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EXECUTIVE SUMMARY

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Information on the size and sex composition of the catch is an important component of rock lobster stock assessments. This work examines the performance of alternative catch sampling regimes. No formal standards have been established for either the precision of catch sampling or of the stock indicators arising from assessments. Thus, it was not possible to estimate a single most appropriate catch sampling regime. Rather, several catch sampling regimes are compared in terms of (a) sampling precision and (b) the precision of stock indicators arising from using the data that they generate in an assessment model.

Two reference datasets from logbook and observer catch sampling programmes were compiled. These datasets were sampled 100 times using each sampling regime and the precision of each quantified. A smaller number of samples were used to estimate stock indicators of the rock lobster assessment model.

For the logbook type of sampling there was negligible difference between the simulated and the sampled sex-size frequencies at 30% participation rates. The effect of sampling imprecision on assessment model outputs was less clear. Relatively large variation in stock indicators occurred at high participation rates.

At low participation rates the number of pots sampled per logbook participant is less important in determining precision than the participation rate itself. However, at high participation rates the converse is true. For example, a similar precision is obtained from 40% participation with 2 pots per participant and 30% participation with 4 pots per participant.

For the observer type of sampling, there was relatively little improvement is precision with sampling intensities above 0.4 trips per vessel–area.

These simulations suggest that sufficient precision in catch samples is obtained from (a) participation rates of 30% for the logbook programme and (b) sampling rates of 0.3 trips per vessel per area for the observer programme.

1. INTRODUCTION

Fisheries research and monitoring is done to provide information with which to manage fisheries. All else being equal, more information will allow better management of the resource, which in turn should allow a greater long-term harvest. However, research and monitoring cost money, which in turn reduces the net value of the fishery (MacCall 1990). Thus the collection of information needs to be optimised. There are two ways in which this can be done.

Firstly, for a given cost, sampling effort should be allocated so that the information obtained is maximised. Alternative sampling strategies can be compared in terms of the precision with which they estimate variables of interest (Andrew & Chen 1997). For example, McGarvey & Pennington (2001) considered an optimal design for estimating the mean number of lobster per potlift and the mean length of lobsters caught in the rock lobster (*Jasus edwardsii*) fishery in South Australia.

Secondly, because of the diminishing returns of sampling, there is a point at which the marginal cost of sampling is higher than the marginal benefit in terms of increased long-term harvest (MacCall 1990, McDonald & Smith 1997, McDonald et al. 1997). Punt & Smith (1999) contrasted the performance of a variety of alternative approaches in managing a depleted stock of gemfish (*Rexea solandri*). Their simulations showed that annual resource surveys would result in higher catches, the additional value of which exceeded the cost of undertaking the surveys but that the benefit of collecting age-structure data was less obvious.

This report describes work done as part of Objective 2 of Ministry of Fisheries project CRA1999-01. The aim of this objective was to "determine the volume of length frequency data required from the fishery to obtain a suitable precision in the output from the length-based model used".

Catch sampling data are currently used in annual stock assessments as one of several sets of data that are fitted in order to estimate parameters of the length-based assessment model. The assessment uses Bayesian methods to provide a measure of uncertainty in its estimates of current and future stock status. The model's primary outputs are 10 performance indicators all of which are presented as summaries of their posterior distributions.

One approach to assessing the adequacy of alternative catch sampling regimes is to:

1. simulate a fishery with known dynamics
2. simulate catch sampling of the fishery
3. perform an assessment using each sample, and then
4. compare the precision and accuracy of estimated performance indictors from the assessment with their known values from the simulated fishery.

There are a number of problems with using this approach in the context of the current management of New Zealand rock lobster. Firstly, the output of the assessment model depends not only on catch sampling data but on a suite of other factors, including the weight given to them relative to other datasets. Furthermore, these weights are usually assigned after initial examination of model fits. Thus, to formally assess the effect of alternative sampling regimes on the outputs of the assessment model would require the replication of the entire stock assessment modelling process, including the generation of Bayesian posteriors. This is not feasible.

Secondly, and more fundamentally, to formally assess what volume of catch sampling data is adequate it is necessary to define what is a "suitable precision" in the output from the assessment. This will depend on the management system. For example, a management system that relies completely on outputs of the assessment model will require a greater precision in these outputs than a system that also uses other indicators as the basis for making management changes (e.g., a decision rule that uses CPUE indices). There are no formal management procedures for New Zealand rock lobster fisheries that rely on outputs from the assessment. In general, the performance indicators generated by the model are used only to provide an indication of the status of the stock relative to targets. Consequently, it is not possible to formally assess the effect of the precision of the model outputs on the performance of the fishery. Furthermore, there are currently no targets or guidelines for the precision of assessment outputs in New Zealand rock lobster fisheries. In the absence of such an optimisation criterion, it is not possible to make recommendations on a single optimum intensity of sampling (Francis 1999).

The general approach taken in this study was to compile a dataset of catch sampling from a New Zealand rock lobster fishery, to treat this data set as an entire fishery, and to use this to simulate alternative catch sampling regimes. A statistical measure of the differences in distributions was used as the primary basis for comparing sampling regimes, but examples of how alternative sampling may affect the outputs of the assessment model are shown.

2. METHODS

2.1 Data

Two data sets were compiled from the CRA 8 fishery, which was chosen because it has the best coverage by both the observer and logbook catch sampling programmes. Data from the two programmes were compiled into two separate datasets. The logbook programme samples four pots from all trips from a small proportion of vessels in each area. The observer programme samples all pots from a small proportion of trips from a small proportion of vessels in each area. Thus, the logbook dataset provides a better description of among-vessel and among-trip variation in catch composition and the observer data provides a better description of among-pot variation.

