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Calibrating between offsite and onsite amateur harvest estimates

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EXECUTIVE SUMMARY

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Recreational harvest estimates provided by three independent surveys in 2011–12 were compared in an attempt to detect and correct for any sources of bias that may have influenced one or more of these surveys. Although the scope and spatial extent of each survey differs, each provided estimates for a limited number of fisheries that were also concurrently assessed by at least one other survey. A national panel survey conducted by the National Research Bureau (NRB) provided recreational harvest estimates for all of New Zealand's most commonly fished stocks. NIWA conducted an aerial-access survey of the boat based fishery in FMA 1 that estimated harvests of the five finfish species most commonly caught in this area. A third survey, of the western Bay of Plenty, was undertaken by Blue Water Marine Research (BWM) which combined three forms of creel survey method to estimate boat based harvests of two finfish and two shellfish species. Both NIWA and BWM also used NRB panel data to indirectly estimate additional harvests taken by shore based fishers.

A cursory examination of the combined boat and shore based harvest estimates provided for commonly assessed fish stocks suggests that they are of a broadly similar magnitude given the levels of precision associated with each estimate. The level of discrepancy between alternative survey estimates was lower for the higher tonnage fishers, which suggests that reliable harvest estimates for smaller fisheries may be harder to attain. Some of the discrepancy between alternative survey estimates was attributable to differences in survey scope, such as the inclusion of shore based and charter boat harvests in the NRB estimates, which were not assessed by the NIWA and BWM surveys. Harvest estimates were recalculated for each survey, for the subset of fishing activity that was commonly assessed by all three methods. The harvest estimates for these more directly comparable harvest estimates were of a more similar magnitude, but some differences remained, which were further investigated.

Regression tree analysis of spatially and temporally disaggregated harvest estimates for commonly assessed species suggested that the NIWA survey may have surveyed the FMA 1 fishery in a temporally biased manner, relative to that inferred from NRB estimates calculated for matching temporal strata. This hypothesis was confirmed when the distribution of web camera based counts of boats returning to Sulphur Point on survey days was compared to that occurring on all days, by season and day type. These data suggest that the selection of NIWA survey days during the two winter strata (weekend days and midweek/public holiday days) was biased towards low effort days, which explains why the NIWA estimates were mostly lower than those provided by the NRB survey.

There was no evidence of any systematic difference between the NRB and BWM estimates for the western Bay of Plenty, although marked differences were evident when estimates for individual temporal strata were compared. These results suggest that onsite survey designs should consider higher levels of sampling intensity when subsampling according to a temporal sampling frame.

Comparisons of unscaled individual trip catch data provided by all three surveys suggested that none of the discrepancy in harvest estimates could be attributed to biased sampling from the fishing population, or because fishers misreported their catch. There is some evidence to suggest that unsuccessful trips may have gone unreported to NRB, these missed zero catch events will not result in biased harvest estimates as they do not account for any additional and unassessed harvest.

Any further exploration of differences between alternate survey estimates is problematic because the onsite and offsite surveys were based on fundamentally different sampling frames, although the remaining influence of any unresolved sources of bias is likely to be acceptably low given the degree

of similarity seen in uncorrected harvest estimates with their associated level of precision. When using the estimates, fisheries managers should also consider other unassessed sources of recreational harvest, such as that taken from commercial fishing vessels under a S.111 dispensation, although the survey estimates discussed here should encompass the vast majority of any harvesting that took place during the period assessed. We conclude that the recreational harvest estimates provided by three independent surveys in 2011–12 are reasonably accurate and fit for management purposes.

1. INTRODUCTION

Fisheries managers require reliable and defensible recreational harvest estimates for all of New Zealand's fish stocks. Although many surveys have provided recreational harvest estimates for a range of temporal and spatial scales over the last 20 years, there has often been much debate about the reliability of these estimates because independent information has not been available to assess their validity. In 2011–12, however, MPI commissioned independent surveys from three research providers, and a comparison of the harvest estimates provided by these surveys gives unparalleled insight into the likely accuracy of these estimates.

Each survey provider used fundamentally different methods to estimate recreational harvests. The largest of these surveys was a national panel survey conducted by the National Research Bureau (NRB), in which a national face-to-face survey was used to recruit diarist for the following fishing year. This offsite approach is capable of providing harvest estimates for all of New Zealand's fish stocks, although diarist data is self-reported and not independently observed. The second survey was an aerial-access survey of FMA 1 conducted by the National Institute of Water and Atmospheric Research (NIWA). The harvest estimates provided were based on independent and verifiable observations, but this method was only capable of assessing the catch taken from boat based fisheries. The third survey approach, used by Blue Water Marine Research, combined three creel survey methods to estimate the boat based harvest of four species taken by recreational fishers from the western Bay of Plenty. Both the NIWA and BWM surveys rely on NRB panellist data to estimate the harvest taken by shore based fishers.

Harvest estimates and data are compared for those fisheries assessed by two or more survey approaches, in an attempt to detect and correct for significant sources of bias and to infer the potential accuracy of these estimates.

Overall Objective:

1. To contribute to the design and implementation of an integrated amateur harvest estimation system.

Specific Objective:

1. To develop methods to corroborate and calibrate harvest information collected from concurrent onsite and offsite surveys.

2. To apply the methods developed to data collected in 2011/12 under MAF projects to corroborate and calibrate harvest estimates to the greatest extent practical.

2. DATA AND METHODS

The purpose of this study was to compare harvest estimates provided by three independent but concurrent harvest estimation surveys, and to attempt to detect and correct for any significant sources of bias that could have influenced one or more of these surveys. The three surveys considered here were:

- A national panel survey of recreational fishers (except for those living in the Chatham Islands) undertaken by the National Research Bureau (NRB) (Wynne-Jones et al. 2014).
- An aerial overflight survey of the boat based fishery in FMA 1 conducted by NIWA (Hartill et al. 2013),
- A multi-method creel survey of boat based fishers in the western Bay of Plenty, undertaken by Blue Water Marine Research (BWM) (Holdsworth 2013).

The spatial extent of the area covered by each these surveys is shown in Figure 1.

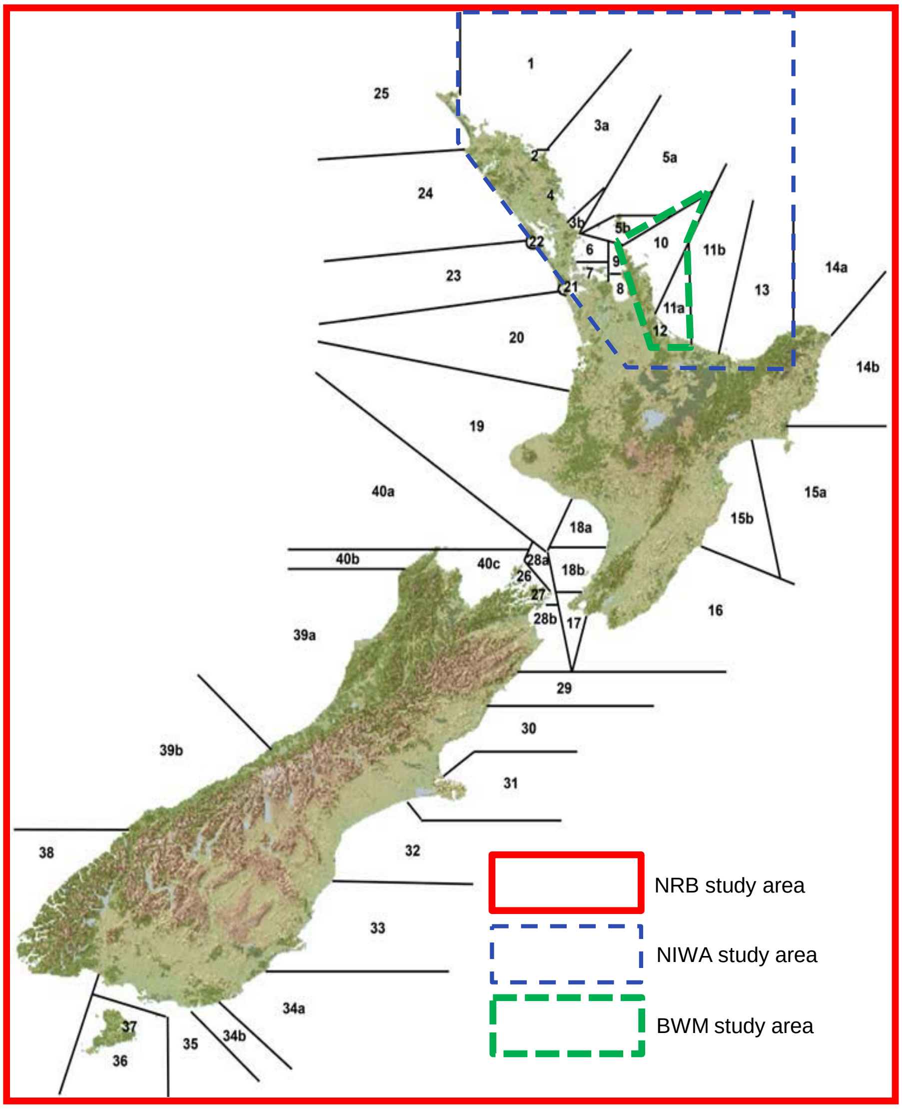

Figure 1: Spatial extent of areas covered by three independent surveys of recreational fisheries during the 2011–12 fishing year. Smaller numbered areas denote zones used during the NRB panel survey. The NIWA study area equates to Fisheries Management Area 1 (FMA 1) which can be further divided up into three regions: East Northland (NRB areas 1 to 5), the Hauraki Gulf (NRB areas 6 to 9), and the Bay of Plenty (NRB areas 10 to 13). The BWM survey was conducted in the western Bay of Plenty (NRB diary areas 10, 11a, and 12).

All three surveys were conducted throughout the 2011–12 fishing year (October to September), which can be further divided into combinations of seasonal (summer – October to April; and winter – May to September) and day type strata (weekend/public holiday days; and midweek days).

