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Tini a Tangaroa

Intercalibration of research vessels, *Kaharoa* and *Kaharoa II*, for inshore bottom trawl surveys

New Zealand Fisheries Assessment Report 2026/12

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PLAIN LANGUAGE SUMMARY

The new Earth Sciences New Zealand research vessel *Kaharoa II* arrived in New Zealand in August 2024. *Kaharoa II* (36 m) is larger and more capable than the 28 m *Kaharoa*, which was launched in 1981 and was used for previous New Zealand inshore trawl surveys.

The change in research vessel from *Kaharoa* to *Kaharoa II* provided an opportunity to standardise survey gear and protocols across all inshore surveys. To allow continuation of existing inshore survey time-series for key fish species, an intercalibration experiment was carried out on the west coast South Island in March–April 2025.

The intercalibration was designed as a paired-tow comparison, where the two vessels towed on parallel tracks in the same direction, so that both vessels experienced the same tidal and wave conditions, with a minimum separation distance. Fifty-nine paired tows were conducted.

Biomass catchability ratios from the intercalibration were derived and these will be used to adjust future *Kaharoa II* survey catch results in the short term.

EXECUTIVE SUMMARY

Devine, J.; MacGibbon, D.; Underwood, M.; Jones, E.; O’Driscoll, R.; Beentjes, M.; Hamill, J. (2026). Intercalibration of research vessels, *Kaharoa* and *Kaharoa II*, for inshore bottom trawl surveys.

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This report presents results from a bottom trawl intercalibration experiment between *Kaharoa* and *Kaharoa II*. The experiment was carried out during the west coast South Island (WCSI) survey in Mar-Apr 2025 and estimates species-specific catchability ratios between the two vessels.

The new Earth Sciences New Zealand research vessel *Kaharoa II* arrived in New Zealand in August 2024. *Kaharoa II* (36 m) is larger and more capable than the 28 m *Kaharoa*, which was launched in 1981 and was used for previous inshore trawl surveys. The change in research vessel from *Kaharoa* to *Kaharoa II* provided an opportunity to standardise survey gear and protocols across all inshore surveys. As part of the transition from the *Kaharoa* to *Kaharoa II*, and to allow continuation of existing inshore survey time-series, an intercalibration experiment was carried out to account for differences in vessel, gear (a new net was designed), and trawling procedures (e.g., shorter tow distance, using speed through water of 3.4 knots).

The intercalibration was designed as a paired-tow comparison, where the two vessels towed on parallel tracks in the same direction, so that both vessels experienced the same tidal and wave conditions. Minimum separation distance between the vessels averaged 1.5 km. The intercalibration was completed successfully; 59 of the 63 survey stations were completed by both vessels, with an additional 5 stations completed by *Kaharoa II* to supplement length and catch rate information.

For the target species of the WCSI, only a few species had biomass ratios close to one (i.e., snapper, spiny dogfish). *Kaharoa II* appeared to have higher catchability for John dory, but reduced catchability for all other target species, including giant stargazer, red cod, tarakihi, school shark, and rig. Some target species of the ECSI survey (elephantfish and sea perch *Helicolenus percooides*), were caught relatively infrequently (i.e., at only a few paired stations). For dark ghost shark, another ECSI target species, the number of paired stations where both vessels caught fish was higher and the length frequency distribution was relatively similar, so the estimated biomass ratio from the WCSI, despite being low, might be able to be applied to the ECSI. Variation of catches within a stratum for most species was higher than expected.

Differences in catchability between the two vessels may be due to the reduced tow time (i.e., larger fish like school shark not tiring and dropping into the net), the faster tow speed on *Kaharoa II*, or because the new trawl gear was designed to fish lighter on the bottom. For example, the large difference in catchability between the vessels for red gurnard in Tasman and Golden Bays compared to the west coast may have been a combination of net design, faster speed over ground, and tidal flow. For several target species, the length frequency distributions were similar, indicating little difference in selectivity based on size composition. *Kaharoa II* tended to have greater catchability for faster swimming species (e.g., jack mackerel, trevally), most likely due to the faster tow speed.

Biomass catchability ratios from the intercalibration will be used to convert the time series in the short term, with the intention that, for species with age-based assessments, the stock assessment model should be able to estimate catchability coefficients for each survey series once several surveys with the new vessel and gear have been conducted. These species include snapper, red gurnard and tarakihi.

1. INTRODUCTION

Fishery independent data, such as trawl surveys, are usually the most reliable source of information for assessing fish stock trends and for providing basic biological information on multiple species. Changes may occur in the vessels and gear used for trawl surveys over time, particular for long time series, and these changes may lead to changes in species catchability or size selectivity (Miller 2013). Changes in catch efficiency and size selection between survey vessels need to be determined and allowed for before data from two, or more, vessel survey series can be combined into a single series (Cadigan & Dowden 2010). Intercalibration studies are typically used to derive calibrated vessel correction coefficients for the main survey species by comparing catches from the various vessel-gear combinations (Cadigan & Dowden 2010; Kotwicki et al. 2017; Pelletier 1998). International best practice for intercalibration studies includes the use of paired-tow comparisons, where vessels tow near to each other in space and time, as this reduces spatiotemporal variability of the catch (Bagley et al. 2015; Pelletier 1998).

The new Earth Sciences New Zealand research vessel *Kaharoa II* arrived in New Zealand in August 2024. *Kaharoa II* (36 m) is a larger, more powerful, and more capable vessel than the 28 m *Kaharoa*, which was launched in 1981 and was used for New Zealand inshore trawl surveys prior to the arrival of *Kaharoa II*. The change in research vessel from *Kaharoa* to *Kaharoa II* provided an opportunity to standardise survey gear and protocols across all inshore surveys. A new two-panel wing trawl was built by Motueka Nets to replace the two trawl nets previously used, one for the North Island survey and one for the South Island surveys. The design process included input from inshore fishers and Earth Sciences NZ vessel skippers, net makers, and scientists, and aimed to design a trawl that was suitable for the range of target species and bottom conditions encountered by all inshore bottom trawl surveys, be aligned with modern net designs currently used by the commercial industry, and be made of modern materials that could be more easily sourced. The resulting net has similar overall dimensions to the net used for previous South Island inshore survey trawl but is made of modern materials and uses more efficient trawl doors.

Additional changes in trawling procedures were agreed by the Inshore Working Group (14 October 2024) and included standardising tow speed to 3.4 knots, relative to water (not ground), and tow distance to 1.5 nautical miles. Standardising the towing speed to speed through water (STW) rather than speed over ground (SOG) reduces the variation in the speed the net moves through water under different tidal conditions and should reduce any variation in catch efficiency due to e.g., the speed and endurance of fish as they are herded in front of the net under different tidal flow conditions. In addition, on 5 March 2025, Fisheries New Zealand agreed to an increase in sweep length from 55 m to 110 m to optimise the sweep angle of the new trawl, a recommendation from Earth Sciences NZ investigations conducted prior to the intercalibration study (Jones et al. 2026).

Earth Sciences NZ's initial proposal was to conduct separate intercalibration trials for each of the five ongoing Fisheries New Zealand inshore demersal fish trawl surveys (WCNI, WCSI, ECSI, Hauraki Gulf, and Bay of Plenty). To support the design of the intercalibration trials, a simulation exercise was first conducted that investigated 12 different scenarios, including different catchabilities, varying uncertainty, and subsets of species and areas (Appendix 1). The simulations showed that if stochastic uncertainty around catchability was 20% or higher, all survey stations were likely to be needed for the intercalibration to estimate catchability ratios for the target species of each survey, and that more stations would be necessary if within-strata variability was high and for most other species. There did not appear to be significant benefits in restricting intercalibration experiments to only key strata in each survey for the target species due to differences in species distributions. The simulation did not investigate scenarios where correction coefficients from one survey were applied to another (as that was not a consideration at the time) nor did it look at size selectivity despite this being a recommendation of the study.

Due to funding constraints, it was only possible for one intercalibration experiment, to be carried out; this being for the WCSI survey in Mar–Apr 2025. Species specific catchability ratios were estimated as part of this project with the intention that these catchability ratios would also be applied to ECSI surveys conducted by *Kaharoa II* after the *Kaharoa* was sold in mid-2025. There was no intercalibration undertaken for the WCNI (including the South Taranaki Bight, STB) as this survey has shifted to a new timing and as such, represents the start of a new series (Jones et al. 2026). The Hauraki Gulf and Bay of Plenty inshore bottom trawl surveys have since been discontinued; hence it was deemed there was no need to calibrate *Kaharoa II* for these surveys.

This research was carried out under Fisheries New Zealand research project INT2024-01: Inshore trawl surveys (WCNI, WCSI, ECSI) and fulfils specific project objective 9: to carry out a trawl intercalibration between *Kaharoa* and *Kaharoa II* during the WCSI survey and estimate species-specific catchability ratios from the intercalibration.

2. METHODS

2.1 Intercalibration design

A paired-tow comparison intercalibration design was used, which required the two vessels to tow parallel tracks in the same direction, so that both vessels experienced the same tidal and wave conditions (Bagley et al. 2015; Pelletier 1998). The *Kaharoa* was the lead vessel and determined the station placement and timing as the WCSI survey was being conducted by this vessel, using the standard gear and trawling protocols (e.g., random stratified trawl survey, tow speed over ground of 3.0 knots, (see MacGibbon et al. 2026). The station position was considered the midpoint of the tow for both vessels. *Kaharoa II* would alternate which side of *Kaharoa* it towed (i.e., port or starboard), depending on e.g., seabed conditions, strata boundary.

Minimum separation distance between the vessels was 1.5 km, which was based on gear trial tows conducted on the WCNI survey indicating that snapper catch rates were influenced by gear and vessel noise at lesser distances (Jones et al. 2026). Where this separation distance was not possible because space was very limited, such as inner Golden Bay in 10–20 m or in areas where the bathymetry changes were large, separation distance was the maximum distance possible.

Paired tows were to be as close in time as possible. Because the distance towed by the *Kaharoa* was twice the distance of the new vessel, the protocol was that *Kaharoa* would start towing first. However, it was recognised that, due to the speed-through-water requirement of 3.4 knots, *Kaharoa II* might overtake *Kaharoa* on some stations depending on tidal conditions.

Procedures for foul shots included

1. If *Kaharoa* had a foul shot and *Kaharoa II* gear was not in the water, *Kaharoa II* would not shoot their gear and follow the lead of *Kaharoa* (i.e., head to alternate station, retake station).
2. If *Kaharoa* had a foul shot and *Kaharoa II* gear was in the water, *Kaharoa II* would complete the station and call it an extra tow.
3. If *Kaharoa* completed the station but *Kaharoa II* had a foul shot, both vessels would move to the next station and *Kaharoa II* would complete the station along a new tow path as soon as feasible.

In addition, if there was extra time at the end of the day (e.g., distance was too far to the next station to be completed during daytime hours), *Kaharoa II* would use that time to do additional gear investigations or to take extra tows for additional data.

2.2 Vessels, gear, and trawling procedures

Kaharoa is a 28 m stern trawler with a beam of 8.2 m, displacement of 302 t, engine power of 522 kW, and can trawl to depths of 500 m. The two-panel trawl net used during the survey was designed and constructed in 1991 specifically for South Island inshore trawl surveys and was fitted with a 60 mm knotless codend (Beentjes & Stevenson 2008). Trawling procedures are detailed in MacGibbon et al. (2026); procedures important for the intercalibration design and analysis included towing speed (measured as SOG) of 3.0 knots, tow duration of one hour (approximately 3 n. miles), minimum acceptable tow length of 1.5 n. miles, sweep length of 55 m, and warp length of 200 m for all tows less than 70 m depth and with a warp to depth ratio applied for deeper depths (Table 1). A net monitor and doorspread sensors provided information on headline height and doorspread, and a conductivity temperature depth sensor (CTD) was mounted on the headline.

Kaharoa II is a 36 m stern trawler with a beam of 9.5 m, gross tonnage 499 t, and engine power of 956 kW. The two-panel wing trawl has a headline length of 25.6 m and a fishing line length of 32.4 m, with mesh sizes of 150 mm in the wings and body of the trawl and 120 mm in the taper. The codend mesh was 60 mm, with a twine thickness of 6 mm and chaffing gear on the bottom panel. The net was fished with 110 m long sweeps, 55 m long bridles and 4.41 m² (883 kg) Thyboron trawl doors. Further details including net plan are described in Underwood et al. (2026). Trawling procedures for the intercalibration included towing speed (measured as STW) of 3.4 knots and tow length of 1.5 n. miles (minimum acceptable distance of 0.8 n. miles), where towing began when the net reached the bottom, as indicated by the net monitors, and ended when hauling began (Table 1). Warp length was the same as that for the *Kaharoa*. Marport sensors (net monitor and doorspread) provided information on headline height and doorspread, while a ZebraTech bottom contact sensor was mounted in the centre of the groundrope. Additional sensors (RBR Solo3 depth sensors) were mounted on the headline and footrope to provide additional information on bottom contact and confirm proper spread of the gear while fishing. A Dolphin Dissuader Device (DDD) and CTD were also mounted on the headline of the net. When feasible, cameras were attached at key points on the headline or groundrope to collect footage to confirm that the spread of the gear was as expected.

Table 1: Key gear and trawling procedures for the *Kaharoa* and *Kaharoa II* during the intercalibration experiment on the west coast South Island survey.

| <i>Kaharoa</i> | <i>Kaharoa II</i> |
|---|--|
| Net: 2-panel design constructed in 1991 specifically for South Island surveys | Net: 2-panel wing trawl with 25.6 m headline length and 32.4 m fishing line |
| “V” trawl doors (3.4 m ² , 540 kg) fitted with Marport sensors | Thyboron Type 11 trawl doors (4.41 m ² , 883 kg) fitted with Marport sensors |
| Bottom contact sensor on centre of groundrope | Bottom contact sensor on centre of groundrope |
| – | Wingspread monitored with Marport sensors |
| Headline height of approximately 4.5–5 m | Headline height of approximately 4–5 m |
| Microcat CTD data logger attached to the headline | Microcat CTD data logger attached to the headline |
| Marport net monitor attached to the headline | Marport net monitor attached to the headline |
| Sweep length 55 m | Sweep length of 110 m |
| Doorspread 69–90 m | Doorspread 95–120 m |
| Tow speed: speed over ground of 3.0 knots | Tow speed: speed through water of 3.4 knots, measured from the vessel acoustic doppler speed log |
| Tow duration: 1 hour (minimum acceptable distance of 1.5 n. miles) | Tow length: 1.5 n. miles (minimum acceptable distance of 0.8 n. miles) |
| – | Additional sensors (RBR solo3 depth sensors) mounted along groundrope and headline |
| Standardised optimal warp:depth ratio for different depths | Standardised optimal warp:depth ratio for different depths |
| Gear parameters closely monitored | Gear parameters closely monitored |

Kaharoa

Daylight hours only

Kaharoa II

Daylight hours only

2.3 Catch and biological sampling

The catch from each tow was sorted into species and weighed on electronic motion-compensating Marel scales to the nearest 0.1 kg. Organisms were identified to species where possible. A randomly selected sub-sample of up to 200 fish of all species were measured and sexed on both vessels, while additional biological information and otoliths were collected from target and key QMS species on the *Kaharoa* (MacGibbon et al. 2026).

2.4 Intercalibration analyses

The goal of the intercalibration was to estimate the ratio of catch rates or relative catch efficiency of the new vessel compared to the old vessel. This was done by: (1) deriving biomass ratios for all species captured at a relatively high frequency during the intercalibration by both vessels; (2) the application of length-based paired-tow comparison methods to the survey target species length-frequency observations. Length-based methods were trialled because selectivity (or catchability), in addition to being affected by fish behaviour and aspects of the gear, is determined by the size of the fish (Miller 2013), while paired tow comparison allow for gear-specific information to be combined to better inform trends in abundance (Bagley et al. 2015; Pelletier 1998). A length-based ratio provides a specific conversion factor for each size class, which more accurately corrects for the difference in catchability.

The WCSI survey target species are red cod (*Pseudophycis bachus*), red gurnard (*Chelidonichthys kumu*), snapper (*Chrysophrys auratus*), stargazer (*Kathetostoma giganteum*), tarakihi (*Nemadactylus macropterus*), John dory (*Zeus faber*), spiny dogfish (*Squalus acanthias*), rig (*Mustelus lenticulatus*), and school shark (*Galeorhinus galeus*). Because catchability ratios as estimated from the WCSI survey will be applied to the ECSI survey, length-based methods were also investigated for the additional ECSI target species, sea perch (*Helicolenus percoides*), elephantfish (*Callorhinchus milii*), and dark ghost shark (*Hydrolagus novaezelandiae*).

Biomass ratios

Biomass ratios were estimated as the biomass from *Kaharoa II* to *Kaharoa*, i.e., new vessel to old vessel. Biomass was estimated by the swept area method of Francis (1981; 1989) using R-SurvCalc, an updated version of the C++ trawl survey analysis program SurvCalc (Francis 2009) implemented in the R-programming language. Biomass was estimated using all stations that had a gear performance code of satisfactory or better for both vessels (i.e., no indication that catch was affected by gear performance), and included the extra stations conducted by *Kaharoa II*. References to 'biomass' are to relative abundance estimates unless otherwise stated.

The following assumptions were made for calculating biomass estimates:

1. The area swept during each tow equalled the distance between the doors multiplied by the distance towed.
2. Vulnerability was 1.0. This assumes that all fish in the area swept were caught and there was no escapement.
3. Vertical availability was 1.0. This assumes that all fish in the water column were below the headline height and available to the net.
4. Areal availability was 1.0. This assumes that the fishstock being sampled was entirely within the survey area at the time of the survey.
5. Within the survey area, fish were evenly distributed over both trawlable and non-trawlable ground.

None of these assumptions are likely to be correct but were adopted for all the trawl survey time series of relative biomass (Stevenson & Hanchet 1999).

Confidence intervals for the biomass ratios were calculated using the delta method to account for the uncertainty in both vessel estimates and their correlation (Oehlert 1992; Powell 2007). For each species i , the variance of the ratio (R), estimated as biomass *Kaharoa II* (B_{K2}) divided by biomass *Kaharoa* (B_{K1}) was approximated as:

$$\text{Var}(R_i) = (1/B_{K1_i}^2) \times [\text{Var}(B_{K2_i}) + R_i^2 \times \text{Var}(B_{K1_i}) - 2R_i \times \text{Cov}(B_{K2_i}, B_{K1_i})],$$

where $\text{Var}(B_{K2_i})$ and $\text{Var}(B_{K1_i})$ were estimated from the survey CVs, and the covariance term

$$\text{Cov}(B_{K2_i}, B_{K1_i}) = \rho \times \text{SD}(B_{K1_i}) \times \text{SD}(B_{K2_i}),$$

and ρ was estimated as the Pearson correlation between the stratum-level biomass estimates of each vessel. Because this was a paired tow design, the biomass estimates were positively correlated (median $\rho = 0.72$), which had the effect of reducing uncertainty in the ratio compared to assuming independent samples. The 95% confidence intervals of the ratio were constructed assuming a log-normal distribution, e.g., $R \times \exp(\pm 1.96 \times \text{CV}(R))$.

Length-based investigations

Length frequency data

Scaled length frequency and cumulative proportion by length data was used to determine differences in vessel length selectivity. Scaled length frequency distributions were estimated by the area-swept method (Francis 1981; 1989) using an updated version of Earth Sciences NZ's catch-at-length-and-age software, CALA (Francis & Bian 2011). Cumulative proportion by length was used to determine differences in selectivity based on size composition of each vessels catch.

Length-based modelling

Catch in numbers by length (unscaled) for paired tows were initially used to investigate length-based differences in catchability and whether differences might be due to changes in towing speed or key gear parameters. Catch in numbers (unscaled) was initially chosen to avoid confounding in the model where a term was both part of the response variable and a potential covariate (e.g., distance towed, doorspread). Additional covariates included speed over ground (as speed through water was not available for both vessels), headline height, distance towed, and depth. Because all models were investigating the difference in catch at size between the new vessel relative to the old vessel, covariates were included as log ratios (LR) of new to old vessel, estimated as

$$LR_i = \log \left(\frac{\text{covariate } K2_i}{\text{covariate } K1_i} \right),$$

where $K2$ is *Kaharoa II*, $K1$ is *Kaharoa*, for covariate i . LR_i was then scaled by the standard deviation of LR_i , which allows the covariates to be comparable in terms of variation (not in units); a value of zero indicates that the parameter was equal for both vessels, positive values indicate that the parameter was larger/greater for the *Kaharoa II*, and negative values, for *Kaharoa*.

