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Comparison of recreational harvest estimates provided by the National Panel Survey and aerial-access survey in 2017–18

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Two fundamentally different survey methods were used in 2017–18 to provide alternative sets of recreational harvest estimates for direct comparison to assess the reliability of the methods used and to attempt to detect any biases that may have influenced either survey. The survey methods were: a National Panel Survey (NPS) of all of New Zealand's marine recreational mainland fisheries, which was conducted by the National Research Bureau (NRB); and an aerial-access survey conducted by the National Institute of Water and Atmospheric Research (NIWA). The scope of the NPS was far broader than the aerial-access survey, and harvest estimates were compared for five key species (snapper, kahawai, trevally, tarakihi, and red gurnard) caught by a commonly defined set of recreational anglers fishing within three regions of Fisheries Management Area 1 (FMA 1).

There was a reasonably high degree of similarity between the regional and combined region harvest estimates provided by the two surveys for the five key species, in the number and tonnage of fish harvested and the precision of these estimates.

The aerial-access harvest estimates were mostly higher than the NPS estimates. Individual fisher catch data and regional harvest estimates for each species were further disaggregated by season (summer and winter) and day type (midweek days and weekend/public holiday days) to explore possible causes for this pattern. Bootstrapped survey estimate ratio distributions and boosted regression tree modelling of the disaggregated data highlighted a broadly consistent seasonal pattern; the summer strata estimates for the two surveys were of a similar magnitude, but the aerial-access harvest estimates were higher than the NPS estimates in both winter strata. The difference between the two sets of winter harvest estimates was more pronounced for the midweek day type stratum during this season. This pattern was independently confirmed by camera-based counts of the number of boats returning daily to a high traffic boat ramp in each region of FMA 1. The number of boats returning to these ramps on winter midweek days surveyed by the aerial-access survey was on average greater than the number of boats returning to those ramps on all days falling within the same temporal stratum. The discrepancy between the two sets of survey estimates can therefore be partially explained by the chance random selection of a non-representative sample of aerial-access survey days during the winter midweek, and to a lesser extent, winter weekend/public holiday strata.

Similar analytical methods were used to compare spatially and temporally disaggregated trip bag distributions reported by fishers participating in the two surveys. These analyses found clear evidence of under-reporting of zero catch trips and single fish catch trips by NPS panellists. Although the under-reporting of zero catch trips had no influence on the total annual harvest reported by these fishers, the under-reporting on single fish catch trips is a concern, because this will lead to an underestimation of harvests by the NPS survey.

The results of the comparisons of the harvest estimates provided by these surveys in 2017–18 are broadly similar to the conclusions drawn from a previous comparison of harvest estimates provided by these two survey approaches in 2011–12. Evidence of random chance selection of non-representative survey days was also found for the 2011–12 aerial-access survey during the winter strata, as was under-reporting of zero catch trips by NPS panellists. The detection of under-reporting of single catch trips by NPS panellists in 2017–18 is a new finding that should be addressed if possible.

Overall, both survey methods provide reasonably similar estimates at comparable levels of precision. Either of these methods can therefore be used quantify recreational harvests with some confidence.

1. INTRODUCTION

Reliable catch statistics are required to inform stock assessment modelling for some important shared stocks and for the setting and allocation of sustainable catch limits across all sectors of the fishing community. Commercial fishers are required to routinely submit catch returns, but recreational fishers are not required to report their catch and some form of survey is therefore required to estimate amateur harvest levels.

Several survey methods have now been developed in New Zealand and used to estimate recreational harvests taken from a wide range of fisheries. Three of these methods were used to concurrently estimate recreational harvests taken from a set of commonly defined fisheries in 2011–12, and to test the reliability of each survey approach. These methods were: a National Panel Survey (NPS) of all New Zealand's recreational fisheries, conducted by National Research Bureau (NRB) (Wynne-Jones et al. 2014); an aerial-access survey of the boat-based fishery in FMA 1, conducted by NIWA (Hartill et al. 2013); and an extensive creel survey of the boat-based fishery in the western Bay of Plenty, conducted by Bluewater Marine Research (BWMR) (Holdsworth 2016).

The harvest estimates provided by these three surveys were broadly similar, especially for the fisheries with the highest catch. Edwards & Hartill (2015) conducted statistical pairwise comparisons of alternative survey-specific harvest estimates and disaggregated data for a range of fish stocks, to explore potential sources of bias associated with each survey method. These analyses identified some survey-specific sources of bias, but their influence was considered to be relatively minor given the high degree of similarity between the harvest estimates provided by the three surveys.

There is an ongoing need to monitor levels of recreational harvesting, and to corroborate the reliability of the methods used to estimate these harvests. A second National Panel Survey of New Zealand's recreational fisheries was therefore undertaken in 2017–18 (Wynne-Jones et al. 2019), alongside an aerial-access survey of the boat-based fishery in FMA 1 (Hartill et al. 2019). Both surveys followed survey designs and methods similar to those used in 2011–12, so that comparisons could be made across survey approaches through time.

The overall objective of this study (Fisheries New Zealand Research Project MAF2018/01) was *to continue the implementation and interpretation of the integrated amateur harvest estimation system*. The specific objectives were: *to compare the harvest estimates provided by alternative survey methods in 2017–18*; *to identify the potential causes of any differences between estimates that are considered to be important for fisheries management decision-making*; and *to recommend any necessary changes to the design or implementation of future surveys to minimise bias in estimates of harvest*.

2. DATA AND METHODS

The purpose of this study was to compare harvest estimates provided by two 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 both surveys. These surveys 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. 2019);
- an aerial-access survey of the boat-based fishery in FMA 1 conducted by NIWA (Hartill et al. 2019).