Although the NRB panel survey provided harvest estimates for a wide range of species caught throughout New Zealand, the NIWA and BWM surveys only provided estimates for a subset of the species that were landed within their respective study areas. Pairwise comparisons of harvest estimates were therefore restricted to those fisheries for which two or more independently derived estimates were available (Table 1).

Table 1: Harvest estimates (tonnes) provided by three independent surveys of recreational fisheries in FMA 1 during the 2011–12 fishing year. The NIWA estimates do not include harvests taken from charter boats, whereas the BWM estimates do. None of the NRB estimates include harvests taken by fishers younger than 15.

Species	Area	NRB (incl charter)	NRB (excl charter)	NIWA	BWM
Snapper	SNA 1 (FMA 1)	3981.0 (0.08)	3791.9 (0.08)	3753.6 (0.06)	–
	East Northland	908.8 (0.12)	868.8 (0.13)	717.9 (0.14)	–
	Hauraki Gulf	2381.1 (0.11)	2254.4 (0.12)	2490.1 (0.08)	–
	Bay of Plenty	691.1 (0.12)	668.7 (0.12)	545.6 (0.12)	–
Kahawai	KAH 1 (FMA 1)	957.7 (0.07)	933.0 (0.07)	942.0 (0.08)	–
	East Northland	203.7 (0.13)	197.9 (0.14)	191.2 (0.16)	–
	Hauraki Gulf	390.7 (0.09)	376.9 (0.09)	482.9 (0.13)	–
	Bay of Plenty	363.2 (0.11)	358.2 (0.11)	287.8 (0.12)	–
	Western Bay of Plenty	238.8 (0.14)	237.1 (0.14)	165.0 (0.15)	251.0 (0.09)
Red gurnard	GUR 1 west (FMA 1)	48.7 (0.16)	47.5 (0.16)	23.6 (0.09)	–
	East Northland	8.6 (0.42)	8.5 (0.43)	3.2 (0.30)	–
	Hauraki Gulf	15.6 (0.17)	15.1 (0.18)	5.7 (0.14)	–
	Bay of Plenty	24.4 (0.26)	23.8 (0.26)	14.7 (0.13)	–
	Western Bay of Plenty	16.0 (0.35)	15.8 (0.35)	9.8 (0.16)	15.0 (0.10)
Trevally	TRE 1 (FMA 1)	164.8 (0.11)	154.1 (0.11)	123.8 (0.12)	–
	East Northland	52.8 (0.22)	47.8 (0.23)	30.1 (0.25)	–
	Hauraki Gulf	53.0 (0.16)	50.0 (0.16)	52.2 (0.21)	–
	Bay of Plenty	59.0 (0.19)	56.3 (0.19)	41.4 (0.16)	–
Tarakihi	TAR 1 (FMA 1)	115.1 (0.22)	96.5 (0.25)	67.2 (0.15)	–
	East Northland	15.1 (0.26)	13.6 (0.26)	12.0 (0.43)	–
	Hauraki Gulf	4.0 (0.27)	3.6 (0.29)	2.1 (1.01)	–
	Bay of Plenty	93.6 (0.27)	79.3 (0.27)	53.1 (0.16)	–
Rock lobster	Western Bay of Plenty	15.0 (0.44)	14.9 (0.44)	–	9.0 (0.17)
Scallops	Western Bay of Plenty	13.7 (0.26)	13.7 (0.26)	–	24.0 (0.18)

The estimates given in Table 1 are expressed in terms of weight (tonnes) rather than numbers harvested. The following analyses were based on associated estimates of numbers caught however, as the NRB survey did not directly provide harvest weight estimates, and data from the three surveys were universally available in terms of estimates of numbers caught.

Harvest estimates were compared in a pairwise fashion using a ratio q, with NRB estimates considered as the 'true' value as the NRB survey provided harvest estimates for all fisheries including the subset of fisheries assessed by the NIWA and BWM surveys:

$$q = \frac{H}{H^{TRUE}}$$

If a harvest estimate was close to that produced by NRB then q would be approximately equal to 1.0. Each harvest estimate has an associated coefficient of variation (CV). To obtain an estimate of uncertainty in q, a parametric bootstrap was performed with 2000 draws from an assumed log-normal error distribution.

Disaggregated harvest estimates were also compared, which were nested by:

- region: East Northland, Hauraki Gulf and Bay of Plenty (including estimates for the Western Bay of Plenty only);
- season;
- day-type;

given CVs reported for each level of disaggregation. Recalculating the CV at the appropriate level of disaggregation was important, since the sample size diminishes as the data are subdivided and the uncertainty in the disaggregated estimates is therefore increased. It was also necessary to estimate coefficient values directly for the trip level data, with uncertainty assessed via nested non-parametric bootstrap.

Preliminary investigations showed that although harvest estimates provided by alternative surveys were of a similar magnitude, differences were more apparent at higher levels of disaggregation (i.e. differences were more evident when estimates were compared at finer regional and temporal scales). To investigate this further, regression tree methods were used. This approach provided a simple means of determining the explanatory factors which best described the distribution of coefficient (q) values.

The tree based regression was performed using recursive partitioning. This approach sequentially partitions the data according to explanatory factors that maximise reduction in the residual error. Starting with the pooled data, the method uses an analysis of variance to select a factor which yields the greatest increase in R^2, continuing this process along each branch of the tree until the addition of further factors does not yield a marginal increase in R^2 greater than a pre-defined threshold. For the analyses presented here, this threshold was set at 0.01.

Harvest estimates provided by alternative surveys were compared at two scales: a comparison of NRB and NIWA estimates by region of FMA 1, and a comparison of NRB, NIWA and BWM estimates for the western Bay of Plenty.

2.1 Comparison of harvest estimates from FMA 1

The FMA 1 and regional estimates provided by the NRB and NIWA surveys for the five most commonly caught species are mostly of a similar magnitude (Figure 2). The estimates produced by NIWA are slightly lower than the NRB estimates for the larger snapper and kahawai fisheries, with more pronounced differences evident for the less commonly landed trevally, red gurnard and tarakihi fisheries.

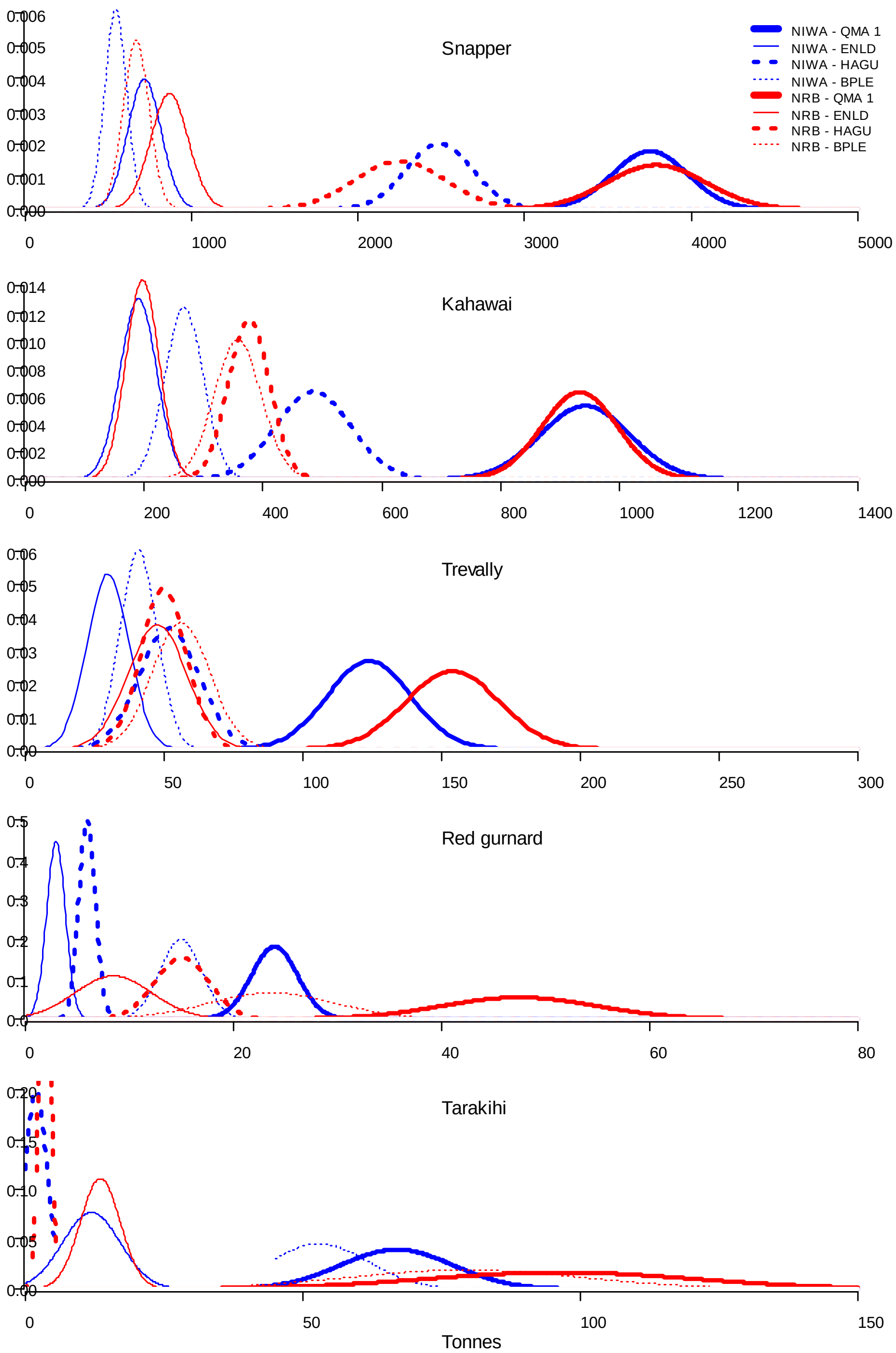

Figure 2: Harvest in tonnes by species and region, estimated by NRB and NIWA. These harvest estimates do not include landings from charter boats. Distributions illustrate the uncertainty around each estimate, assuming normality.