For both data sets, all pots that were sampled were compiled according to assessment period (6 month time periods from 1 April to 30 September and 1 October to 31 March), statistical area, vessel, and trip number. Only data from the assessment periods 97 (autumn-winter 1993) to 110 (spring-summer 1999) were used. For both datasets, pots that were sampled but which caught no lobster were included.

The compiled datasets are from a proportion of all vessels and trips in the actual fishery. To make each dataset more similar to the size of the CRA 8 fishery, they were expanded so that in each period the number of vessels in each area was the same as in the actual fishery. This was done by sampling vessels in the dataset with replacement.

2.2 Sampling

Sampling was simulated in a hierarchical manner. For each period, a certain number of areas were sampled, within which a certain number of vessels were sampled, within which a certain number of trips were sampled, within which a certain number of pots were sampled. Thus each sampling regime has four parameters:

1. Number of areas sampled
2. Number of vessels sampled within each area
3. Number of trips sampled within each vessel
4. Number of pots sampled within each trip

These parameters can be set as fixed numbers or a proportion. For example, 10 vessels can be sampled in each area, or 75% of vessels can be sampled in each area. For a logbook programme, percentage participation is of primary interest. For an observer programme, how many trips to make and how to distribute them among areas is of primary interest. Consequently, the following sampling experiments were done.

Experiment 1. Alternative logbook participation rates

The existing logbook programme (4 pots per trip sampled) with alternative proportions of vessels in each statistical area sampled. Vessels, trips, and pots sampled without replacement. Logbook data set used.

Experiment 2. Alternative logbook participation rates and alternative number of pots sampled per trip

As for Experiment 1, but simultaneously sampling alternative numbers of pots per trip.

Experiment 3. Alternative observer sampling rates.

The existing observer programme (all pots per trip sampled) with alternative sampling rates (average number of trips per vessel). Trips were assigned to areas in proportion to the number of vessels fishing in the area in that period. Vessels and trips were sampled with replacement. This experiment was done separately with the logbook and observer datasets.

A sample of pots was generated according to each sampling regime for each assessment period. When a pot was sampled the lobster caught in that pot were binned into sex (male, immature female, mature female) and size (2 mm bins from 30–32 mm to 90+ mm tail width) categories. Each sampling regime was simulated 100 times.

2.3 Evaluation of samples

The following statistic was used to summarise the difference between the overall and sampled catch compositions for each replicate sample,

$$\delta = \sum_{p,g,s} \frac{\left(\dot{o}_{p,g,s} - o_{p,g,s}\right)^2}{\dot{o}_{p,g,s}}$$

where $\dot{o}_{p,g,s}$ is the proportion in the entire data set and $o_{p,g,s}$ is the proportion in the sample in period p, sex category g, and size class s. This statistic approaches zero as the sample approaches the overall catch composition. It is similar to the chi-squared statistic but uses proportions rather than frequencies to compare observed and expected values. It was inappropriate to use the chi-square statistic for these analyses because the total number of lobsters sampled varies among the sampling regimes.

To provide some indication of the effect of sampling imprecision on the outputs from the assessment model, the model was fitted to 10 replicate samples from each regime in Experiment 1. This was done by inputting the sampled catch compositions for each of the sampled periods into the stock assessment model. Historical and observer catch samples were retained and all other model inputs were exactly the same as those used in the 2000 assessment for the NSS stock. The assessment weighs catch samples from each area and month (based on the catch in that stratum and the number of trips and lobsters sampled), and calculates an effective sample size. To maintain consistency between sampling regimes, in this study the same weight, 37.4, was used for all samples (the average of weights for logbook samples in the NSS assessment in 2000). The results are compared to estimates for the entire data set for three key performance indicators from the model: B_{05}/B_{00}, B_{00}/B_{MSY}, B_{00}/B_0, B_{05}/B_{MSY}. It should be noted that due to the difference in weightings given to catch samples in this study, outputs from the model are not comparable to official assessment results for the NSS.

3. RESULTS

Results are presented as boxplots of the δ statistic for each sampling regime. A boxplot shows the median as a line, the 25% and 75% quartiles as a box, and the most extreme points that are within 1.5 times the interquartile range as whiskers. Any points outside this range are shown individually.

Experiment 1. Alternative logbook participation rates

The precision of samples increased as a greater proportion of vessels was sampled but at a decreasing rate (Figure 1). To illustrate how the δ statistic reflects departures from the true catch composition, examples of sampled catch composition distributions are plotted (Figures 2 and 3). Even at the relatively low participation rate of 10% the sampled distribution appears to differ little from that for the entire dataset. At 30% participation rates, differences between sampled and entire compositions appear to be negligible.

The effect of sampling imprecision on outputs of the model is less clear (Figure 4). There was relatively large variation in outputs even at 50% participation. This may be a reflection of using outputs from the mode of the joint posterior distribution which are likely to be less stable than summary statistics from the posterior distribution which assessments are based upon. Nonetheless, there is far less precision in model outputs at 10 and 20% participation rates than at 30% and greater. There is also evidence of bias in three of the outputs when participation rates are less than 30%

Experiment 2. Alternative logbook participation rates and alternative numbers of pots sampled

At low participation rates the number of pots sampled is less important in determining precision than the participation rate itself (for example 10% participation and 4 pots has a higher δ statistic than 20% participation and 1 pot; Figure 5). However, at higher participation rates the converse is true (for example a similar precision is obtained from 40% participation and 2 pots and 30% participation and 4 pots; Figure 5).

Experiment 3. Alternative observer sampling rates

Observer type sampling is more pessimistic when performed on the logbook data than when performed on the observer data (Figures 6 and 7). This is because the logbook data have higher among-vessel and trip variation. Nonetheless, both sets of data suggest that the marginal benefit of sampling is relatively small above 0.4 trips per vessel.