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

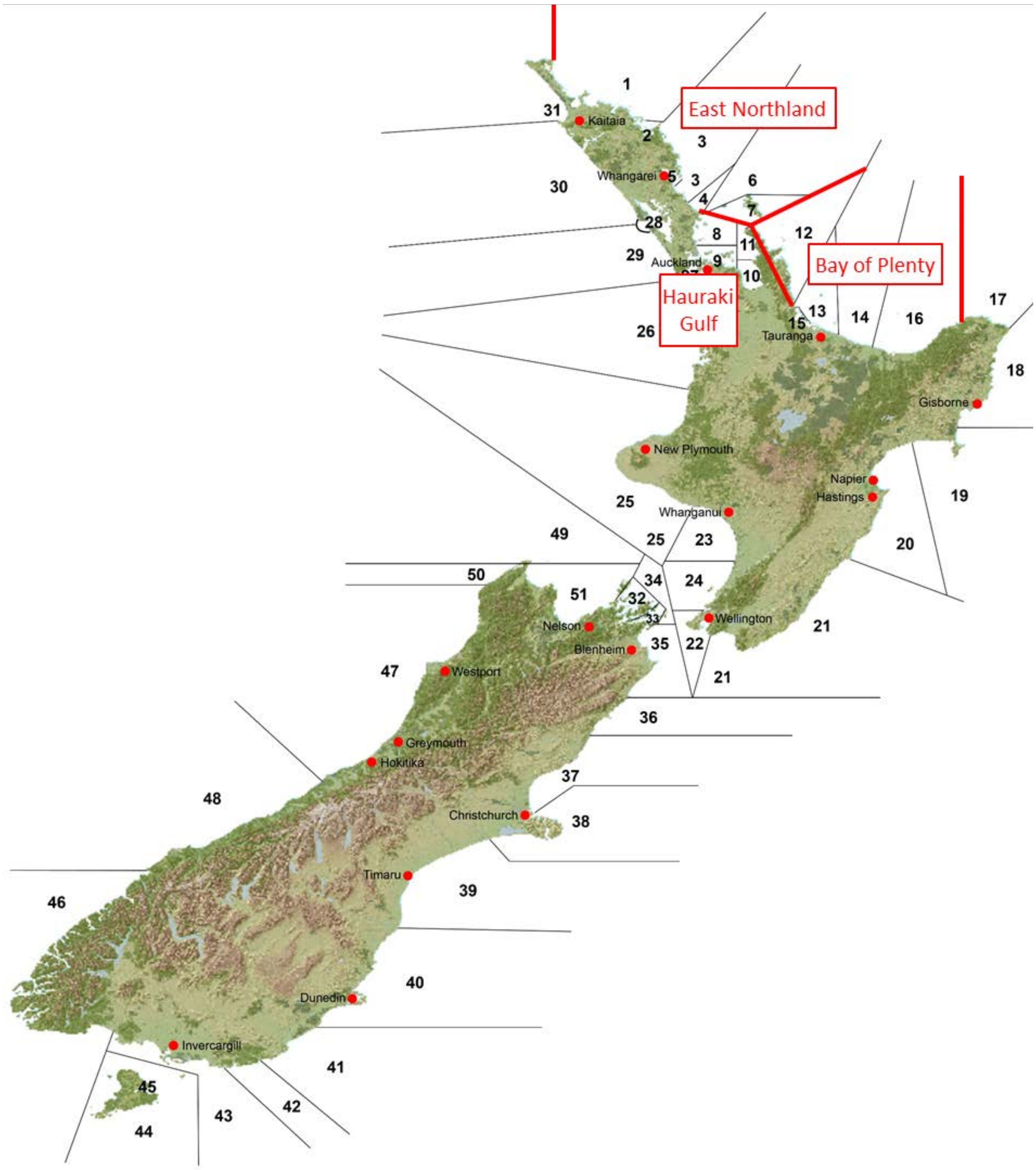

Figure 1: Spatial extent of areas covered by two independent surveys of recreational fisheries during the 2017–18 fishing year. Smaller numbered areas denote zones used during the NRB National Panel Survey, which encompassed all New Zealand's mainland marine coastal zone. The NIWA aerial-access study area covered Fisheries Management Area 1 (FMA 1) which has been further divided up into three regions: East Northland (NRB areas 1 to 7), the Hauraki Gulf (NRB areas 8 to 11), and the Bay of Plenty (NRB areas 12 to 16).

Both surveys were conducted throughout the 2017–18 October fishing year (1 October to 30 September). The aerial-access survey was stratified by season (summer – October to April, and winter – May to September) and day type within each season (weekend/public holiday days, and midweek days).

The NPS survey provided recreational harvest estimates for all New Zealand's recreationally fished marine stocks, but the aerial-access survey provided harvest estimates only for finfish species commonly landed from boats fishing in FMA 1. All comparisons of the data and estimates provided by the two surveys are therefore focused on the boat-based fisheries in East Northland, the Hauraki Gulf, and the Bay of Plenty, for the five most commonly caught species: snapper (*Pagrus auratus*), kahawai (*Arripis trutta*), red gurnard (*Chelidonichthys kumu*), tarakihi (*Nemadactylus macropterus*), and trevally (*Pseudocaranx dentex*) (Table 1).

Harvest estimates from these two surveys are compared in Table 1, but they are not necessarily the same as those given by Hartill et al. (2019) and Wynne-Jones et al. (2019), because the estimates derived for comparisons are based on commonly defined subsets of the available data so that direct comparisons can be made.

The first comparability issue to address was the unequal demographic coverage of the two surveys. Prescribed ethical standards prevent offsite survey providers such as NRB from interviewing individuals who are 15 years or younger without prior written consent from their guardians; consequently, their catch and effort is not estimated by an NPS survey. This was not an issue for the aerial-access survey, because data are collected from all participants in a fishing party, regardless of their age, with younger members of the public usually accompanied by adults when fishing. All fishers interviewed as part of the aerial-access survey were asked to categorise their age, so that aerial-access harvest estimates could also be calculated for those fishers who were 15 years or older at the time of the interview only.

Table 1: Comparison of harvest estimates provided by the 2017–18 National Panel Survey and a concurrent aerial-access survey of the recreational fishery in FMA 1. Estimates are given for the five most commonly harvested finfish species taken from three regions of FMA 1, in terms of numbers and tonnage harvested (with associated Coefficients of Variation in brackets). Landed catches attributed to fishers younger than 15 were excluded from the data used to calculate these aerial-access harvest estimates, to make them more comparable to those provided by the NPS survey. Neither set of harvest estimates include catches taken from charter boat vessels. Percentage differences are given for each pair of estimates. ENLD is East Northland, HAGU is Hauraki Gulf, and BPLE is Bay of Plenty. Fish stocks in FMA 1 are SNA 1 (snapper), KAH 1 (kahawai), GUR 1 (red gurnard), TAR 1 (tarakihi), and TRE 1 (trevally).

		Harvest estimates - numbers (1000s)			Harvest estimates - weight (t)		
Species	Region	NPS comparable aerial-access estimate	NPS harvest estimate	Difference	NPS comparable aerial-access estimate	NPS harvest estimate	Difference
Snapper	ENLD	543 (0.10)	563 (0.12)	-4%	700 (0.10)	761 (0.12)	-8%
	HAGU	1 685 (0.07)	1 352 (0.11)	25%	1 908 (0.07)	1 578 (0.11)	21%
	BPLE	560 (0.10)	551 (0.12)	2%	649 (0.10)	627 (0.12)	3%
	SNA 1	2 788 (0.05)	2 467 (0.07)	13%	3 257 (0.05)	2 967 (0.07)	10%
Kahawai	ENLD	177 (0.12)	128 (0.14)	39%	301 (0.13)	219 (0.14)	37%
	HAGU	282 (0.08)	207 (0.10)	36%	487 (0.08)	357 (0.10)	36%
	BPLE	222 (0.11)	211 (0.11)	5%	370 (0.11)	356 (0.11)	4%
	KAH 1	681 (0.06)	545 (0.07)	25%	1 158 (0.06)	933 (0.07)	24%
Red gurnard	ENLD	8 (0.22)	11 (0.30)	-29%	4 (0.22)	4 (0.30)	-26%
	HAGU	22 (0.17)	41 (0.21)	-46%	9 (0.21)	17 (0.21)	-50%
	BPLE	37 (0.14)	33 (0.16)	13%	17 (0.15)	14 (0.16)	19%
	GUR 1 (east)	68 (0.10)	85 (0.14)	-21%	29 (0.11)	36 (0.14)	-20%
Tarakihi	ENLD	9 (0.31)	9 (0.39)	0%	8 (0.29)	7 (0.39)	3%
	HAGU	0.1 (0.57)	3 (0.37)	-96%	0.1 (0.57)	2 (0.37)	-95%
	BPLE	44 (0.14)	42 (0.15)	-4%	36 (0.15)	38 (0.19)	-7%
	TAR 1 (east)	53 (0.13)	59 (0.16)	-11%	45 (0.13)	50 (0.16)	-12%
Trevally	ENLD	36 (0.14)	28 (0.13)	28%	47 (0.15)	38 (0.13)	21%
	HAGU	22 (0.14)	20 (0.17)	10%	24 (0.13)	22 (0.17)	7%
	BPLE	49 (0.14)	42 (0.15)	17%	68 (0.14)	58 (0.15)	17%
	TRE 1	107 (0.08)	90 (0.09)	19%	139 (0.09)	118 (0.09)	17%

The coverage of charter boat catches by the NPS is also incomplete because tourist fishers are not included in this survey of New Zealand residents. Charter boat catches reported by panellists were therefore removed from the NPS data before harvest and variance estimates were recalculated, to improve their comparability with the aerial-access estimates, which do not include catches landed from charter boats.