Generalised additive mixed models (GAMMs) were used so that trends were not constrained to be linear and random effects (stratum and paired station) could be included; the variation specific to each stratum and paired station could thus be taken into consideration but not be included as part of the general population-level trend (Miller 2013; Trenkel & Skaug 2005; Wood 2017). This distinction was needed when applying the length-based conversions to a different survey (e.g., ECSI). Several distributions, binomial (or if overdispersed, quasibinomial), negative binomial, and beta, were trialled

because a review of intercalibration length-based modelling methodology indicated that constraints of the data for a particular species could be better fit with alternate distributions (i.e., one size does not fit all) (Kotwicki et al. 2017; Thygesen et al. 2019; Yin & Benoît 2022; Zhou et al. 2014).

For all distributions, initial fits of the models were restricted to include only length and the random terms, paired station and stratum, because if there was no length effect, there was no need to continue with the analysis. Covariates were inspected for co-linearity and, where they existed, co-linear terms were not included in the same model. Several covariates were known to change with depth (e.g., headline height, doorspread, swept area, length), therefore a depth-interaction term was initially included. Smoothing terms were heavily penalised to avoid overfitting, including the use of a gamma term to encourage smoother, more conservative fits; using a penalised version of either a thin plate or cubic regression spline, depending on the covariate; and a parameterisation that encourage variable selection, i.e., which shrank the smoothing term to 0 if there was no effect. All GAMMs were conducted using the *mgcv* package (Wood 2010; Wood 2017) in R version 5.4.1 (R Core Team 2025).

Binomial distribution

If tests indicated that data were overdispersed, the quasibinomial distribution was used. The probability (P) that a fish was caught by *Kaharoa II* given that it was caught by either vessel was modelled as:

$$\text{logit}(P) = \log\left(\frac{P}{1-P}\right) = \beta_0 + f(\text{length}) + \text{random effects} + \text{covariate} .$$

The model formulation did not change if the quasibinomial distribution was used, but the variance includes a dispersion parameter, which when greater than 1, indicates that data are overdispersed (this is then incorporated in the confidence interval estimation). Data were weighted so that stations with more information (i.e., greater catch) were given greater weight as $N/\text{mean}(N)$, where N was the total number caught by both vessels at that paired station (for all lengths).

Negative binomial distribution

The expected number of fish (μ) caught was modelled as:

$$\log(\mu) = \beta_0 + f(\text{length}) + \text{random effects} + \text{covariates} .$$

The variance was estimated as $\text{Var}(\text{count}) = \mu + \mu^2/\theta$, where θ is an overdispersion parameter. An offset was used to model the rate, e.g., $\log(\text{total catch at that length and station})$ and weights, as described for the binomial distribution were used so that stations with more information were given greater weight.

Beta distribution

Data were transformed into proportions (proportion of fish caught by *Kaharoa II* for that length and station). The beta distribution cannot handle proportions that are exactly 0 or 1, so data were transformed using the approach of Smithson & Verkuilen (2006), i.e., $y^* = (y(n-1) + 0.5)/n$, where n is the sample size. The expected proportion (μ) was modelled as:

$$\text{logit}(\mu) = \beta_0 + f(\text{length}) + \text{random effects} + \text{covariates} .$$

The variance was estimated as $\text{Var}(p) = \mu(1-\mu)/(\varphi+1)$, where φ is a precision parameter (e.g., larger φ indicates less variance). Data were weighted so that stations with more information (i.e., greater catch) were given greater weight as $\text{weights} = n \times N$, where n is the total count for that length class at that station (the denominator of the proportion) and N is the number caught by both vessels at that paired station (for all lengths).

3. RESULTS

Summaries of the west coast South Island surveys (*Kaharoa* trip KAH2502, *Kaharoa II* trip KHR2504) were reported in MacGibbon et al. (2026) and Underwood et al. (2026), and only information relevant for the intercalibration are repeated here. Throughout the results, Tasman and Golden Bays (TBGB) are often presented separately from the remainder of the west coast, which is called west coast South Island (WCSI). When referring to the entire survey, ‘WCSI survey’ will be used.

3.1 Intercalibration implementation

A total of 63 stations were conducted by *Kaharoa* that were considered acceptable for biomass estimation (MacGibbon et al. 2026), while *Kaharoa II* conducted 64 stations, of which 5 were extra stations allocated to collect additional information for the intercalibration (Underwood et al. 2026). *Kaharoa II* did not complete all stations of the WCSI survey: two stations were foul shots and there was no time to retake the stations; one station crossed over the stratum boundary into stratum 14 (and was allocated to that stratum as an extra tow); and one tow was within stratum but over the depth limit for that stratum (not considered a viable station) (Table 2).

Table 2: West coast South Island survey strata, including the number of stations completed by the *Kaharoa*, number of paired stations with the *Kaharoa II*, and number of extra stations completed by *Kaharoa II* within each stratum. * denotes where the number of paired stations by the *Kaharoa II* were different from the number of planned stations within that stratum.

| Stratum | Depth (m) | Area (km ²) | No. of phase-1 stations, <i>Kaharoa</i> | No. paired stations, <i>Kaharoa II</i> | No. extra stations, <i>Kaharoa II</i> |
|-------------------|-----------|-------------------------|---|--|---------------------------------------|
| 1 | 20–100 | 1 343 | 3 | 3 | – |
| 2 | 100–200 | 4 302 | 5 | 5 | – |
| 5 | 25–100 | 1 224 | 3 | 3 | – |
| 6 | 100–200 | 3 233 | 3 | 3 | 1 |
| 7 | 25–100 | 927 | 3 | 3 | – |
| 8 | 100–200 | 2 354 | 4 | 3* | 1 |
| 9 | 200–400 | 1 877 | 3 | 3 | – |
| 11 | 25–100 | 1 438 | 5 | 5 | – |
| 12 | 100–200 | 2 054 | 5 | 5 | – |
| 13 | 200–400 | 1 101 | 3 | 2* | – |
| 14 | 25–100 | 851 | 3 | 3 | 1 |
| 15 | 100–200 | 881 | 3 | 2* | – |
| 16 | 200–400 | 319 | 3 | 2* | – |
| 17 | 20–33 | 307 | 3 | 3 | – |
| 18 | 20–42 | 947 | 3 | 3 | – |
| 19 | 20–70 | 2 436 | 5 | 5 | – |
| 20 | 10–20 | 217 | 3 | 3 | 2 |
| 21 | 10–20 | 165 | 3 | 3 | – |
| Total – core area | | | 57 | 53 | 3 |
| Total | | | 63 | 59 | 5 |

Kaharoa was the lead vessel for all but two stations. *Kaharoa II* typically began towing when *Kaharoa* was halfway (or more) through their tow because of the time it took to add the additional sensors to the trawl gear. *Kaharoa* finished their tow before *Kaharoa II* had gear in the water on six stations, often due to delays caused by the attachment or tangling of the additional sensors and cameras. One paired tow was completed a few hours later due to *Kaharoa II* coming fast, and one station was conducted on a separate day because it was not possible for *Kaharoa II* to retake the tow immediately.

Distance between vessels on paired tows conducted at the same time ranged between 0.4–3.5 km (average 1.5 km; Appendices 2 and 3). The smallest separation distance was at one station in Golden Bay, which had restricted areas for tow paths because of mussel farms, while greater separation distances tended to be because of poor or foul seabed conditions. Average separation distance in Tasman and Golden Bays (TBGB) (strata 17–21), where it mattered most because these strata had high snapper densities, was 1.3 km. The paired tow that was conducted on a separate day (four days later) was near but not directly overlapping the same tow path as *Kaharoa* (stratum 13, Appendix 3). Measurements of headline height and doorspread, together with observations that the doors and other bottom-contacting components of the trawl gear were polishing well (i.e., from contact with the seabed), indicated that the gear was operating correctly on both vessels (see MacGibbon et al. 2026; Underwood et al. 2026). The additional sensors and cameras mounted on the groundrope and headline of the *Kaharoa II* trawl gear also indicated that the gear was performing as it should (Figures 1, 2).

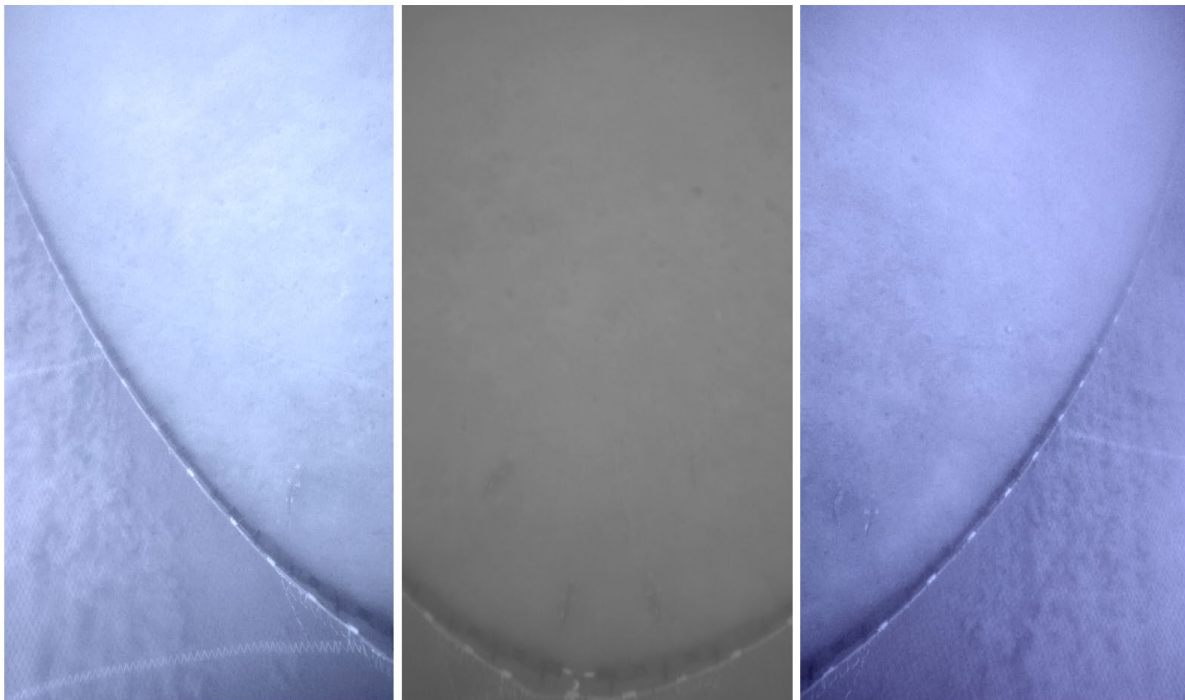


Figure 1: View from cameras mounted on *Kaharoa II* trawl looking at the port wing (left), central ground gear (middle), starboard wing (right) showing contact with the seabed and sand clouds produced from the seabed contact.

Comparison of key gear parameters

Doorspread, headline height, and speed over ground were measured for both vessels, while wingspread and speed through water were measured only on the *Kaharoa II*. Headline height, doorspread, and wingspread changed with depth, as expected (Figure 3). *Kaharoa II* had a greater headline height than *Kaharoa* (average 4.6 m and 4.3 m, respectively), but the maximum change with depth was broadly similar for both vessels (1.0 m and 0.8 m, respectively) (Figure 3, Appendix 4). The maximum change in wingspread was 10 m for the *Kaharoa II*, while the maximum change in doorspread was 70 m for *Kaharoa II* but only 35 m for *Kaharoa*. Doorspread ranges did not overlap for the two vessels (Appendix 4). Variability with stratum (i.e., depth) for headline height and doorspread was generally greater for *Kaharoa II*.

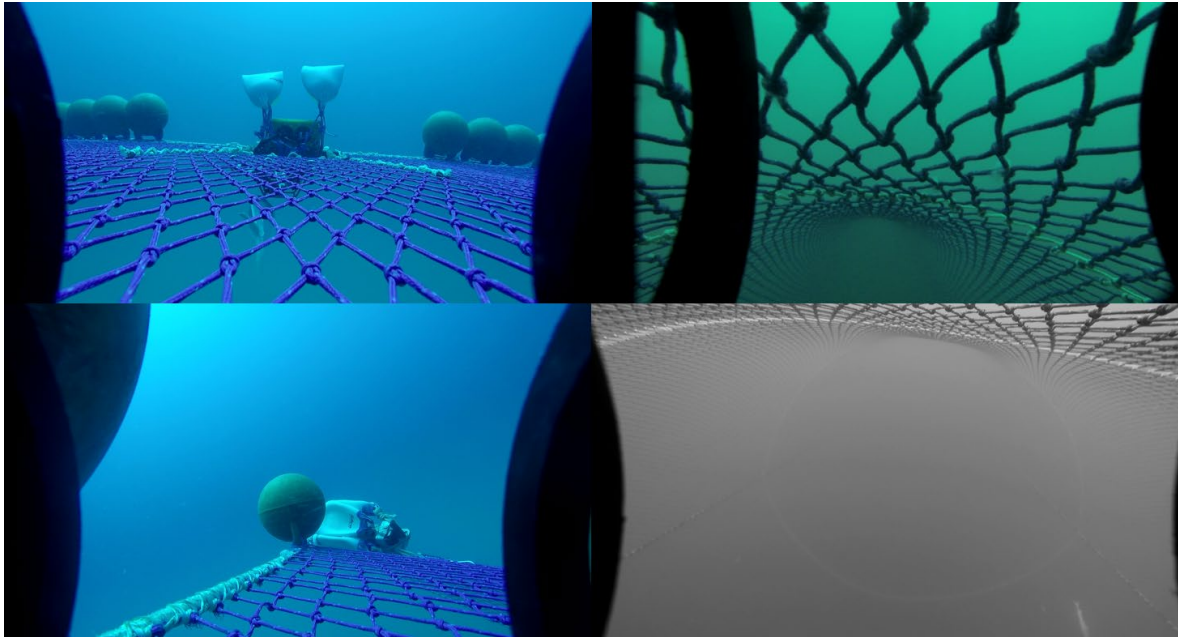


Figure 2: View from cameras mounted on *Kaharoa II* trawl looking towards the headline with a view of the speed explorer and floats of the headline (top left), downward towards the codend (top right), along headline at the CTD (bottom left), and aft from the headline (bottom right).

Kaharoa II towed at an average speed through water (STW) of 3.46 knots. Targeting a speed through water of 3.4 knots using the vessel acoustic doppler on *Kaharoa II* was difficult, as evidenced by the high variability among strata (and thus depth) (Figure 4, Appendix 4). Variability within strata was partially due to highly variable weather conditions but was mainly because *Kaharoa II* followed the lead of *Kaharoa*, which opted to tow into the tide whenever possible. Speed, measured as speed over ground (SOG), was assessed to look for key differences between vessels (Figure 4, Appendix 4). Standardising the towing speed to STW rather than SOG will reduce the effect of speed (at the net) varying due to e.g., tow direction in relation to tidal flow or prevailing currents. STW will remain relatively constant but the effect on SOG will be to decrease when fishing into water flow and increase when fishing in the same direction as water flow. This effect was apparent in strata 2, 6, and 8, when STW was generally between 3.4–3.6 knots, but SOG ranged between 3.0–3.4 knots, whereas in shallower strata (Tasman Bay Golden Bay (TBGB) strata and west coast (WCSI) strata 1, 5, 7, 11, and 14), STW was similar but the decrease in SOG was much less (Figure 4). A comparison of SOG to STW for *Kaharoa II* also indicated that variability was less in TBGB (Figure 4).

Distance towed was typically 3 n. mile for *Kaharoa* and 1.5 n. mile for *Kaharoa II* (Figure 5). Shorter distances were typically due to the trawl beginning to destabilise (e.g., entering foul ground, hauled early). Doorspread swept area (estimated as doorspread multiplied by distance) were greater for the *Kaharoa* (Figure 5), mainly as a result of the longer tow distance used, despite *Kaharoa II* having a greater doorspread (Figure 3, Appendix 4). Doorspread swept-area differences lessened in deeper water (strata 9, 13, and 16) as *Kaharoa II* doorspread increased. *Kaharoa II* wingspread swept area differences were nearly a factor of ten less than doorspread swept area estimates and generally increased with depth once deeper than 200 m (Figure 5), which was a result of wingspread increasing with depth (Figure 3).

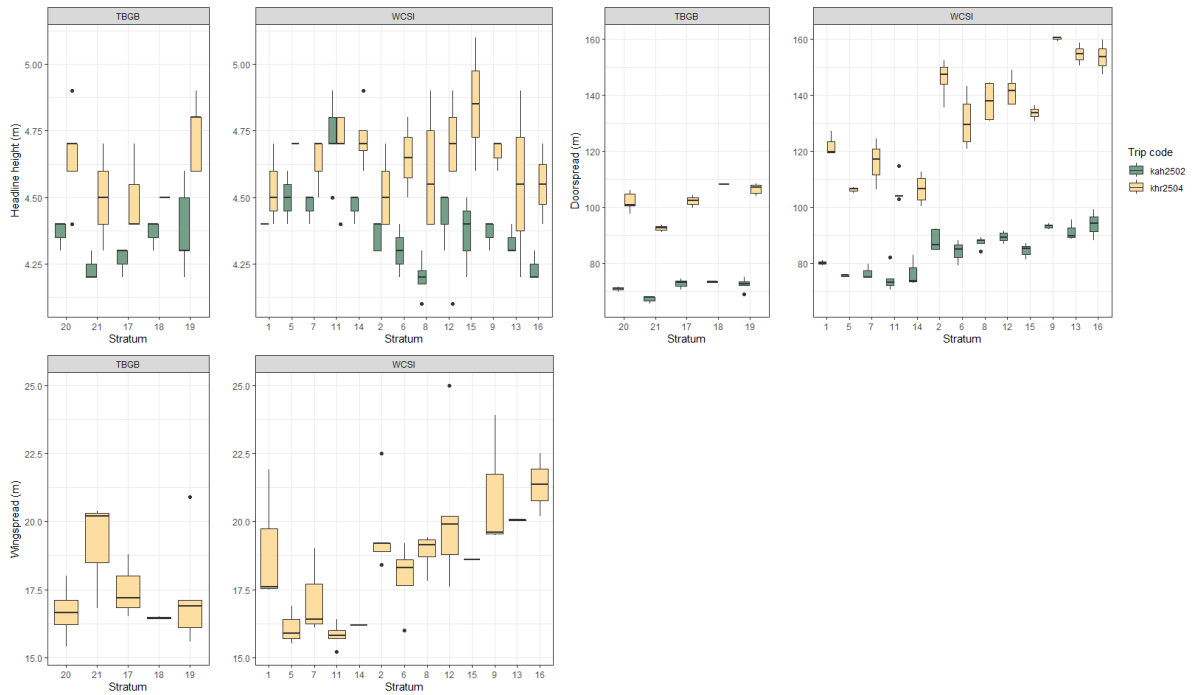


Figure 3: Interquartile range in headline height (top left), doorspread (top right), and wingspread (bottom left) by stratum for *Kaharoa* (KAH2502, green) and *Kaharoa II* (KHR2504, yellow). Dark line within coloured bar indicates the median, bars are data within the 25th and 75th percentile (IQR), whiskers are $1.5 \times$ IQR, and outliers are indicated by points. Strata have been ordered from shallowest to deepest, and Tasman and Golden Bays (TBGB) strata are shown separately from the west coast strata (WCSI).

