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Discards of Cod from the 2006 Canadian Groundfish Fishery on Eastern Georges Bank

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ABSTRACT

Achieving catches that match multiple quotas in mixed fisheries can be difficult. In 2006, the Canadian quota for cod on eastern Georges Bank was 1,326 mt while the quota for haddock was 14,520 mt. The disparity in cod and haddock quotas created an environment where discarding of cod was a potential hazard. The differences between ratios of cod to haddock between at-sea observed fishing and unobserved fishing were used to detect potential discarding and to estimate discards. Two estimators were evaluated, the re-transformed average of the natural logarithm of the ratios and the ratio of the sum of cod to the sum of haddock. The ratio of sums method was recommended for routine application because it was more robust to the presence of sub-trips with small catches that may display erratic cod to haddock ratios and it did not require separate consideration of zero cod and haddock catches. Discarding was not evident for fixed gear fisheries. With few exceptions, discarding appeared to occur by all mobile gear fleets in both zones and all quarters. In total, discards of cod from the Canadian groundfish fisheries on Georges Bank in 2006 were 237 mt.

RÉSUMÉ

Il peut être difficile de réaliser des prises qui concordent avec des quotas multiples dans les pêches mixtes. En 2006, le quota canadien pour la morue dans la partie est du banc Georges était de 1 326 tm, tandis que celui de l’aiglefin était de 14 520 tm. La disparité entre les quotas de morue et d’aiglefin a créé une situation susceptible d’entraîner des rejets de morue. Les différences entre les ratios de morue par rapport à l’aiglefin pour la pêche surveillée par des observateurs en mer et pour la pêche non surveillée par des observateurs en mer ont servi à calculer les rejets potentiels et à en faire des estimations. Deux estimateurs ont été évalués : la moyenne du logarithme naturel retransformée des ratios et le ratio de la quantité totale de morue par rapport à la quantité totale d’aiglefin. La méthode du ratio entre les quantités totales a été recommandée pour une application de routine car elle résistait mieux à l’existence de sorties secondaires susceptibles de fausser les ratios entre la quantité de morue et la quantité d’aiglefin, et parce qu’elle n’exigeait pas de tenir compte de façon distincte des prises ne comptant aucune part de morue ou d’aiglefin. Dans le cas des pêches aux engins fixes, il n’y a pas de données indiquant qu’il y a eu des rejets. À quelques exceptions près, toutes les flottilles d’engins mobiles semblent avoir rejeté des prises dans les deux zones et tous les trimestres. Au total, les rejets de morue dans les pêches du poisson de fond sur le banc Georges ont été de 237 tm.

Introduction

Catch quotas are a principal feature of Canadian fisheries management. Achieving catches that match multiple quotas in mixed fisheries can be difficult. The different species are not necessarily caught in proportion to their population biomass by the various fisheries. In 2006, the Canadian quota for cod on eastern Georges Bank was 1,326 mt while the quota for haddock was 14,520 mt. The 2006 Canadian groundfish fishery primarily targeted haddock and tried to avoid the capture of cod, although there was some directing for pollock. Fishermen used a variety of techniques, including gear modification and alteration of fishing locations, to achieve an appropriate species mix in their catch. Nonetheless, the disparity in cod and haddock quotas created an environment where discarding of cod was a potential hazard.

All groundfish trips to Georges Bank are subject to dockside monitoring by an independent contracted party. These companies are responsible for recording the weight that is landed by species and collecting the log books that fishermen are required to complete for each trip. The log books are used to pro-rate the total weight to the individual fishing events during the trip, thereby attributing the catch to location and date/time of capture. The landings data are considered reliable. Operations at sea are subject to a variable amount of observation, also by an independent contracted party, averaging overall about 30% coverage of days fished in 2006 for the Canadian groundfish fishery on Georges Bank. Discarding of cod is not permitted in Canadian groundfish fisheries. Accordingly, discarding of cod does not occur on observed trips. The purpose of this paper is to evaluate data for evidence of discarding on unobserved trips and to determine the total catch of cod, including discards.

Data and Methods

Approach

Under similar conditions, the ratio of cod to haddock in the catch, landings plus discards, should be the same whether fishing is observed or not. Therefore, consider the following equality

$$\frac{{}^{L}C_U + {}^{D}C_U}{{}^{L}H_U + {}^{D}H_U} = \frac{{}^{L}C_O + {}^{D}C_O}{{}^{L}H_O + {}^{D}H_O},$$

where *C* represents cod and *H* represents haddock with *L* and *D* designating landings and discards respectively and *U* and *O* designating unobserved and observed respectively. As discarding does not occur on observed fishing operations and assuming that haddock are not discarded on unobserved fishing operations, since those quotas are not considered limiting, the equality can be simplified to

$$\frac{{}^{L}C_U + {}^{D}C_U}{H_U} = \frac{C_O}{H_O}.$$

Rearranging gives

$${}^{L}C_U + {}^{D}C_U = \frac{C_O}{H_O} H_U .$$

Defining the landings multiplier parameter *m* as

$$m = \frac{C_O}{H_O} \Big/ \frac{{}^{L}C_U}{H_U}$$

and substituting shows that cod catch (landings + discards) from unobserved fishing is obtained by multiplying cod landings from unobserved fishing by *m*.

$${}^{L}C_U + {}^{D}C_U = m\,{}^{L}C_U$$

Discards from unobserved fishing are then simply the cod landings subtracted from this cod catch

$${}^{D}C_U = \left(m\,{}^{L}C_U\right) - {}^{L}C_U$$

For example, consider a situation where the cod to haddock ratio for observed fishing was 0.4 and the ratio for unobserved fishing was 0.2. This suggests cod may have been discarded on the unobserved fishing. The multiplier to apply to the cod landings from the unobserved fishing to obtain the actual catch (landings plus discards) would be 0.4/0.2=2. If the landings of cod for the unobserved fishing were 100 mt, the estimate of total catch of cod for the unobserved fishing would be 200 mt, implying discards of 100 mt.

The landings multiplier, *m*, is based on ratios of cod to haddock. Factors that are expected to affect the species composition include fishing fleet, fishing ground location and season. Quarters were used to stratify season. The definition of fishing fleets and zones aimed to identify strata within which fishing outcomes were relatively homogeneous.

The Canadian quotas are sub-allocated to quota groups. Sub-allocation of shares to quota groups varies by species. Therefore, the quota mix varies substantially by quota group. The quota mix can be an important determining factor in discarding behaviour. Accordingly, fishing fleets were defined by quota groups (Table 1). Generally, quota groups comprise vessels that are similar with respect to size and gear. A quota group's allocation may be fished by vessels smaller than those in the group under the Temporary Vessel Replacement Program (TVRP is a mechanism by which a fleet can contract another fleet to catch their quota without transferring the quota). Almost all of the 2006 catch by the MG 65'-100' and the >100' fleets was taken by vessels less than 65' under the TVRP program.

Zones were defined for Georges Bank based on areas of fishing concentration and homogeneity of species composition (Fig. 1). While there appears to be considerable local scale variation in species composition, the zones could not be made too small given the observer sampling intensity.

Estimates of the landings multiplier parameter *m* were derived by fishing fleet, zone and quarter in order to compute discards.

Data & Data Preparation

Landings of cod and haddock for 2006 were obtained from the fisheries statistics database maintained by the Maritimes Region of Fisheries and Oceans Canada. Trips were classified as observed or unobserved. Fishermen have indicated that small catch quantities of a species may not get recorded for each fishing event on a logbook. Rather, those catches may be aggregated and attributed to the largest catch of that species for the day.