Aerial-access harvest estimates always include a relative adjustment to boat-based harvest estimates to allow for the shore-based catch, which is based on catch by fishing platform data provided by the most recent NPS. The same data are therefore essentially used by both the NPS and the aerial-access survey in 2017–18 to account for the shore-based catch from each fishery, and both sets of harvest estimates should be directly comparable in this regard.

The NPS and aerial-access survey estimates given in Table 1 are expressed both in terms of numbers and tonnage weight harvested. The overall pattern of pairwise differences between harvest number estimates is essentially the same as that for harvest weight estimates, but the magnitude of these percentage differences varies slightly by fishery (Table 1). These small differences occur because the fish weight data used by each survey method to convert harvest number estimates into harvest weight estimates are applied at a different catch resolution. With the NPS survey, a separate creel survey is used to provide mean fish weight estimates for each fish stock, and these are then multiplied by estimates of the total number of fish harvested from each fishery, to estimate the weight of fish taken by recreational fishers from each fish stock (Davey et al. 2019). With the aerial-access survey, however, the weight of each landing is calculated directly from the length composition of the same landing, before any amalgamation and scaling of the survey data to provide fishery wide harvest estimates. The calculation of harvest weight estimates from the aerial-access survey data is therefore more direct and nuanced than the analytical methods used for the NPS. All further analyses described in this report are therefore based on comparisons of harvest numbers, rather than harvest weights, because this metric provides the most consistent basis for any analytical attempt to detect sources of bias that may affect one or more survey method.

The analytical methods used in this report broadly follow those described by Edwards & Hartill (2015), which were explored further by Hartill & Edwards (2015).

The harvest estimates given in Table 1 were initially compared in a pairwise fashion by calculating a ratio q

$$q = \frac{H^{A-A}}{H^{NPS}}$$

where $H^{A\text{–}A}$ was the harvest estimate provided by the aerial-access survey, and H^{NPS} was the harvest estimate provided by the National Panel Survey. If an aerial-access harvest estimate was close to that produced by the NPS then q should be approximately equal to 1.0. To obtain an estimate of uncertainty in q, a parametric bootstrap was performed with 2000 draws from an assumed log-normal error distribution defined by the coefficient of variation (CV) calculated for each estimate. A significant difference between the harvest estimates provided by the two surveys is evident when there is no overlap between the 95th percentile distribution of the bootstrap estimates and an equivalent q value of 1.0.

To detect sources of bias that led to consistent differences between the estimates provided by the two surveys, the harvest estimates given in Table 1 were further disaggregated by:

- Season: summer and winter;
- Day type: midweek days and weekend/public holiday days.

Bootstrapped distributions of q ratios were generated for all combinations of disaggregation (species, region, season, and day type) and plotted to determine whether their 95th percentiles overlapped with an equivalent q value of 1.0, and to highlight any pattern that may be explained by the consistent presence of one of these disaggregation factors.

Although this disaggregated bootstrap simulation approach provides a more nuanced way of assessing the differences seen between the two sets of harvest estimates, than that shown in Table 1, other methods are required to determine the relative explanatory power of each disaggregation factor. Boosted Regression Tree (BRT) modelling of the combined ensemble of bootstrapped q values generated for each combination of disaggregation factors was therefore used to identify which covariates (disaggregation factor) best explained the differences between the two sets of harvest estimates.

For this analysis the BRT model averaged across a large number of regression trees. With each regression tree, the combined ensemble of 2000 bootstrapped q ratios that had already been generated for each combination of disaggregation factors, was sequentially split by the factor that best explained the magnitude of the response variable q (Hastie & Friedman 2001). Each successive tree was fitted to the ensemble set of bootstrapped q estimates and reweighted after each iteration so that the selection probability of each data point was inversely proportional to its fit to the most recent regression tree model. This iterative boosting approach therefore provides an intuitive and robust way to explore and determine which categorical variables best explained the differences seen between the two sets of harvest estimates.

The BRTs were fitted to the data using the *gbm* (Ridgeway 2013) and *dismo* (Hijmans et al. 2013) packages in *R* (R Development Core Team 2014). A Gaussian error structure was assumed for $\ln(q)$ and all covariates were presented to the BRT algorithm for selection. For each fit, the number of trees was optimised to minimise the mean predictive deviance estimated through 10-fold cross-validation (Elith et al. 2008). By adjusting the tree complexity and learning rate, the optimum number of trees was over 1000 for each run, which is considered sufficient for inference (Elith et al. 2008).

Raw catch per trip data provided by the two surveys were also compared. This comparison was restricted to catch per trip level data reported by boat-based fishers using rod and line methods only. Catches of snapper, kahawai, red gurnard, tarakihi, and trevally were calculated for each trip and redefined as zero catch fishing events and non-zero (number of fish harvested per trip) fishing events for each species. These data were used to calculate and tabulate the probability of a zero catch trip (P0) being reported by fishers during each survey, for each species, region, season, and day type factor combination. Plots comparing proportional catch per trip (bag size) distributions for the two surveys were also generated at the same combination of disaggregation levels. The purpose of these comparisons of zero catch probabilities and bag size distributions was to investigate whether the fishers who participated in the two surveys reported their catch in a different, and therefore potentially biased, manner. A similar exploration of raw catch data provided by the 2011–12 NPS and the aerial-access survey suggested that panellists were less likely to report zero catch trips and more likely to report larger bag sizes (or perhaps conversely less likely to report smaller bag sizes; Edwards & Hartill 2015).

Non-parametric bootstrap q ratio distributions were also generated from the raw catch per trip data. These q ratio distributions were calculated by initially bootstrapping the catch per trip data collected during each survey, for each combination of species, region, season, and day type factor, from which bootstrap P0 and catch per trip ratios could be calculated in a similar manner to that done for the harvest estimates. Consistent patterns in the distributions of P0 and catch per trip qs across one or more disaggregation factor would indicate differences in the reporting behaviour of fishers participating in the two surveys, and a potential source of bias experienced by one or both surveys.

BRT modelling of the combined ensemble of q values calculated from the positive catch per trip data (i.e., excluding zero catch trips) was also used to explore which of the disaggregation factors best explained the differences between the two survey data sets, in a similar manner to the BRT modelling of the harvest estimates.

3. RESULTS

3.1 Comparison of harvest estimates

The harvest estimates provided by the 2017–18 NPS and aerial-access survey for the recreational fishery in FMA 1 were mostly of a similar magnitude and reasonably precise (Table 1, Figure 2). The aerial-access harvest estimates were higher than the NPS estimates for snapper, kahawai, and trevally, but mostly lower for tarakihi and red gurnard. The degree of similarity between these two sets of harvest estimates is similar to that seen in 2011–12, when the NPS estimates were mostly higher than those provided by the aerial-access survey (see Hartill & Edwards 2015).