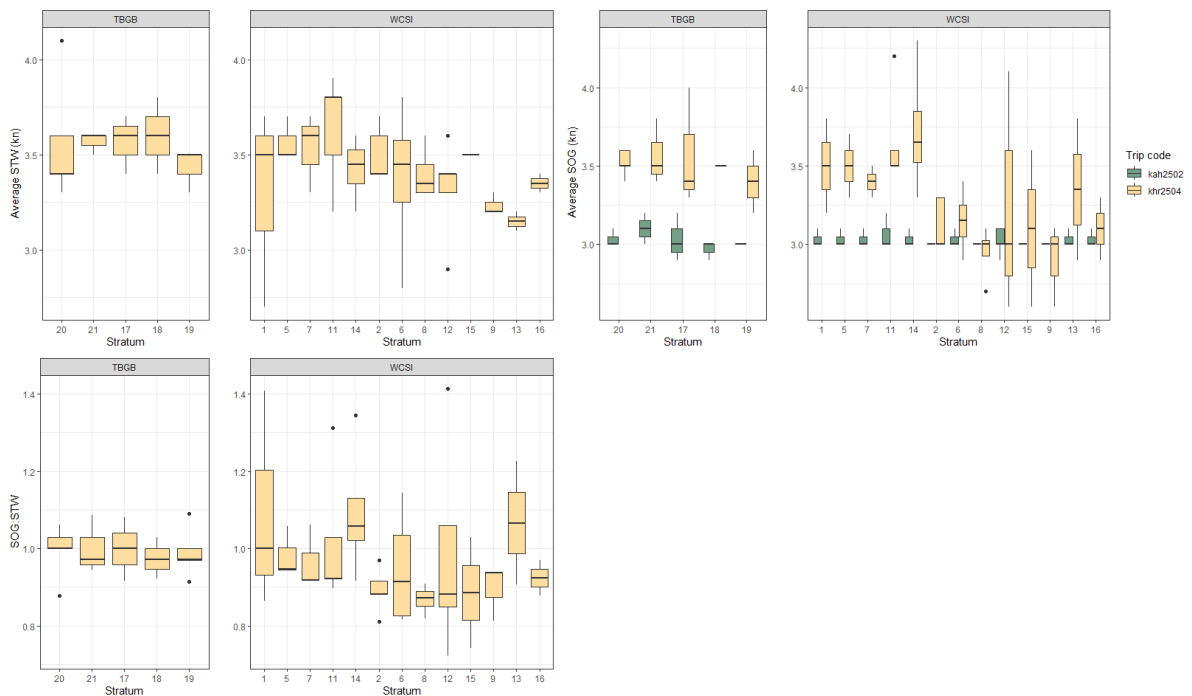


Figure 4: Interquartile range (see Figure 3) in speed over ground (SOG; top left), speed through water (STW; top right), and the ratio of SOG to STW (bottom left) by stratum for *Kaharoa* (KAH2502, green) and *Kaharoa II* (KHR2504, yellow). A ratio of SOG:STW less than 1 indicates that STW was greater than SOG. Strata have been ordered from shallowest to deepest, and Tasman and Golden Bays strata (TBGB) are shown separately from the west coast strata (WCSI).

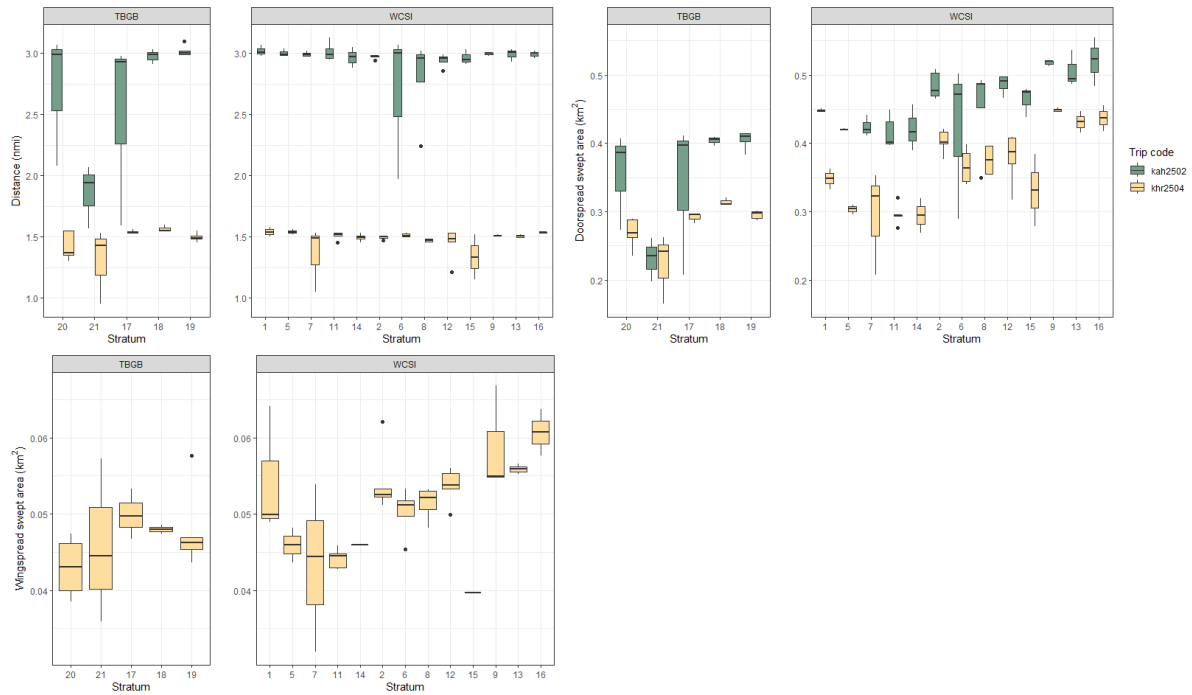


Figure 5: Interquartile range (see Figure 3) in distance towed (top left), estimated doorspread swept area (top right), and estimated wingspread swept area (bottom left) by stratum for *Kaharua* (KAH2502, green) and *Kaharua II* (KHR2504, yellow). Strata have been ordered from shallowest to deepest, and Tasman and Golden Bays (TBGB) strata are shown separately from the west coast (WCSI) strata.

3.2 Catch comparison

MacGibbon et al. (2026) and Underwood et al. (2026) detail the spatial distribution in catch rates, biomass and coefficient of variation (CVs) (total and by stratum), and length frequency distributions, including by sex and life stage, for the WCSI target species. These summaries are not repeated unless needed to show information for paired station comparisons.

Biomass ratios

Estimated biomass ratios (*Kaharua II* to *Kaharua*) for the target species of the WCSI and ECSI surveys varied between 0.23–1.11 and were close to one for snapper, spiny dogfish, and elephantfish (Table 3). Some ECSI survey target species (*Helicolenus percoides*, elephantfish, and dark ghost shark), were not well represented in the intercalibration (Table 3). Sea perch was differentiated into bigeye sea perch (*H. barathri*) and sea perch (*H. percoides*), noting that *H. percoides* is a target species of the ECSI survey. For completeness, biomass ratios for all species that had been caught by both vessels at (minimum) one station, excluding non-QMS invertebrates, are in Appendix 5.

Because of large differences in red gurnard catch between TBGB and WCSI strata, the Inshore Working Group (29 Oct 2025) requested that information for red gurnard be presented separately for the two areas. Estimated catchability ratios were still less than one for both areas (*Kaharua II* to *Kaharua*), but to convert *Kaharua* biomass to the equivalent *Kaharua II* biomass, the reduction would be greater in TBGB strata than for WCSI strata (Table 3).

Table 3: Estimated biomass, CV, catch ratio (including 95% confidence limits), and number of stations (no. stns) by vessel for target species of the WCSI and ECSI surveys, using all valid stations from the WCSI intercalibration between *Kaharoa* (K) and *Kaharoa II* (K2). Sea perch corresponds to *Helicolenus percooides*.

| Species | <i>Kaharoa</i> (K) | | <i>Kaharoa II</i> (K2) | | K2 to K | | | K to K2 | | | No. Stns | |
|------------------|--------------------|----|------------------------|----|---------|-------|-------|---------|-------|-------|----------|----|
| | Biomass | CV | Biomass | CV | Lower | Ratio | Upper | Lower | Ratio | Upper | K | K2 |
| Snapper | 4 453 | 13 | 4 736 | 15 | 0.97 | 1.06 | 1.16 | 0.86 | 0.94 | 1.03 | 41 | 44 |
| Red gurnard | 1 896 | 13 | 1 081 | 21 | 0.45 | 0.57 | 0.73 | 1.38 | 1.75 | 2.23 | 45 | 40 |
| Red gurnard–TBGB | 645 | 14 | 156 | 30 | 0.18 | 0.24 | 0.33 | 3.01 | 4.13 | 5.67 | 17 | 18 |
| Red gurnard–WCSI | 1 251 | 18 | 926 | 24 | 0.62 | 0.74 | 0.89 | 1.13 | 1.35 | 1.62 | 28 | 22 |
| Giant stargazer | 724 | 23 | 286 | 24 | 0.30 | 0.40 | 0.53 | 1.91 | 2.53 | 3.35 | 26 | 22 |
| Tarakihi | 660 | 13 | 441 | 16 | 0.58 | 0.67 | 0.77 | 1.30 | 1.50 | 1.73 | 39 | 35 |
| John dory | 219 | 20 | 244 | 20 | 0.98 | 1.11 | 1.26 | 0.79 | 0.90 | 1.02 | 31 | 33 |
| Red cod | 879 | 31 | 401 | 57 | 0.26 | 0.46 | 0.81 | 1.23 | 2.19 | 3.89 | 30 | 26 |
| Spiny dogfish | 2 662 | 34 | 2 554 | 44 | 0.70 | 0.96 | 1.31 | 0.76 | 1.04 | 1.42 | 42 | 40 |
| School shark | 467 | 30 | 206 | 30 | 0.29 | 0.44 | 0.68 | 1.48 | 2.27 | 3.49 | 36 | 26 |
| Rig | 515 | 21 | 264 | 23 | 0.41 | 0.51 | 0.64 | 1.56 | 1.95 | 2.45 | 40 | 32 |
| Elephant fish | 87 | 55 | 90 | 61 | 0.46 | 1.04 | 2.33 | 0.43 | 0.96 | 2.16 | 7 | 4 |
| Ghost shark | 587 | 37 | 209 | 38 | 0.28 | 0.36 | 0.46 | 2.20 | 2.81 | 3.58 | 24 | 18 |
| Bigeye sea perch | 42 | 31 | 46 | 24 | 0.93 | 1.10 | 1.31 | 0.77 | 0.91 | 1.08 | 12 | 13 |
| Sea perch | 28 | 37 | 7 | 55 | 0.08 | 0.23 | 0.69 | 1.44 | 4.30 | 12.82 | 16 | 11 |

Key species – catch and length frequencies

Data are presented for paired stations, unless otherwise stated, and use all data available from all strata.

Table 4: Summary of paired stations: number of fish measured, caught (unscaled), and scaled to the biomass for both vessels, where catch of at least one vessel was greater than zero. Number of paired tows is differentiated between where catch was greater than zero for at least one vessel vs for both vessels. K indicates *Kaharoa* and K2 is *Kaharoa II*. Species codes in Appendix 5.

| Species | No. measured | | No. caught | | No. fish (scaled) | | No. paired tows | |
|----------|--------------|-------|------------|-------|-------------------|-----------|-----------------|-----------|
| | K | K2 | K | K2 | K | K2 | 1 vessel | 2 vessels |
| SNA | 3 176 | 3 190 | 5 641 | 5 235 | 2 553 156 | 2 574 819 | 42 | 38 |
| GUR | 3 831 | 2 548 | 7 074 | 2 817 | 6 342 701 | 3 497 641 | 43 | 35 |
| GUR–TBGB | 1 849 | 383 | 2 476 | 383 | 2 243 312 | 395 560 | 17 | 16 |
| GUR–WCSI | 1 982 | 2 165 | 4 598 | 2 434 | 10 441 796 | 6 610 126 | 26 | 19 |
| GIZ | 240 | 89 | 240 | 89 | 248 607 | 116 960 | 23 | 20 |
| JDO | 182 | 139 | 182 | 139 | 180 979 | 192 647 | 35 | 27 |
| NMP | 829 | 486 | 829 | 486 | 805 848 | 570 075 | 39 | 29 |
| RCO | 1 289 | 689 | 2 383 | 1 186 | 1 715 797 | 1 197 487 | 27 | 24 |
| SPD | 1 801 | 1 601 | 3 255 | 2 052 | 3 534 380 | 3 590 802 | 40 | 36 |
| SCH | 213 | 116 | 213 | 116 | 253 576 | 218 517 | 39 | 21 |
| SPO | 452 | 162 | 452 | 162 | 298 088 | 150 687 | 39 | 28 |
| ELE | 33 | 23 | 33 | 23 | 27 832 | 24 608 | 7 | 4 |
| GSH | 374 | 103 | 374 | 103 | 583 901 | 224 570 | 24 | 12 |
| HBA | 637 | 828 | 1 089 | 1 100 | 966 784 | 1 192 696 | 15 | 8 |
| HPC | 180 | 45 | 180 | 46 | 267 983 | 74 872 | 17 | 7 |
| SPE | 817 | 873 | 1 269 | 1 146 | 1 185 750 | 1 219 683 | 23 | 17 |

Snapper

Of the 59 paired stations, snapper were caught by at least one vessel at 42 stations and by both vessels at 38 stations (Table 4). The four stations where one vessel did not catch snapper were on the WCSI and consisted of 10 fish or less. Total catch in number was similar between vessels and highly variable within a stratum for both vessels (Table 4, Figure 6). Estimated catch, using all valid biomass tows, also indicated that, for some strata, differences between vessels were not as great as indicated when assessing catch in numbers (unscaled) (e.g., strata 5 and 7).

Despite the variable catches, the scaled length frequency distributions indicated that both vessels caught fish of similar size, with relatively minor differences, e.g., *Kaharoa* caught marginally more snapper under 20 cm and between 37–42 cm, while *Kaharoa II* caught slightly more fish between 45–60 cm (Figure 7). Differences by sex for smaller fish are not of concern as these differences were mainly due to the ability to determine the sex of small individuals (e.g., sex was not determined on *Kaharoa II* for fish less than about 22 cm). Estimated CVs for the scaled length distributions were slightly lower for *Kaharoa*, but CVs for both vessels were less than 19%. After taking tow distance and doorspread into account, catch density (kg per km²) from most paired tows were relatively similar, with only a few paired tows where estimated catch density from *Kaharoa II* was substantially more than from *Kaharoa* (SNA Figure 8).

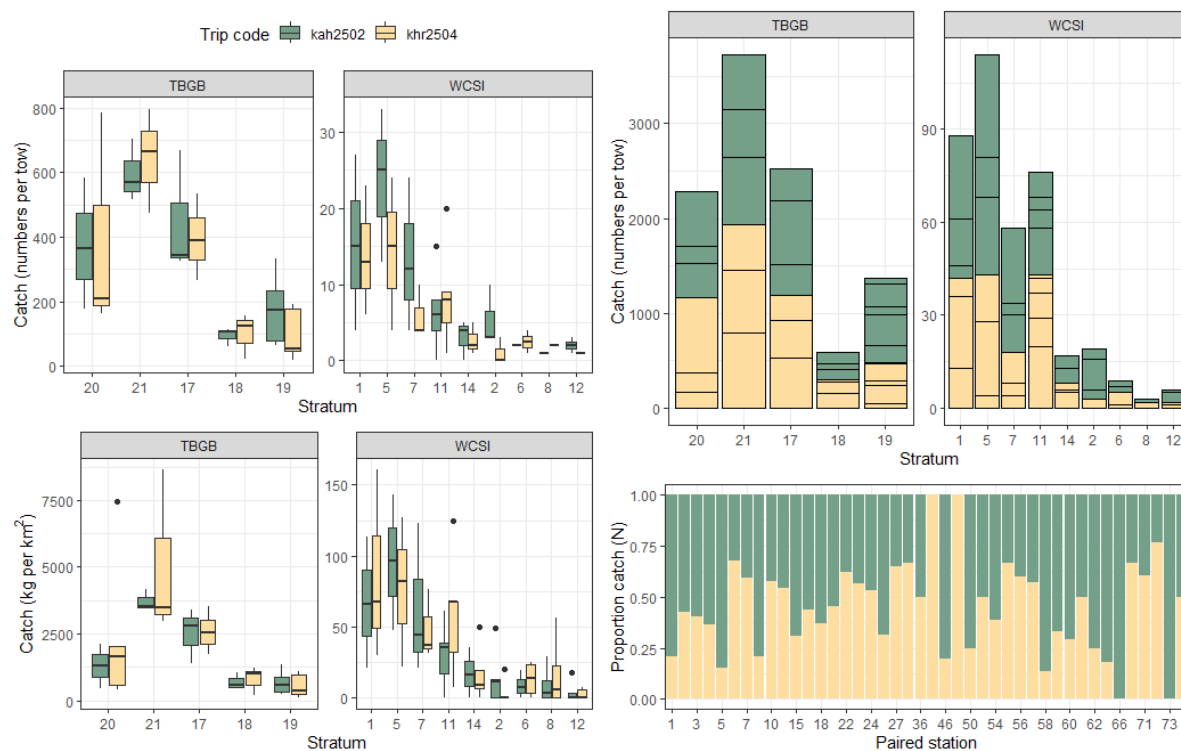


Figure 6: Snapper interquartile distribution of catch (numbers, unscaled) by stratum and vessel (top left), interquartile distribution of swept area catch (kg per km²) (bottom left), total catch (numbers, unscaled) by stratum, station, and vessel (top right), and proportion of catch by vessel within each paired station (bottom right). Strata have been ordered from shallowest to deepest, and Tasman and Golden Bays (TBGB) strata are shown separately from the west coast (WCSI) strata. Interquartile plot is as described in Figure 3. Divisions in stacked bar plot (top right) indicate catch from a station. *Kaharoa* data are in green and *Kaharoa II*, yellow.

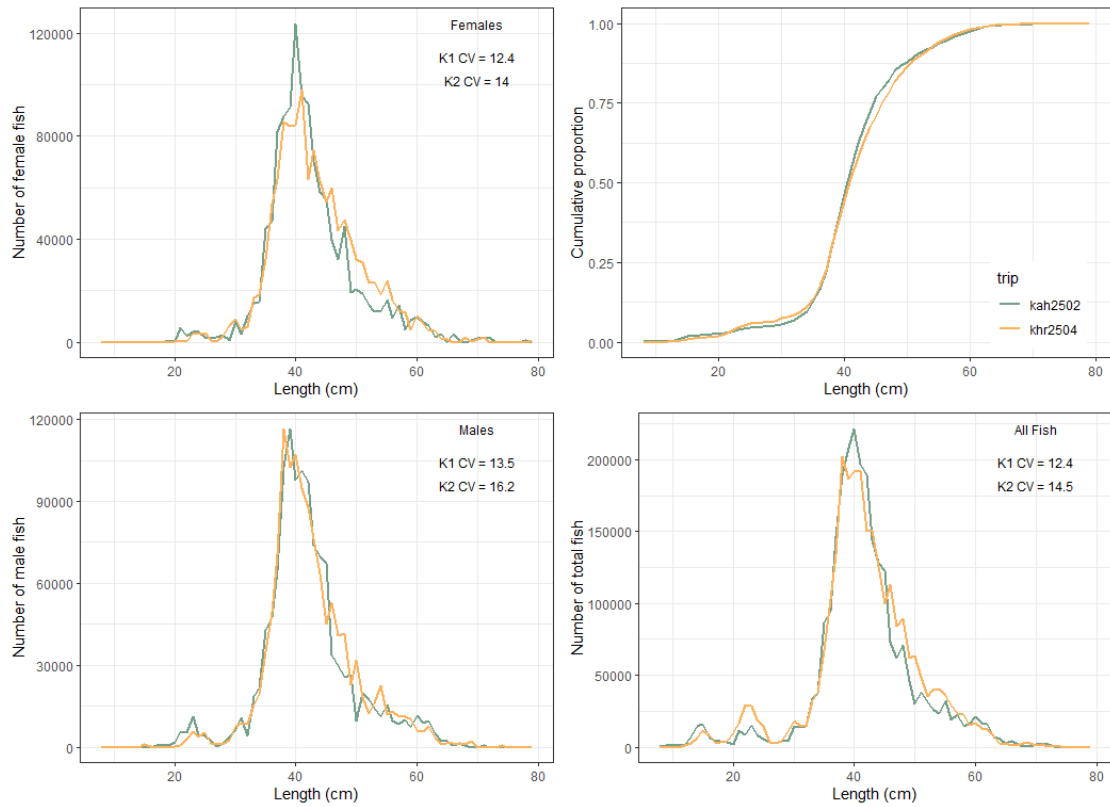


Figure 7: Snapper scaled length frequency distributions for male (bottom left), female (top left), and all fish (bottom right), and cumulative proportion by length (top right) for *Kaharoa* (green line) and *Kaharoa II* (yellow line). The extra tows conducted by the *Kaharoa II* were included. CVs of the length distribution are included in the length frequency plots. Cumulative proportions were not scaled to total catch of both vessels.