Exploration confirmed a disparity in the frequency of small catches recorded in the logbooks compared to the observer records. To counter this effect and to reduce the high variability associated with small catches, catches from all fishing events from a trip were aggregated within each zone. Therefore the basic record unit was the aggregate of catches from a trip within each zone, referred to as a sub-trip.

Use of a separator panel when fishing a bottom otter trawl on Georges Bank was mandatory in 2006 unless an observer was on board. Observed sub-trips where the separator panel was removed were excluded from the analyses as these were not representative of unobserved fishing. Also, trips where the observer deployment was for management purposes rather than routine monitoring were excluded as these might not be representative either.

The Canadian groundfish fishery on Georges Bank may target cod, haddock, pollock or yellowtail flounder. Few cod were caught in the limited pollock directed fishing by mobile gear. Very few cod were caught in a small number of exploratory sub-trips by mobile gear searching for yellowtail flounder. Cod are also taken by limited fisheries using gillnet or handline that direct for cod and therefore are not considered to discard cod. As in previous recent years therefore (Van Eeckhaute and Gavaris 2004), virtually all the cod for 2006 were caught in Zones A and B during fishing targeting for haddock (Table 2). Accordingly, discards were only derived for Zones A and B and for the designated fleets targeting haddock, i.e. excluding pollock and yellowtail flounder targeted fishing by mobile gear and cod targeted fishing by gillnet and handline. Sub-trips that sought pollock were identified as those where the catch of pollock exceeded the catch of cod and haddock or observed sub-trips where the declared species sought was pollock. Some instances of sub-trips where the catch of pollock exceeded the catch of cod and haddock were not removed because examination of catches by set indicated that the sub-trip was haddock directed but unexpectedly encountered a school of pollock. A small amount of catch by a vessel experimenting with a new bottom trawl configuration was excluded from comparisons because the bycatch from this vessel might not be comparable to the rest of the fleet. The amount of cod landed from other zones by all the excluded fishing activity was relatively low; therefore any potential estimated discards would be inconsequential.

Estimation

The data for each fleet, zone and quarter grouping were analyzed separately to derive an estimator of the landings multiplier. The ratios of cod to haddock typically have a skewed distribution (Figure 2) and their average would generally not possess desirable statistical properties, therefore average ratios were not considered further. Two estimators were evaluated, the re-transformed average of the natural logarithm of the ratios and the ratio of the sum of cod to the sum of haddock.

A few sub-trips occurred where either the catch of cod or the catch of haddock were zero. This was likely due to either aborted trips or to brief forays into a zone. These pose a complication for logarithmic transformation and therefore had to be excluded. The implications of including or excluding the zero catches on estimation of m using the ratio of sums were investigated.

The aggregate catch of cod, haddock and pollock from traditional groundfish trips is generally of the order of a few to tens of tons. By partitioning trips into sub-trips, brief forays into a zone may result in small catches of cod, haddock and pollock. Previous investigation (Van Eeckhaute and Gavaris 2004) of running averages of the ratio of cod to haddock plus pollock on sub-trips ordered from smallest catch to largest revealed that the ratio was rather erratic when the aggregate catch was less than 1 mt. The implications of including or excluding sub-trip records where the aggregate catch of cod, haddock and pollock was less than 1 mt on estimation of *m* were considered.

Ln transform estimator

For each fleet, zone and quarter grouping the ratio of cod to haddock from sub-trips, Y_i, can be modeled as

$$Y_i = \mu\left(m^X\right)\varepsilon_i$$

where X is 0 when the sub-trip was unobserved and 1 when the sub-trip was observed, μ is the average cod to haddock ratio for unobserved sub-trips, m is the landings multiplier and ε is random error. Taking natural logarithms gives

$$\ln Y_i = \ln \mu + (\theta X) + \varepsilon_i$$

where θ=ln m.

An estimator of θ is obtained directly from application of ordinary least squares regression. Assuming that ε are distributed according to a Gaussian distribution, an unbiased estimator of the landings multiplier, m, is given by

$$\hat{m}_{\ln} = e^{\hat{\theta}} g_\nu\left[-\frac{\nu+1}{\nu}\frac{\hat{\sigma}_\theta^2}{2}\right]$$ (Bradu and Mundlak 1970)

where ν are the degrees of freedom and $g_\nu(arg)$ can be approximated by e^{arg} for sufficiently large degrees of freedom (Ebbeler 1973).

An analytical estimate of the variance of the ln transform estimator of the landings multiplier is given by

$$e^{2\hat{\theta}}\left\{g_\nu^2\left[-\frac{\nu+1}{\nu}\frac{\hat{\sigma}_\theta^2}{2}\right] - g_\nu\left[-\frac{\nu+1}{\nu}2\hat{\sigma}_\theta^2\right]\right\}$$ (Bradu and Mundlak 1970).

Ratio of sums estimator

The landings multiplier, m, can be estimated as the observed to unobserved ratio of the sum of cod divided by the sum of haddock from sub-trips for each fleet, zone quarter,

$$\hat{m}_r = \frac{\sum_i C_O}{\sum_i H_O} \Bigg/ \frac{\sum_j {}^L C_U}{\sum_j H_U}.$$

An analytical estimate of the variance of the ratio of sums estimator of the landings multiplier is given by

$$\hat{m}_r^{\,2}\left(\left(\hat{\sigma}_{r_O}/\hat{r}_O\right)^2 + \left(\hat{\sigma}_{r_U}/\hat{r}_U\right)^2\right)$$

where r_O and r_U are the cod to haddock ratios for observed and unobserved fishing respectively, assuming that observed and unobserved samples are not correlated. An estimator of the standard errors, $\hat{\sigma}_r$, for these ratios is given by

$$\hat{\sigma}_r = \sqrt{\frac{\sum_i (C - rH)^2}{n-1}} \Big/ \overline{H}\sqrt{n}$$ (Cochran 1977).

Inference

A landings multiplier of 1 signifies that the cod to haddock ratios were the same for observed and unobserved fishing. It is possible to obtain estimates of landings multipliers less than 1, signifying that the ratio of cod to haddock was higher in the unobserved fishing. When the landings multiplier is equal to or less than 1, it can be inferred that discarding did not occur. When the landings multiplier is greater than 1, it can be inferred that discarding is suspected. The larger the multiplier, the stronger is the evidence for discarding and the greater are the estimated discards. Due to random variation, landings multipliers that are only slightly greater than 1 may not warrant an inference that discarding indeed occurred. Van Eeckhaute and Gavaris (2004) did not calculate discards when the estimated landings multiplier was within one standard error of 1. The sampling distribution of the landings multiplier is not symmetric however, and this practice does not ensure a consistent confidence level. Here, empirical bootstrap confidence distributions were derived to evaluate the uncertainty in the landings multiplier estimate.

A confidence distribution can be used to make an inference statement about the landings multiplier, e.g. the probability that the landings multiplier estimate is less than 1. Typically a sample is collected from which inferences can be made about a parameter of interest if something is known about the frequency distribution from which the sample is drawn. This only holds for some special parameters, like a mean, when the frequency distribution is of a particular form or if the sample size is large. An exact analytical confidence distribution for the landings multiplier is not easily derived.

The bootstrap provides an automatic way of obtaining confidence distributions of estimators in general situations. If we had many samples we could calculate many estimates to construct the confidence distribution, but typically only one sample is available. The bootstrap is based on the notion of a bootstrap sample. A simple bootstrap sample is a data replicate that is obtained by *sampling with replacement* from the original data. The bootstrap samples are used to calculate bootstrap replicates of the estimator. The distribution of these estimator replicates can be used to make confidence statements.