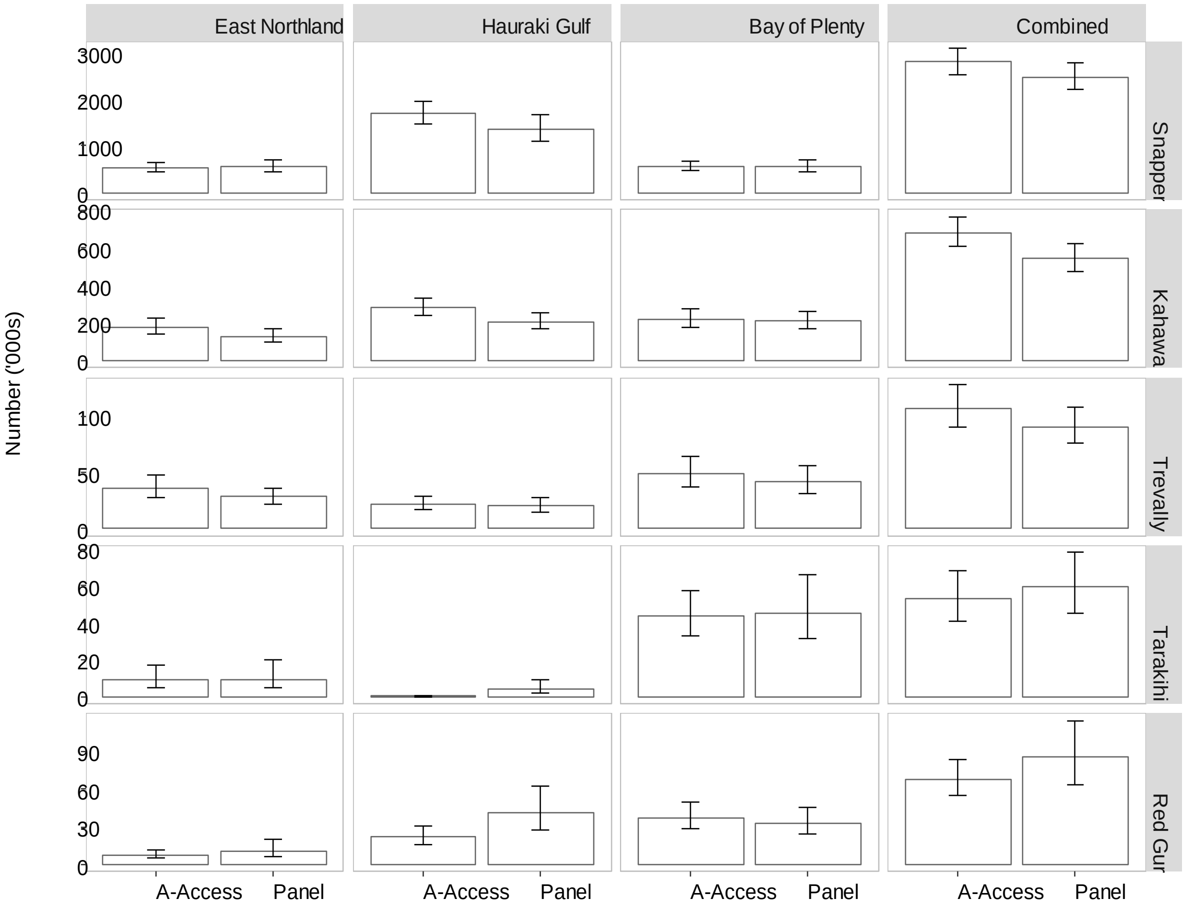

Figure 2: Comparison of aerial-access survey and National Panel Survey estimates of the number of fish harvested by recreational fishers in 2017–18 from each region of FMA 1 and for all three regions combined, for the five most commonly caught finfish species. Error bars denote standard errors.

Bootstrap comparisons of the harvest estimates (Figure 2) show a reasonable degree of statistical comparability between the two sets of harvest estimates, with most *q* ratio distributions indicating higher aerial-access harvest estimates (Figure 3). The most notable statistically significant difference between the two sets of harvest estimates (box plot tails not overlapping an equivalent *q* value of 1.0) is for the kahawai harvest estimates in the Hauraki Gulf. The discrepancy between the tarakihi and red gurnard survey estimates for the Hauraki Gulf may be due to random chance given the small number of fishing events during which these species were caught in this region (Appendix 1). It is also possible that these differences are due to mis-reporting or species misidentification, because some of the tarakihi catches reported by NPS panellists fishing in the Hauraki Gulf were for shore-based fishing events, which is unlikely for this species in this region of FMA 1.

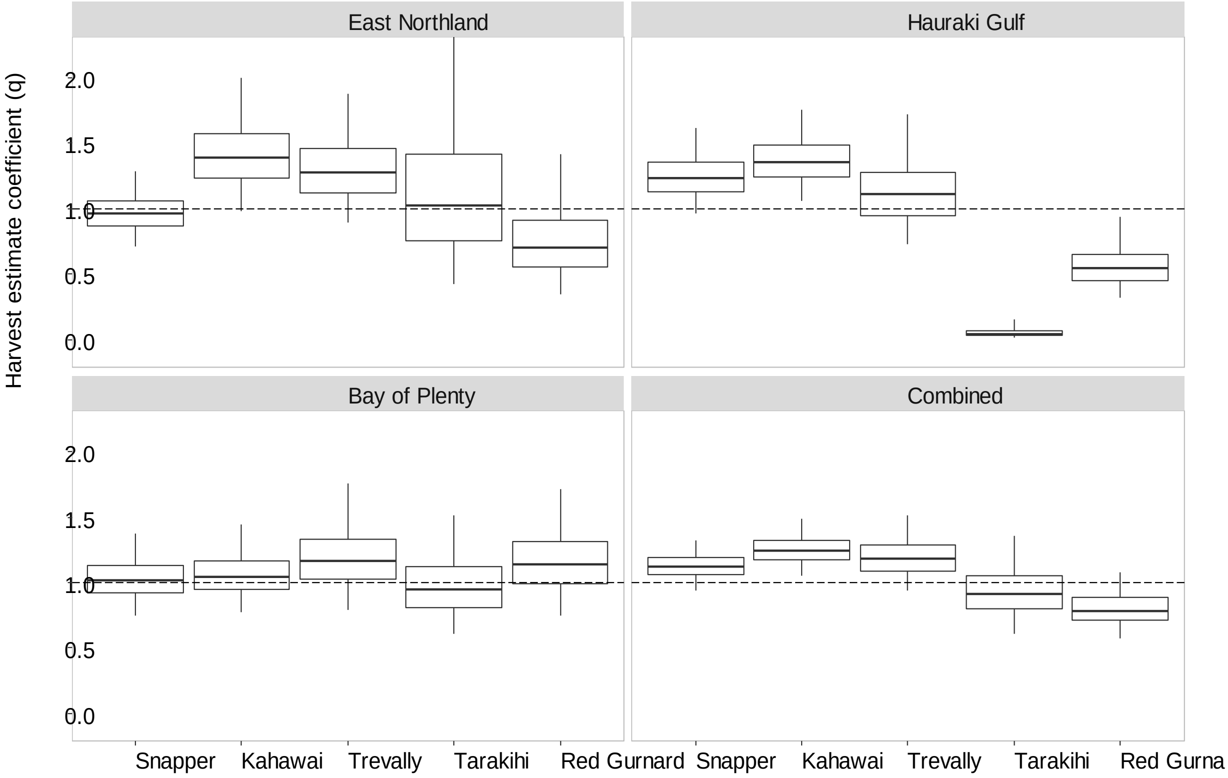

Figure 3: Distributions of *q* ratios calculated from bootstrapped aerial-access and NPS harvest estimates. Distributions with 95th percentile tails overlapping an equivalent *q* value of 1.0 indicate no significant difference between the harvest estimates provided by the two surveys for a given fishery.

The tendency for aerial-access harvest estimates to be higher than the NPS estimates is at least partially explained when the regional harvest estimates for each species are further disaggregated by season and day type (Figure 4). The bootstrap *q* distributions for the winter midweek and, to a lesser extent, the winter weekend harvest estimates are substantially greater than an equivalent *q* value of 1.0 for most species in each region, which suggests biased harvest estimation at these times.