The scope of the estimates given in Table 1 differ because the NRB survey did not assess the harvest taken by fishers younger than 15 years of age, and the NIWA survey did not assess harvests taken by shore based fishers (although allowances for shore based harvesting are included in the NIWA and NRB estimates given in Table 1, which were based on NRB data). Both the NRB and NIWA harvest estimates for FMA 1 were therefore recalculated, based on data which excluded any catches reported by fishers younger than 15 and by shore based fishers. These revised estimates are therefore more directly comparable. Neither set of harvest estimates include charter boat landings.

The significance of differences between the revised NRB and NIWA survey estimates was tested by bootstrapping each estimate given its respective CV and calculating a ratio (q) for each pair of bootstrap estimates. Results indicated that for each species $q < 1.0$ (Figure 3), indicating that NIWA estimates were lower than the NRB estimates. From the distributions of q values, it was possible to infer whether the coefficient was significantly different from 1.0. If the 95% confidence intervals did not contain 1.0, then we could conclude that the NIWA and NRB estimates are significantly different at the 5% level. Using this measure, we found the estimates for trevally and red gurnard to be significantly different, but not the estimates for snapper, kahawai or tarakihi (Table 2).

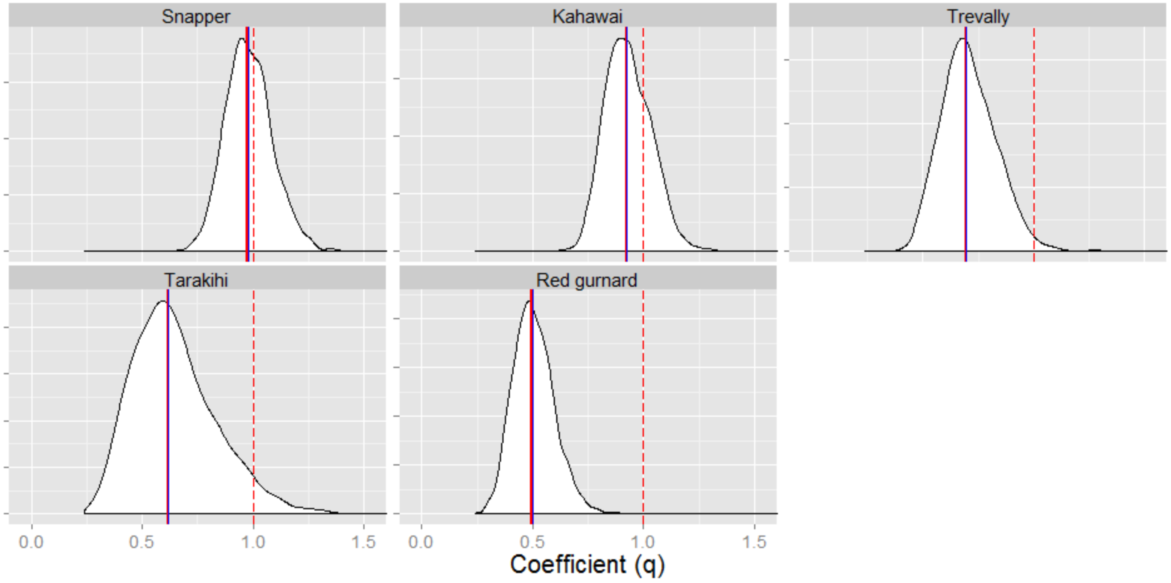

Figure 3: Distributions of *q* values comparing NIWA and NRB harvest estimates for FMA 1. The red and blue vertical lines indicate the median of the distribution and the *q* value obtained from the ratio of the actual harvest estimates, respectively. The vertical dashed line indicates *q*=1 for comparative purposes.

Table 2: Distributions of *q* values from harvest estimates by NIWA and NRB for FMA 1.

			Quantile
Species	2.5%	50%	97.5%
Snapper	0.793	0.976	1.202
Kahawai	0.753	0.924	1.138
Trevally	0.496	0.697	0.962
Tarakihi	0.351	0.619	1.081
Red gurnard	0.347	0.497	0.705

To investigate correlative factors which may help to explain differences between the NIWA and NRB harvest estimates, we first plotted *q* distributions at the region level. Consistent with the aggregated results, NIWA estimates were consistently lower than the NRB estimates (q<1.0). Distributions differ between regions, with some significant differences that were not apparent when regions were aggregated (Figure 4). However, there are other explanatory factors which may have played a role, in particular the season and day on which the data were collected. To investigate the causes of the observed discrepancies we subjected the harvest *q* values to a tree based regression. This method split the data into four parts using analysis of variance (Table 3), detecting differences between harvest estimates at the level of the season and day type, but not according to the species and region. Mean coefficients for each terminal node of the tree are shown in Figure 5. This suggested that the differences observed above might be due to differences in the sampling and/or scaling at the temporal level, rather than at the spatial level.

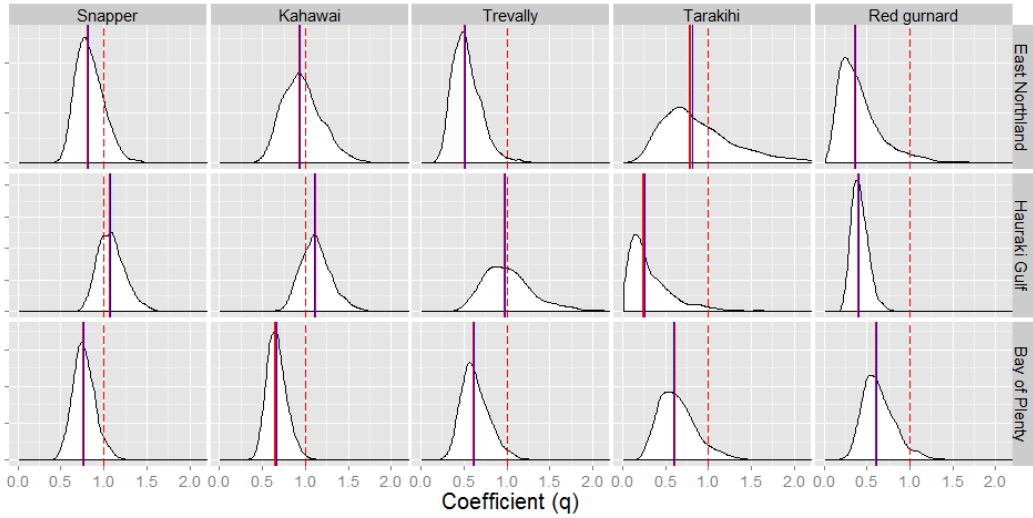

Figure 4: Distributions of *q* values at region disaggregated level within FMA 1.

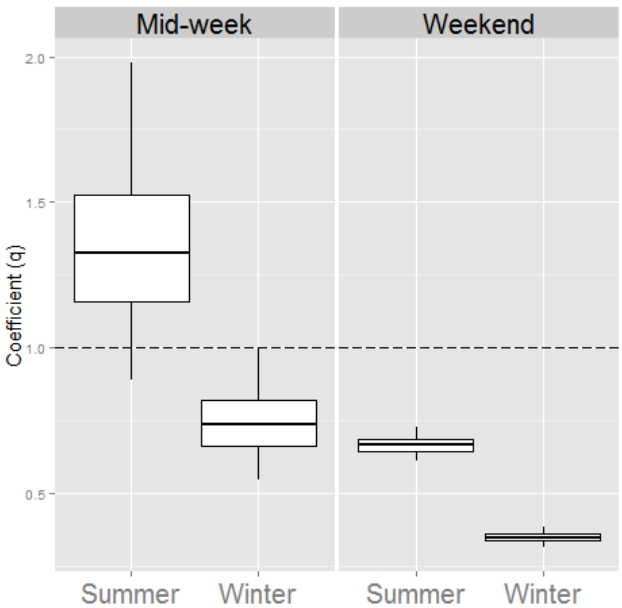

Figure 5: Regression tree output showing mean *q* values for nodes of the regression tree. Boxplots indicate 50% and 95% confidence intervals around the mean, assuming a log-normal error distribution and CVs calculated analytically.

Table 3: Improvements in R^2 recorded by recursive partitioning of *q* values comparing harvest estimates from NIWA and NRB.

Number of partitions	R^2	Increase in R^2
0	0.000	-
1 (season)	0.296	0.296
2 (day type)	0.439	0.143
3	0.473	0.034

To investigate consistency of this pattern across each species and region, we performed a parametric bootstrap of the harvest estimates at the same level of disaggregation as the regression tree output and calculated coefficient values. These results were consistent with the regression tree output (Figure 6), showing *q* values closer to one for mid-week data, and higher for summer compared to the winter. There was no clear pattern across regions and species, again consistent with the regression tree output, which did not identify these factors as capable of explaining the variation in the data.

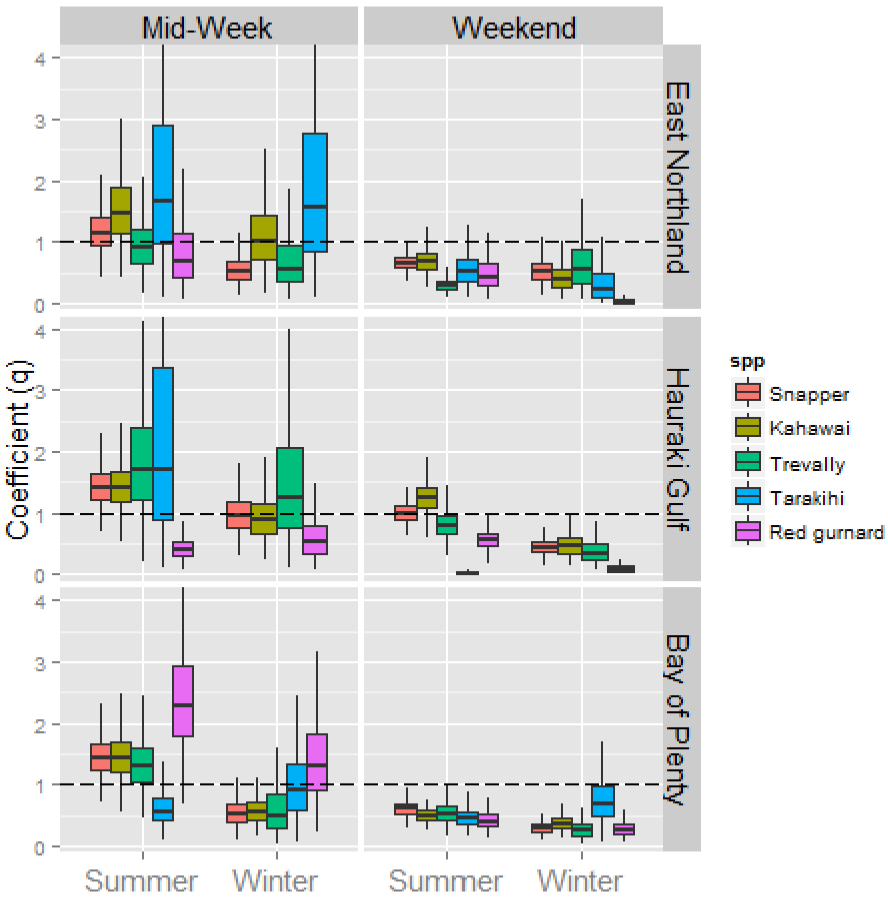

Figure 6: Bootstrapped *q* values at the species and region level for comparison with the regression tree output.