Statistical properties for a parameter of interest can be obtained from a bootstrap simulation Efron and Tibshirani (1993). Letting η represent any parameter of interest, the statistical properties of an estimator $\hat{\eta}$ are derived from the bootstrap replications of the estimator, $\hat{\eta}^b$. The replicates are computed by applying the estimation formulae to bootstrap samples. The bootstrap estimates of variance and bias are

$$Var(\hat{\eta}) = \sum_{b=1}^{B} \left(\hat{\eta}^b - \overline{\eta}\right)^2 \Big/ B - 1$$

$Bias(\hat{\eta}) = \overline{\eta} - \hat{\eta}$

where

$\overline{\eta} = \sum_{b=1}^{B} \hat{\eta}^b \Big/ B$.

The "raw" distribution of the estimator replicates can be used directly to make confidence statements. The *percentile* confidence distribution of the interest parameter is defined as the proportion of bootstrap replicates, $\hat{\eta}^b$, less than or equal to that value,

$$\hat{\Omega}(x) = \text{Prob}\{\hat{\eta} \le x\} = \frac{\#\{\hat{\eta}^b \le x\}}{B}$$

where B is the total number of bootstrap replicates.

For some situations, the estimator is biased and so the percentile confidence distribution is not accurate. An automatic procedure for adjusting for the bias is available. The *bias-corrected percentile* method of Efron and Tibshirani (1993) improves on the percentile method by adjusting for differences between the median of the bootstrap percentile density function and the estimate obtained with the original data sample. The bias-corrected percentile confidence distribution of the interest parameter is obtained by constructing the paired values $(\hat{\eta}^b_{BC}, \alpha)$. The α are the respective probability levels equal to $1/B, 2/B, 3/B, \cdots, B-1/B$. For each α, calculate the bias adjusted quantity,

$$\hat{\eta}^b_{BC} = \hat{\Omega}^{-1}\left(\Phi(2z_0 + z_\alpha)\right).$$

Here, Φ is the cumulative distribution function of a standard normal variate, $z_\alpha = \Phi^{-1}(\alpha)$ and $z_0 = \Phi^{-1}\left(\hat{\Omega}(\hat{\eta})\right)$. The term z_0 achieves the bias adjustment. The notation $\hat{\Omega}^{-1}(\ )$ or $\Phi^{-1}(\ )$ is used to represent the inverse distribution function, i.e. the critical value corresponding to the specified probability level. Note that computations are not carried out for $\alpha = B/B$ because $z_\alpha = \Phi^{-1}(\alpha = 1)$ is not defined.

Results & Discussion

Using only those sub-trips where the catches of cod and haddock were not zero and where the combined catch of cod, haddock and pollock exceeded 1 mt, the estimates of 2006 discards were similar for the ln transform and the ratio of sums methods, showing no systematic patterns (Figure 3). The comparisons were done by zone and quarter for the 3 fleets where there were sufficient data, MG<65', >100' and FN. An estimator may be preferred over others if it possesses higher precision and lower bias. For both methods, the analytical estimates of variance were similar to those obtained using the bootstrap. The bootstrap results were used to compare the relative precision of the ln transform and ratio of sums methods. The ratio of the standard errors from the two methods shows values fairly uniformly distributed about 1 (Figure 4), suggesting that neither estimator is consistently more precise. The ratio of the biases from the two methods is more often less than 1

(Figure 5), suggesting that the ratio of sums may be somewhat less biased. However, the bias from either method was typically quite low.

As noted earlier, sub-trips where the combined catch of cod, haddock and pollock was less than 1 mt were excluded in the above comparisons. This was done to avoid undue influence from sub-trips with small catches where the ratios tend to be more erratic. The cutoff of 1 mt is arbitrary. A method that is robust to the presence of these erratic values and does not require imposition of an arbitrary rule would be preferred. Estimates of discards from the ratio of sums and the ln transform methods when all sub-trips were included were compared to those excluding sub-trips with less than 1 mt of cod, haddock and pollock. The results indicate that the discard estimates from the ratio of sums remained virtually identical while those from the ln transform method could be substantially altered, either higher or lower (Figure 6).

A further complication with the ln transform method was the inability to easily incorporate zero catches of cod or haddock. To account for the effect of zero catches, a more complicated estimator assuming a delta distribution (Aitchison and Brown 1957), rather than a lognormal distribution, or an external mechanism accounting for differences in the occurrence of zero catches between observed and unobserved fishing would have to be devised. The zero catches do not present any problem for the ratio of sums method.

While the two methods gave similar results with well conditioned data, the ratio of sums method was more robust to the presence of sub-trips with small catches that may display erratic cod to haddock ratios and it did not require separate consideration of zero cod and haddock catches. These characteristics considerably enhance the ease of application. On balance therefore, the ratio of sums method is recommended for routine application and was used for subsequent analyses.

The ratio of sums method was applied to obtain the landings multipliers by fleet, zone and quarter (Table 3). The associated standard errors from the bootstrap analyses are also shown. Bootstrap confidence distributions of the landings multiplier were examined to determine if it could be inferred that discarding occurred (Figures 7-11). The percentile and bias corrected confidence distributions were generally coincident, indicating that the bias is small. Discards were calculated for cases where the reference landings multiplier of 1 intersected the bias corrected confidence distribution at a probability of 0.2 or less. There was no convincing indication of discarding for FG<45. There was insufficient data to estimate landings multipliers for FG45-65 and FG65-100. Considering the lack of evidence for discarding by the FG<45, no discards were calculated for the FG45-65 and the FG65-100 fleets. Due to the paucity of observations, the analysis for MG65-100 used pooled data across quarters 3 and 4 in Zone B. With few exceptions, discarding appeared to occur by all mobile gear fleets in both zones and all quarters. In total, discards of cod from the Canadian groundfish fisheries on Georges Bank in 2006 were 237 mt (Table 4).

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Table 1. Designated fisheries participating in the Canadian groundfish fishery on Georges Bank and their initial haddock to cod quota ratios in 2006.

Designation	Description	haddock:cod quota ratio
FG<45	fixed gear (longline only), vessels less than 45’	4.3
FG 45-65	fixed gear (longline only), vessels between 45’ and 65’	6.3
MG<65	mobile gear (bottom trawl only), vessels less than 65’	19.2
FG 65-100	fixed gear (longline only), vessels between 65’ and 100’	14.0
MG 65-100	mobile gear (bottom trawl only), vessels between 65’ and 100’	14.0
>100	vessels greater than 100’ (bottom trawl only)	63.5
FN	first nations (bottom trawl only)	20.0

Table 2. Landings of cod from the Canadian fisheries on Georges Bank. Discards may occur during unobserved fishing. Discard calculations were examined for haddock targeted fishing in Zones A and B by quarter for the designated fleets (shaded cells), accounting for virtually all of the unobserved cod landings.

	Zone A				Zone B				other zones	Total
FLEET	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**all Q**	
Observed										**264**
FG<45		1	5		3	2	23		1	
FG 45-65			1					2		
MG<65	0	0	7	4	25	36	28	7	15	
FG 65-100							2			
MG 65-100			0		2	1	2			
>100		0	3	4	6	14	11	2	4	
FN		0	1	0	6	7	7	0	4	
other		0	2	8	0	3	6	10	0	
Unobserved										**832**
FG<45			91	26		11	362	78	6	
FG 45-65			1	3			1	13		
MG<65	0	0	10	10	10	9	90	29	2	
FG 65-100			0				7			
MG 65-100			0		1		3	2		
>100			2	4	2		14	9	0	
FN		0	3	1	5	1	19	4	1	
other		0		1				0		
Total										**1096**

Table 3. Estimated landings multipliers (± standard errors) for designated fleets by zone and quarter. Shaded values indicate that discarding was not inferred.