4. DISCUSSION

Without a definition of the necessary precision it is impossible to answer the question "How much catch sampling is enough?" The necessary degree of precision will in turn depend upon the management system in place for the fishery. Indeed, the sampling of the fishery is a part of the management system and can only be formally assessed as part of a management strategy evaluation (e.g., Punt & Smith 1999).

However, based on our examination of qualitative differences between sampled and entire catch compositions and limited outputs from the assessment model, some recommendations can be made. The precision and accuracy of fishery performance indicators derived from the model deteriorated when logbook participation rates fell below 30%. This corresponded to a median δ statistic of 0.65. Based on this result, and examinations of differences between sampled and true catch compositions, we suggest that a δ statistic of 0.6 be used as a rough threshold for the minimum necessary degree of sampling precision.

Thus, it is recommended that participation rates of 30% or higher should be the target for the logbook programme. On the basis of sampling the observer data (which is most optimistic about observer sampling efficiency), a *minimum* sampling rate of 0.3 trips per vessel is recommended for observer catch sampling. Because the sampling of the observer data is likely to be optimistic, we suggest a *target* sampling rate of 0.5 is appropriate. This is in the absence of logbook sampling being conducted in the same area.

According to Ministry of Fisheries Catch Effort and Landing Returns, in CRA 8 there were between 112 and 196 vessel-area combinations within each season over the period examined. Thus a sampling rate of 0.3 equates to between 34 and 59 trips per season. Although these recommendations are based on data from CRA 8, similar degrees of variation between areas, vessels, trips and pots are likely to exist elsewhere. Thus, the minimum sampling rate is likely to be similar. However, because CRA 8 is the largest fishery in New Zealand, the recommended minimum rate of 0.3 trips per vessel per area for the observer programme will equate to fewer trips in other areas (Table 1).

5. ACKNOWLEDGMENTS

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Table 1: Number of vessel/statistical area combinations recorded in CELR data for assessment period 109 (autumn-winter 1999) and corresponding minimum and target number of observer trips required.

CRA	Number of vessel/area combinations	Minimum number of trips (rate = 0.3)	Target number of trips (rate = 0.5)
1	30	9	15
2	48	14	24
3	38	11	19
4	69	21	35
5	46	14	23
6	42	13	21
7	29	9	15
8	118	35	59
9	23	7	12

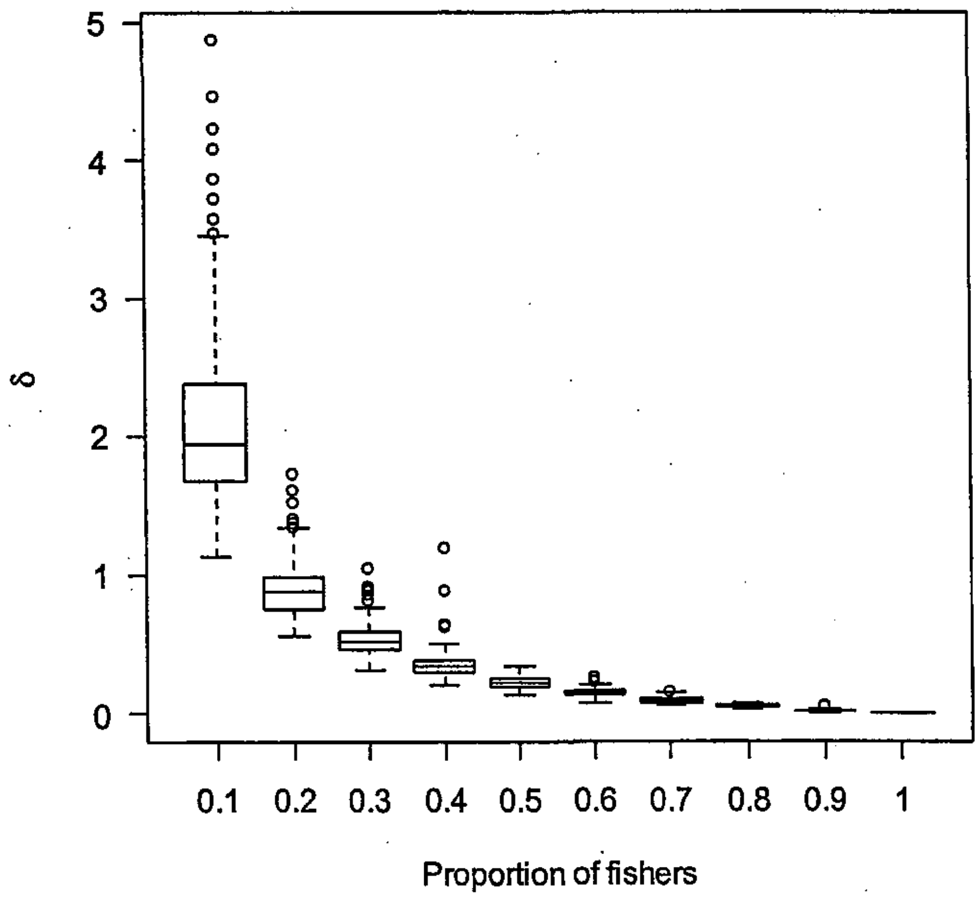


Figure 1: Effect of the proportion of vessels sampled on the precision of catch samples from the logbook programme.