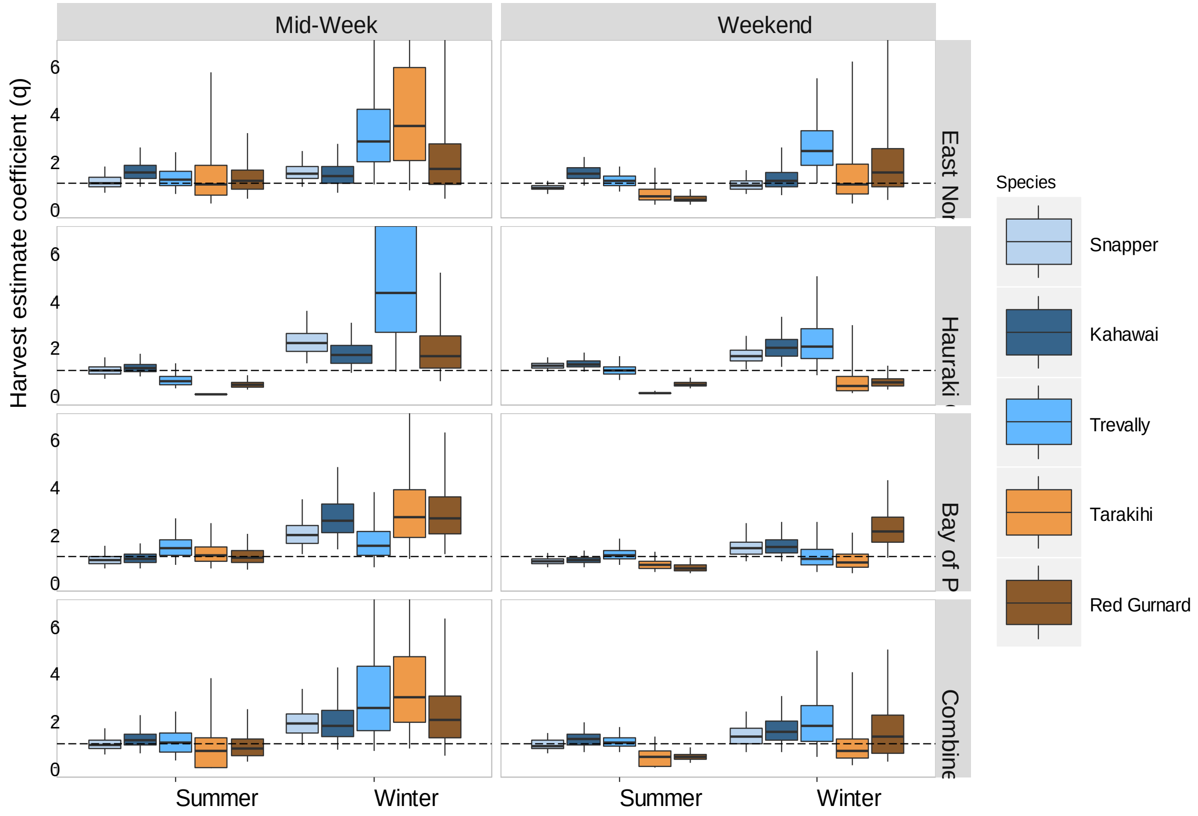

Figure 4: Distributions of *q* ratios calculated for temporally disaggregated bootstrapped aerial-access and NPS harvest estimates.

The disaggregation factors that BRT modelling identified as having the greatest power to explain differences between the two sets of survey harvest estimates were the *Season* covariate, followed by *Species* (Table 2). Similar evidence of non-representative temporal sampling by an aerial-access survey was found when estimates from concurrent surveys of these fisheries in 2011–12 were compared (Edwards & Hartill 2015). A comparison of image-based counts of the number of boats returning to a high traffic boat ramp in each region, on surveyed days vs. all days of the 2017–18 fishing year suggests that the random pre-selection of winter survey days was by chance biased towards busier than average fishing days (Figure 5), especially in East Northland.

Table 2: Influence metrics for explanatory covariates obtained from BRT fits to bootstrapped relative survey coefficients (*q*s) generated from harvest estimates and raw catch per trip data. Numbers represent the proportion of the explained variance attributed to each explanatory variable by each BRT.

Factor	Harvest estimates	Catch per trip data
Season	0.40	0.45
Species	0.27	0.29
Day type	0.24	0.18
Region	0.09	0.08

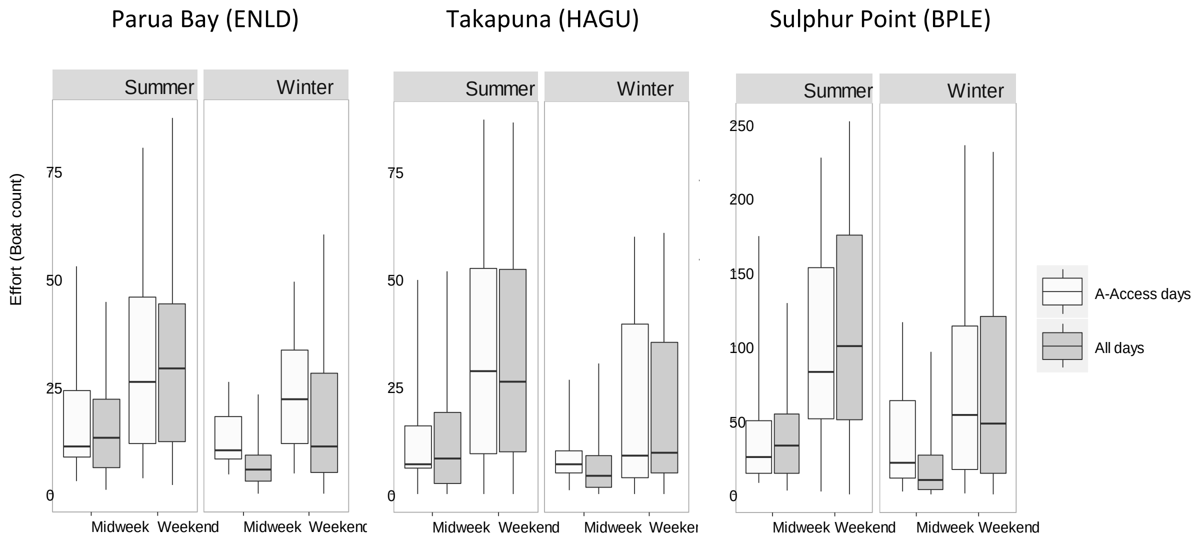

Figure 5: Distribution of daily digital camera-based counts of the number of boats returning to the club ramp at Parua Bay (East Northland), and the public ramps at Takapuna (the Hauraki Gulf), and Sulphur Point (Bay of Plenty), relative to the distribution of counts occurring on the subsample of days that were surveyed by the aerial-access survey, by temporal stratum. Bars denote the upper and lower quartile range of the daily traffic counts and whiskers denote the 95th percentiles of these traffic counts.

3.2 Comparison of raw catch per trip data

Differences in the catch per trip (bag) frequencies reported by fishers participating in the two surveys also partially explain why the aerial-access survey harvest estimates were mostly higher than the NPS estimates.

The incidence of single fish landings of snapper and kahawai (and, to a lesser extent, red gurnard and trevally) relative to the incidence of larger bag sizes was noticeably higher in the aerial-access creel survey than that reported by fishers participating in the National Panel Survey (Figure 6). The harvest per trip data collected during aerial-access survey interviews of fishers returning to boat ramp at the end of their trip should be more reliable because the landed catch was actually observed and not self-reported at a later date. It is also possible, however, that some of the fishing parties interviewed at boat ramps during the aerial-access survey may have shared the attribution of the catch amongst themselves more evenly when they were interviewed as a group. Similar sharing or misattribution could also occur during telephone interviews for the National Panel Survey.