	Zone A				Zone B			
	Q1	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
FG<45			0.75±0.23			0.41±0.43	1.05±0.26	
FG 45-65								
MG<65		0.64±0.08	1.88±0.46	1.59±0.32	1.48±0.48	1.90±0.60	1.70±0.32	2.79±0.65
FG 65-100								
MG 65-100							2.91±1.33	
>100			2.18±0.65	1.06±0.51	3.02±2.66		2.62±0.47	3.58±1.41
FN			1.63±0.86		1.14±0.41	1.45±0.47	2.41±0.71	1.89±1.51

Table 4. Estimated discards of Atlantic cod from the Canadian groundfish fishery on Georges Bank in 2006.

	Zone A				Zone B				
	Q1	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Total**
FG<45									
FG 45-65									
MG<65			9	6	5	8	63	51	**143**
FG 65-100									
MG 65-100							7	4	**10**
>100			2		4		22	23	**51**
FN			2			1	27	4	**33**
Total									**237**

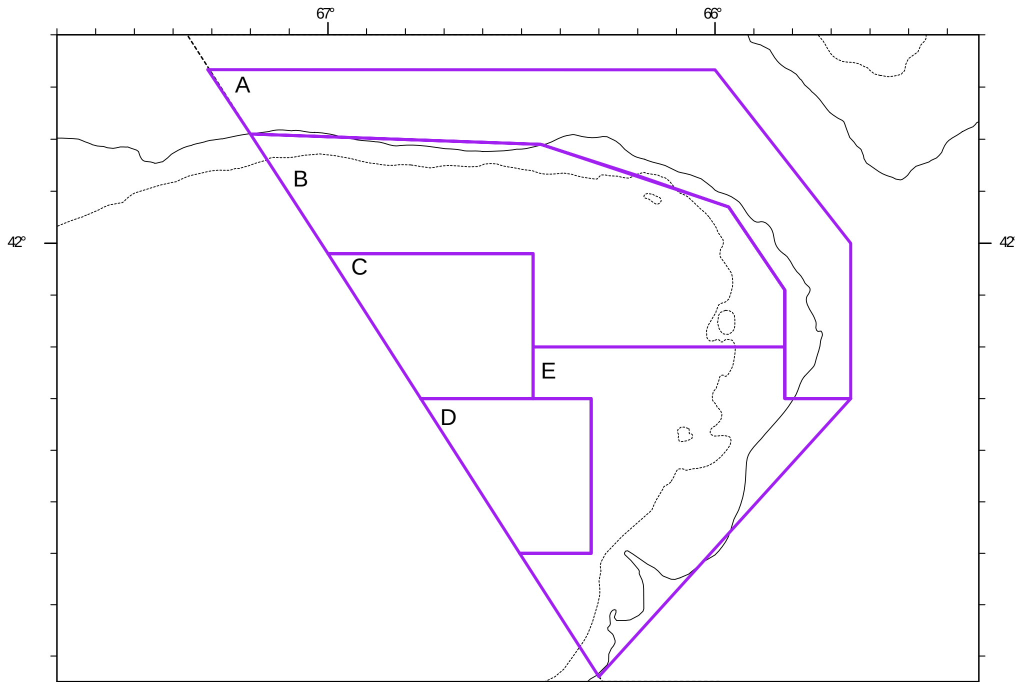

Figure 1. The Canadian portion of Georges Bank was partitioned into five zones that were used for the analysis.

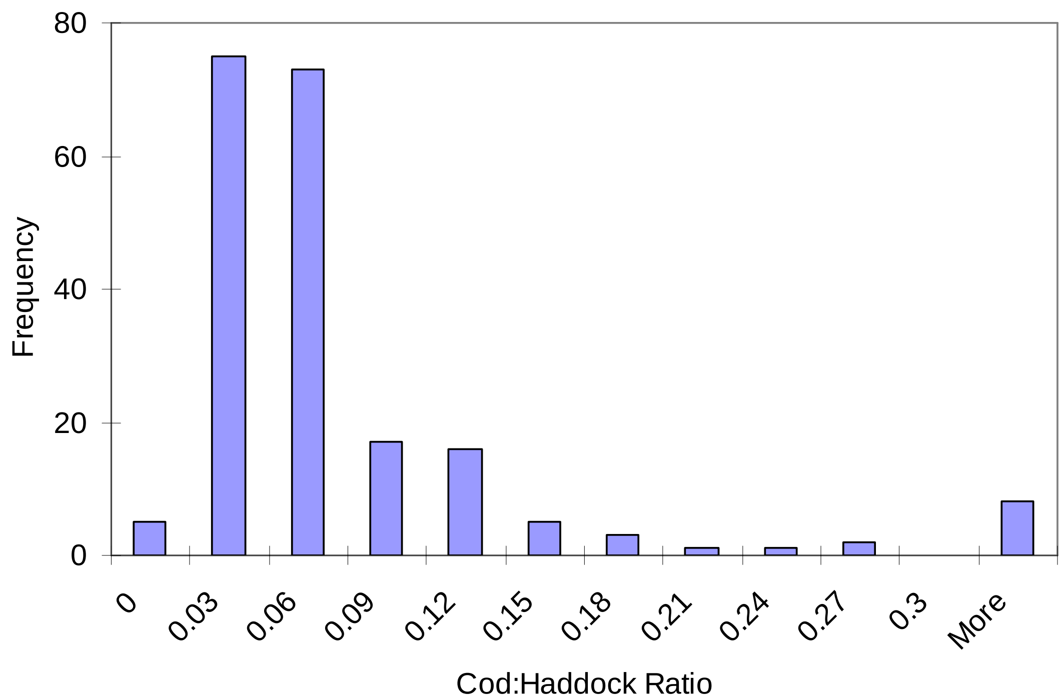

Figure 2. Illustrative example of the skewed distribution for the cod to haddock ratio using data from the MG<65' fleet in Zone B during the 3rd quarter.