As noted above, temporal differences in the *q* values could be due either to the collection of biased fisher catch-effort data, or the non-representative scaling of these data within each temporal stratum. To differentiate between these two hypotheses, we next examined *q* values in the raw trip data. Trip level data were split into zero catch (*P0*) and non-zero catch events.

Trip level comparisons are shown in Figures 7a to 7e, for each species. There are a number of inferences that can be made from these analyses. Firstly, reporting of a non-zero catch is rare for tarakihi, red gurnard and trevally, as most of the trip data records for these species were a zero. *P0* data therefore only accounts for a small degree of the variation observed in overall *q* values for these species. For snapper and kahawai, however, non-zero catches were more frequently represented in the data, and *q* values for *P0* were mostly greater than 1.0, which suggests that the NIWA survey observed more zero catch trips (and conversely, the NRB survey less). Regardless, higher *q* values for snapper and kahawai during the winter suggest that the probability of a zero catch trip is greater at this time of year.

Importantly there appears to be no pattern in the *q* values for catch per non-zero trip across day type or season. The *q*s for non-zero trip data were mostly less than 1.0 and seemingly closer to one than the final harvest estimate in most cases. This indicates that the catch per non-zero trip is usually lower in the NIWA survey, but more similar between the two survey methods than the final harvest estimate.

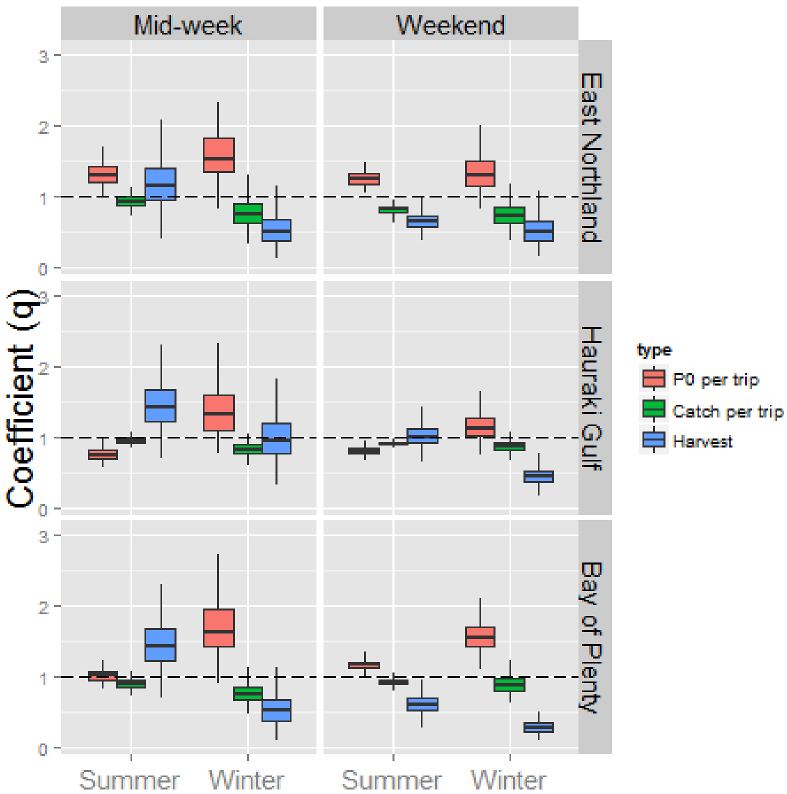

Figure 7a: Trip and harvest bootstrapped *q* values for snapper comparing NRB and NIWA estimates.

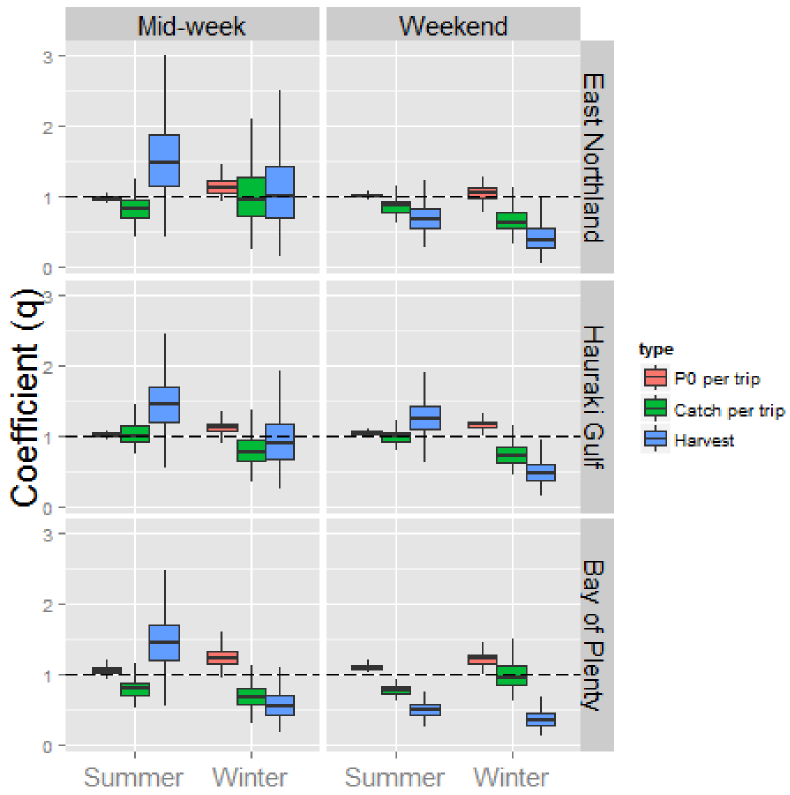

Figure 7b: Trip and harvest bootstrapped *q* values for kahawai comparing NRB and NIWA estimates.

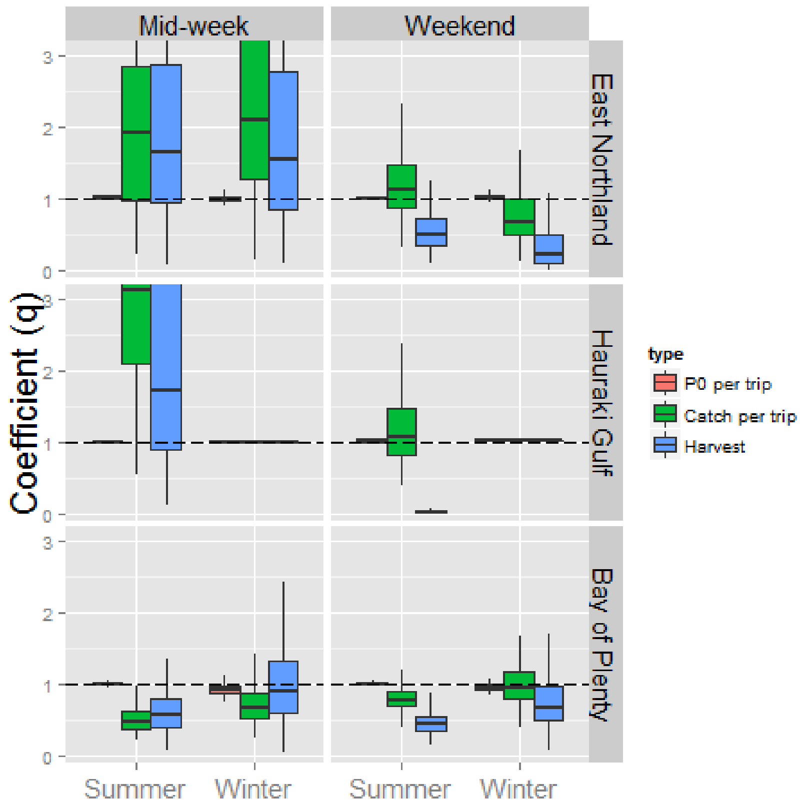

Figure 7c: Trip and harvest bootstrapped *q* values for tarakihi comparing NRB and NIWA estimates.

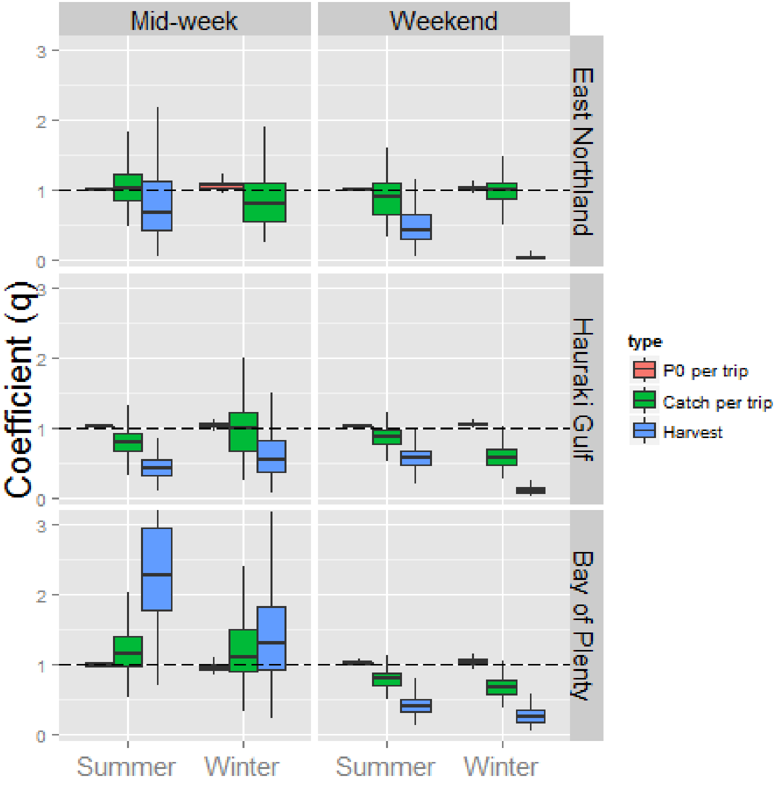

Figure 7d: Trip and harvest bootstrapped *q* values for red gurnard comparing NRB and NIWA estimates.

