Summer)
Upper Fraser (Spring)
West Vancouver Island (Fall)
Upper Georgia Strait (Summer and Fall)
Lower Georgia Strait (Summer and Fall)
Central British Columbia Coast (Summer and Fall)

Appendix Table 1. Estimated mean contributions, with standard deviations (SD) and coefficients of variation (CV), for the 25 stock groups with sample sizes of 100, 200, 300, 400, and 500 fish. Sample analyzed: TT89MJ4.

SAMPLE:	100 FISH SAMPLE			200 FISH SAMPLE			300 FISH SAMPLE			400 FISH SAMPLE			500 FISH SAMPLE		
TT89MJ4	MEAN	SD	CV	MEAN	SD	CV	MEAN	SD	CV	MEAN	SD	CV	MEAN	SD	CV
STOCK GROUP															
SACRAMENTO GROUP	5.8%	4.0%	69.7%	5.9%	3.0%	51.2%	5.7%	2.2%	39.7%	6.5%	2.5%	38.9%	5.4%	2.0%	37.3%
CALIFORNIA COASTAL	1.2%	2.1%	174.8%	1.1%	1.6%	138.4%	1.2%	1.6%	132.5%	1.0%	1.3%	131.7%	1.3%	1.3%	100.0%
KLAMATH GROUP	1.1%	1.8%	165.8%	1.0%	1.2%	119.9%	1.1%	1.4%	123.3%	1.0%	1.0%	103.1%	1.1%	0.9%	77.7%
SMITH GROUP	0.3%	1.1%	355.7%	0.6%	1.9%	291.2%	0.4%	1.1%	278.3%	0.4%	1.0%	281.9%	0.3%	0.9%	262.8%
S. OREGON COASTAL	1.6%	2.6%	163.9%	1.2%	1.5%	121.2%	1.8%	1.9%	105.1%	1.5%	1.5%	104.1%	1.5%	1.3%	91.8%
N. OREGON COASTAL	2.6%	3.2%	121.7%	2.5%	2.1%	84.8%	2.4%	1.9%	81.2%	2.2%	1.4%	64.0%	2.2%	1.5%	66.5%
L. COLUMBIA GROUP	4.2%	4.0%	94.8%	4.6%	2.9%	63.2%	4.1%	2.4%	59.6%	5.1%	2.8%	55.5%	4.5%	2.4%	51.9%
L. COLUMBIA,/BONNEV.	23.1%	6.5%	27.9%	22.3%	4.7%	21.2%	22.6%	3.8%	16.6%	20.7%	3.7%	17.8%	22.2%	3.4%	15.5%
U. COLUMBIA GROUP	0.2%	0.6%	351.4%	0.0%	0.3%	750.0%	0.0%	0.0%		0.0%	0.1%	999.9%	0.0%	0.0%	
SNAKE GROUP	0.1%	0.3%	363.0%	0.0%	0.1%	540.0%	0.0%	0.1%	950.0%	0.0%	0.0%		0.0%	0.0%	
U. COLUMBIA/SNAKE(SU)	1.5%	2.2%	142.3%	1.3%	1.9%	147.4%	1.1%	1.8%	156.4%	1.2%	1.5%	131.1%	1.1%	1.5%	140.5%
U. COLUMBIA/SNAKE (F)	4.4%	4.8%	108.7%	4.0%	3.3%	83.0%	4.6%	3.1%	67.0%	4.5%	3.3%	72.8%	4.7%	2.8%	60.6%
N. WA COASTAL	0.4%	1.7%	406.9%	0.1%	0.7%	510.8%	0.1%	0.6%	570.3%	0.1%	0.5%	692.6%	0.1%	0.3%	610.9%
WA COASTAL GROUP	0.2%	1.2%	762.2%	0.1%	0.7%	999.9%	0.0%	0.0%		0.1%	0.8%	981.2%	0.0%	0.0%	
N. PUGET SOUND GROUP	0.3%	0.9%	330.9%	0.3%	0.9%	275.9%	0.2%	0.6%	265.8%	0.2%	0.4%	264.4%	0.1%	0.5%	343.8%
PUGET SOUND GROUP	39.3%	6.9%	17.5%	40.7%	5.4%	13.3%	40.5%	3.8%	9.4%	41.5%	3.6%	8.6%	41.6%	3.5%	8.3%
L. FRASER GROUP (SP,SU)	0.2%	0.5%	297.5%	0.1%	0.3%	344.6%	0.0%	0.2%	388.1%	0.0%	0.1%	950.0%	0.0%	0.0%	587.5%
L. FRASER GROUP (F)	7.1%	4.0%	56.6%	8.9%	3.0%	33.6%	9.2%	2.9%	31.2%	10.1%	2.5%	24.9%	9.9%	1.8%	18.1%
THOMPSON GROUP	3.0%	2.7%	89.1%	2.0%	1.8%	89.6%	2.0%	1.6%	79.5%	1.7%	1.2%	68.0%	1.5%	1.0%	61.9%
MID FRASER GROUP	0.4%	0.7%	194.0%	0.6%	0.8%	132.4%	0.5%	0.5%	118.5%	0.4%	0.5%	118.7%	0.6%	0.6%	95.5%
UPPER FRASER GROUP	0.7%	1.2%	173.2%	0.7%	1.0%	140.8%	0.8%	0.7%	92.0%	0.7%	0.7%	98.9%	0.7%	0.6%	93.7%
W. VANCOUVER IS.	0.6%	1.3%	206.6%	0.6%	1.1%	184.4%	0.4%	0.9%	200.4%	0.2%	0.6%	261.6%	0.3%	0.5%	193.2%
U. GEORGIA STRAIT	1.0%	2.2%	209.4%	0.7%	1.0%	153.7%	0.8%	1.2%	152.0%	0.7%	1.0%	143.7%	0.5%	0.7%	136.0%
L. GEORGIA STRAIT	0.6%	1.5%	225.0%	0.6%	1.1%	196.8%	0.5%	0.9%	185.7%	0.4%	0.7%	197.8%	0.3%	0.6%	208.1%
CENTRAL B.C. COAST	0.2%	0.4%	294.7%	0.0%	0.2%	479.5%	0.0%	0.1%	700.0%	0.0%	0.1%	643.5%	0.0%	0.0%	