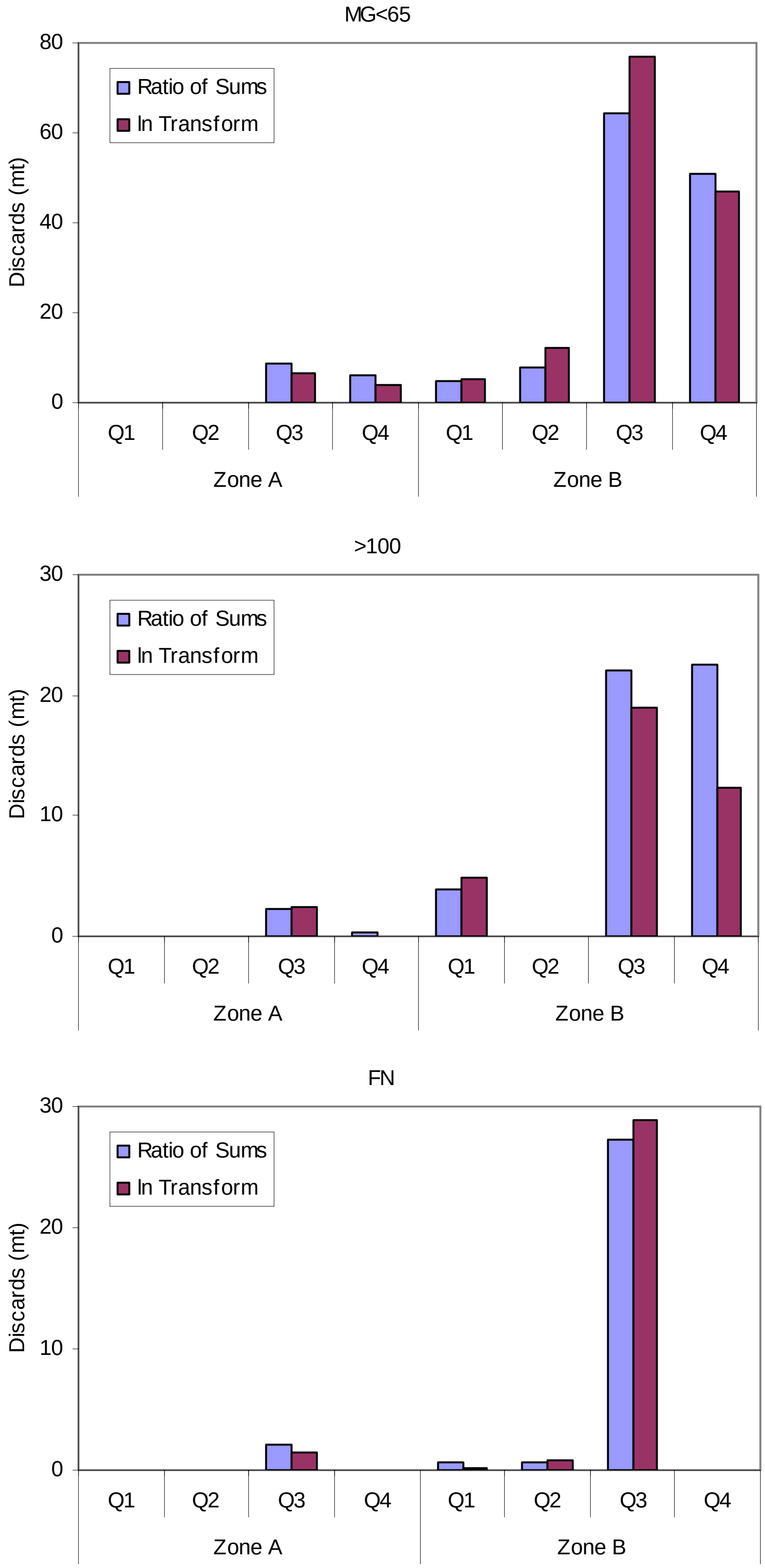

Figure 3. Comparison of discard estimates using the ln transform and the ratio of sums method shows similar results without any systematic patterns.

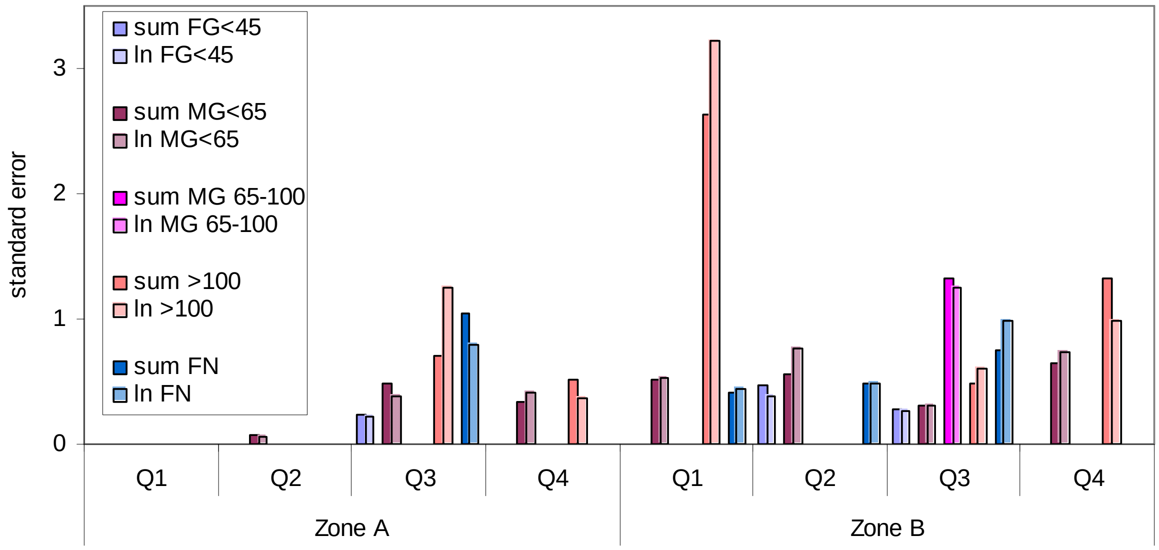

Figure 4. Comparison of the standard errors for discards from the ratio of sums and the ln transform methods suggests that the precision is similar. The solid bars represent the ratio of sums method and the hatched bard represent the ln transform method.

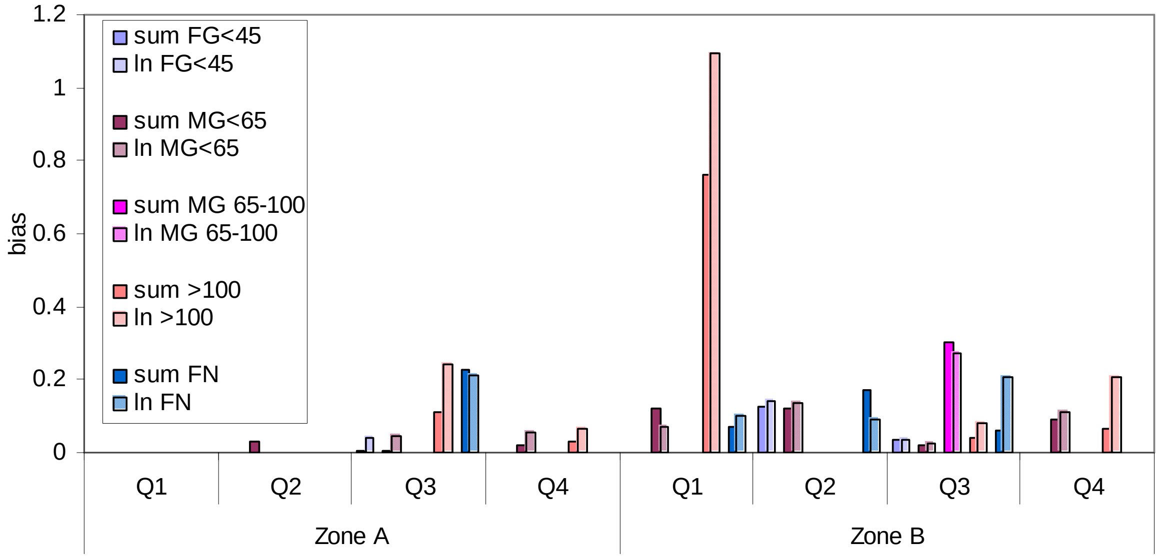

Figure 5. Comparison of the biases for discards from the ratio of sums and the ln transform methods suggests that the ratio of sums has somewhat lower bias. However, the bias for both methods was typically low. The solid bars represent the ratio of sums method and the hatched bard represent the ln transform method.