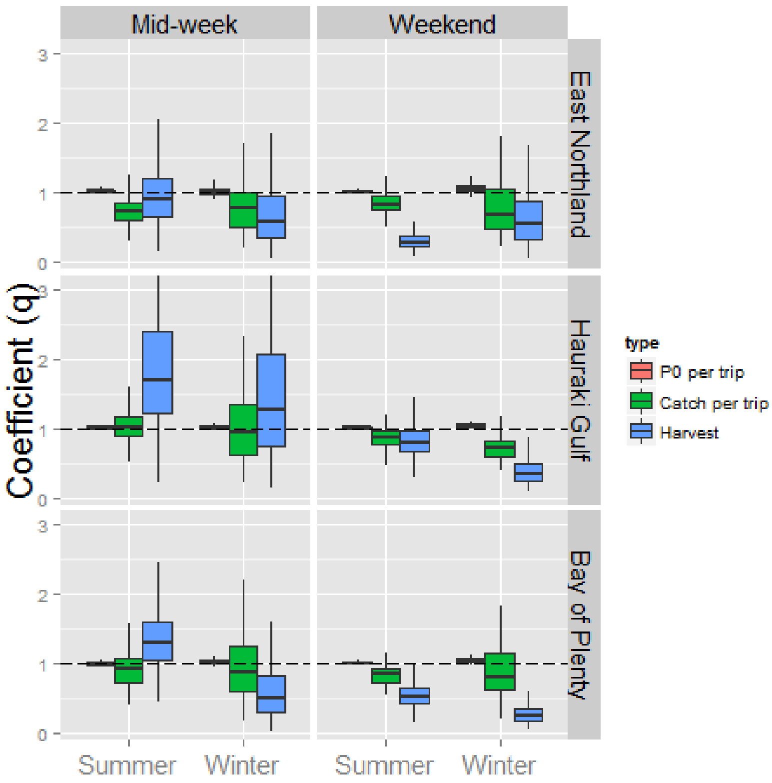

Figure 7e: Trip and harvest bootstrapped *q* values for trevally comparing NRB and NIWA estimates.

Since the qs were mostly less than 1.0 for the trip level data, this partly explains differences in the final harvest estimates, which also exhibit values of q that were less than 1.0. However the trip level data does not explain the pattern that exists across season and day type identified by the regression (see Figure 5). There must have been an additional bias introduced when scaling the trip level data up to a harvest estimate. One obvious place to look for this bias is in the effort data collected by NIWA, as this survey was conducted within a temporal subsampling design. An estimate of effort is an important component of the final harvest estimates produced using the NIWA survey method. Non-representative sampling within one or more temporal stratum could explain much of the difference seen between the NRB and NIWA estimates.

We used daily traffic count data provided by a web camera overlooking the Sulphur Point boat ramp at Tauranga to examine whether the selection of days surveyed by NIWA was representative in terms of levels of boat based effort. It can be seen clearly from these data that in most cases the boat counts per day for NIWA are less than the overall boat counts from all days combined (Figure 8). In other words, the NIWA survey appears to underestimate the traffic across the boat ramp. This is particularly the case at the weekend and during the winter months.

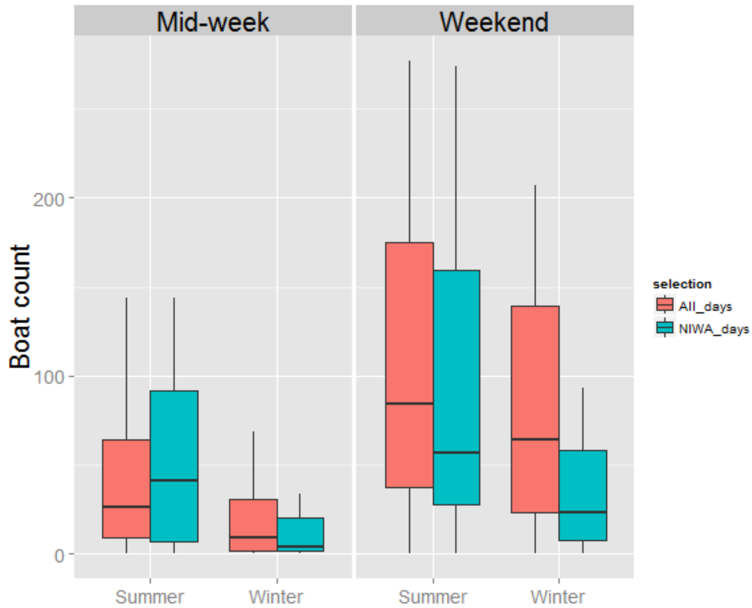

Figure 8: Distribution of web camera based daily traffic counts for NIWA survey days compared to the distribution of counts observed in all days within each temporal stratum.

Since the NIWA survey uses estimates of effort to scale up trip catch data, any underestimation of effort will result in negatively biased harvest estimates. Interestingly, the biases observed in the web camera data are an exact match to the pattern identified by the tree based regression. From these data alone we might therefore expect overestimated harvest estimates (possibly leading to q values greater than one) on mid-week days in the summer, but underestimated harvests at other times (giving q values less than one). Thus the web camera data provides an explanation for the fact that NIWA survey estimates are lower than the NRB estimates during the weekend, and produced a lower harvest estimate in the winter compared to the summer. To illustrate the consequence of this bias, we re-calculated q values using data collected mid-week (during both seasons combined) only, when the selection of days surveyed was broadly representative in terms of daily boat effort (Figure 8). As might have been expected, q values are increased overall, and are not significantly different from 1.0 for any of the species (Figure 9 and Table 4).

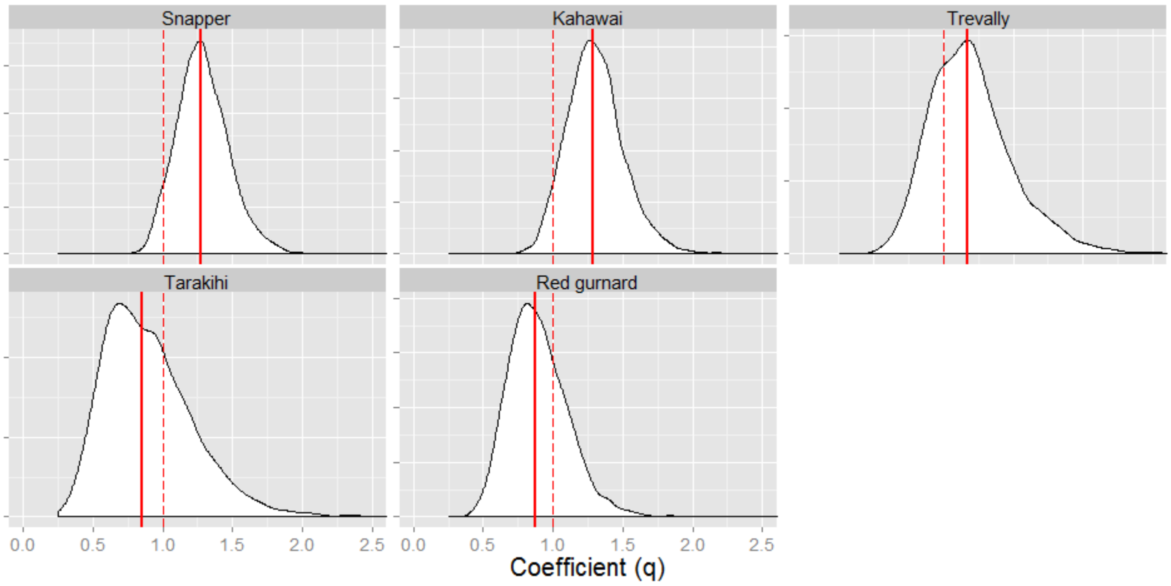

Figure 9: Distributions of *q* values from harvest estimates using data collected by NRB and NIWA on mid-week days only (both seasons combined), when web camera data suggests that NIWA sampling was most representative in terms of fishing effort.

Table 4: Distributions of *q* values from harvest estimates using data collected by NRB and NIWA on mid-week days only.

	Quantile		
Species	2.5%	50%	97.5%
Snapper	0.962	1.274	1.694
Kahawai	0.95	1.289	1.737
Trevally	0.722	1.169	1.879
Tarakihi	0.43	0.851	1.658
Red gurnard	0.549	0.871	1.378

2.2 Comparison of harvest estimates for the western Bay of Plenty

Harvest estimates were also compared for the western Bay of Plenty, from which estimates are available from all three surveys (Table 1, Figure 10). The NIWA estimates for red gurnard and kahawai are less than those provided by the NRB and BWM surveys, which are very similar in magnitude. The level of discrepancy between the BWM and NRB estimates for rock lobster and scallops is greater, but the relative direction of that discrepancy differs by species.