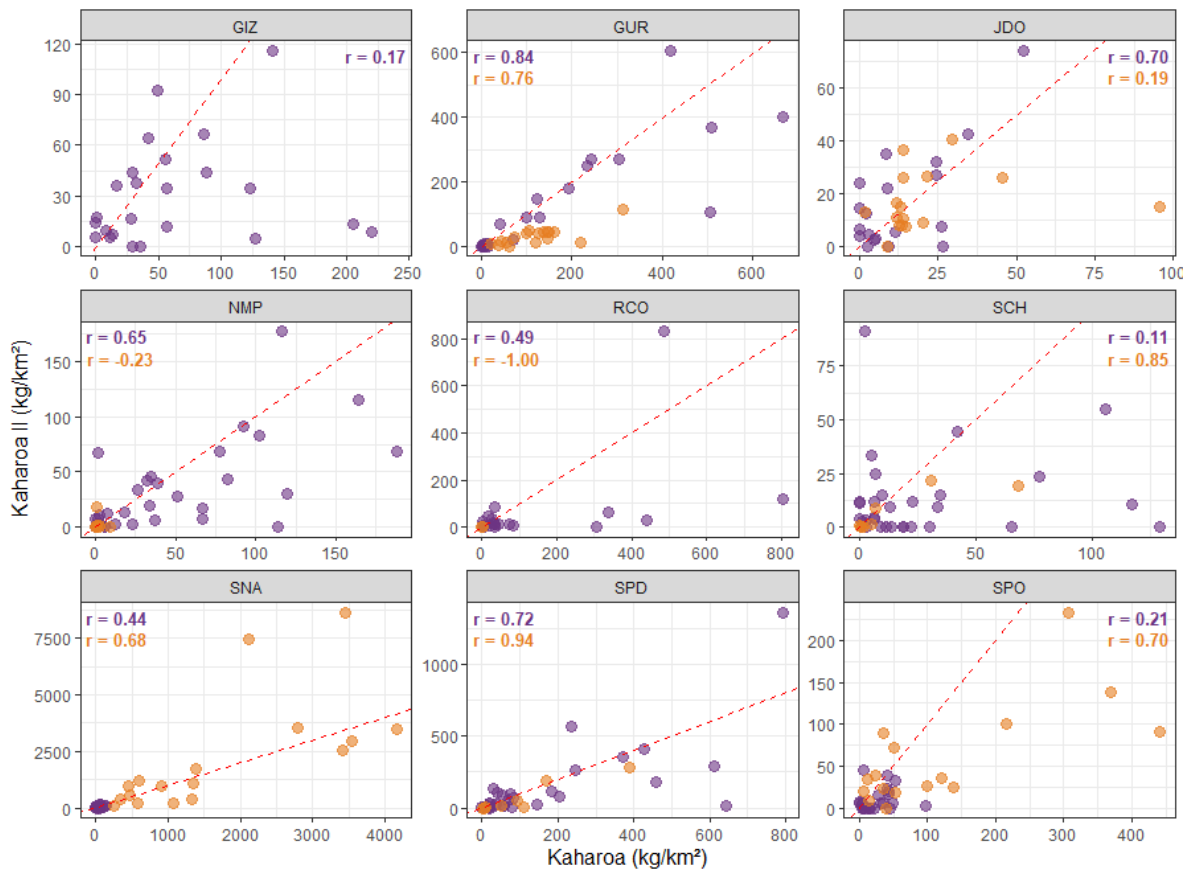


Figure 8: Swept area catch (catch density kg km^{-2}) by paired tows for WCSI target species, with Tasman and Golden Bays stations (orange) differentiated from WCSI stations (purple), Dotted line indicates the 1:1 line. Correlations were estimated across paired stations within TBGB and WCSI. The level of paired-tow correlation is denoted by the Pearson correlation statistics (r); r values > 0.0 indicate ‘strong’ correlation; r values > 0.7 denote ‘very strong’ correlation.

Red Gurnard

Red gurnard were caught by at least one vessel at 43 stations and by both vessels at 35 stations (Table 4). Of the stations where only one vessel caught red gurnard, one was in TBGB (35 fish caught) and the rest on the WCSI (between 1–9 fish caught). Catch in numbers within a stratum was more variable on the WCSI than in TBGB for both vessels (Figure 9). Kaharoa caught more red gurnard overall, and noticeably more red gurnard in TBGB, than *Kaharoa II* (Table 4, Figure 9). These differences in catch were still visible after accounting for differences in doorspread and distance towed, estimated catch (kg per km^2) was much higher for *Kaharoa* in TBGB. When comparing estimated catch (biomass) for paired stations, catch densities were usually relatively similar between vessels on the WCSI with a few notable exceptions, but much higher for *Kaharoa* in TBGB (GUR Figure 8).

The length frequencies of red gurnard caught in TBGB differed greatly between the two vessels, including *Kaharoa II* not catching red gurnard under about 22 cm length and catching fewer than expected between 22–27 cm (Figure 10). Differences in catch by length were less on the WCSI, but again, *Kaharoa II* did not catch as many fish as *Kaharoa* (Figure 10).

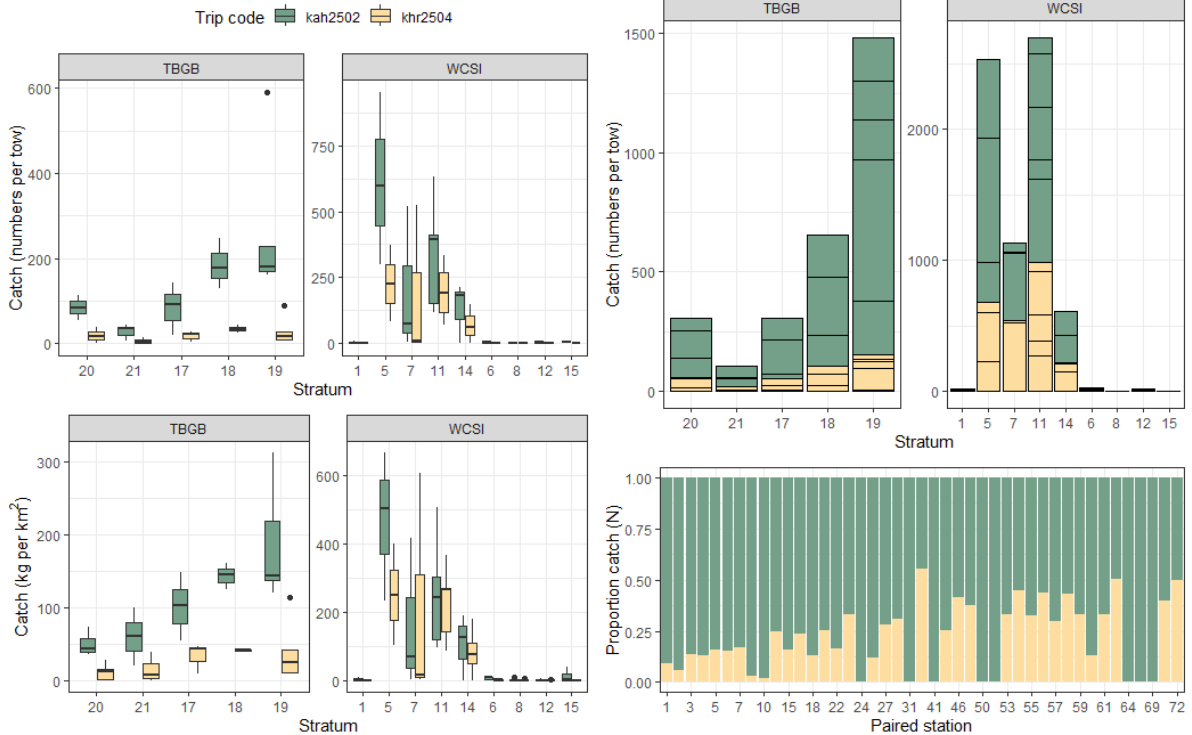


Figure 9: Red gurnard interquartile distribution of catch (numbers, unscaled) by stratum and vessel (top left), interquartile distribution of swept area catch (kg per km²) (bottom left), total catch (numbers, unscaled) by stratum, station, and vessel (top right), and proportion of catch by vessel within each paired station (bottom right), as described in Figure 6.

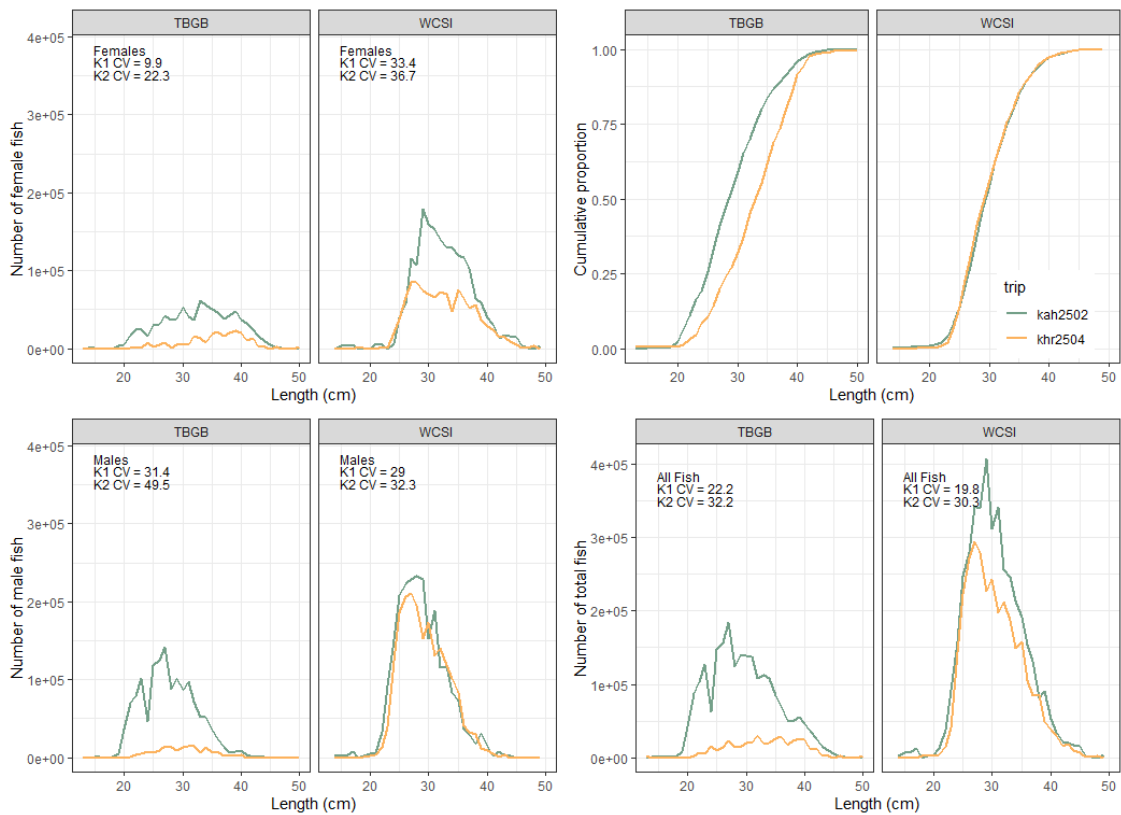


Figure 10: Red gurnard scaled length frequency distributions for male (bottom left), female (top left), and all fish (bottom right), and cumulative proportion by length (top right) for *Kaharoa* (green line) and *Kaharoa II* (yellow line) presented separately for Tasman and Golden Bays (TBGB) and west coast South Island (WCSI) (see Figure 7).

Giant stargazer

Giant stargazer were caught only on the WCSI and by both vessels at 20 paired stations (Table 4). Catches were generally small and variable for both vessels, with larger catches in the 200–400 m strata southwards along the WCSI (e.g., strata 8, 12, and 15; Figure 11). These differences between the two vessels may be due to faster tow speed on *Kaharoa II* resulting in less herding into the path of the net, or because the gear was designed to sit lighter on the bottom, and thus hard-to-bottom dwelling species may go under the sweeps and ground gear. Catch densities from the paired tows were poorly correlated (GIZ Figure 8).

The small catch numbers are thought to account for the minor observed length frequency differences (Figure 12). Generally, both vessels caught fish of a similar length range (Figure 12).

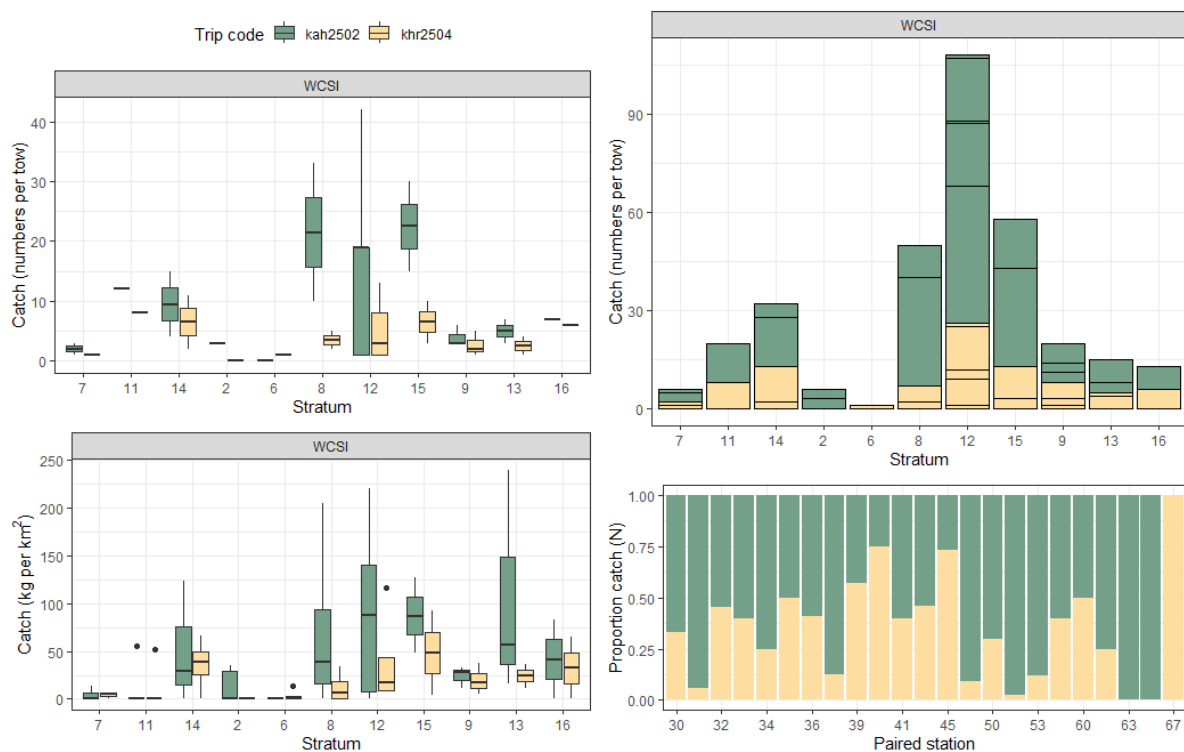


Figure 11: Giant stargazer interquartile distribution of catch (numbers, unscaled) by stratum and vessel (top left), interquartile distribution of swept area catch (kg per km²) (bottom left), total catch (numbers, unscaled) by stratum, station, and vessel (top right), and proportion of catch by vessel within each paired station (bottom right), as described in Figure 6.

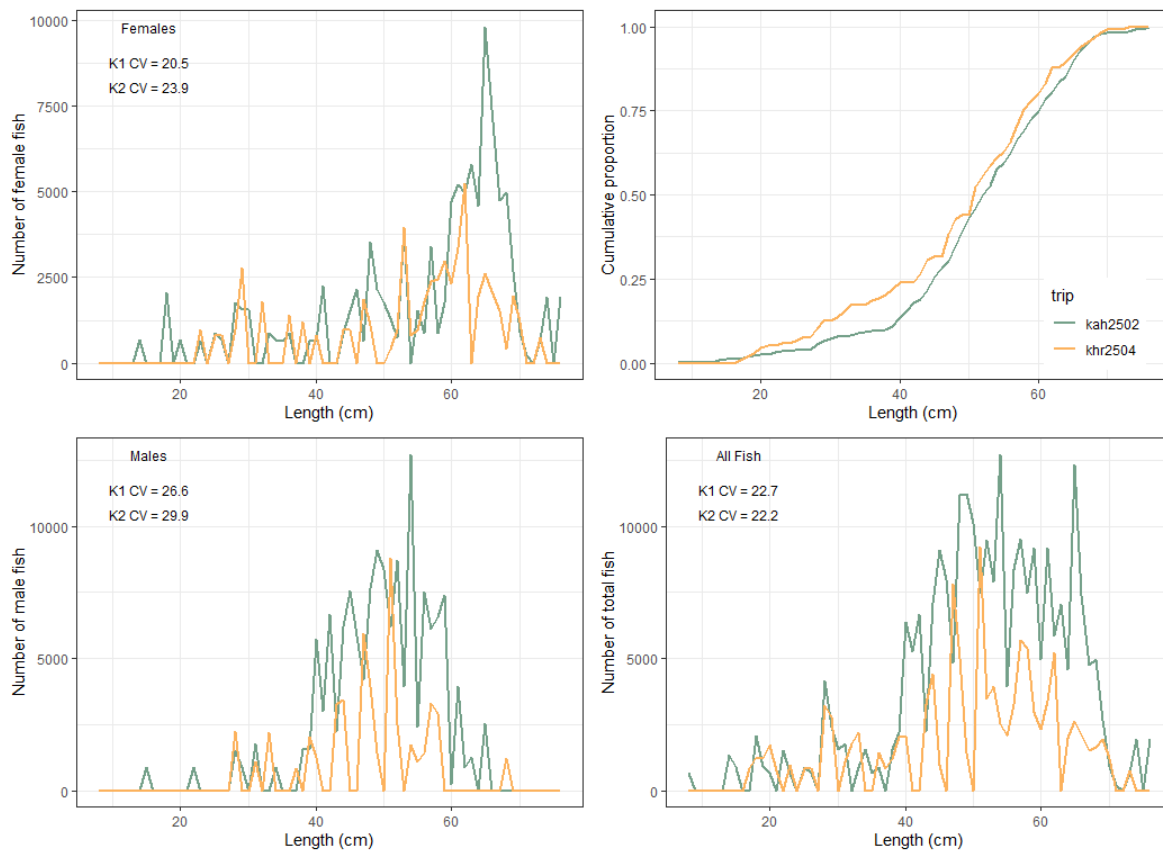


Figure 12: Giant stargazer scaled length frequency distributions for male (bottom left), female (top left), and all fish (bottom right), and cumulative proportion by length (top right) for *Kaharoa* (green line) and *Kaharoa II* (yellow line) (see Figure 7).

John dory

John dory was caught by both vessels at 27 stations (Table 4). Of the stations where only one vessel caught John dory, catches were relatively small; one catch of 2 fish in TBGB and between 1–6 fish caught on the WCSI. John dory catch numbers were relatively small and variable (Figure 13). Catch density estimates showed that there was good correlation (0.70) between paired stations on the WCSI (JDO Figure 8). Despite the small catches, the length distributions indicated that both vessels caught fish of similar size (Figure 14).

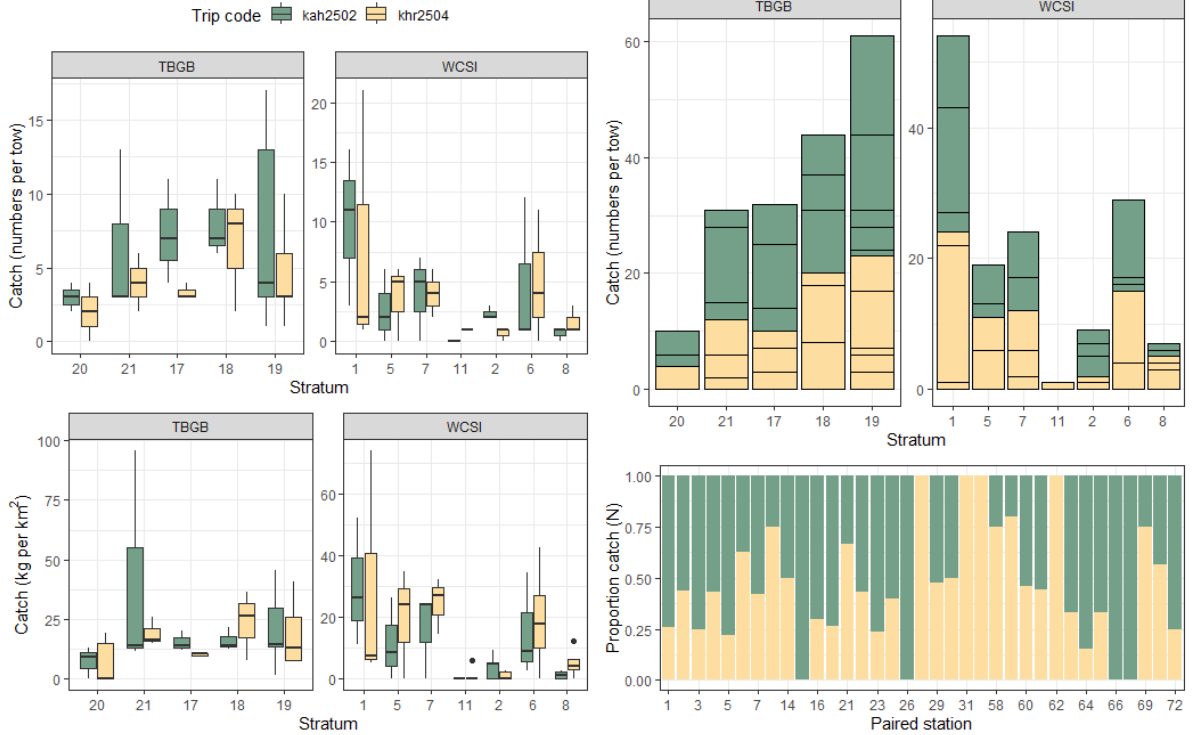


Figure 13: John dory interquartile distribution of catch (numbers, unscaled) by stratum and vessel (top left), interquartile distribution of swept area catch (kg per km²) (bottom left), total catch (numbers, unscaled) by stratum, station, and vessel (top right), and proportion of catch by vessel within each paired station (bottom right), as described in Figure 6.