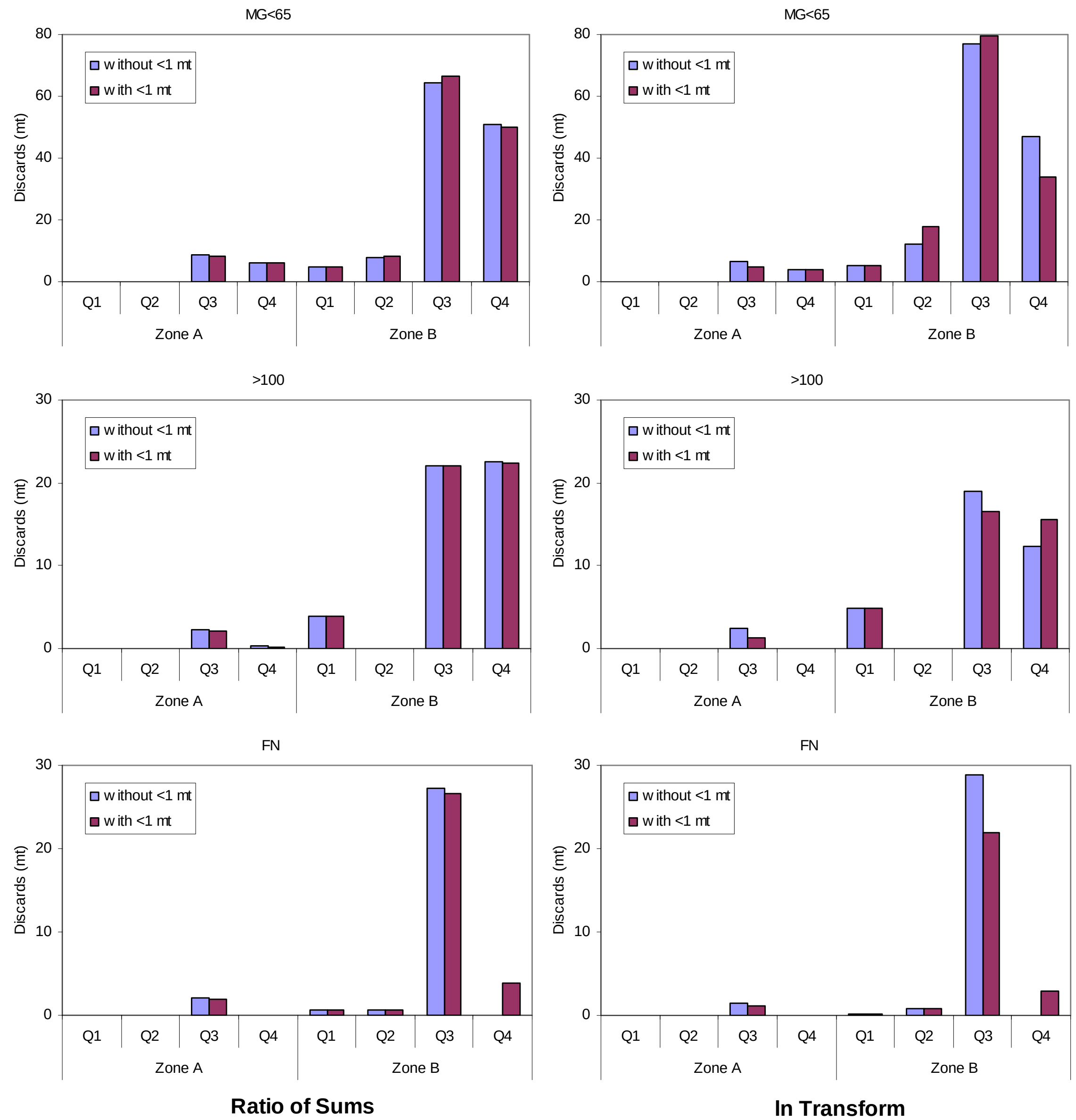

Figure 6. Comparison of robustness to sub-trips with small catches and potentially erratic cod to haddock ratios indicates that results from the ratio of sums method remain virtually unchanged while those from the ln transform method can be substantially altered.

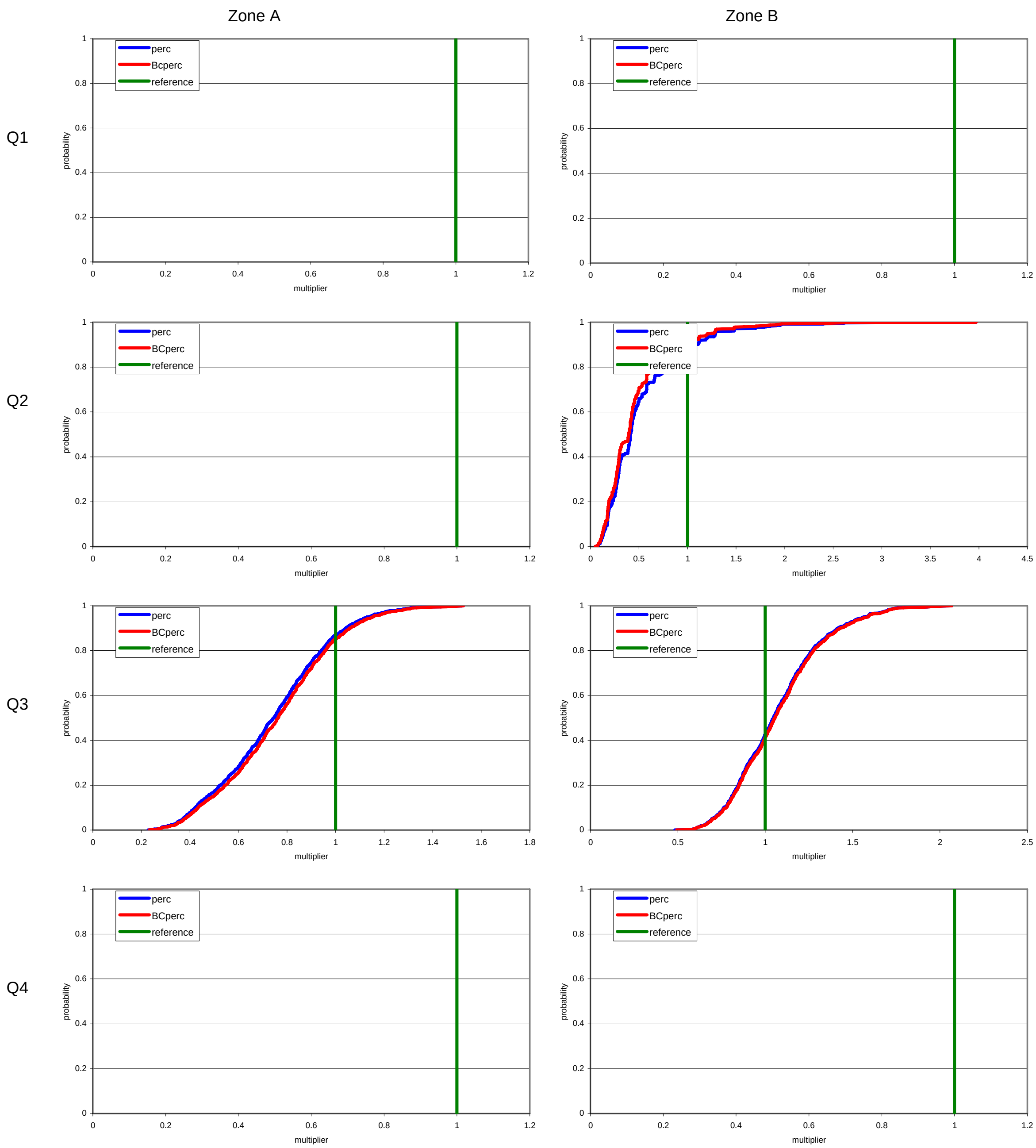

Figure 7. Confidence distributions of the landings multipliers for the FG<45 fleet.