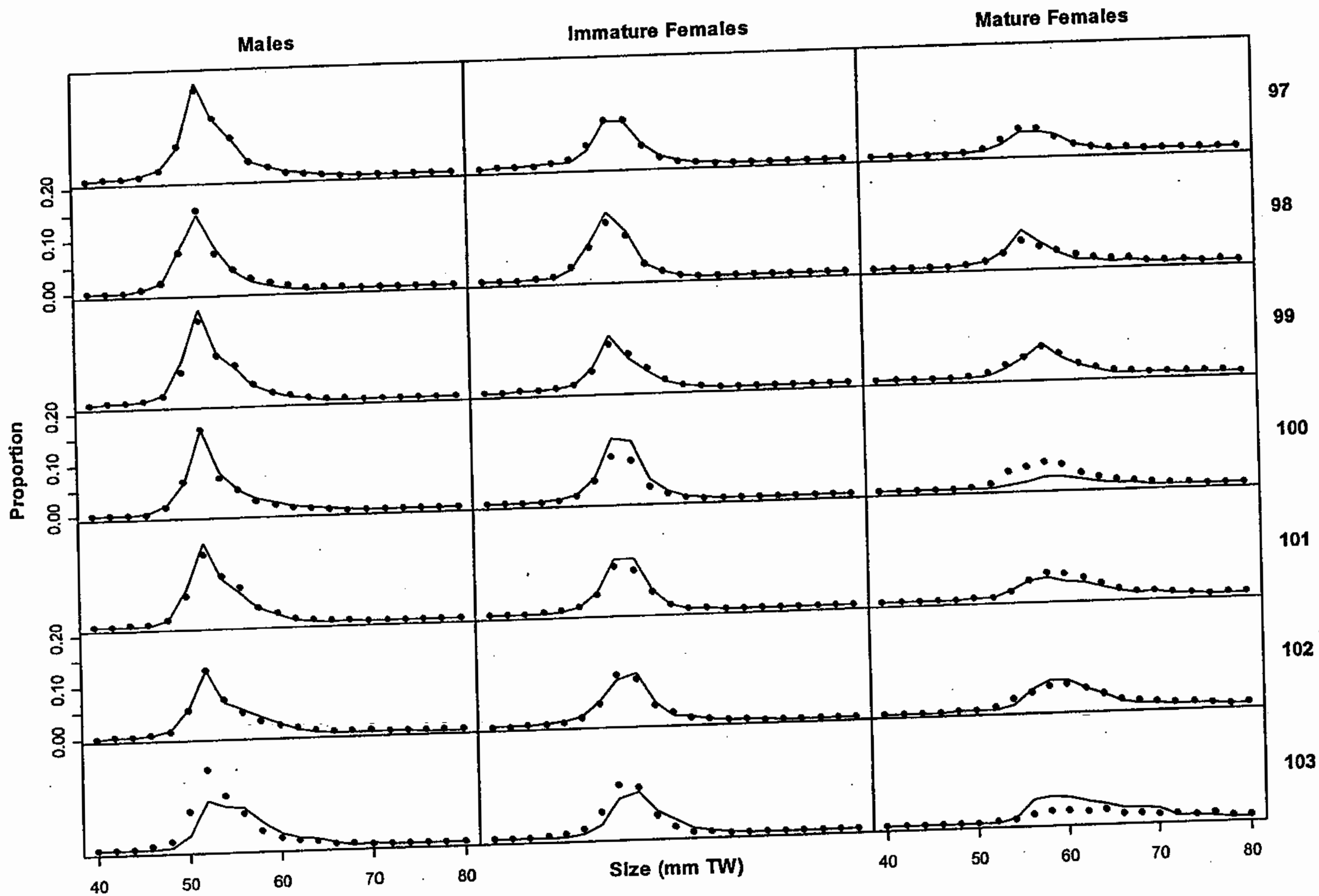
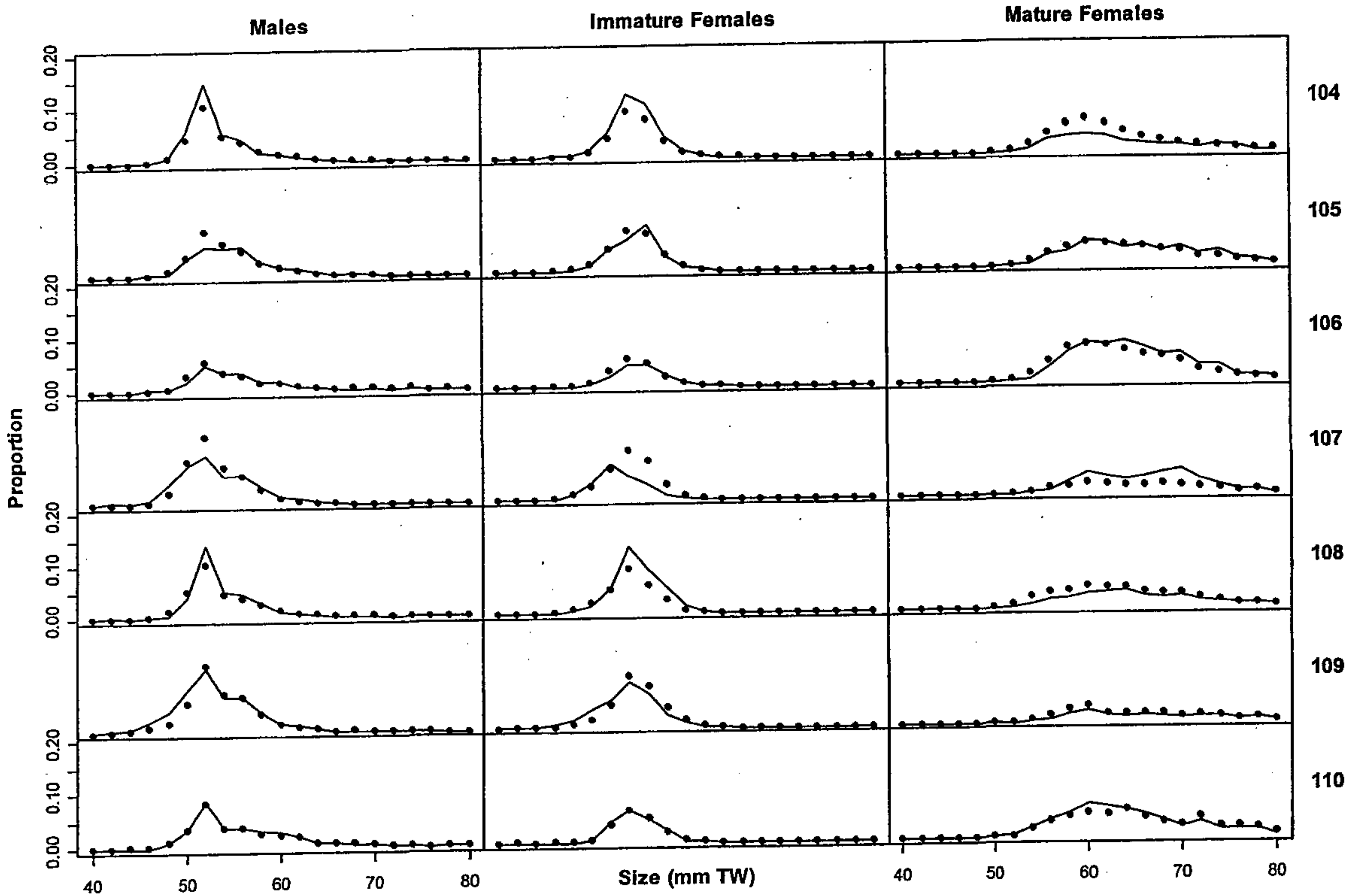