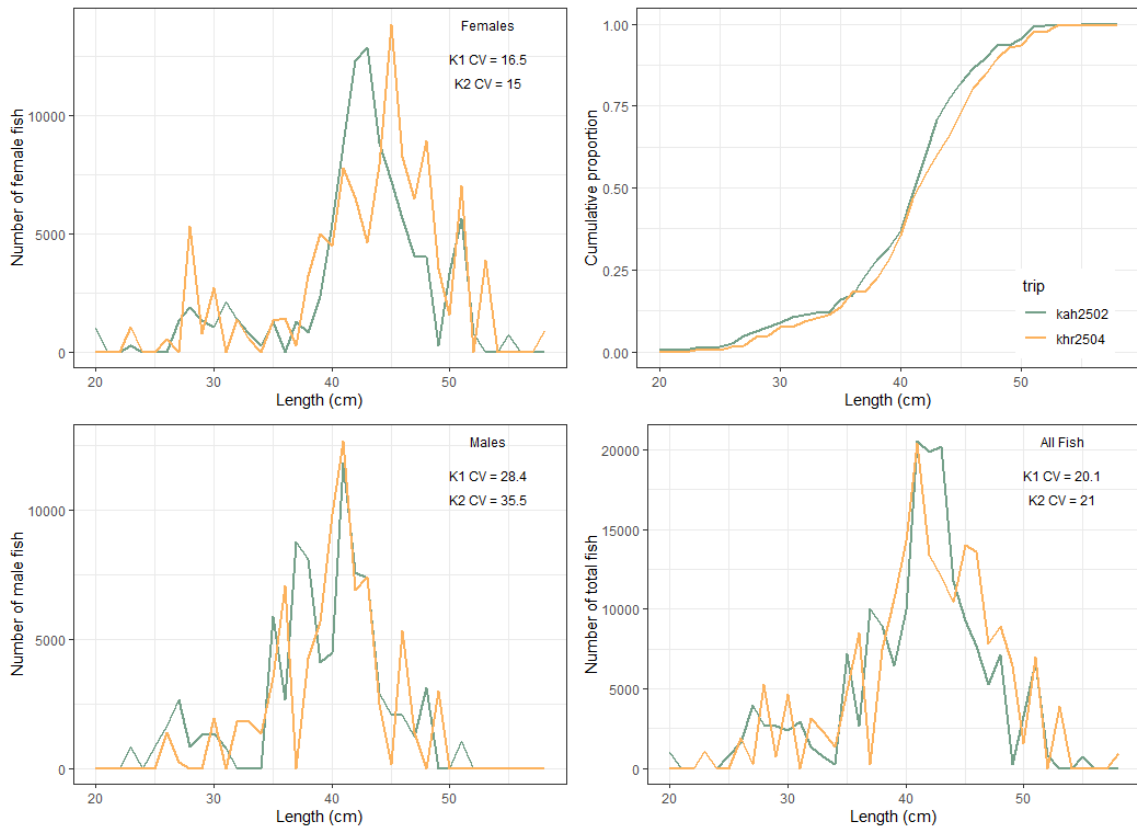


Figure 14: John dory scaled length frequency distributions for male (bottom left), female (top left), and all fish (bottom right), and cumulative proportion by length (top right) for *Kaharoa* (green line) and *Kaharoa II* (yellow line) (see Figure 7).

Tarakihi

Of the 59 paired stations, tarakihi were caught by both vessels at 29 stations (Table 4). Where only one vessel caught tarakihi: 5 stations were in TBGB and consisted of catches between 1–8 fish; and of the 5 WCSI stations, 4 had catches between 1–7 fish, while one caught 79 fish. Catches at paired stations were variable (Figure 15). Tarakihi are a schooling species and with the minimum separation distance employed during the intercalibration, often one vessel would encounter a school while the other vessel would not. Differences in the catch density estimates for paired stations also possibly reflected the schooling nature of tarakihi, but WCSI stratum catch densities were highly correlated (0.65) between vessels (NMP Figure 8). Both vessels caught fish of a similar length range; neither vessel caught tarakihi in large amounts of a size between 25–30 cm (i.e., there may be a missing cohort in the population), and *Kaharoa II* appeared to not catch many fish between 30–33 cm (Figure 16).

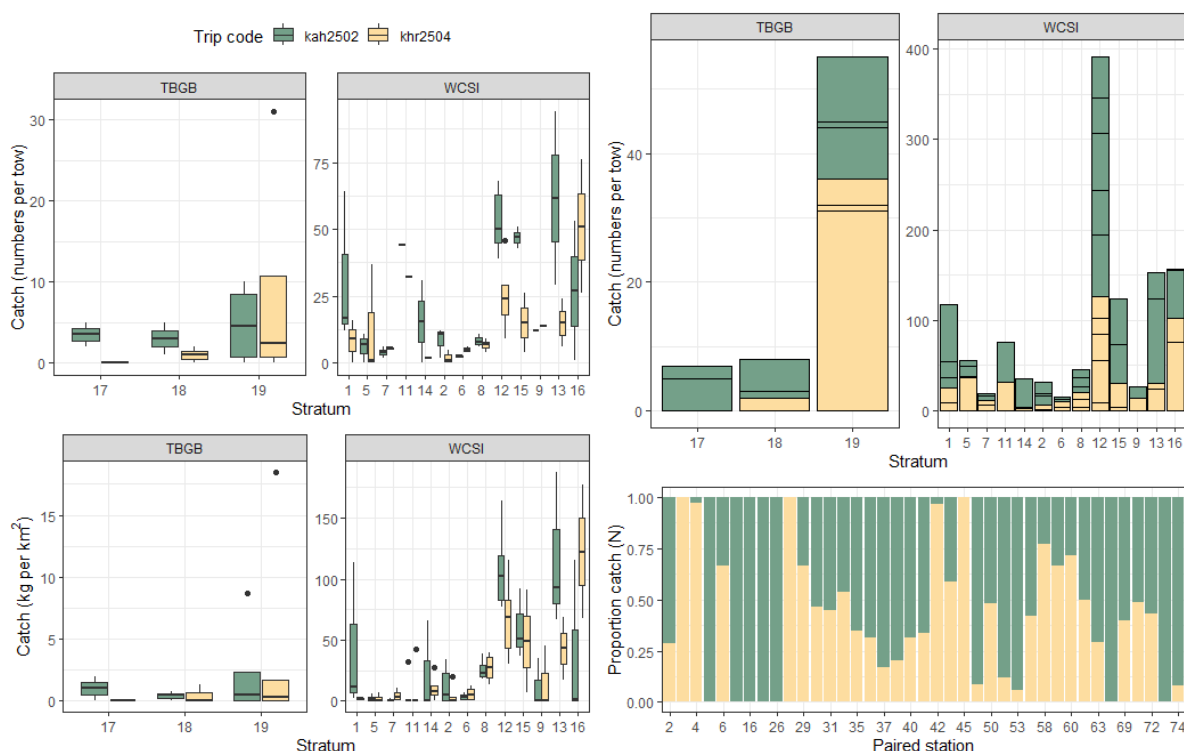


Figure 15: Tarakihi interquartile distribution of catch (numbers, unscaled) by stratum and vessel (top left), interquartile distribution of swept area catch (kg per km²) (bottom left), total catch (numbers, unscaled) by stratum, station, and vessel (top right), and proportion of catch by vessel within each paired station (bottom right), as described in Figure 6.

Because of the patchiness of tarakihi schools and the effect this might have on (for example) the length-based modelling, the Inshore Working Group (29 Oct 2025) requested that only paired stations where both vessels caught fish of a sufficient number be included (10 fish per vessel per station was chosen). This resulted in 12 paired stations in 8 WCSI strata, of which, only one stratum had more than one station (stratum 12) (Figure 17). With this restriction of data, the length distribution of tarakihi caught by both vessels was much more similar, with the main difference being that *Kaharoa II* caught more fish less than 15 cm (Figure 17).

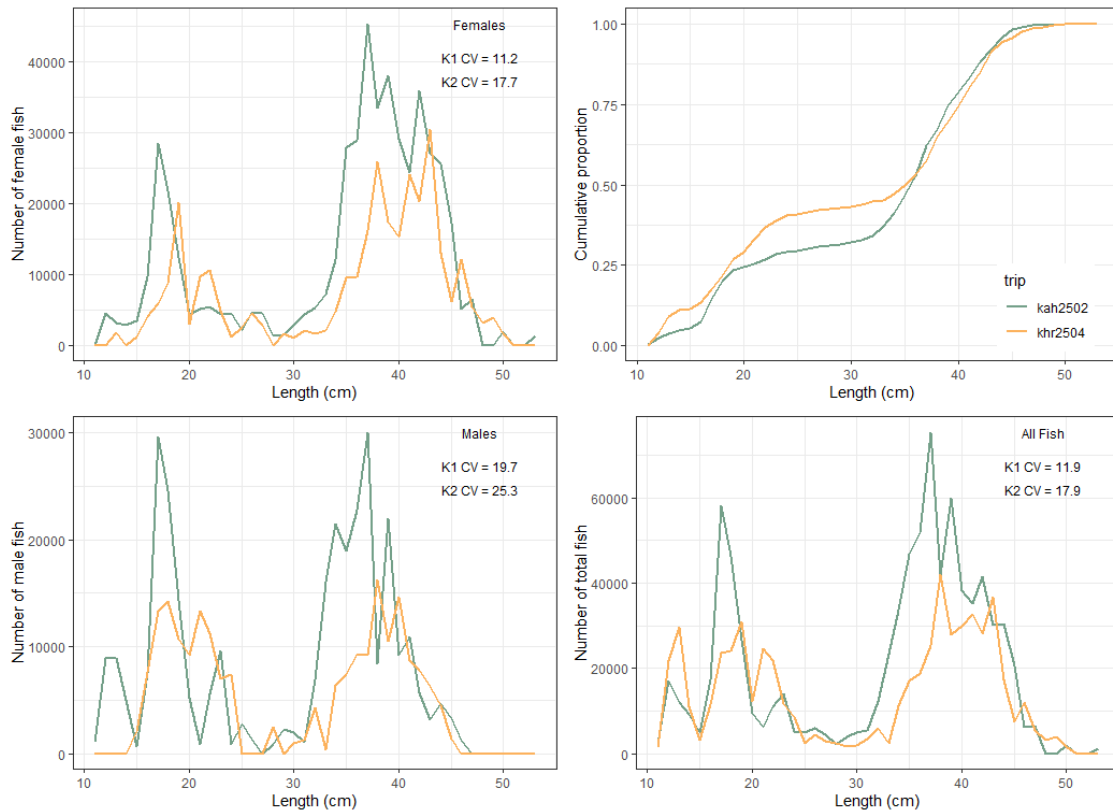


Figure 16: Tarakihi scaled length frequency distributions for male (bottom left), female (top left), and all fish (bottom right), and cumulative proportion by length (top right) for *Kaharoa* (green line) and *Kaharoa II* (yellow line) (see Figure 7).

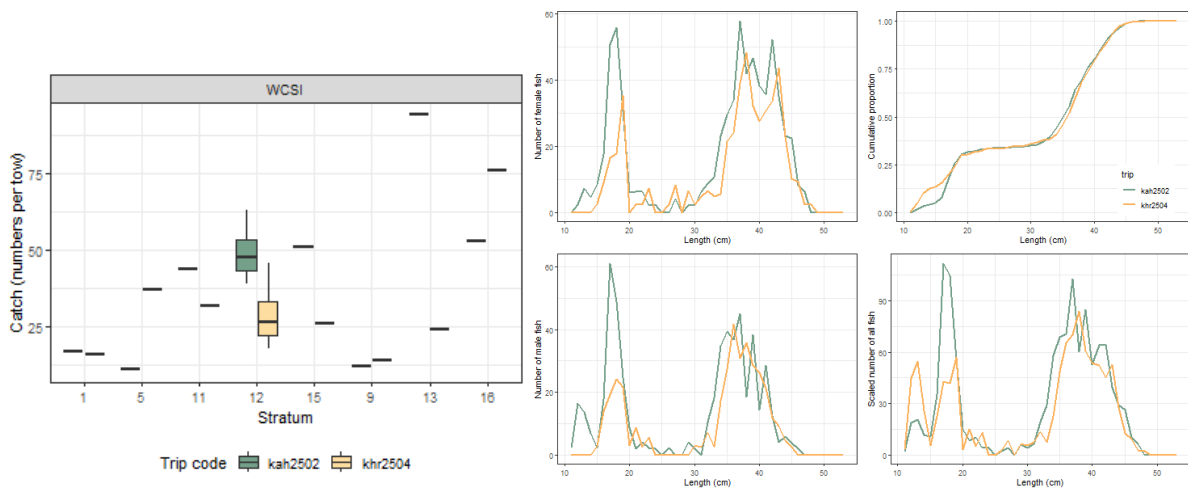


Figure 17: Interquartile distribution of tarakihi catch (numbers, unscaled) by stratum after restricting to stations where at least 10 fish were caught by each vessel, as described in Figure 6 (left); and (right) scaled length frequency distributions for male (bottom left), female (top left), and all fish (bottom right), and cumulative proportion by length (top right) for *Kaharoa* (green line) and *Kaharoa II* (yellow line) (see Figure 7).

Red cod

Red cod were caught by both vessels at 24 paired stations (Table 4). In TBGB, red cod were only caught by one vessel at two separate stations (1 fish each station) (Figure 18). Catches of red cod were variable within strata and greater catches were generally observed with the *Kaharoa* (Figure 18). Patches of high red cod density were apparently relatively small because usually only one vessel had high catches (RCO Figure 8). While the length range caught by both vessels was similar, *Kaharoa II*

caught more small fish (under 22 cm), while Kaharoa caught more larger individuals (over 35 cm) (Figure 19).

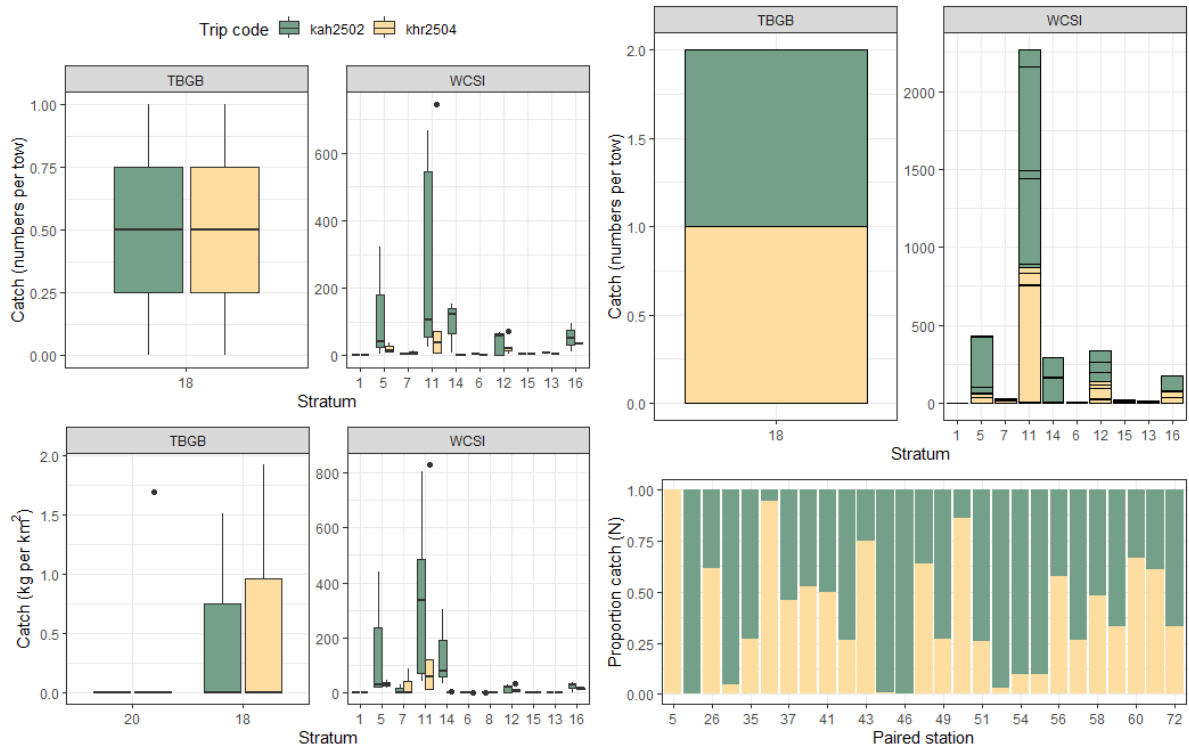


Figure 18: Red cod interquartile distribution of catch (numbers, unscaled) by stratum and vessel (top left), interquartile distribution of swept area catch (kg per km²) (bottom left), total catch (numbers, unscaled) by stratum, station, and vessel (top right), and proportion of catch by vessel within each paired station (bottom right), as described in Figure 6.

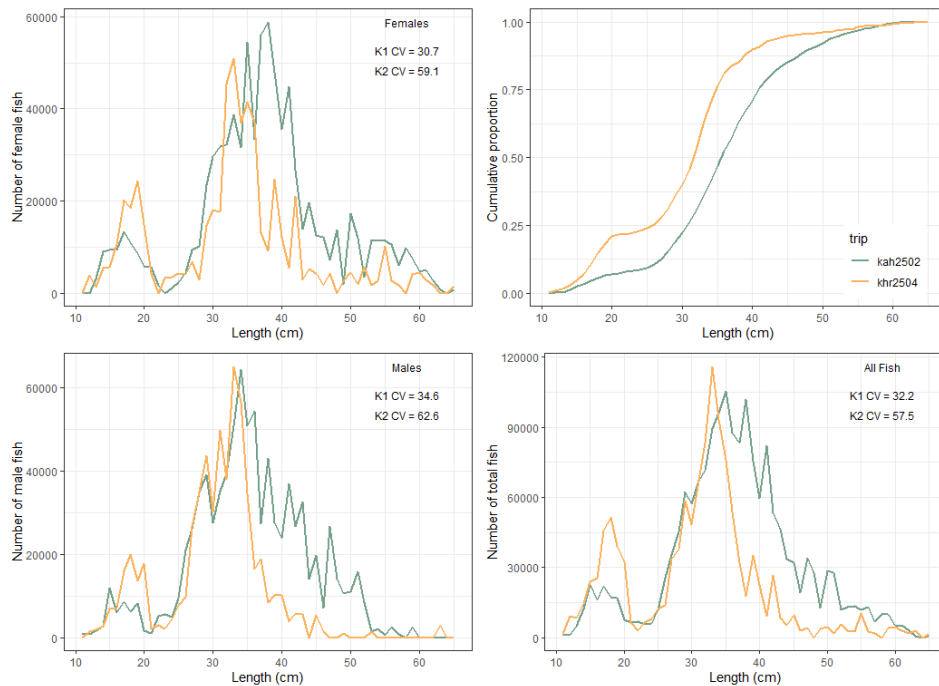


Figure 19: Red cod scaled length frequency distributions for male (bottom left), female (top left), and all fish (bottom right), and cumulative proportion by length (top right) for *Kaharoa* (green line) and *Kaharoa II* (yellow line) (see Figure 7).

Spiny dogfish

Spiny dogfish were caught by both vessels at 36 stations (Table 4). For stations where only one vessel caught spiny dogfish, catch numbers were low (1–5 fish) and only one station was within TBGB (Figure 20). As with most other target species, catch of spiny dogfish was highly variable within and between strata (Figure 20). Differences in swept area catch for deeper strata were not as great as catch in numbers, most likely a reflection of greater increase in doorspread with depth for *Kaharoa II*. Paired-tow catch densities were relatively similar at densities less than 500 kg per km² (SPD Figure 8). The length of fish caught by both vessels was broadly similarly, with key differences being that Kaharoa caught slightly more fish less than 50 cm and Kaharoa II caught more spiny dogfish between 55–65 cm (Figure 21).