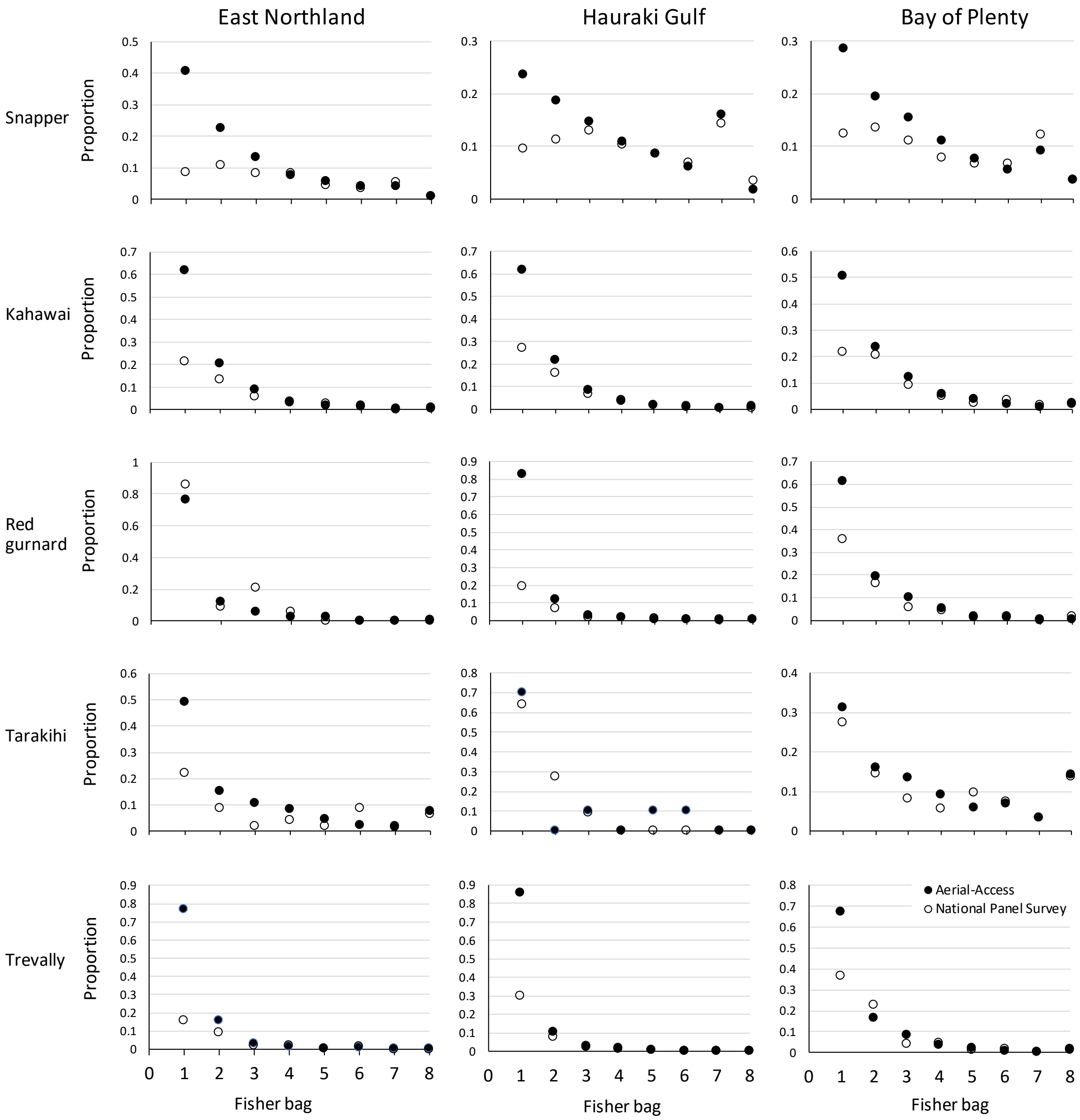

Figure 6: Comparisons of proportional bag per trip distributions reported by fishers participating in the aerial-access survey (solid circles) and National Panel Survey (open circles), by species by region.

The general tendency for NPS panellists to under-report the incidence of single fish landings is also evident when bootstrap *q* distributions are generated from the temporally disaggregated catch per trip data summarised in Appendix 1 (Figure 7). All the snapper *q* ratio distributions and the majority of those calculated for kahawai, trevally, and kahawai predominantly fall below an equivalent *q* value of 1.0, indicating lower average trip catch rates reported by the NPS panellists. This suggests that the apparent under-reporting of single fish harvest trips by NPS panellists seen in Figure 6 is due to the reporting behaviour of these fishers, and not those interviewed during the aerial-access survey. Any apparent over-reporting of single fish landings during the aerial-access survey that might be attributed to more successful fishers sharing the attribution of their catch with less successful co-fishers is negated when catch rates are averaged across trips.

The results of the BRT modelling of catch per trip data were very similar to the BRT modelling of harvest estimates, with the *Season* covariate once again having the greatest explanatory power, followed by *Species* (see Table 2). The significance of the seasonal term may reflect seasonal differences in catch rates, e.g., an increased incidence of single trip catches in winter that were less likely to be reported by NPS panellists.

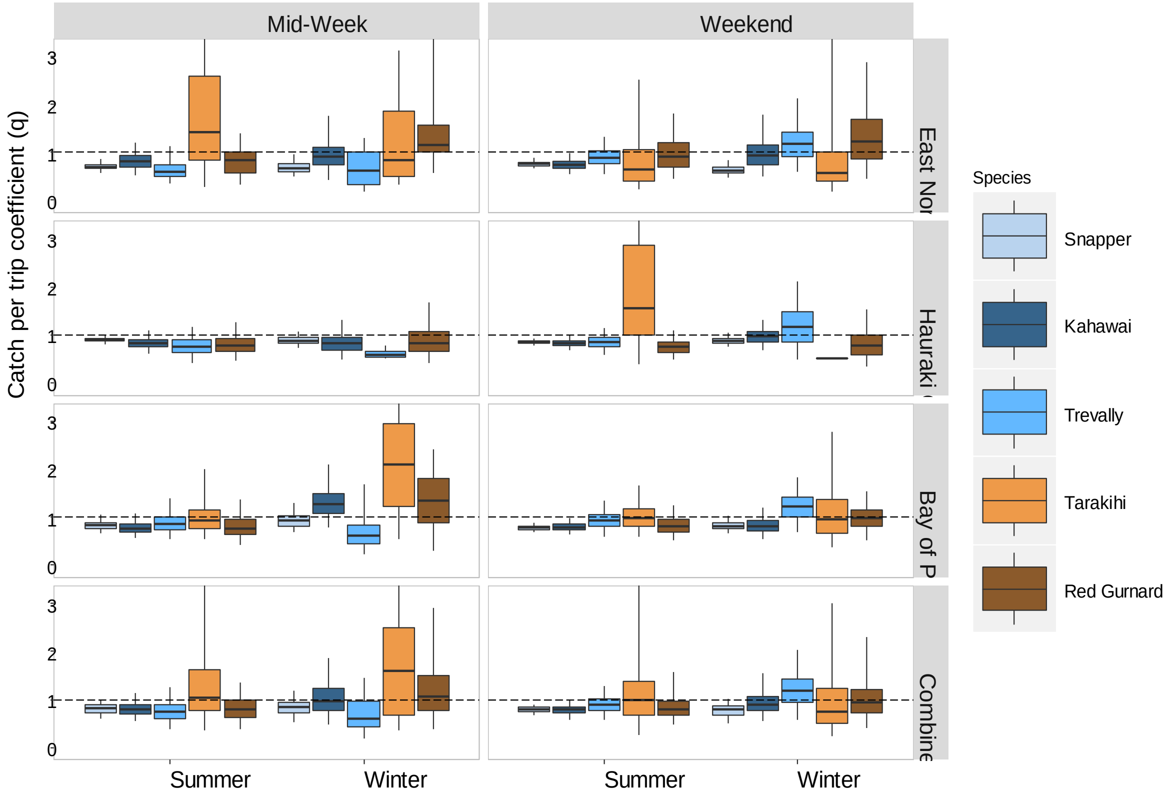

Figure 7: Distributions of *q* ratios calculated from bootstrapped harvest per trip data reported by fishers participating in the 2017–18 aerial-access survey and National Panel Survey, for the five most commonly caught finfish species, by region and temporal stratum.