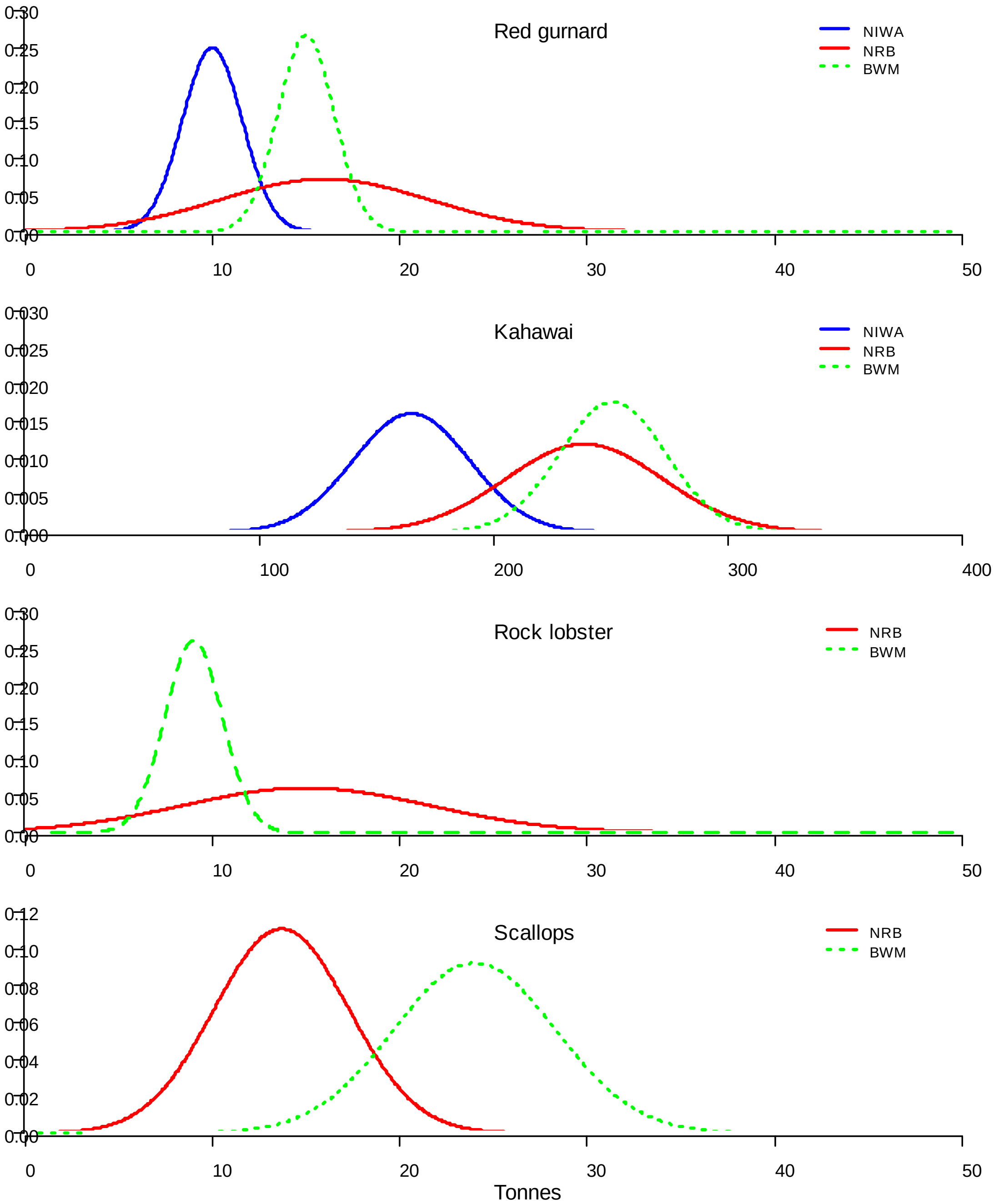

Figure 10: Harvest in tonnes by species in the western Bay of Plenty, estimated by NRB, NIWA and BWM. Distributions illustrate the uncertainty around each estimate, assuming normality.

2.2.1 Comparison of NRB and BWM estimates for the western Bay of Plenty

There was limited overlap in the species surveyed between NIWA and BWM (Figure 10), and we therefore initially compared BWM and NRB estimates, assuming again that NRB estimates represented the 'true' harvest. Results from this comparison are shown in Figure 11 With the exception of scallops, all *q* values were less than 1.0, indicating that NRB harvest estimates were larger. Given uncertainty in the estimates, none of the *q* values were significantly different from one at the 5% level (Table 5).

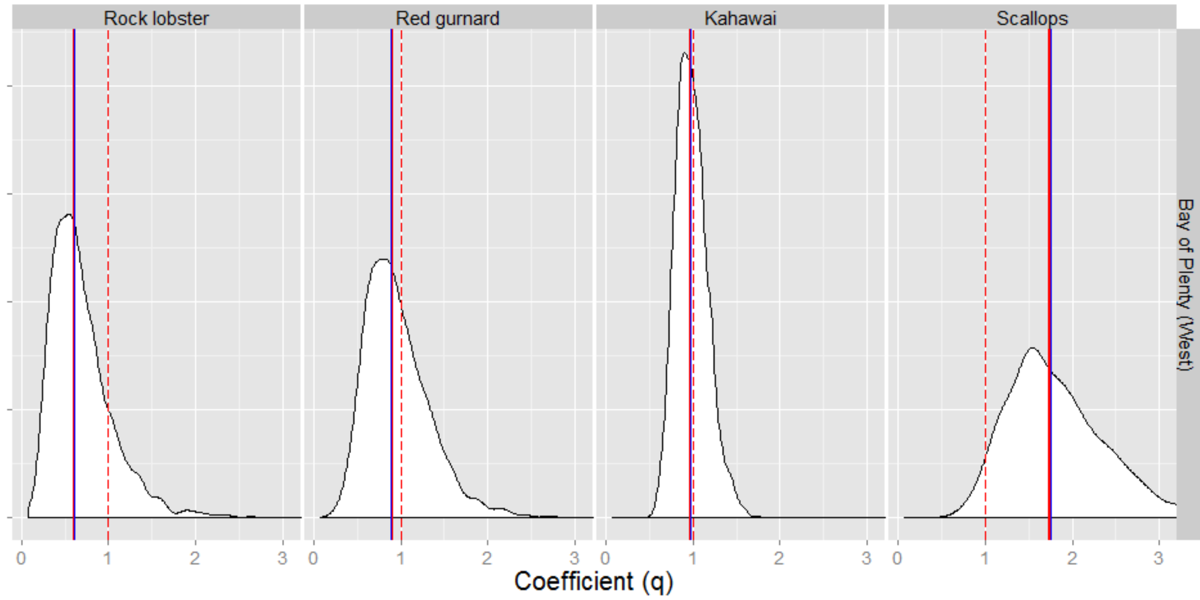

Figure 11: Distributions of *q* values from harvest estimates by BWM and NRB.

Table 5: Distributions of *q* values from harvest estimates by BWM and NRB.

			Quantile
Species	2.5%	50%	97.5%
Rock lobster	0.234	0.613	1.56
Red gurnard	0.422	0.900	1.864
Kahawai	0.677	0.969	1.402
Scallops	0.946	1.736	3.25

Consistent with these similarities, a tree based regression did not detect any explanatory factors that significantly partitioned the data. For the sake of completeness, we also illustrate the data disaggregated by day type and season, including *q* values estimated directly from the trip level data (Figures 12a to 12d). At this level of disaggregation the data clearly show large positive and negative discrepancies between alternative survey estimates, particularly for red gurnard and rock lobster. These discrepancies are not evident in the trip level data and must therefore be errors in how the trip data were scaled to produce the final harvest. When aggregated, however, these errors appear to cancel out, as illustrated by similarity of the final harvest estimates for all temporal strata combined (see Figure 11).

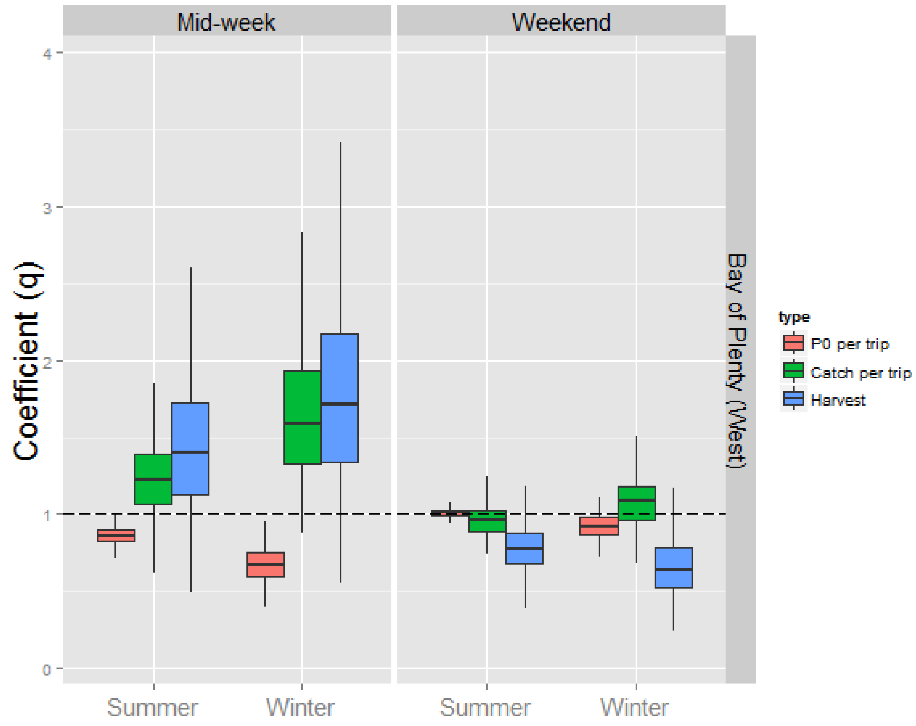

Figure 12a: Trip and harvest bootstrapped *q* values for kahawai comparing BWM and NRB estimates for the western Bay of Plenty.