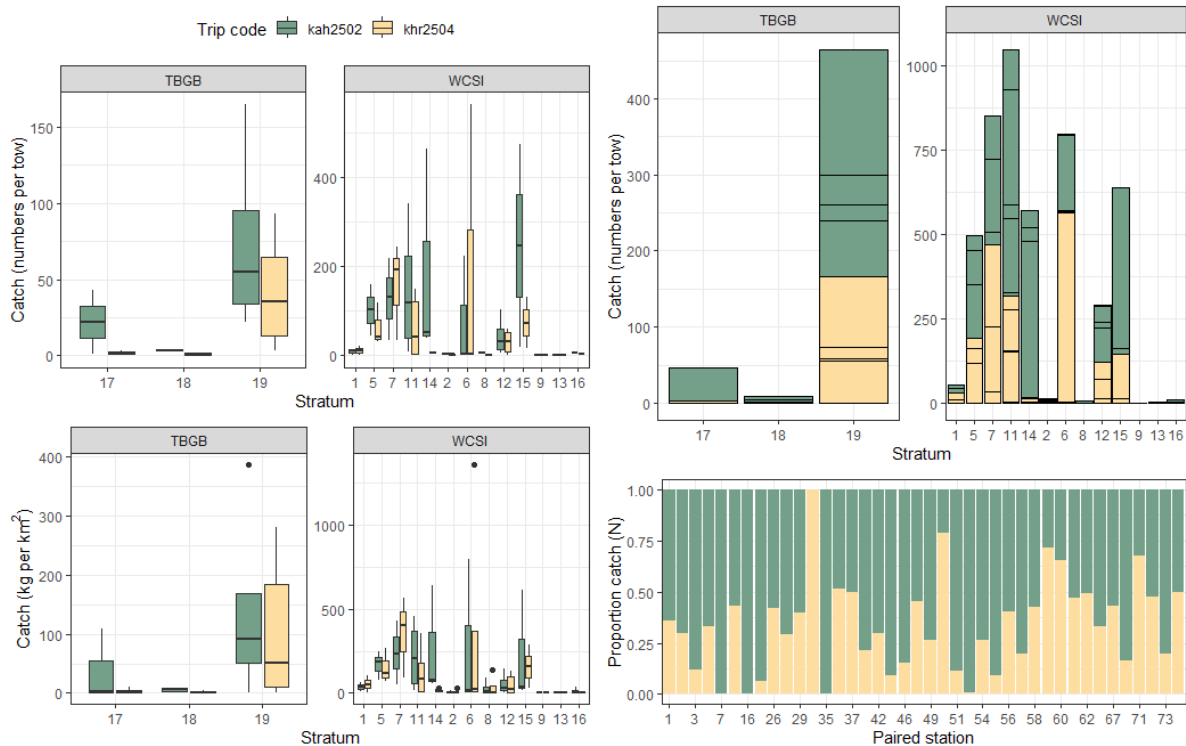


Figure 20: Spiny dogfish interquartile distribution of catch (numbers, unscaled) by stratum and vessel (top left), interquartile distribution of swept area catch (kg per km²) (bottom left), total catch (numbers, unscaled) by stratum, station, and vessel (top right), and proportion of catch by vessel within each paired station (bottom right), as described in Figure 6.

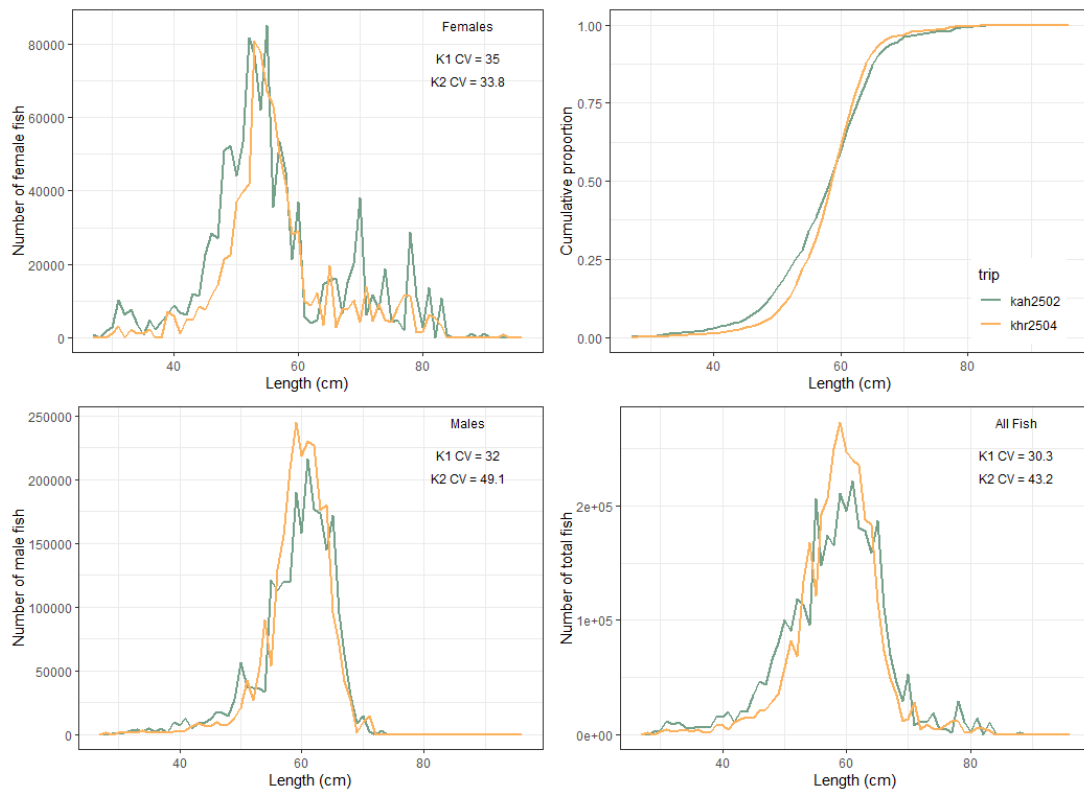


Figure 21: Spiny dogfish scaled length frequency distributions for male (bottom left), female (top left), and all fish (bottom right), and cumulative proportion by length (top right) for *Kaharoa* (green line) and *Kaharoa II* (yellow line) (see Figure 7).

School shark

While school shark were caught by at least one vessel at 39 paired stations, both vessels caught school shark at only 21 paired stations (Table 4). Catch of school shark was smaller in TBGB and could be highly variable within a tow (e.g., between 1–33 individuals) and stratum (Figure 22). There was relatively poor correspondence in the paired tow catch density results (SCH Figure 8). Stratum differences in biomass were less than differences in catch in numbers, particularly in TBGB (Figure 22).

Both vessels caught individuals less than 50 cm in similar proportions, but *Kaharoa* caught more individuals greater than 100 cm (Figure 23). These differences could be due to the differences in sweep angles and speed (e.g., herding capability) of the two vessels or the shorter tow distance (i.e., on shorter tows large individuals are able to swim ahead of the net without tiring).

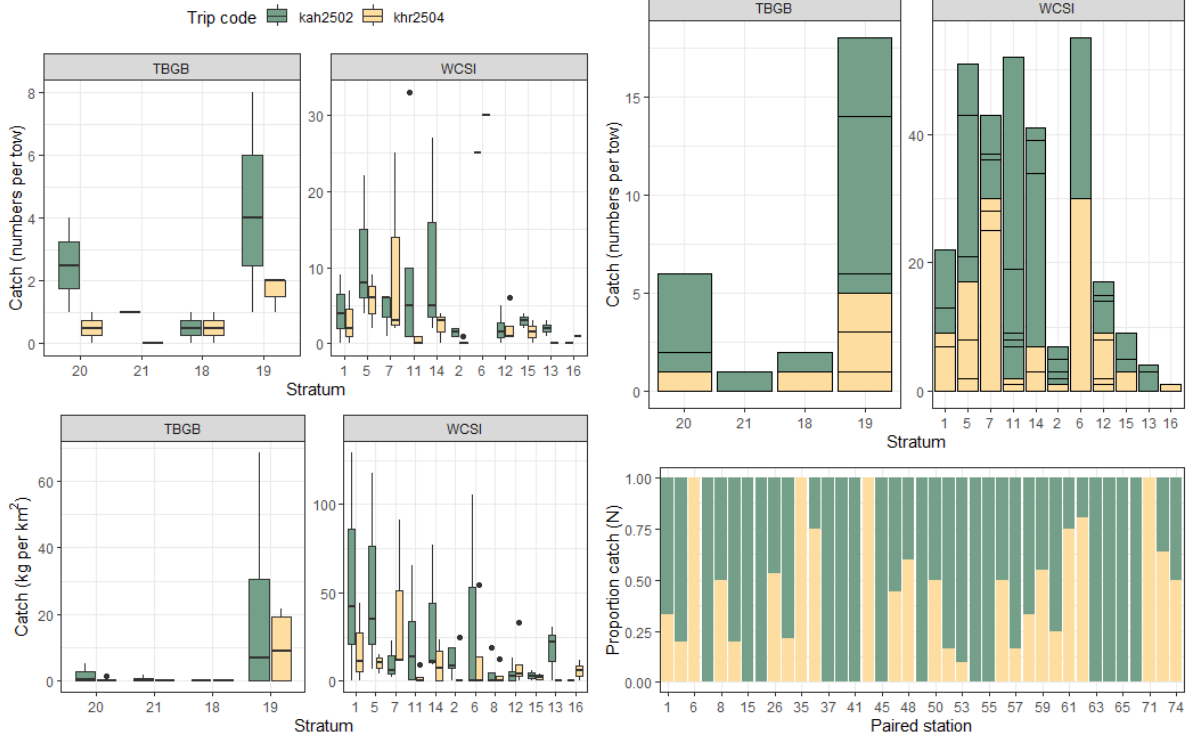


Figure 22: School shark interquartile distribution of catch (numbers, unscaled) by stratum and vessel (top left), interquartile distribution of swept area catch (kg per km²) (bottom left), total catch (numbers, unscaled) by stratum, station, and vessel (top right), and proportion of catch by vessel within each paired station (bottom right), as described in Figure 6.

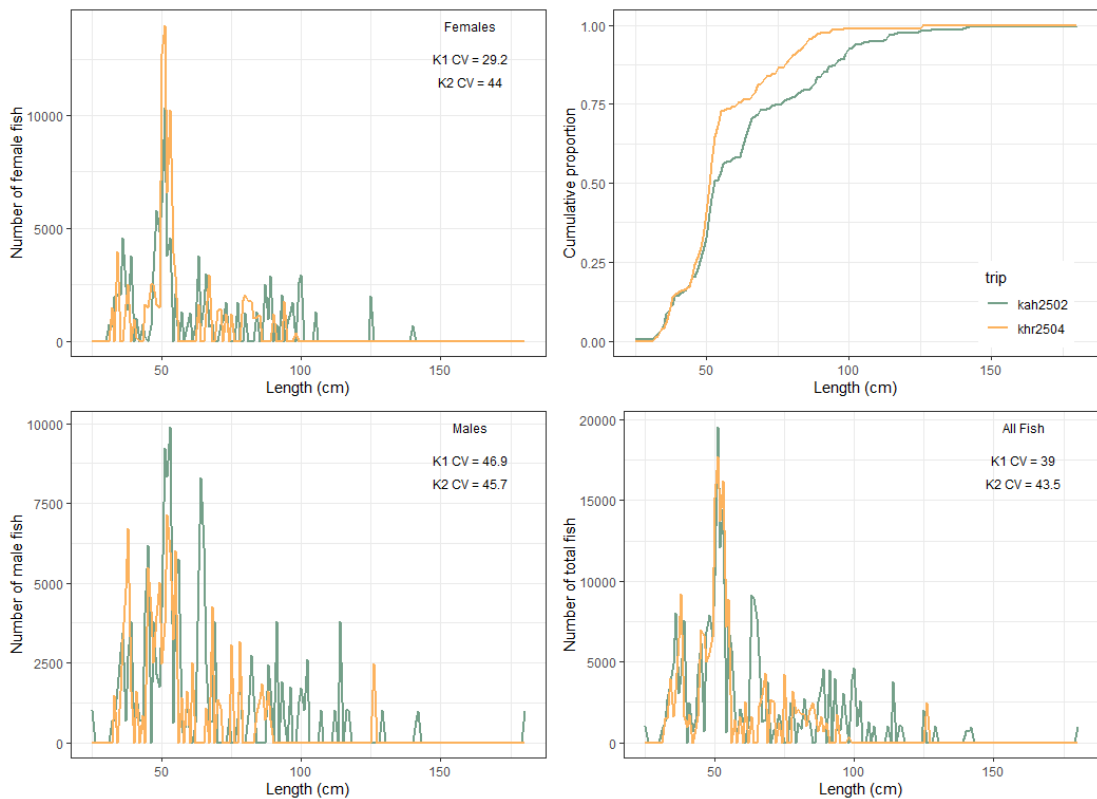


Figure 23: School shark scaled length frequency distributions for male (bottom left), female (top left), and all fish (bottom right), and cumulative proportion by length (top right) for *Kaharoa* (green line) and *Kaharoa II* (yellow line) (see Figure 7).

Rig

Rig were caught at 39 paired stations, of which both vessels caught rig at 28 paired stations (Table 4). Where only one vessel caught rig, 1 station was in TBGB (5 fish) and the rest were in WCSI and caught between 1–7 fish. Overall, catches were variable for the paired stations and within a stratum, and catches were overall greater in TBGB or the 20–100 m strata on the WCSI (Figure 24). Catch density paired-tow comparisons indicated that Kaharoa catch density estimates were much higher in TBGB, but generally more similar for WCSI paired tows (SPO Figure 8).

Despite the low catch numbers by both vessels (maximum catch of 60 individuals), the length frequencies of the vessels were broadly similar (Figure 25). Kaharoa caught more individuals in the 50–80 cm range, which again, might be a consequence of the differences in sweep angle and towing speed (e.g. herding capabilities of the two vessels) or the shorter tow distance (i.e., on shorter tows being able to swim ahead of the net without tiring).

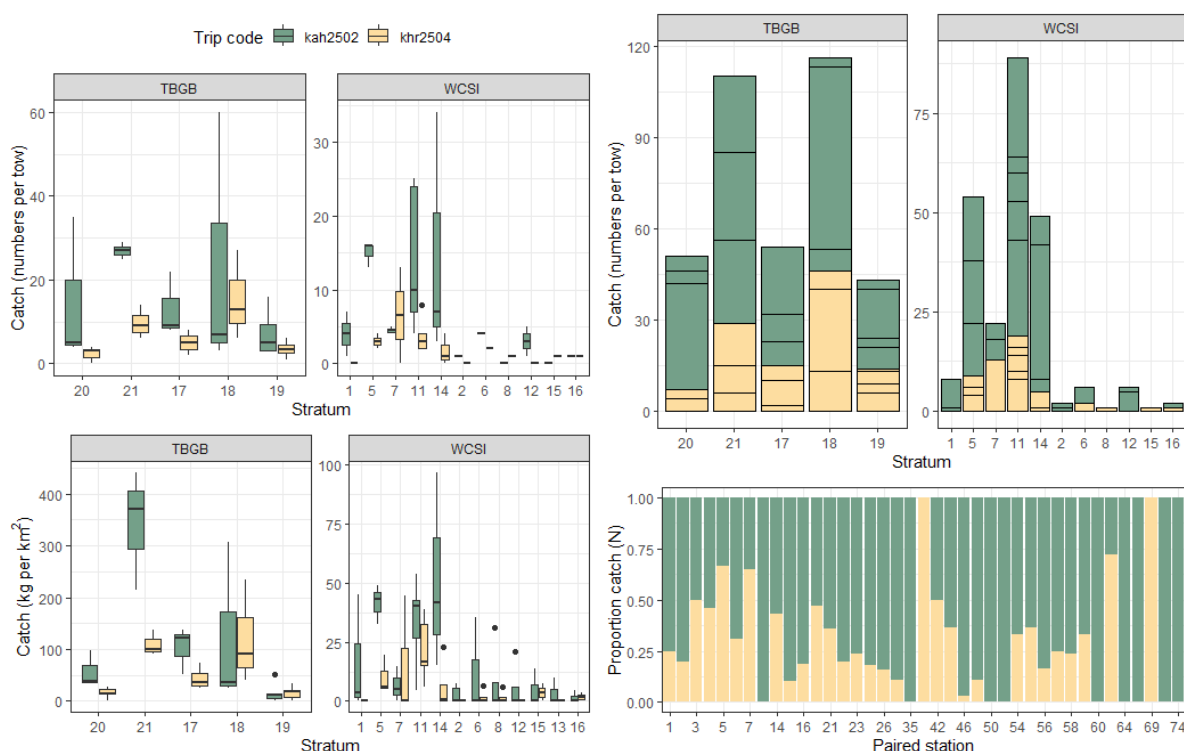


Figure 24: Rig interquartile distribution of catch (numbers, unscaled) by stratum and vessel (top left), interquartile distribution of swept area catch (kg per km²) (bottom left), total catch (numbers, unscaled) by stratum, station, and vessel (top right), and proportion of catch by vessel within each paired station (bottom right), as described in Figure 6.

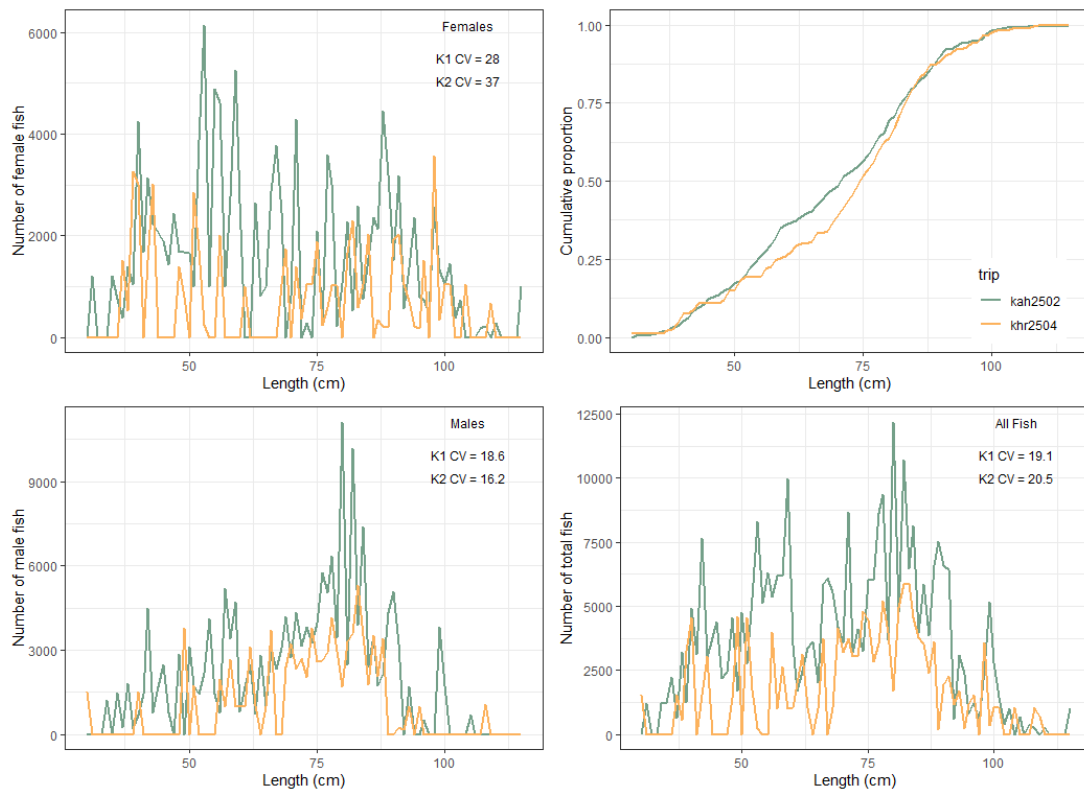


Figure 25: Rig scaled length frequency distributions for male (bottom left), female (top left), and all fish (bottom right), and cumulative proportion by length (top right) for *Kaharoa* (green line) and *Kaharoa II* (yellow line) (see Figure 7).

Sea perch (Helicolenus percoides, H. barathri)

Sea perch (both species) were caught by both vessels at 14 paired stations, but if considering only *Helicolenus percoides*, this reduces to 7 stations (Table 4). This section presents results for combined species (*H. percoides* and *H. barathri*); individual species results can be found in Appendix 6. Sea perch were only caught on the WCSI, and catches were higher in strata deeper than 100 m, with very small catches in the 20–100 m strata (Figure 26). Two paired stations recorded one species on one vessel and the other species on the other, which was either because of misidentification or due to differences in trawling depth between the two vessels. The length distribution sampled by both vessels for the combined sea perch species was broadly similar, indicating no systematic differences in catchability with length between vessels (Figure 27).