The incidence of zero catch trips is also higher in the aerial-access catch per trip data set, indicating under-reporting of unsuccessful fishing trips by panellists (Table 3). The level of under-reporting of zero catch trips was even greater than that seen for single fish harvest trips (see Figure 6). The extent of this under-reporting bias by NPS panellists is clearly evident from the distributions of bootstrapped *q* ratios generated for snapper and kahawai (Figure 8). Any under-reporting of zero catch trips by NPS panellists will have no effect on the magnitude of harvest estimates provided by this survey method, because the annual harvest reported by each panellist remains unchanged when unsuccessful trips are ignored. There may, however, be implications for other uses of the same data (e.g., estimates of the number of trips may be negatively biased).

Table 3: Proportion of trips from which fish were not harvested (P0), by species, region, and temporal stratum. Boxed pairs of P0 statistics indicate where a higher proportion of the trips reported by NPS panellists reported zero catch trips for a given species.

			Snapper		Kahawai		Red gurnard		Tarakihi		Trevally	
Region	Season	Day type	A-A	NPS	A-A	NPS	A-A	NPS	A-A	NPS	A-A	NPS
ENLD	Summer	Weekend	0.47	0.19	0.80	0.77	0.99	0.96	0.99	0.99	0.94	0.92
		Mid week	0.49	0.15	0.83	0.72	0.98	0.97	0.98	0.97	0.94	0.90
	Winter	Weekend	0.55	0.14	0.83	0.76	0.97	0.95	0.98	0.95	0.93	0.94
		Mid week	0.48	0.13	0.87	0.84	0.96	0.91	0.91	0.95	0.95	0.94
HAGU	Summer	Weekend	0.27	0.12	0.77	0.74	0.97	0.94	0.999	0.994	0.97	0.95
		Mid week	0.21	0.08	0.80	0.77	0.96	0.94	1.000	0.995	0.98	0.96
	Winter	Weekend	0.26	0.11	0.74	0.70	0.94	0.88	0.999	0.996	0.97	0.96
		Mid week	0.23	0.04	0.75	0.69	0.925	0.926	0.999	1.000	0.96	0.99
BPLE	Summer	Weekend	0.57	0.23	0.77	0.54	0.95	0.88	0.96	0.91	0.91	0.88
		Mid week	0.54	0.25	0.77	0.54	0.94	0.86	0.93	0.91	0.93	0.84
	Winter	Weekend	0.44	0.20	0.76	0.60	0.87	0.84	0.91	0.88	0.93	0.93
		Mid week	0.45	0.18	0.76	0.60	0.87	0.88	0.88	0.93	0.94	0.85
FMA 1	Summer	Weekend	0.42	0.17	0.78	0.69	0.97	0.93	0.98	0.97	0.94	0.93
		Mid week	0.39	0.14	0.79	0.70	0.96	0.93	0.97	0.97	0.95	0.92
	Winter	Weekend	0.39	0.14	0.76	0.68	0.92	0.89	0.96	0.95	0.947	0.948
		Mid week	0.37	0.10	0.78	0.70	0.91	0.91	0.93	0.97	0.95	0.95
Overall			0.41	0.15	0.78	0.69	0.95	0.92	0.97	0.97	0.94	0.93

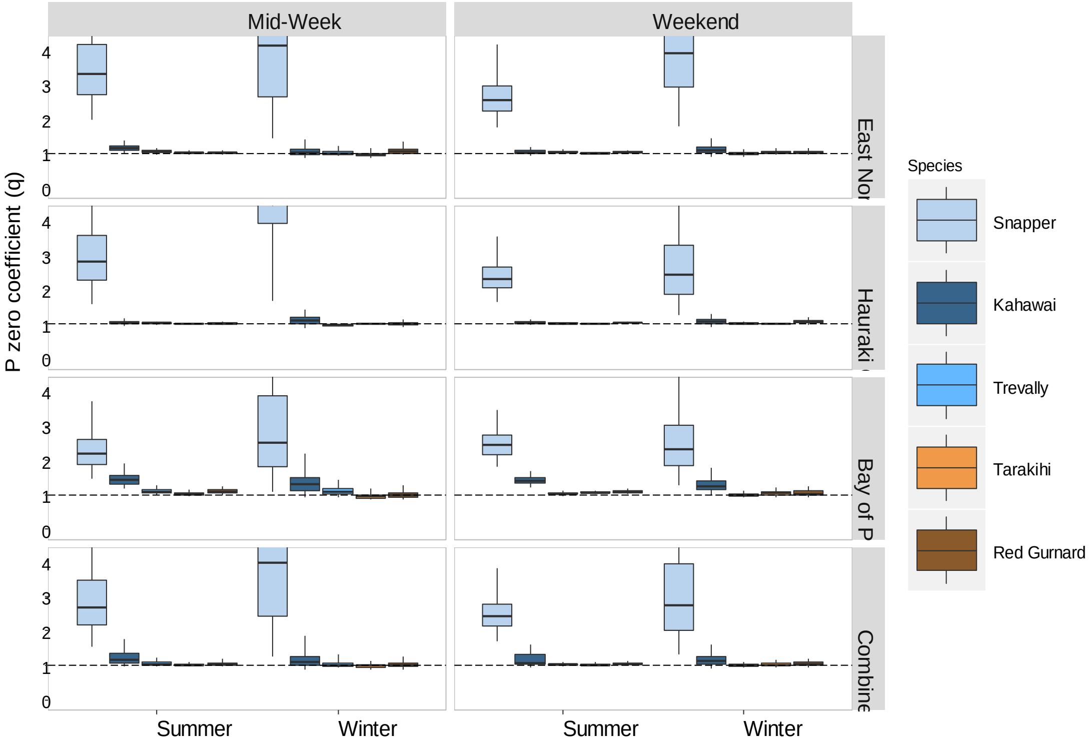

Figure 8: Distributions of *q* ratios of the proportion of zero catch trips calculated from bootstrapped harvest per trip data reported by fishers participating in the 2017–18 aerial-access survey and National Panel Survey, for the five most commonly caught finfish species, by region and temporal stratum. Species are given across the x-axis in the order listed in the legend.

4. DISCUSSION

The overall findings from this comparison of harvest estimates provided by the National Panel Survey and aerial-access survey conducted in 2017–18 are broadly similar to those concluded from a similar comparison of estimates provided by these methods in 2011–12 (Edwards & Hartill 2015). The harvest estimates provided by these two fundamentally different survey methods are of a similar magnitude, which suggests they are sufficiently accurate and suitable for fisheries management purposes. The analyses presented here have identified some sources of bias, although their impact on the reliability of the harvest estimates is considered relatively minor.

The aerial-access harvest estimates were mostly higher than the NPS estimates in 2017–18 and lower in 2011–12. There is good evidence to suggest these discrepancies were due to random chance selection of non-representative survey days in one or more of the temporal strata surveyed by each of the aerial-access surveys. Web camera boat ramp traffic data suggest that quieter than average days were surveyed during the winter of 2011–12 (Edwards & Hartill 2015), and it has been shown here that busier than average days were surveyed during the winter midweek stratum and, to a lesser extent, the winter weekend/public holiday stratum in 2017–18. The number of days surveyed during both the winter strata was increased from seven days in 2011–12 to eight in 2017–18 to increase the likelihood of a representative sample being pre-selected by random chance, but this modest increase in sampling effort has not been sufficient.