- continued -

Appendix Table 1. Estimated mean contributions, with standard deviations (SD) and coefficients of variation (CV), for the 25 stock groups with sample sizes of 100, 200, 300, 400, and 500 fish (continued). Sample analyzed: MT90A12.

SAMPLE:	100 FISH SAMPLE			200 FISH SAMPLE			300 FISH SAMPLE			400 FISH SAMPLE			500 FISH SAMPLE		
MT90A12	MEAN	SD	CV	MEAN	SD	CV	MEAN	SD	CV	MEAN	SD	CV	MEAN	SD	CV
STOCK GROUP															
SACRAMENTO GROUP	10.9%	5.7%	52.5%	10.9%	3.9%	36.3%	11.2%	3.3%	29.9%	11.0%	2.3%	21.1%	10.6%	2.1%	19.9%
CALIFORNIA COASTAL	1.4%	1.9%	135.4%	1.0%	1.4%	135.7%	1.1%	1.3%	122.6%	1.1%	1.1%	99.6%	1.0%	1.1%	104.0%
KLAMATH GROUP	0.5%	1.2%	261.2%	0.2%	0.6%	239.7%	0.1%	0.4%	300.0%	0.1%	0.3%	256.0%	0.1%	0.3%	261.3%
SMITH GROUP	0.1%	0.7%	481.6%	0.2%	0.5%	319.9%	0.1%	0.4%	584.8%	0.0%	0.3%	723.1%	0.0%	0.0%	1200.%
S. OREGON COASTAL	0.8%	2.3%	296.7%	0.6%	1.2%	205.8%	0.6%	1.1%	180.3%	0.6%	1.0%	183.3%	0.8%	1.3%	161.2%
N. OREGON COASTAL	2.0%	2.6%	130.1%	2.2%	2.0%	91.6%	2.1%	1.7%	80.5%	1.7%	1.3%	77.0%	2.1%	1.5%	70.9%
L. COLUMBIA GROUP	12.7%	7.8%	61.1%	12.7%	6.4%	50.5%	13.1%	5.3%	40.4%	13.5%	4.5%	33.1%	13.3%	4.6%	34.4%
L. COLUMBIA,/BONNEV.	47.2%	10.0%	21.1%	47.6%	6.8%	14.4%	48.1%	5.6%	11.7%	47.5%	5.2%	11.0%	48.0%	4.6%	9.5%
U. COLUMBIA GROUP	1.3%	1.7%	134.6%	1.1%	1.2%	110.7%	1.1%	1.2%	104.1%	0.9%	0.9%	96.3%	0.9%	0.8%	80.7%
SNAKE GROUP	0.1%	0.6%	475.6%	0.1%	0.2%	380.6%	0.0%	0.1%	692.3%	0.0%	0.1%	356.8%	0.0%	0.1%	426.9%
U. COLUMBIA/SNAKE(SU)	1.2%	2.5%	203.6%	1.1%	1.9%	161.9%	0.9%	1.4%	153.0%	0.9%	1.5%	180.9%	0.8%	1.3%	153.1%
U. COLUMBIA/SNAKE (F)	5.7%	5.7%	101.0%	6.5%	3.6%	55.7%	5.9%	3.2%	55.4%	6.5%	3.1%	47.25%	6.7%	2.6%	39.5%