Figure 2: An example of entire (dots) and sampled (lines) catch compositions from Experiment 1 with 10% of vessels participating in each area. For this example $\delta = 1.75$.



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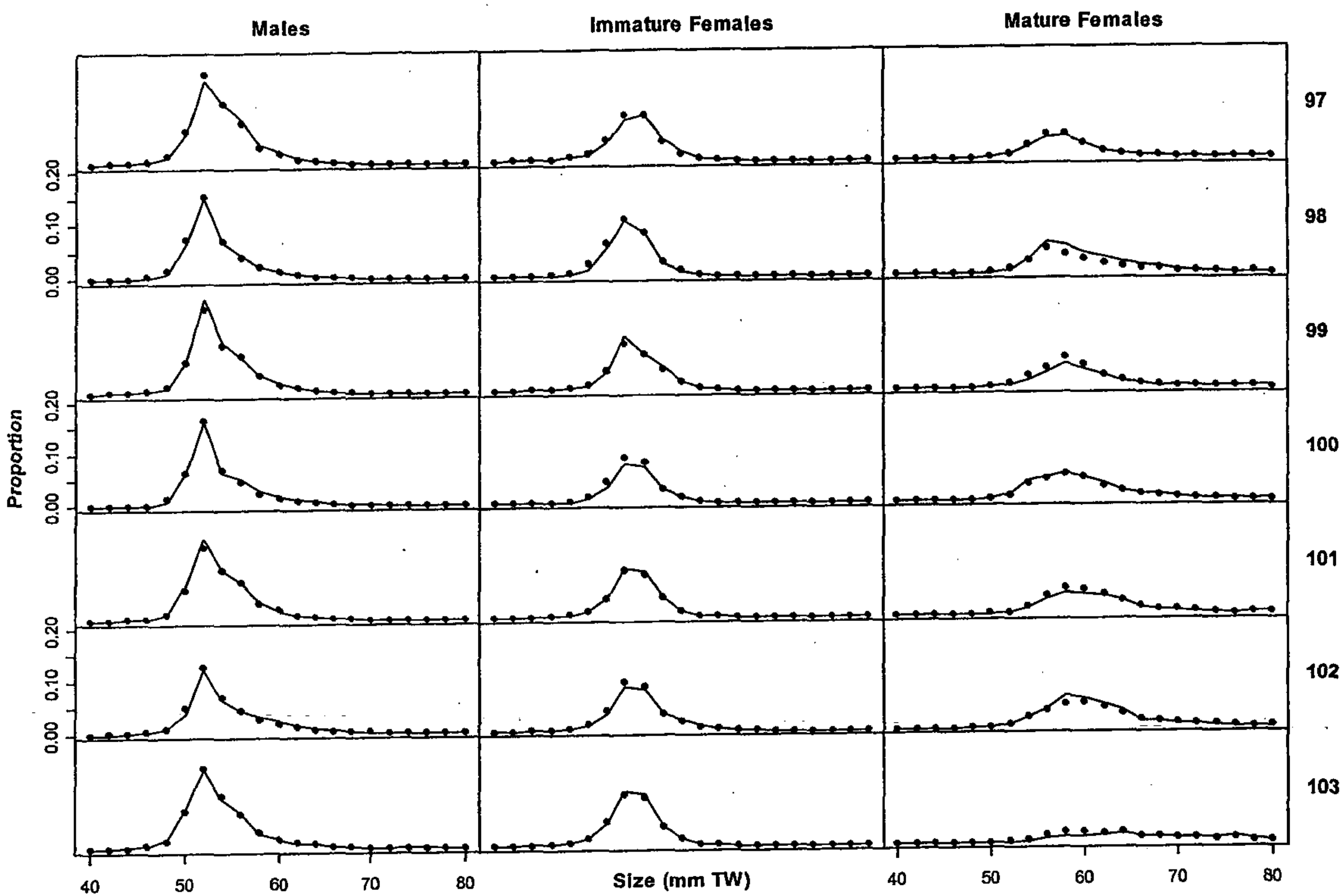

Figure 3: An example of entire (dots) and sampled (lines) catch compositions from Experiment 1 with 30% of vessels participating in each area. For this example $\delta = 0.474$