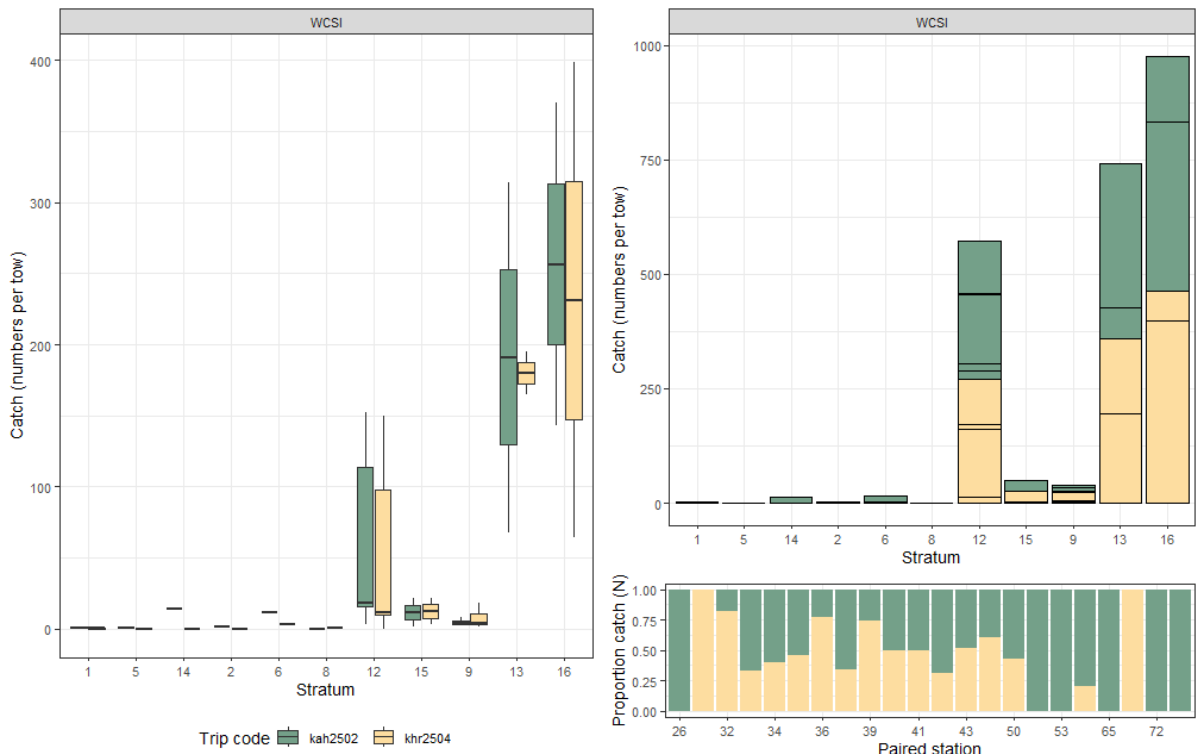


Figure 26: Interquartile distribution of sea perch catch (numbers, unscaled) by stratum and vessel (right), total catch (numbers, unscaled) by stratum, station, and vessel (top right), and proportion of catch by vessel within each paired station (bottom right), as described in Figure 6.

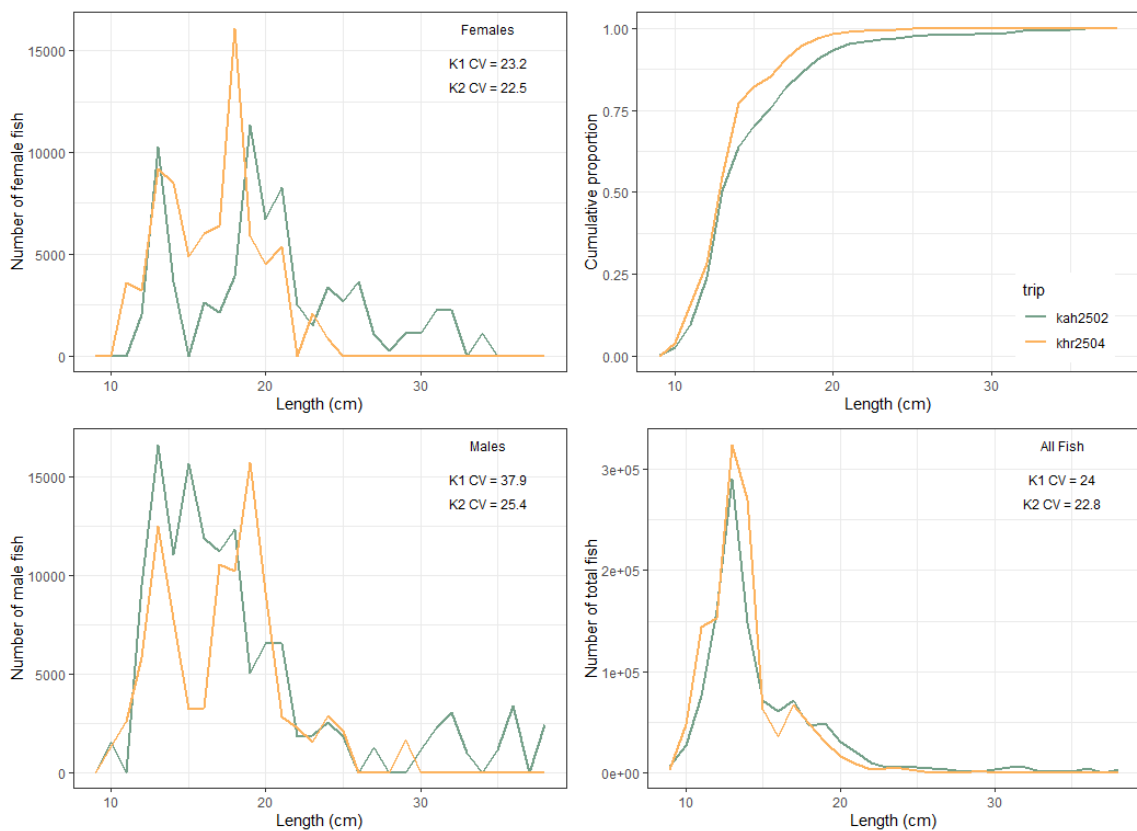


Figure 27: Sea perch scaled length frequency distributions for male (bottom left), female (top left), and all fish (bottom right), and cumulative proportion by length (top right) for *Kaharoa* (green line) and *Kaharoa II* (yellow line) (see Figure 7).

Elephantfish

Elephantfish were caught infrequently by both vessels, only 4 stations registered catch by both vessels and there were only 56 fish caught in total (Table 4). Elephantfish were only caught on the WCSI and catch per tow for the four paired stations ranged between 2–17 fish (Figure 28). Too few fish were measured to adequately make conclusions about catchability differences with length between the two vessels (Figure 29).

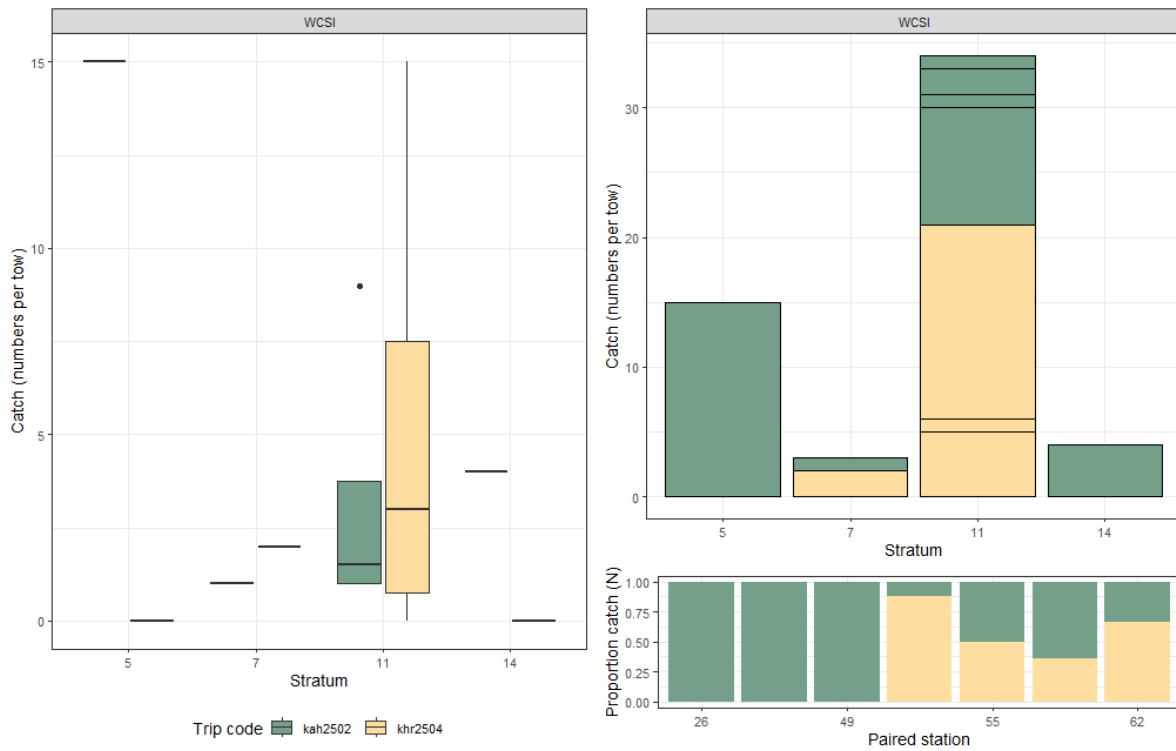


Figure 28: Interquartile distribution of elephantfish catch (numbers, unscaled) by stratum and vessel (right), total catch (numbers, unscaled) by stratum, station, and vessel (top right), and proportion of catch by vessel within each paired station (bottom right), as described in Figure 6.

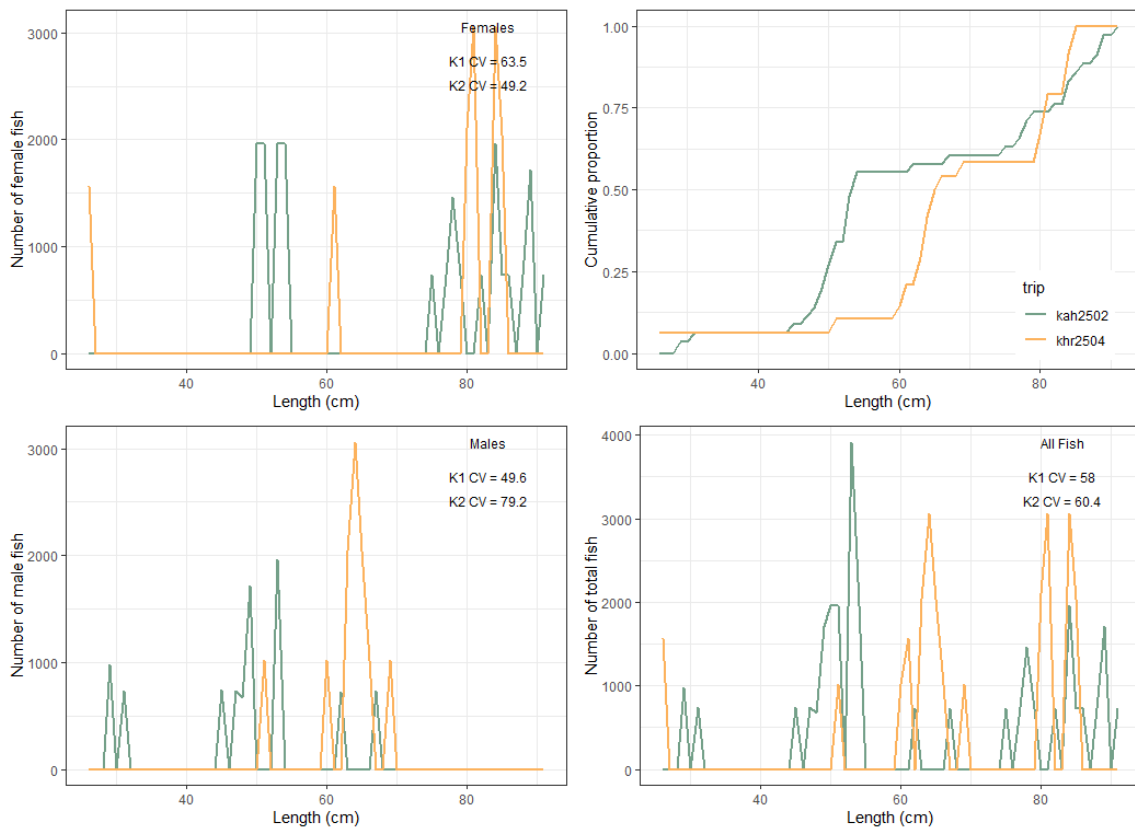


Figure 29: Elephantfish scaled length frequency distributions for male (bottom left), female (top left), and all fish (bottom right), and cumulative proportion by length (top right) for *Kaharoa* (green line) and *Kaharoa II* (yellow line) (see Figure 7).

Dark ghost shark

Both vessels caught dark ghost shark at 12 paired stations (Table 4). Of the stations where only one vessel caught this species, catches ranged between 1–44 individuals. Catches were higher with the *Kaharoa* and, for both vessels, catches were highly variable both within paired stations and within strata (Figure 30). Despite the differences in catch between the vessels, the length distributions and cumulative proportion caught by length were broadly similar (Figure 31).

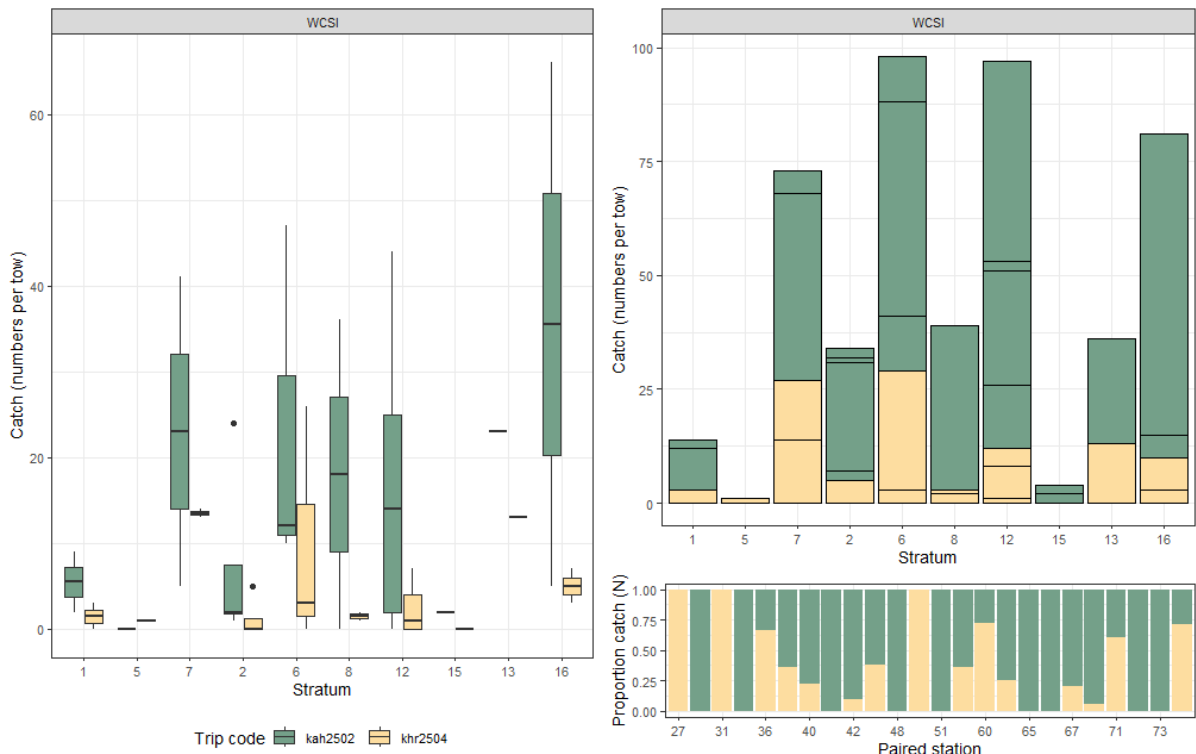


Figure 30: Interquartile distribution of dark ghost shark catch (numbers, unscaled) by stratum and vessel (right), total catch (numbers, unscaled) by stratum, station, and vessel (top right), and proportion of catch by vessel within each paired station (bottom right), as described in Figure 6.

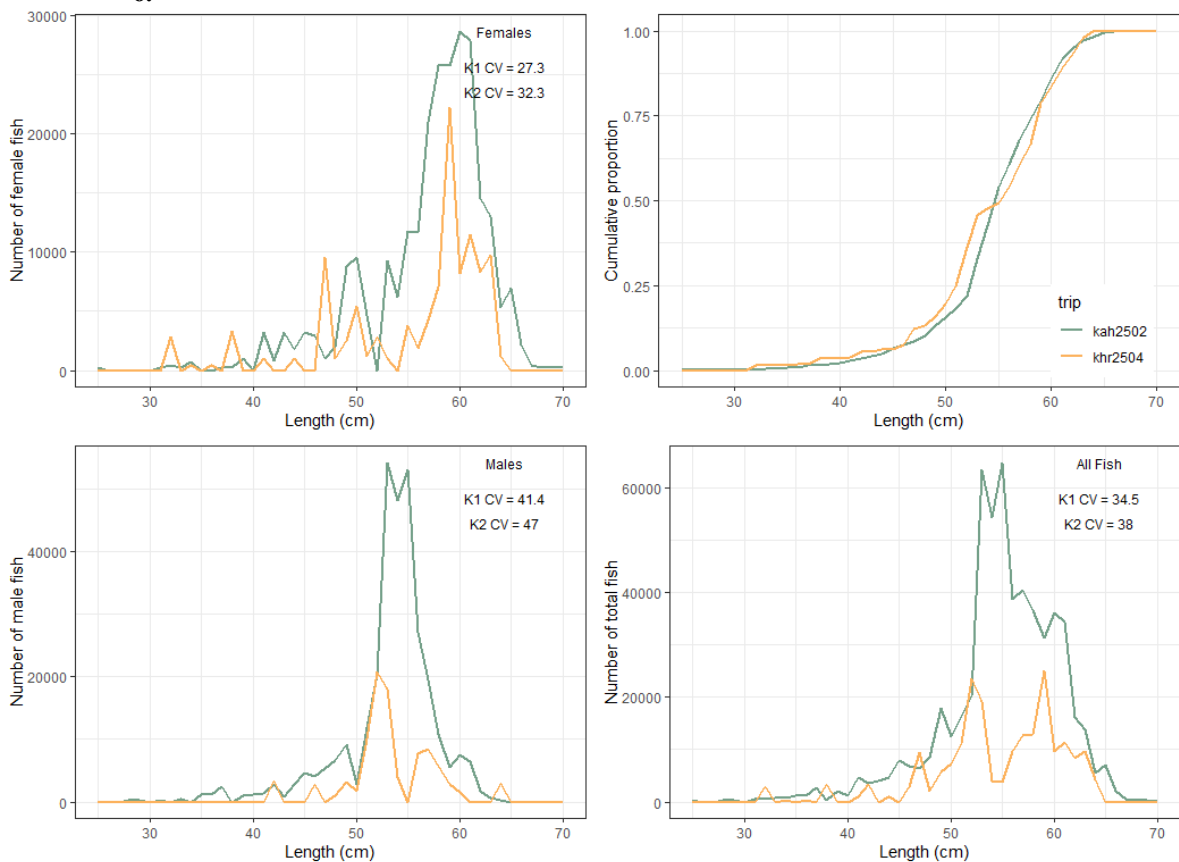


Figure 31: Dark ghost shark scaled length frequency distributions for male (bottom left), female (top left), and all fish (bottom right), and cumulative proportion by length (top right) for *Kaharoa* (green line) and *Kaharoa II* (yellow line) (see Figure 7).

All other species

Length frequency distributions and cumulative proportion by length for all other species that had adequate data from both vessels are included in Appendix 6.

Length-based modelling

At the time of the intercalibration design (Appendix 1), it was noted that there would likely be limited data to conduct length-based analyses. Full results and diagnostics of length-based modelling were presented to the Inshore Working Group (29 Oct 2025, 27 Jan 2026). The WG noted that the three model formulations (e.g., distributions) all poorly fitted the observed data and therefore concluded that an intercalibration based on size-composition modelling was not worth pursuing at this stage. The WG suggested that the size composition data for key species could be used within the relevant stock assessments to derive vessel- and species-specific selectivity functions. No further length comparison results are presented here.