N. WA COASTAL	0.1%	0.6%	417.8%	0.1%	0.3%	457.9%	0.0%	0.1%	766.7%	0.0%	0.0%		0.0%	0.0%	
WA COASTAL GROUP	0.0%	0.3%	704.8%	0.0%	0.0%		0.0%	0.0%		0.0%	0.0%	0.05%	0.0%	0.0%	
N. PUGET SOUND GROUP	0.2%	0.6%	362.7%	0.2%	0.6%	366.3%	0.1%	0.3%	632.1%	0.1%	0.3%	390.2%	0.1%	0.4%	527.1%
PUGET SOUND GROUP	12.3%	5.9%	47.7%	12.5%	3.7%	29.6%	12.8%	3.0%	23.3%	13.4%	2.4%	17.9%	12.9%	2.3%	17.6%
L. FRASER GROUP (SP,SU)	0.2%	0.5%	300.6%	0.2%	0.5%	291.7%	0.1%	0.2%	341.8%	0.0%	0.1%	308.6%	0.0%	0.1%	500.0%
L. FRASER GROUP (F)	0.0%	0.3%	950.0%	0.0%	0.3%	770.6%	0.0%	0.2%	507.0%	0.0%	0.1%	510.5%	0.0%	0.1%	722.2%
THOMPSON GROUP	1.1%	1.5%	139.3%	1.0%	1.2%	124.8%	0.9%	0.8%	87.9%	0.8%	0.8%	92.4%	0.7%	0.6%	86.5%
MID FRASER GROUP	0.3%	0.7%	273.9%	0.2%	0.5%	224.6%	0.3%	0.5%	189.0%	0.2%	0.5%	212.9%	0.2%	0.3%	172.6%
UPPER FRASER GROUP	0.2%	0.4%	246.4%	0.2%	0.5%	192.6%	0.1%	0.3%	233.3%	0.1%	0.2%	153.8%	0.1%	0.2%	195.2%
W. VANCOUVER IS.	0.5%	1.3%	239.9%	0.4%	0.8%	189.5%	0.4%	0.8%	179.5%	0.3%	0.7%	205.2%	0.3%	0.6%	193.5%
U. GEORGIA STRAIT	0.2%	0.5%	294.9%	0.1%	0.3%	227.1%	0.3%	0.5%	198.1%	0.2%	0.4%	208.0%	0.3%	0.5%	174.4%
L. GEORGIA STRAIT	0.1%	0.6%	544.0%	0.1%	0.3%	418.3%	0.0%	0.1%	600.0%	0.0%	0.0%	975.0%	0.0%	0.1%	655.6%
CENTRAL B.C. COAST	0.9%	1.4%	146.1%	0.9%	1.2%	135.2%	0.8%	0.8%	102.1%	0.8%	0.8%	99.4%	0.8%	0.8%	97.5%

- continued -

Appendix Table 1. Estimated mean contributions, with standard deviations (SD) and coefficients of variation (CV), for the 25 stock groups with sample sizes of 100, 200, 300, 400, and 500 fish (continued). Sample analyzed: TT89DJ5.