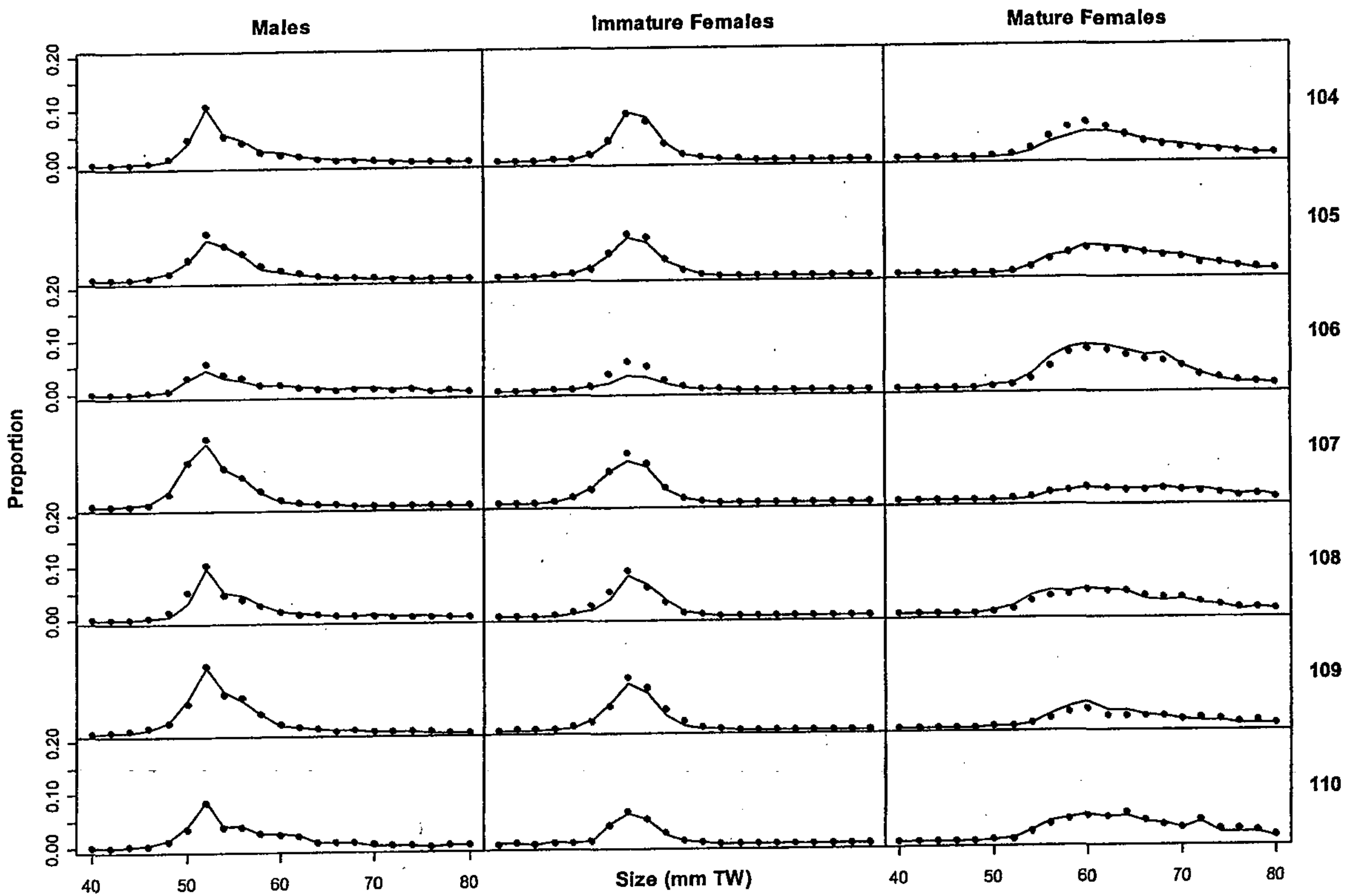

Figure 3 continued.