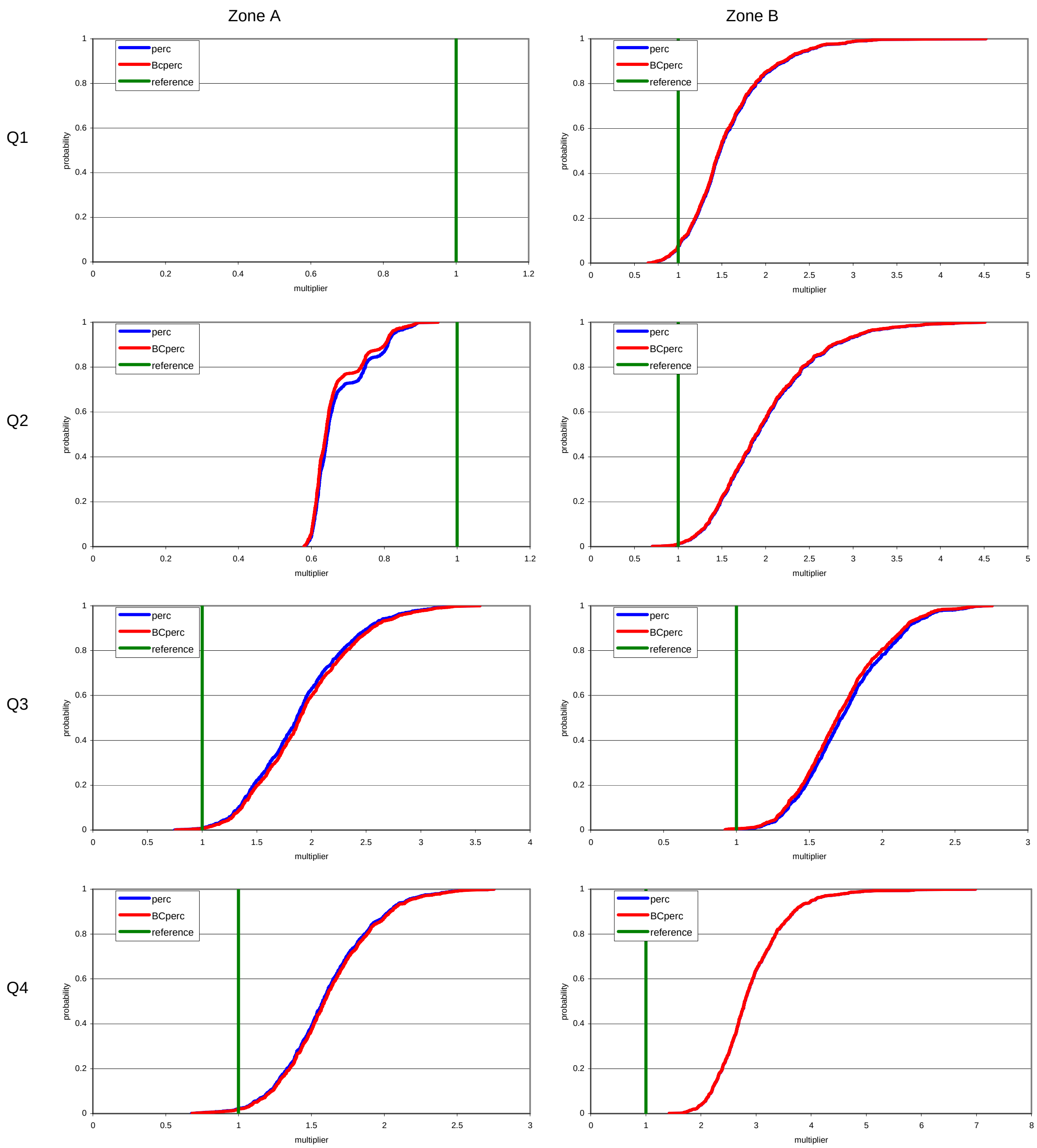

Figure 8. Confidence distributions of the landings multipliers for the MG<65 fleet.

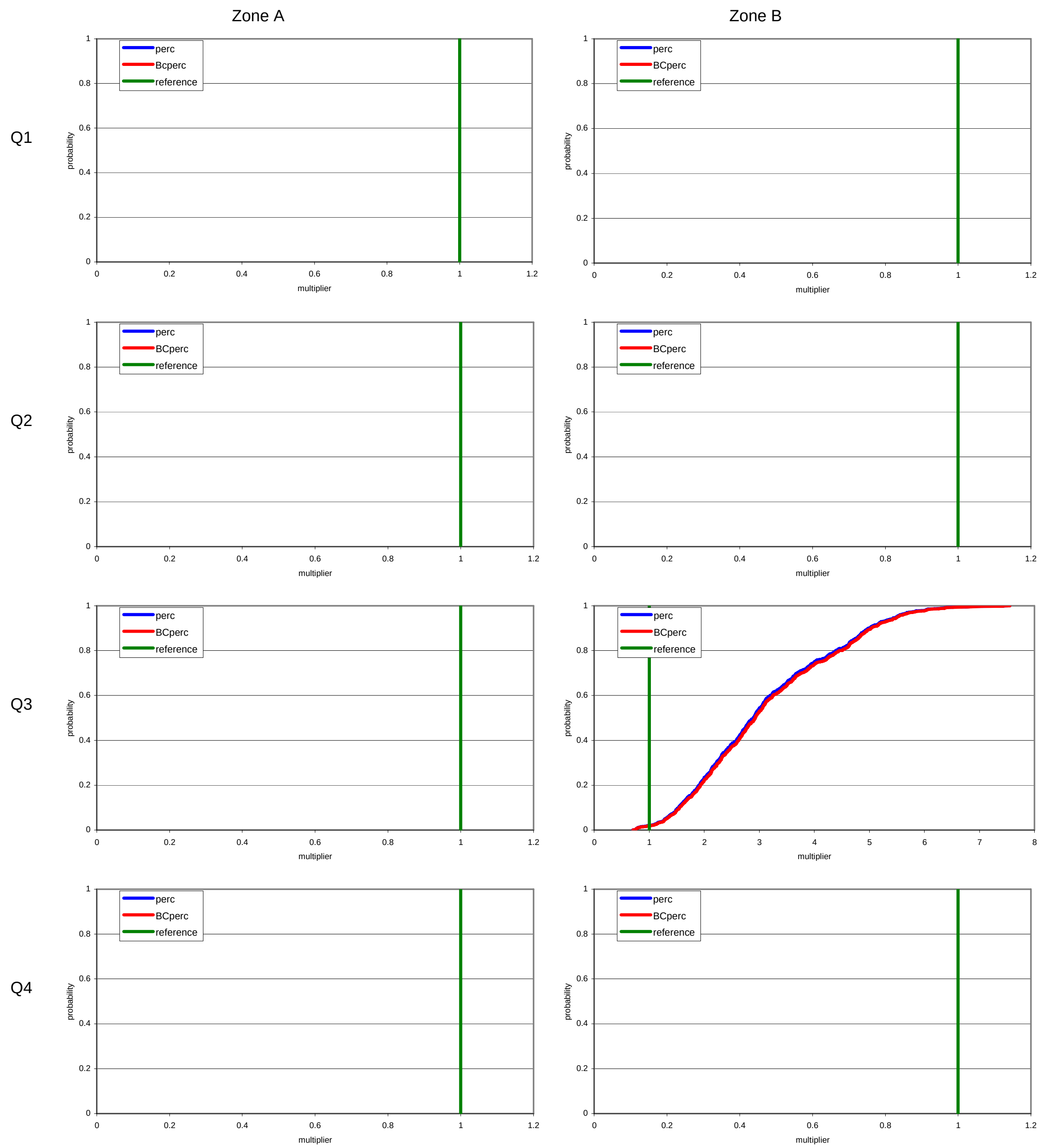

Figure 9. Confidence distributions of the landings multipliers for the MG65-100 fleet.