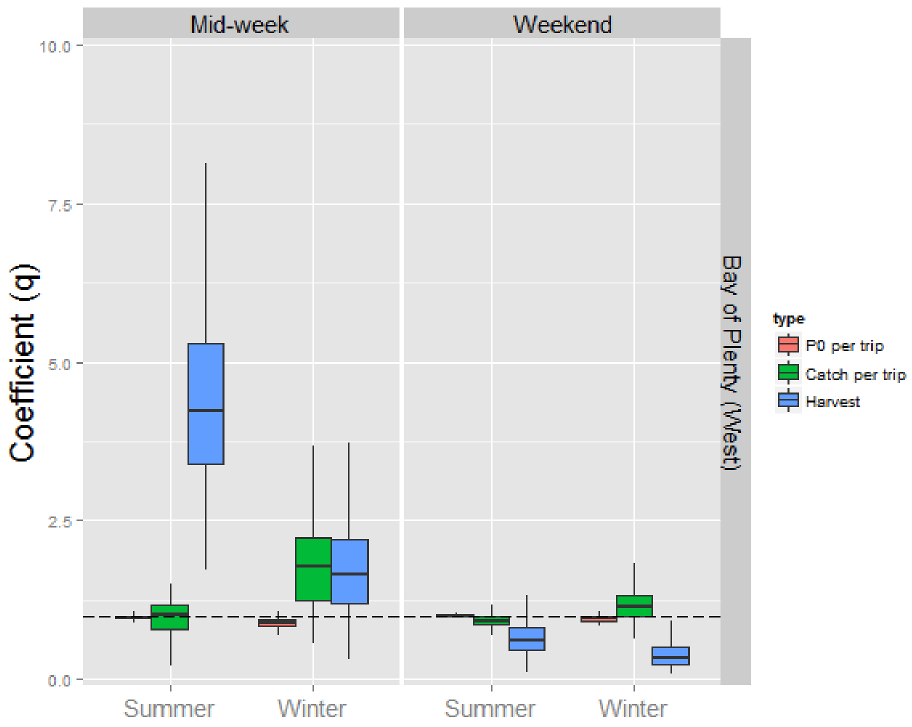

Figure 12b: Trip and harvest bootstrapped *q* values for red gurnard comparing BWM and NRB estimates for the western Bay of Plenty.

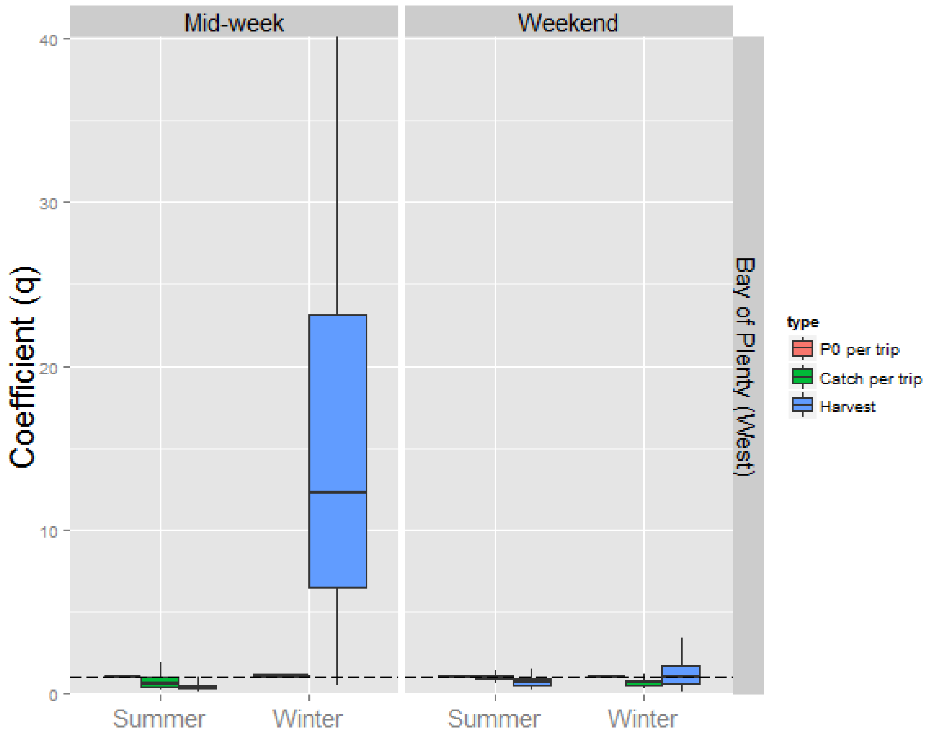

Figure 12c: Trip and harvest bootstrapped *q* values for rock lobster comparing BWM and NRB estimates for the western Bay of Plenty.

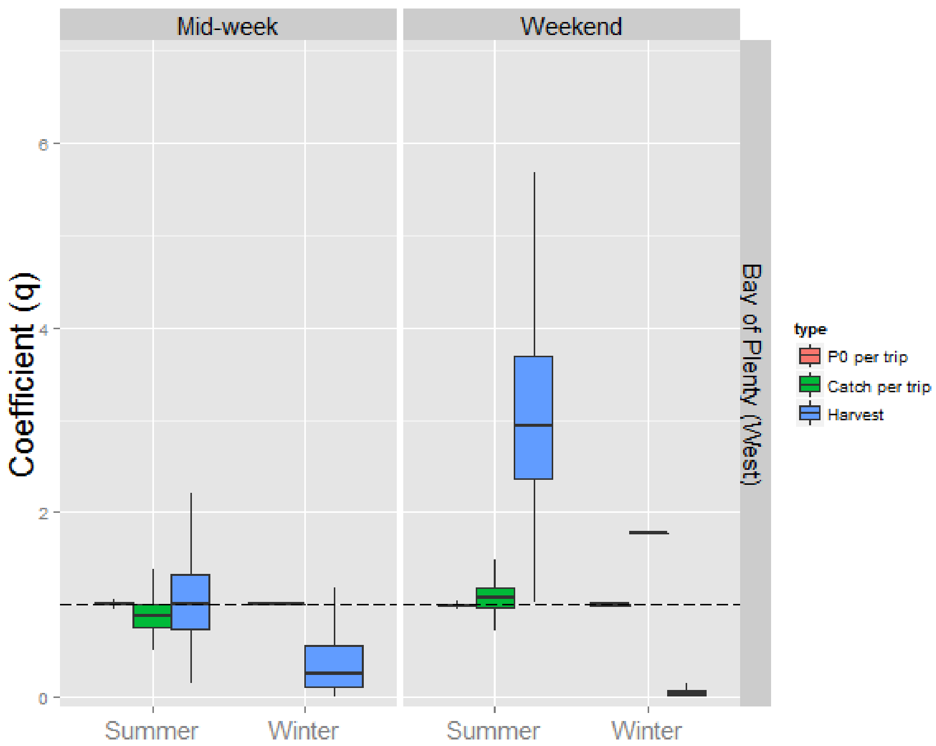

Figure 12d: Trip and harvest bootstrapped *q* values for scallops comparing BWM and NRB estimates for the western Bay of Plenty.

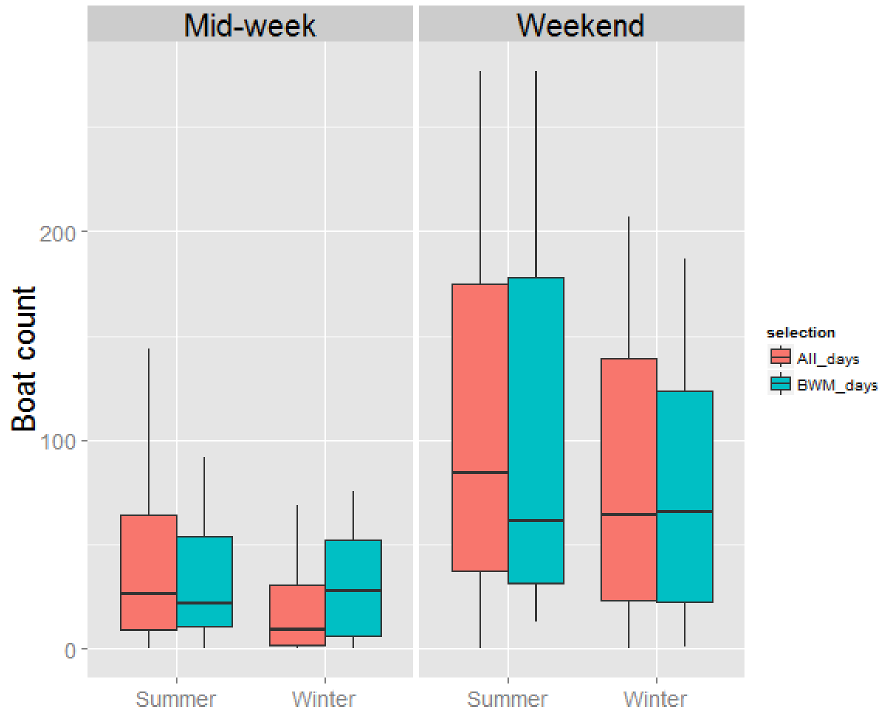

Figure 13: Distribution of web camera based daily traffic counts for BWM survey days compared to the distribution of counts observed in all days within each temporal stratum.

2.2.2 Comparison of NRB and NIWA estimates for the western Bay of Plenty

Finally we compared harvest estimates made by NIWA in the western Bay of Plenty with the NRB estimates for that region. We only show results for kahawai and red gurnard, which were shared with the BWM survey. Consistent with results at the regional level and for QMA1, *q* values were less than 1.0 (Figure 14). Again for completeness, *q* values disaggregated by day type and season are shown in Figures 15a and 15b, which follow a similar pattern to that observed for the whole Bay of Plenty (Figures 7b and 7e).

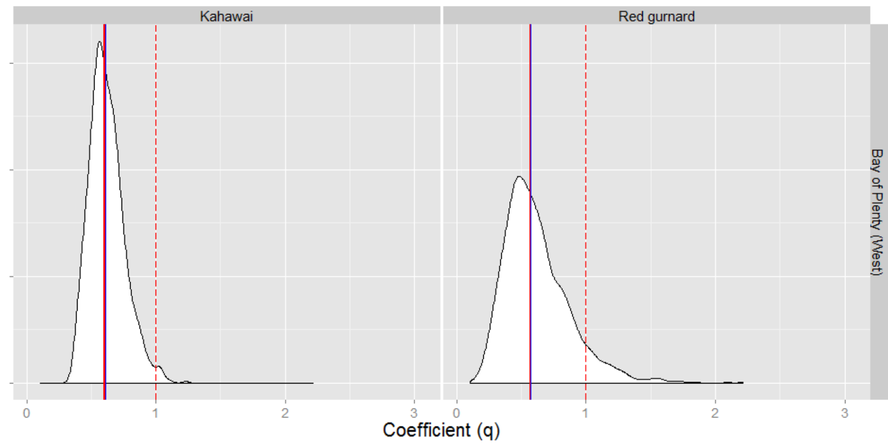

Figure 14: Distribution of *q* vales for a comparison of NIWA and NRB harvest estimates in the western Bay of Plenty.