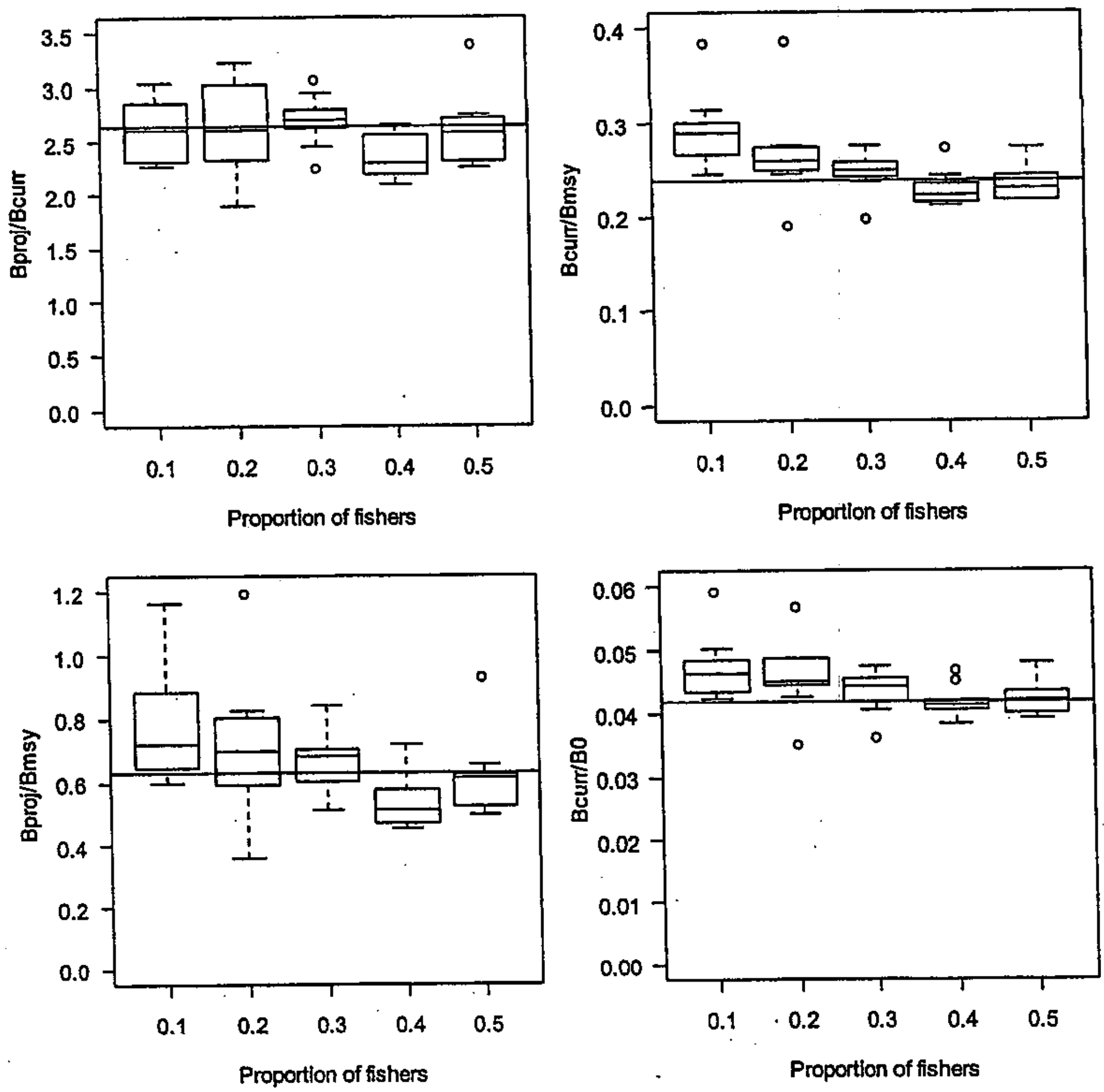

Figure 4: Effects of alternative logbook participation rates sampling on outputs from the assessment model (the horizontal line indicates the estimate obtained from the entire dataset).

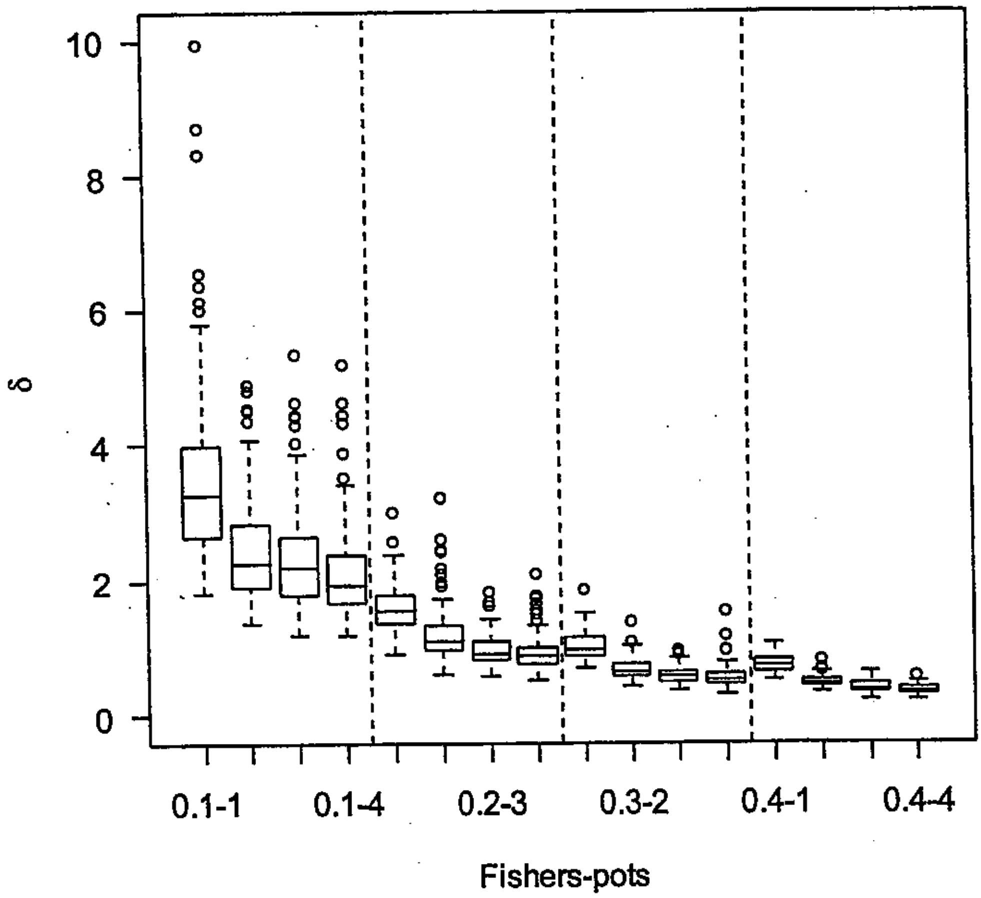

Figure 5: Effect of proportion of vessels and number of pots sampled per trip on the precision of catch samples from the logbook programme. Three outliers for 0.1-1 that had δ values above 10 are not shown.