SAMPLE:	100 FISH SAMPLE			200 FISH SAMPLE			300 FISH SAMPLE			400 FISH SAMPLE			500 FISH SAMPLE		
TT89DJ5	MEAN	SD	CV	MEAN	SD	CV	MEAN	SD	CV	MEAN	SD	CV	MEAN	SD	CV
STOCK GROUP															
SACRAMENTO GROUP	0.3%	0.9%	257.8%	0.3%	0.5%	208.5%	0.3%	0.5%	163.3%	0.3%	0.4%	145.8%	0.3%	0.4%	135.0%
CALIFORNIA COASTAL	0.1%	0.7%	506.9%	0.0%	0.2%	592.3%	0.0%	0.1%	562.5%	0.0%	0.1%	503.6%	0.0%	0.0%	
KLAMATH GROUP	0.4%	0.7%	202.8%	0.2%	0.5%	253.0%	0.3%	0.5%	198.8%	0.2%	0.4%	202.8%	0.3%	0.4%	151.6%
SMITH GROUP	0.0%	0.3%	1010.%	0.0%	0.0%		0.0%	0.4%	1013%	0.0%	0.0%		0.0%	0.0%	
S. OREGON COASTAL	0.5%	1.1%	224.4%	0.6%	0.9%	148.3%	0.6%	1.0%	148.4%	0.9%	1.0%	112.6%	0.7%	0.8%	107.5%
N. OREGON COASTAL	0.8%	1.5%	202.8%	0.7%	1.1%	169.4%	0.6%	0.9%	155.4%	0.4%	0.5%	135.6%	0.4%	0.5%	124.5%
L. COLUMBIA GROUP	1.2%	1.9%	165.0%	1.3%	1.7%	132.4%	0.9%	1.2%	134.4%	0.7%	0.8%	122.3%	0.7%	0.7%	98.7%
L. COLUMBIA/BONNEV.	12.3%	4.5%	36.6%	13.3%	3.3%	25.2%	13.1%	2.8%	21.7%	13.8%	2.5%	18.1%	13.5%	2.2%	16.2%
U. COLUMBIA GROUP	0.2%	0.5%	314.2%	0.0%	0.2%	484.8%	0.0%	0.1%	375.0%	0.0%	0.2%	490.3%	0.0%	0.1%	690.9%
SNAKE GROUP	0.0%	0.0%		0.0%	0.0%		0.0%	0.0%		0.0%	0.0%		0.0%	0.0%	
U. COLUMBIA/SNAKE(SU)	0.7%	1.2%	178.4%	0.5%	1.0%	207.9%	0.5%	0.8%	173.8%	0.5%	0.8%	158.3%	0.6%	0.8%	145.7%
U. COLUMBIA/SNAKE (F)	1.3%	2.4%	179.7%	1.3%	1.7%	131.1%	1.5%	1.7%	114.5%	1.5%	1.6%	103.7%	1.5%	1.4%	93.5%
N. WA COASTAL	0.7%	1.9%	269.9%	0.8%	1.5%	197.5%	0.4%	0.8%	183.7%	0.6%	1.2%	192.8%	0.5%	0.8%	154.1%
WA COASTAL GROUP	0.0%	0.2%	988.9%	0.0%	0.1%	647.1%	0.0%	0.0%		0.0%	0.0%		0.0%	0.2%	520.0%
N. PUGET SOUND GROUP	1.6%	2.4%	150.4%	1.0%	1.8%	171.2%	1.0%	1.6%	154.1%	1.0%	1.5%	153.2%	0.8%	1.0%	134.3%
PUGET SOUND GROUP	51.3%	7.3%	14.2%	52.0%	4.9%	9.3%	52.9%	4.1%	7.8%	52.5%	4.2%	8.0%	52.5%	3.4%	6.5%
L. FRASER GROUP (SP,SU)	0.7%	1.0%	145.2%	0.6%	0.8%	120.2%	0.5%	0.5%	93.2%	0.6%	0.5%	82.7%	0.5%	0.5%	91.3%
L. FRASER GROUP (F)	21.7%	5.5%	25.2%	22.3%	4.5%	20.0%	23.1%	3.6%	15.7%	23.5%	3.1%	13.2%	24.7%	3.1%	12.4%
THOMPSON GROUP	3.3%	2.7%	81.4%	2.2%	1.9%	86.3%	2.2%	2.0%	93.0%	1.9%	1.6%	82.3%	1.3%	1.0%	80.0%
MID FRASER GROUP	0.2%	1.0%	449.8%	0.0%	0.2%	431.6%	0.0%	0.0%	733.3%	0.0%	0.1%	650.0%	0.0%	0.1%	600.0%
UPPER FRASER GROUP	0.3%	0.8%	255.0%	0.3%	0.7%	218.1%	0.1%	0.3%	319.5%	0.1%	0.3%	273.6%	0.1%	0.3%	234.1%
W. VANCOUVER IS.	0.3%	1.2%	434.5%	0.2%	0.6%	251.3%	0.2%	0.6%	279.4%	0.1%	0.3%	384.9%	0.1%	0.4%	359.3%
U. GEORGIA STRAIT	0.2%	0.8%	307.4%	0.2%	0.5%	270.2%	0.1%	0.3%	242.5%	0.2%	0.4%	218.8%	0.1%	0.3%	295.3%
L. GEORGIA STRAIT	1.6%	2.1%	136.9%	1.6%	1.9%	115.8%	1.3%	1.3%	105.3%	1.1%	1.3%	112.0%	1.1%	0.9%	84.9%
CENTRAL B.C. COAST	0.4%	1.0%	215.8%	0.3%	0.5%	158.2%	0.3%	0.5%	137.3%	0.2%	0.3%	156.4%	0.2%	0.3%	148.7