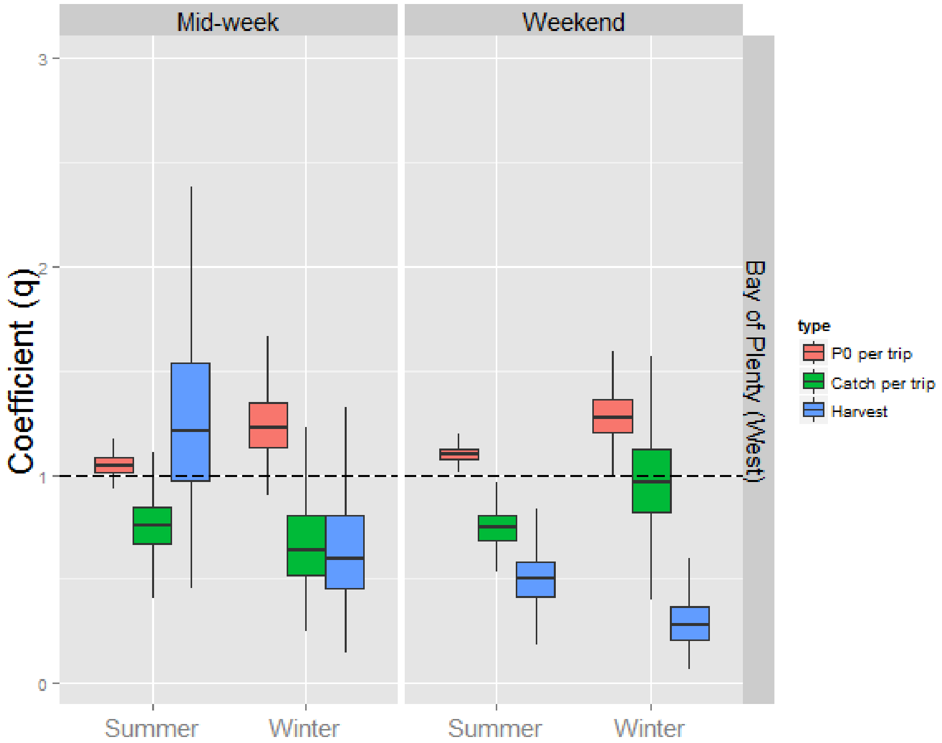

Figure 15a: Trip and harvest bootstrapped *q* values for kahawai comparing NRB and NIWA estimates for the western Bay of Plenty.

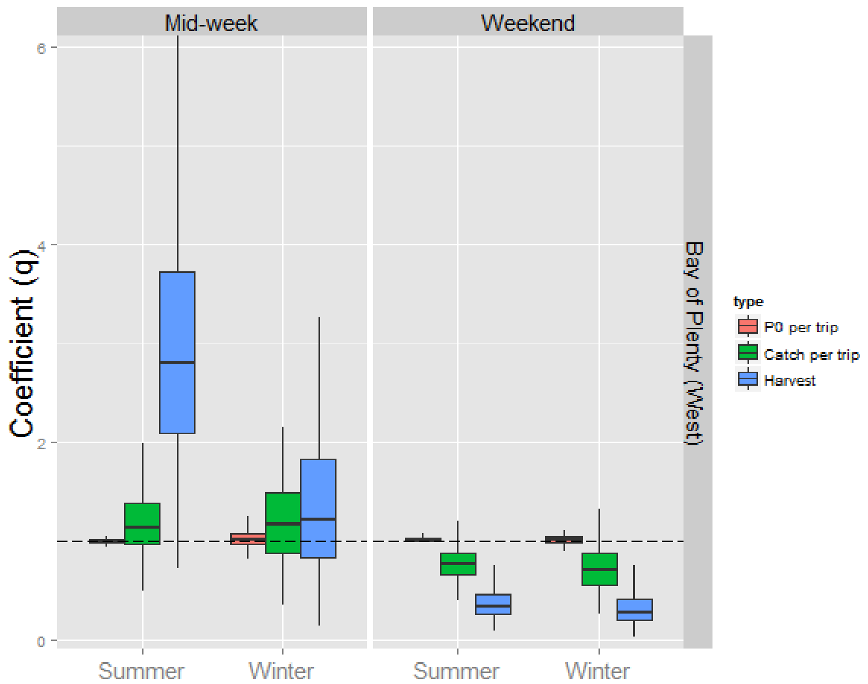

Figure 15b: Trip and harvest bootstrapped *q* values for red gurnard comparing NRB and NIWA estimates for the western Bay of Plenty.

3. DISCUSSION

The harvest estimates for recreational FMA 1 fisheries provided by three independent surveys in 2011 –12 were mostly of a similar magnitude given their associated levels of precision. Harvest estimates provided by alternative surveys for the larger fisheries are more comparable than for the smaller fisheries, which suggests that reliable harvest estimates for less commonly caught species are harder to attain.

Much of the discrepancy between alternative harvest estimates provided by two or more surveys can be attributed to differences in survey coverage. The NRB survey method is potentially capable of estimating the harvest taken by all recreational fishers, with the exception of that taken by fishers younger than 15. Age specific creel survey data collected by NIWA during 2011–12 suggests that the SNA 1 harvest taken by these youth fishers was only in the order of 5% of the total harvest. The scope of the onsite NIWA and BWM surveys was narrower, however, as these methods did not assess any of the harvest taken by shore based fishers. Although the NIWA and BWM estimates ultimately included an allowance for shore based harvesting, these additional harvests were estimated indirectly from NRB panellist data. Further, charter boat harvests were not assessed by the NIWA survey and were only partially assessed by the BWM survey. Harvest estimates were therefore recalculated for all three surveys, for a common subset of fishers: those fishing from boats other than charter boats who were 15 years or older.

When these more directly comparable harvest estimates are compared, the degree of similarity between survey estimates increases, but there is still evidence of a systematic difference between the NIWA and NRB estimates. The majority of the NIWA estimates are less than the NRB estimates, and the probable reason for this becomes increasingly evident as the estimates are further disaggregated. The regression tree analysis of FMA 1 data found significant differences in harvest estimates at the seasonal and day type levels, but no significant differences were evident across species or regions. These results suggest that at least one of these surveys may have sampled the fishery in a temporally biased fashion, and evidence for this could be seen in web camera traffic data. Examination of this survey independent data source indicated that the selection of NIWA survey days during the two winter strata (weekend days and midweek/public holiday days) was biased towards low effort days. This sampling bias would explain why the NIWA estimates were mostly lower than those provided by the NRB survey.

There was no evidence of any systematic difference between the NRB and BWM estimates for the western Bay of Plenty. The harvest estimates for kahawai and red gurnard were of a very similar magnitude, whereas the BWM estimates for rock lobster and scallops were respectively lower and higher than those estimated by the NRB survey. Although large discrepancies were evident when harvest estimates were disaggregated by season and day type, these differences were most likely sampling noise as they largely cancelled out when estimates were aggregated across all temporal strata.

The results of this study therefore suggest that future onsite survey programmes, such as those discussed here, should be conducted at a higher temporal sampling intensity to minimise the chance of over or underestimating average daily levels of effort or harvest. There is no way of predicting daily weather conditions (and hence potential levels of fishing effort) for a 12 month period in the future, and the risk of inadvertently selecting a non-representative sample of days within any temporal stratum decreases as the sample size increases.

Unscaled catch per trip data were also compared, to see if any of the discrepancy between paired survey estimates could be attributed to biased sampling from the fishing population, or because fishers misreported their catch. Although there is some evidence to suggest that some unsuccessful trips may have gone unreported to NRB, these missed zero catch events will not result in biased harvest estimates as they do not account for any additional and unassessed harvest. There is no evidence to suggest that panellists underreport successful fishing trips, which would led to biased NRB harvest estimates.

Any further exploration of differences between alternate survey estimates is problematic because the onsite and offsite surveys were based on fundamentally different sample frames. Although other sources of bias may have been operating, the overall influence of any unresolved bias is probably relatively minor given the degree of similarity observed between uncorrected estimates provided by the three surveys, especially given the level of precision associated with these estimates. We conclude that the recreational harvest estimates provided by three independent surveys in 2011–12 are reasonably accurate and fit for management purposes.

Although the results of this comparative study suggests that any of the three survey methods used is capable of producing reasonably unbiased harvest estimates, a similar comparative approach should be considered in the future, to further test and demonstrate the rigor of the methods used. Studies such as this serve two purposes: to assess the likely degree of accuracy of the harvest estimates they produce; and to explore potential sources of bias that may have occurred so that they can be considered when designing future surveys. Both of these issues are further discussed in Hartill & Edwards (2015), which considers the wider international context of this study, which is arguably without precedent. Almost all attempts to estimate recreational harvests outside of New Zealand have focused on a single survey approach, often with little or no assessment of known or unknown sources of bias. This study has identified some sources of bias, albeit relatively minor, and these should be considered when designing future surveys in New Zealand, and elsewhere.

Fisheries managers should also consider the scope of the surveys undertaken in 2011–12, as they either directly or indirectly estimate most, but not all of the recreational harvest for an assessed fishery. None of the survey methods considered here, for example, include any allowance for recreational catches taken from commercial fishing vessels as part of a S.111 allowance. Ancillary sources of information on recreational harvests such as S.111 reporting have been reviewed by Hartill (2015), and some of these should also be considered alongside survey based estimates that quantify most but not all of the potential recreational harvest from a fishery. In most cases, however, the survey estimates provided by the three surveys should encompass the vast majority of any harvesting that took place for those fisheries in 2011–12.

4. ACKNOWLEDGMENTS

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