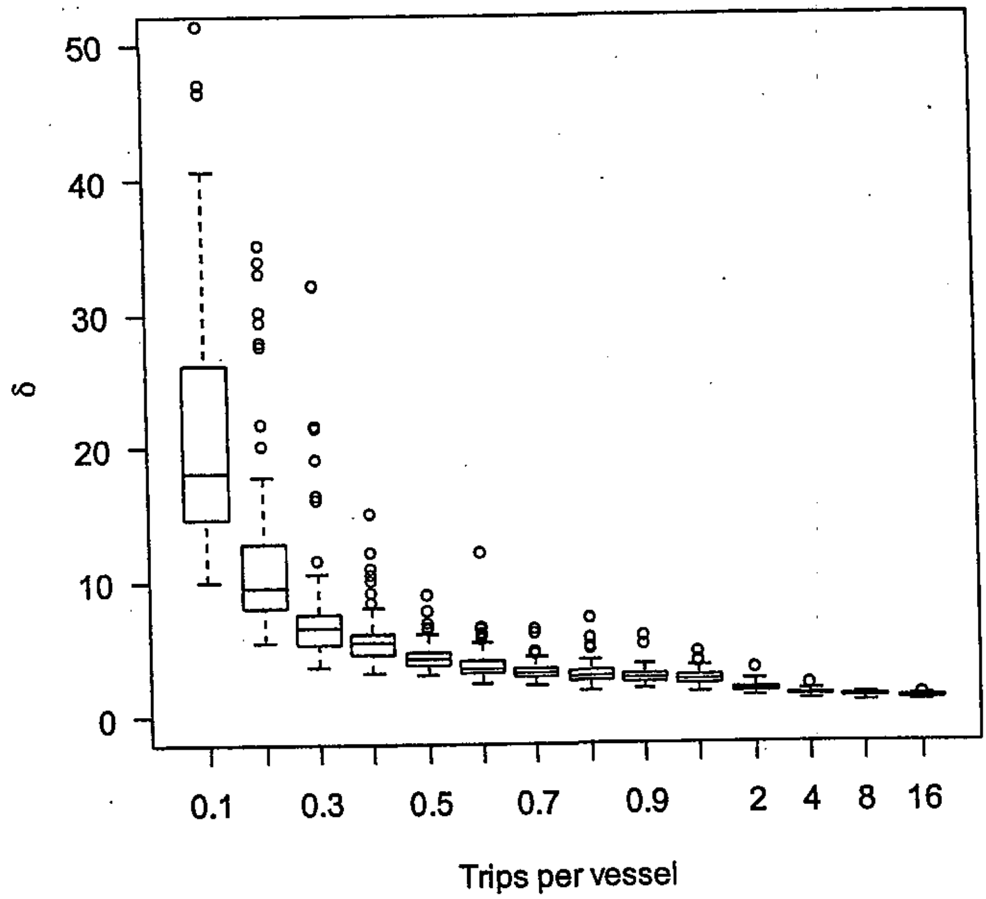

Figure 6: Sampling the logbook dataset with an observer type regime using alternative numbers of trips per vessel.

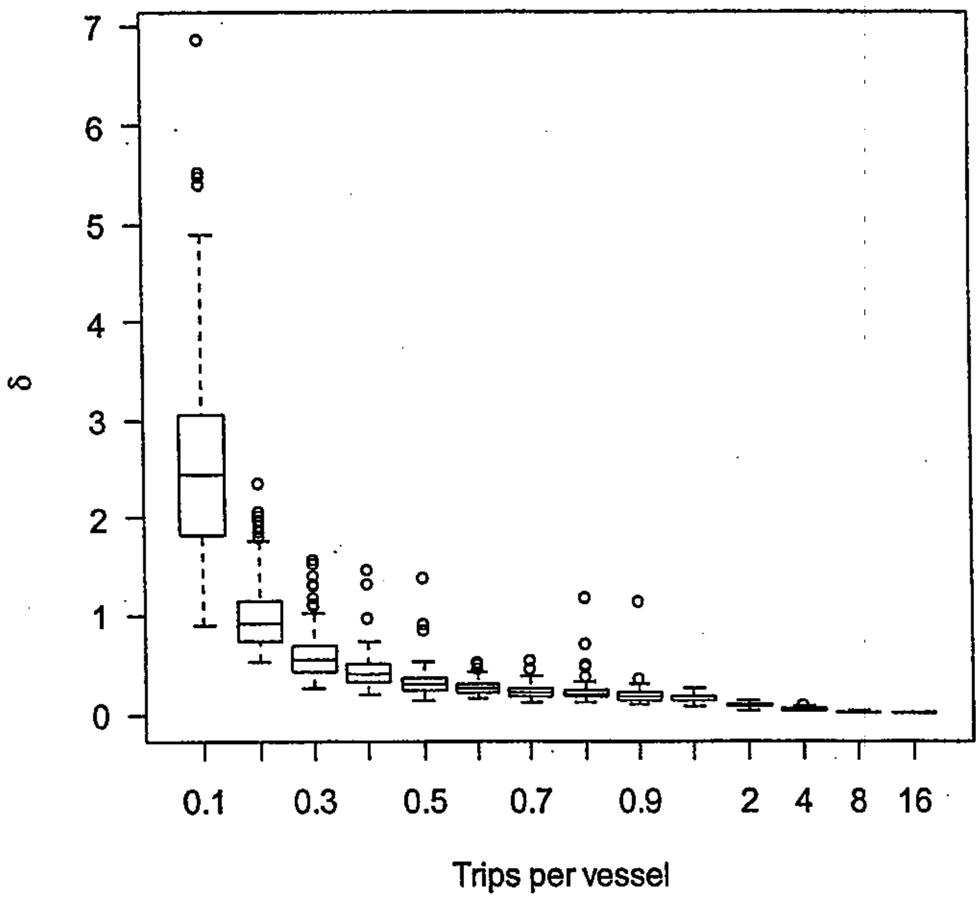

Figure 7. Sampling the observer dataset with an observer type regime using alternative numbers of trips per vessel.