Any further increase in the number of winter days surveyed in the future is probably not warranted, however, given the overall similarity of the two sets of harvest estimates obtained in both years. Aerial-access survey days could be reallocated from the two summer strata, but the majority of the recreational harvest of most finfish species is taken at this time of year. The current allocation of survey effort is based on optimisation simulations of daily boat count data collected during aerial-access surveys of the Hauraki Gulf fishery in 1993–94 and 2003–04. The temporal stratification of survey effort for any future aerial-access survey should be reviewed, regardless, based on harvest per day estimates derived from recent aerial-access surveys, rather than aerial counts of boats fishing on summer days only, in the more distant past.

Camera based traffic data should still be collected throughout the year, to assess the adequacy of the temporal survey design that any future aerial-access survey may be based on. These camera systems provide a cost-effective observational way of detecting temporal sampling frame bias in onsite surveys (such as an aerial-access or census creel surveys).

The detection of bias in an offsite survey (such as an NPS) is more problematic, given the dwelling/population sample frame used. There is no independent list of marine fishers available that can be used to assess whether the selection of panellists is representative, in terms of selection from the fishing population or willingness to claim to be a fisher. Although the sophisticated multi-stage sampling methods used by NRB to identify and recruit panellists have been specifically designed to reduce or avoid the likelihood of known biases occurring (such as self-selection bias), the responses given by interviewees can only be taken at face value. Some of the respondents to the initial screening survey may have pretended to be non-fishers to avoid further questions, but there is no independent way to assess whether this may have happened. This issue was addressed by the follow-up survey conducted by NRB at the end of the survey year, when the fishing activity of a sample of putative non-fishers was queried, but there is still no way of independently corroborating the responses given and, consequently, whether any underestimation of the recreational fishing population (and catch) has occurred.

Independent data are, however, available to assess the reliability of the catch per trip data provided by those who agreed to become NPS panellists. The creel survey bag size frequency data used for these comparisons should be reasonably accurate given the large number of landings that were directly observed by boat ramp interviewers on the day the fish were caught. These comparisons of panellist and creel survey bag frequency distributions provide compelling evidence that panellists often failed to report trips when they caught either no fish or, to a lesser extent, only a single fish. The relative incidence of zero-catch trips was far lower in the panel data. The most likely explanations for this under-reporting behaviour are that the panellists were either embarrassed about their poor catch, or they thought there was little point in reporting such a small catch, especially given the need to go through a lengthy phone interview to do so. Most panellists now rely on smartphones as their primary source of contact and use caller id information to screen incoming calls. It is therefore now easier for a panellist to avoid a trip reporting interview with NRB if they are unwilling to report an unsuccessful trip.

Whereas the under-reporting of zero catch trips does not lead to biased NPS harvest estimates (because the total annual harvest reported by a panellist remains unchanged), any under-reporting of single fish catch trips will result in negatively biased harvest estimates. Any NPS underestimation of the recreational harvest taken from a fishery that would occur as a consequence of this behaviour will be more pronounced when the number of fish landed from a trip tends to be low, as seen for all three regions of TRE 1, when landings of three or more fish are relatively uncommon. The degree of bias caused by under-reporting of single fish landings for more commonly caught species, such as snapper and kahawai, will be relatively low, however, given the far larger number of multiple bag landings, which were presumably reported with higher fidelity.

In summary, the analyses presented here suggest that the aerial-access harvest estimates were probably positively biased to a small degree because the random pre-selection of survey days was ultimately biased by chance towards busier fishing days during the quieter winter temporal strata. Conversely, recreational harvest estimates provided by the NPS may be underestimates, because there is good evidence to suggest that panellists often failed to report trips when they caught only a single fish of a given species. The relative impact of these detected sources of bias is thought to be relatively low, given the high degree of similarity that is still evident between the two sets of harvest estimates. Either survey method can be used to estimate recreational harvests with an acceptable degree of accuracy and precision. This study supports their ongoing use in conjunction with other survey methods to quantify and monitor trends in marine recreational harvesting from New Zealand’s marine fish stocks.

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APPENDIX 1: Number of trips and fish caught by fishers participating in the aerial-access (A-A) and National Panel Survey (NPS) by region and temporal stratum. The number of trips during which each species was landed is given in brackets.

			Trips		Snapper		Kahawai		Red gurnard		Tarakihi		Trevally	
Region	Season	Day type	A-A	NPS	A-A	NPS	A-A	NPS	A-A	NPS	A-A	NPS	A-A	NPS
ENLD	Summer	Weekend	3 749	478	5 080 (1 974)	1 321 (388)	1 326 (743)	253 (108)	85 (56)	31 (18)	142 (50)	32 (7)	303 (209)	64 (40)
		Mid week	1 078	315	1 405 (547)	1 010 (268)	323 (187)	195 (89)	27 (24)	16 (10)	88 (20)	21 (9)	90 (66)	72 (31)
	Winter	Weekend	792	125	817 (360)	389 (107)	266 (138)	61 (30)	34 (20)	9 (6)	38 (15)	26 (6)	77 (53)	9 (7)
		Mid week	501	79	634 (261)	252 (69)	116 (65)	27 (13)	29 (18)	8 (7)	98 (45)	11 (4)	29 (27)	12 (5)
HAGU	Summer	Weekend	7 266	1 084	17 971 (5 315)	3 953 (957)	2 885 (1 653)	583 (280)	223 (189)	106 (64)	18 (7)	10 (7)	295 (252)	71 (50)
		Mid week	1 815	654	5 577 (1 438)	2 697 (604)	641 (372)	318 (151)	87 (71)	61 (38)	–	4 (3)	45 (42)	42 (28)
	Winter	Weekend	1 531	280	4 191 (1 137)	1 053 (249)	751 (403)	155 (84)	129 (88)	66 (33)	2 (2)	2 (1)	73 (47)	16 (11)
		Mid week	844	175	2 588 (653)	786 (168)	381 (214)	124 (55)	96 (63)	25 (13)	1 (1)	–	39 (33)	2 (1)
BPLE	Summer	Weekend	6 034	614	8 046 (2 612)	1 867 (470)	2 943 (1 410)	726 (280)	556 (310)	162 (75)	951 (245)	191 (56)	979 (554)	134 (73)
		Mid week	1 629	298	2 479 (756)	905 (223)	752 (377)	366 (138)	162 (104)	87 (42)	445 (111)	140 (28)	260 (122)	87 (47)
	Winter	Weekend	1 443	169	2 915 (808)	595 (136)	797 (350)	185 (67)	296 (183)	48 (27)	514 (126)	103 (21)	148 (101)	15 (12)
		Mid week	951	82	2 016 (526)	269 (67)	547 (227)	61 (33)	260 (122)	20 (10)	464 (110)	27 (6)	100 (61)	35 (12)
FMA 1	Summer	Weekend	17 049	2 176	31 097 (9 901)	7 141 (1 815)	7 154 (3 806)	1 562 (668)	864 (555)	299 (157)	1 111 (302)	233 (70)	1 577 (1 015)	269 (163)
		Mid week	4 522	1 267	9 461 (2 741)	4 612 (1 095)	1 716 (936)	879 (378)	276 (199)	164 (90)	533 (131)	165 (40)	395 (230)	201 (106)
	Winter	Weekend	3 766	574	7 923 (2 305)	2 037 (492)	1 814 (891)	401 (181)	459 (291)	123 (66)	554 (143)	131 (28)	298 (201)	40 (30)
		Mid week	2 296	336	5 238 (1 440)	1 307 (304)	1 044 (506)	212 (101)	385 (203)	53 (30)	563 (156)	38 (10)	168 (121)	49 (18)
Total			27 633	4 353	53 719 (16 387)	15 097 (3 706)	11 728 (6 139)	3 055 (1 328)	1 984 (1 248)	639 (343)	2761 (732)	567 (148)	2 438 (1 567)	559 (317)