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Appendix Table 1. Estimated mean contributions, with standard deviations (SD) and coefficients of variation (CV), for the 25 stock groups with sample sizes of 100, 200, 300, 400, 500, and 788 fish (continued). Sample analyzed: TT89DJ5 (continued).

SAMPLE:	788 FISH SAMPLE		
TT89DJ5	MEAN	SD	CV
STOCK GROUP			
SACRAMENTO GROUP	0.3%	0.2%	92.0%
CALIFORNIA COASTAL	0.0%	0.0%	
KLAMATH GROUP	0.1%	0.2%	168.3%
SMITH GROUP	0.0%	0.0%	
S. OREGON COASTAL	0.8%	0.6%	78.0%
N. OREGON COASTAL	0.3%	0.4%	122.4%
L. COLUMBIA GROUP	0.6%	0.7%	108.7%
L. COLUMBIA,/BONNEV.	13.4%	1.6%	11.6%
U. COLUMBIA GROUP	0.0%	0.0%	999.9%
SNAKE GROUP	0.0%	0.0%	
U. COLUMBIA/SNAKE(SU)	0.5%	0.7%	142.7%
U. COLUMBIA/SNAKE (F)	1.3%	1.1%	83.4%
N. WA COASTAL	0.5%	0.7%	155.9%
WA COASTAL GROUP	0.0%	0.0%	
N. PUGET SOUND GROUP	0.7%	1.0%	144.0%
PUGET SOUND GROUP	53.6%	2.5%	4.7%
L. FRASER GROUP (SP,SU)	0.5%	0.4%	66.2%
L. FRASER GROUP (F)	24.8%	2.2%	8.7%
THOMPSON GROUP	1.2%	0.8%	68.3%
MID FRASER GROUP	0.0%	0.0%	
UPPER FRASER GROUP	0.0%	0.1%	437.9%
W. VANCOUVER IS.	0.0%	0.2%	610.0%
U. GEORGIA STRAIT	0.1%	0.1%	248.3%
L. GEORGIA STRAIT	1.0%	0.8%	85.6%
CENTRAL B.C. COAST	0.2%	0.2%	145.5%

Appendix Table 1. Estimated mean contributions, with standard deviations (SD) and coefficients of variation (CV), for the 25 stock groups with sample sizes of 100, 200, 300, 400, and 500 fish (continued). Sample analyzed: TT995DJ.