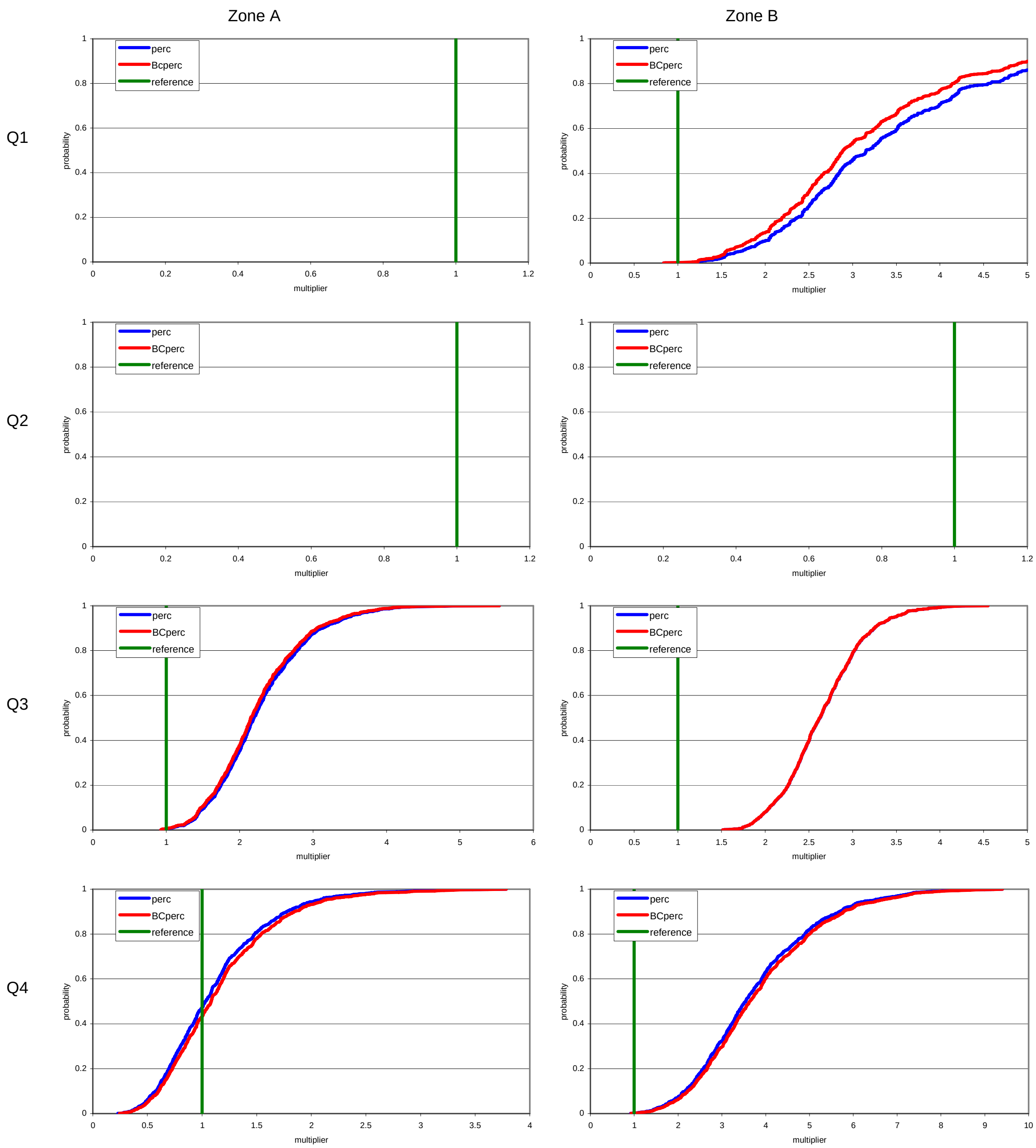

Figure 10. Confidence distributions of the landings multipliers for the >100 fleet.

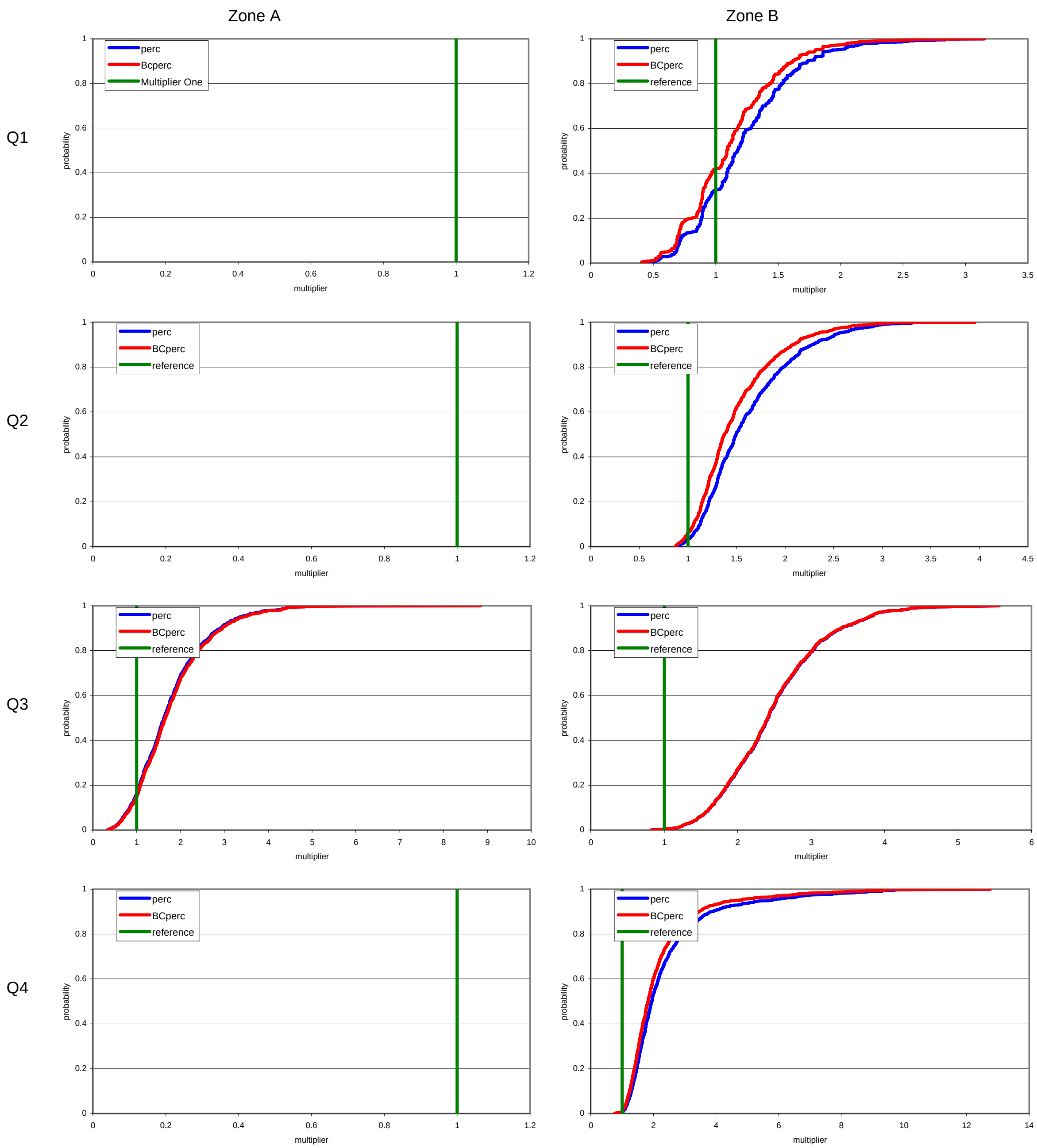

Figure 11. Confidence distributions of the landings multipliers for the FN fleet.