SAMPLE:	100 FISH SAMPLE			200 FISH SAMPLE			300 FISH SAMPLE			400 FISH SAMPLE			500 FISH SAMPLE		
TT995DJ	MEAN	SD	CV	MEAN	SD	CV	MEAN	SD	CV	MEAN	SD	CV	MEAN	SD	CV
STOCK GROUP															
SACRAMENTO GROUP	0.1%	0.4%	673.0%	0.0%	0.0%		0.0%	0.0%		0.0%	0.0%		0.0%	0.0%	
CALIFORNIA COASTAL	1.3%	1.9%	139.3%	0.8%	1.3%	154.9%	0.7%	1.1%	156.8%	0.9%	1.2%	123.9%	0.8%	0.9%	112.1%
KLAMATH GROUP	0.8%	1.5%	191.2%	0.5%	0.8%	177.7%	0.4%	0.6%	164.7%	0.5%	0.7%	153.7%	0.3%	0.5%	186.0%
SMITH GROUP	0.1%	0.8%	700.0%	0.0%	0.3%	676.3%	0.0%	0.2%	706.7%	0.0%	0.1%	1029%	0.0%	0.0%	
S. OREGON COASTAL	0.7%	1.9%	261.7%	1.2%	2.1%	179.6%	0.9%	1.6%	166.3%	1.1%	1.6%	140.1%	1.2%	1.5%	129.0%
N. OREGON COASTAL	0.6%	1.4%	262.8%	0.4%	1.0%	232.0%	0.1%	0.4%	344.3%	0.1%	0.7%	537.3%	0.0%	0.2%	795.2%
L. COLUMBIA GROUP	3.0%	2.9%	97.1%	2.8%	2.5%	88.1%	2.7%	1.9%	71.5%	2.9%	1.7%	57.6%	2.7%	1.5%	53.5%
L. COLUMBIA/BONNEV.	6.0%	4.1%	68.9%	7.0%	3.1%	44.3%	6.5%	2.5%	38.1%	6.3%	1.8%	28.8%	6.8%	2.0%	29.3%
U. COLUMBIA GROUP	0.2%	0.5%	266.5%	0.0%	0.2%	616.0%	0.0%	0.1%	630.8%	0.0%	0.1%	473.7%	0.0%	0.0%	725.0%
SNAKE GROUP	0.0%	0.0%		0.0%	0.0%		0.0%	0.0%		0.0%	0.0%		0.0%	0.0%	
U. COLUMBIA/SNAKE(SU)	1.8%	2.8%	152.3%	2.6%	2.6%	97.1%	1.8%	1.8%	100.7%	2.0%	1.8%	88.1%	2.2%	1.8%	81.9%
U. COLUMBIA/SNAKE (F)	2.5%	3.9%	155.7%	1.3%	2.0%	163.6%	1.4%	2.0%	135.9%	1.5%	2.1%	137.4%	1.3%	1.8%	133.2%
N. WA COASTAL	0.4%	1.2%	268.3%	0.3%	1.2%	465.7%	0.1%	0.4%	541.1%	0.1%	0.9%	609.5%	0.0%	0.1%	999.9%
WA COASTAL GROUP	0.0%	0.1%	857.1%	0.0%	0.0%		0.0%	0.0%		0.0%	0.0%		0.0%	0.0%	
N. PUGET SOUND GROUP	1.1%	1.7%	161.3%	1.0%	1.6%	160.2%	1.2%	1.3%	112.6%	1.0%	1.3%	128.6%	1.0%	1.2%	121.8%
PUGET SOUND GROUP	75.3%	6.5%	8.6%	75.8%	5.0%	6.7%	78.1%	3.9%	4.9%	77.4%	3.0%	3.8%	77.8%	3.0%	3.9%
L. FRASER GROUP (SP,SU)	0.2%	0.5%	243.1%	0.1%	0.4%	262.6%	0.1%	0.3%	228.2%	0.1%	0.3%	297.8%	0.1%	0.2%	263.6%
L. FRASER GROUP (F)	1.6%	1.8%	115.4%	1.9%	1.4%	74.2%	1.8%	1.3%	71.2%	2.0%	1.1%	54.6%	2.0%	1.3%	63.5%
THOMPSON GROUP	0.5%	1.2%	230.9%	0.5%	0.8%	188.0%	0.2%	0.4%	182.9%	0.3%	0.5%	151.9%	0.2%	0.4%	159.6%
MID FRASER GROUP	0.0%	0.1%	891.7%	0.0%	0.2%	781.8%	0.0%	0.1%	757.1%	0.0%	0.0%	999.9%	0.0%	0.0%	980.0%
UPPER FRASER GROUP	0.1%	0.5%	350.3%	0.2%	0.4%	240.4%	0.1%	0.3%	248.9%	0.1%	0.3%	235.2%	0.1%	0.3%	287.0%
W. VANCOUVER IS.	1.6%	1.9%	114.6%	1.3%	1.5%	118.1%	1.3%	1.1%	83.4%	1.4%	1.1%	79.8%	1.3%	1.1%	80.4%
U. GEORGIA STRAIT	0.4%	0.8%	202.9%	0.3%	0.5%	186.2%	0.3%	0.5%	180.5%	0.4%	0.5%	137.6%	0.4%	0.5%	125.5%
L. GEORGIA STRAIT	1.0%	1.6%	160.9%	1.0%	1.4%	129.6%	1.2%	1.2%	102.5%	0.9%	0.9%	101.4%	0.7%	0.7%	107.0%
CENTRAL B.C. COAST	0.7%	1.4%	199.4%	0.9%	1.1%	115.9%	1.0%	0.9%	94.2%	0.8%	0.9%	107.6%	0.9%	0.9%	94.5%