4. SUMMARY

The intercalibration study was completed successfully, with 59 paired survey stations achieved by the two vessels. The Inshore Working Group (29 Oct 2025) recommended using the biomass catchability ratios for converting the time series in the short term. The WG felt that, for species with age-based assessments, the stock assessment modelling should be able to estimate catchability coefficients for each survey series once several surveys have been conducted.

For the target species of the WCSI and ECSI surveys, only a few species had biomass ratios close to one (i.e., snapper, spiny dogfish, and elephantfish), noting that very few elephantfish were caught by either vessel. *Kaharoa II* appeared to have higher catchability for John dory, but reduced catchability for all other target species. Variation of catches within a stratum for most species was higher than expected and, with hindsight, the intercalibration simulation should have included scenarios with variation greater than 30% (Appendix 1). *Kaharoa II* generally had greater catchability for some species, typically faster swimming species, e.g., jack mackerel, trevally (Appendices 5 & 6), which is attributed to the faster tow speed. Care should be taken when using the biomass ratios as, for many schooling species, a single high catch by one vessel may be responsible for the estimate.

Differences in catchability between the two vessels for larger species (e.g., school shark), species that are normally hard-to-bottom (e.g., stargazers), or slower-swimming species (e.g., red gurnard) may be due to the reduced tow time (i.e., fish not tiring and dropping into the net), the faster tow speed on *Kaharoa II* resulting in less herding of slower swimming species into the path of the net, or because the gear was designed to sit lighter on the bottom, and thus hard-to-bottom dwelling species may pass under the sweeps and ground gear. The large difference in catchability between the vessels of red gurnard in TBGB compared to the WCSI may have been a combination of targeting a faster speed over ground and tidal flow. Towing procedure on the WCSI by the lead vessel (and thus implemented by the following vessel, *Kaharoa II*) was to tow into the tide. This had the effect of decreasing speed over ground for *Kaharoa II*, despite maintaining an average speed through water of 3.4 knots. This effect was not apparent in TBGB (see Figure 4).

Estimated CVs of the biomass were generally higher for the *Kaharoa II* and may have been a consequence of the shorter tows. Because tow distance is reduced and catches are generally smaller with the new vessel, future surveys may be able to increase the number of stations within a stratum to lower the CVs, without additional cost.

The Inshore Working Group (29 Oct 2025) noted that for some species, consideration should be given to using wingspread, instead of doorspread, when estimating swept area catch density or biomass.

Wingspread will be consistently measured on all *Kaharoa II* surveys but was not a measurement recorded during the *Kaharoa* surveys; a theoretical wingspread estimate, based on the trawl design, could be used for the *Kaharoa* series.

Some target species of the ECSI survey (elephantfish and sea perch *Helicolenus percooides*), were caught relatively infrequently (i.e., at only a few paired stations). For dark ghost shark, the number of paired stations where both vessels caught fish was higher and the length frequency distribution was relatively similar, so the estimated biomass ratio from the WCSI might be able to be applied to the ECSI.

For many target species, the length frequencies were similar, indicating little difference in selectivity based on size composition. Restricting the comparisons to stations where both vessels caught at least ten individuals reduced some of the differences in size compositions (e.g., tarakihi). Differences in catchability of the smallest (or largest) sizes were notable for some species, such as school shark and TBGB red gurnard (see above for interpretation of differences), but were not apparent for other species, such as rig. Length-based modelling approaches were not successful, most likely due to the limited amount of data, which had been flagged as a potential issue at the design stage.

5. ACKNOWLEDGEMENTS

This project was funded by Fisheries New Zealand under project INT2024-01. We thank the skipper, Lindsay Copland, and crew of RV *Kaharoa* and, of RV *Kaharoa II*, Chris Whalan and his crew, for their active cooperation and enthusiastic assistance during the intercalibration survey. Scientific staff who participated on the *Kaharoa* were Dan MacGibbon, Pablo Escobar-Flores, Darren Stevens, Darren Parsons, Mark Fenwick, and Brent Wood, and on *Kaharoa II*, Jennifer Devine, Mel Underwood, Richard O'Driscoll, Jason Hamill, Mike Beentjes, and Alex Kroch (Fisheries New Zealand). Their hard work and dedication were much appreciated. We were appreciative of the logistical support during the survey provided by Talley's Group Ltd (Nelson division), and Simon Wadsworth and the NIWA Vessels team. We are grateful to Jeremy McKenzie (Earth Sciences New Zealand) and Marc Griffiths (Fisheries New Zealand) for reviews of this report.

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Appendix 1 Intercalibration simulation client report

At the Inshore Working Group meeting (29 Oct 2025), it was agreed that the client report on the intercalibration simulations would be appended to the FAR, so that these analyses could be publicly available. It is therefore included as Appendix 1 below.



Kaharoa intercalibration simulation

Effect of changing catchability and determination of
the number of stations needed for detecting changes
in biomass for Kaharoa inshore surveys

Prepared for Fisheries New Zealand

March 2023

Climate, Freshwater & Ocean Science

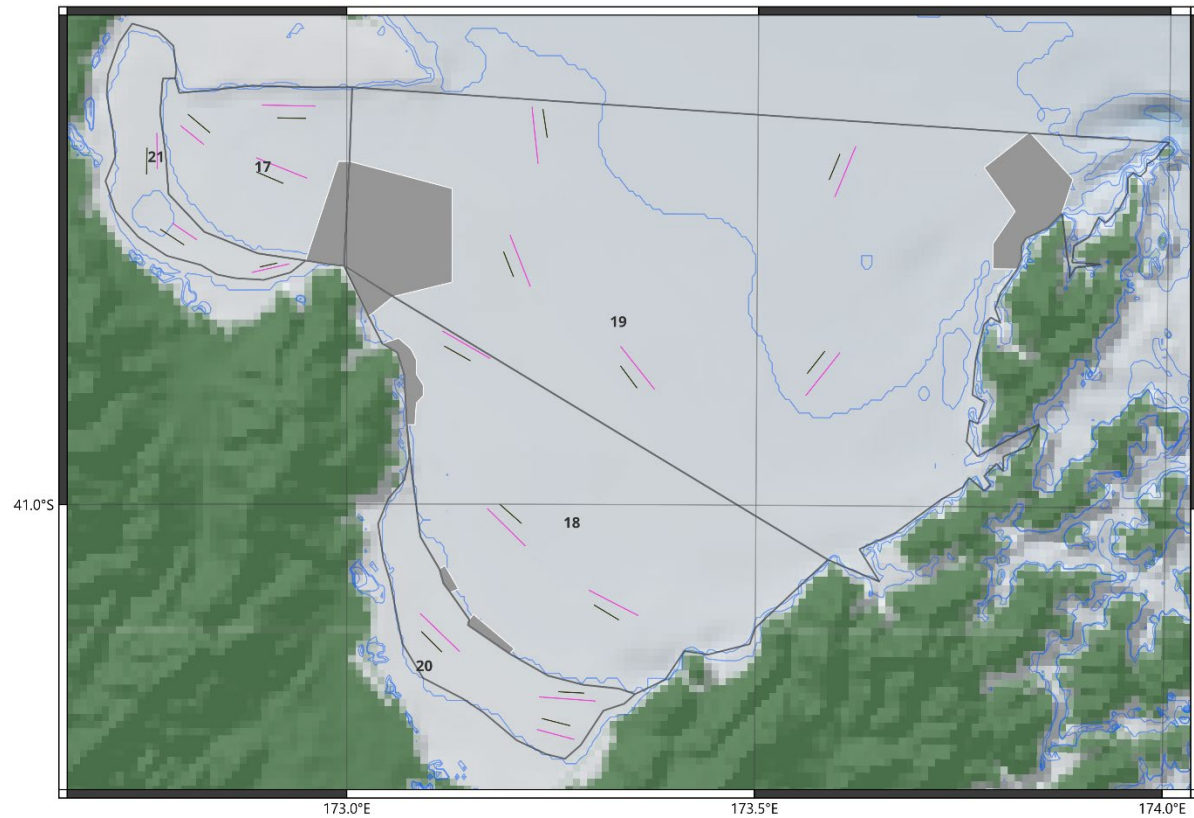
Appendix 2 Distance between paired tows

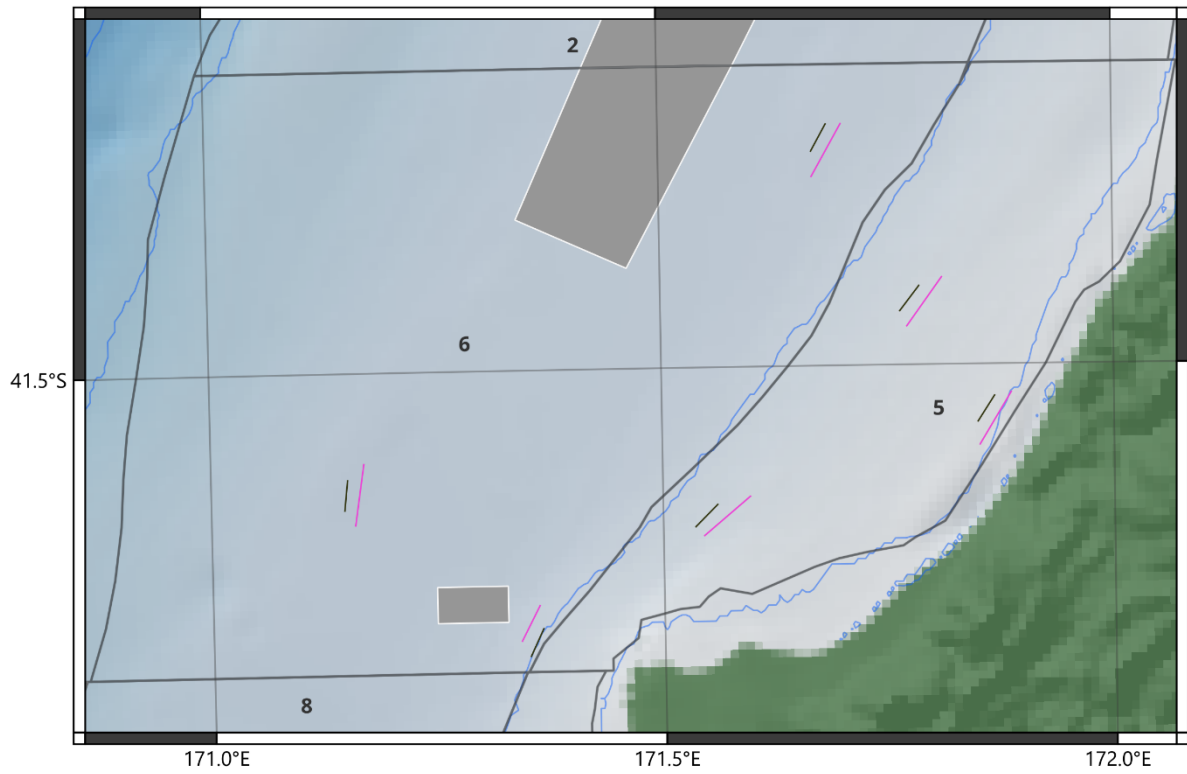
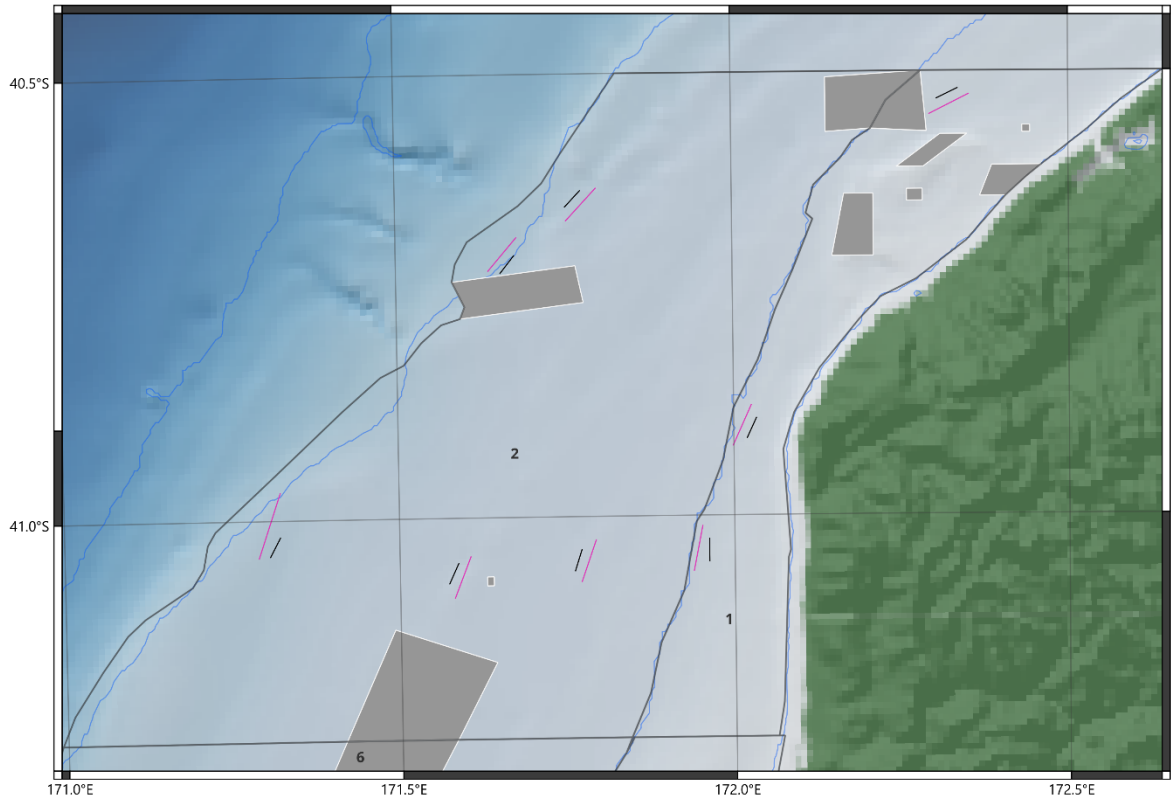
Distance between paired tows at each station.

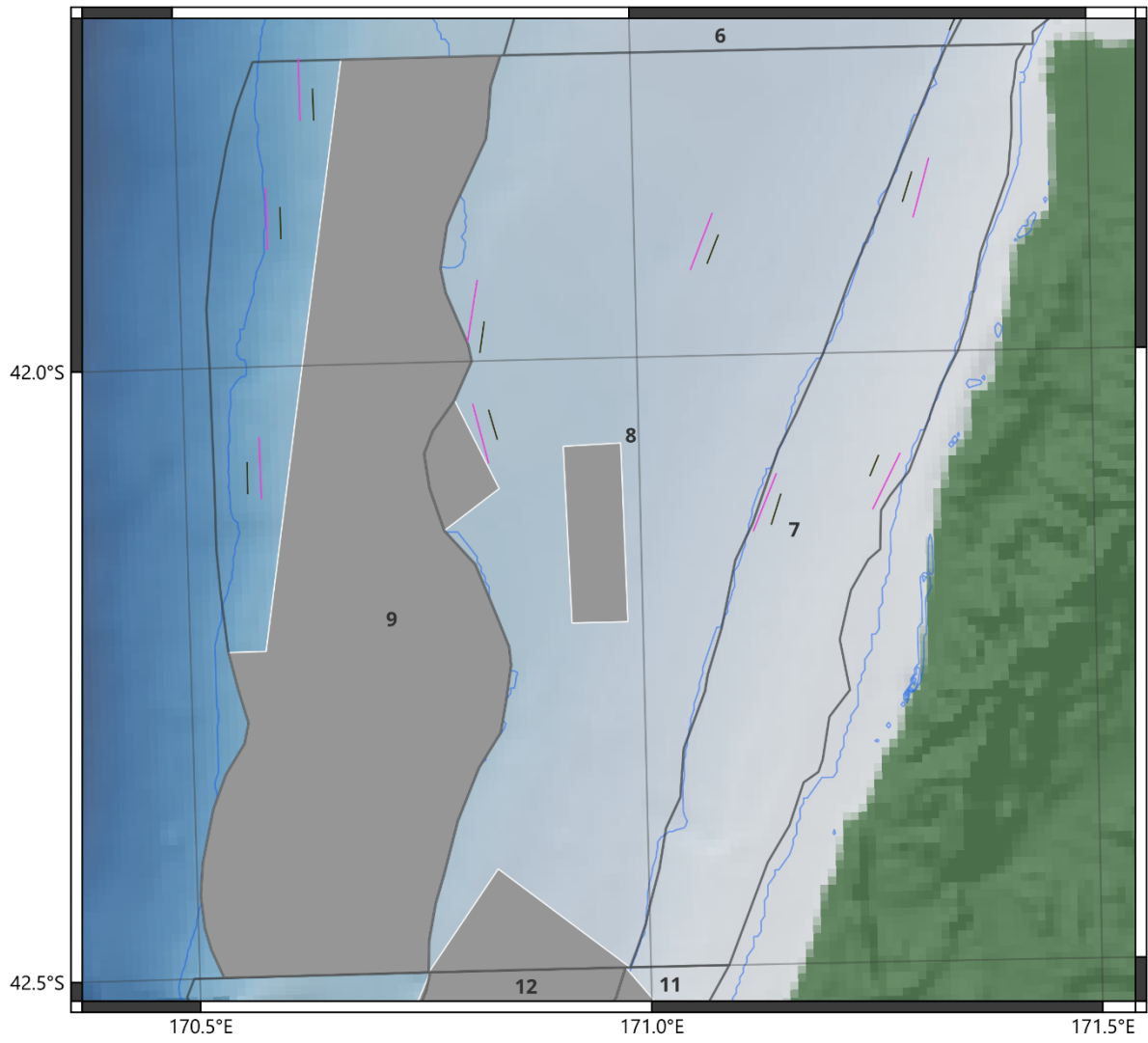
| Kaharoa station no. | Kaharoa II station no. | Stratum | Separation distance (km) |
|---------------------|------------------------|---------|--------------------------|
| 64 | 63 | 1 | 1.36 |
| 65 | 64 | 2 | 1.27 |
| 66 | 65 | 2 | 1.41 |
| 70 | 70 | 2 | 1.22 |
| 71 | 71 | 2 | 1.32 |
| 58 | 56 | 5 | 1.91 |
| 59 | 58 | 6 | 1.85 |
| 69 | 69 | 6 | 1.25 |
| 60 | 59 | 7 | 1.26 |
| 61 | 60 | 7 | 1.80 |
| 62 | 61 | 7 | 1.20 |
| 34 | 30 | 8 | 1.38 |
| 35 | 31 | 8 | 2.55 |
| 68 | 68 | 8 | 1.26 |
| 31 | 27 | 9 | 1.86 |
| 32 | 28 | 9 | 1.33 |
| 33 | 29 | 9 | 1.47 |
| 52 | 50 | 11 | 1.33 |
| 54 | 52 | 11 | 1.97 |
| 55 | 53 | 11 | 1.28 |
| 57 | 55 | 11 | 2.11 |
| 36 | 32 | 12 | 1.24 |
| 40 | 36 | 12 | 1.28 |
| 41 | 37 | 12 | 1.14 |
| 50 | 48 | 12 | 3.45 |
| 51 | 49 | 12 | 1.86 |
| 37 | 33 | 13 | 1.67 |
| 39 | 47 | 13 | 1.57 |
| 47 | 44 | 14 | 2.18 |
| 48 | 45 | 14 | 1.38 |
| 53 | 51 | 14 | 1.39 |
| 45 | 41 | 15 | 1.51 |
| 49 | 46 | 15 | 1.60 |
| 42 | 38 | 16 | 1.33 |
| 43 | 39 | 16 | 1.20 |
| 18 | 15 | 17 | 1.57 |
| 26 | 20 | 17 | 1.37 |
| 6 | 6 | 18 | 1.28 |
| 7 | 7 | 18 | 1.44 |
| 8 | 8 | 18 | 1.23 |
| 1 | 1 | 19 | 1.21 |
| 2 | 2 | 19 | 1.40 |
| 3 | 3 | 19 | 1.30 |
| 4 | 4 | 19 | 1.25 |
| 5 | 5 | 19 | 1.59 |
| 11 | 11 | 20 | 0.80 |
| 16 | 13 | 20 | 1.27 |
| 17 | 14 | 20 | 1.28 |
| 21 | 17 | 21 | 1.49 |
| 24 | 21 | 21 | 0.39 |
| 25 | 19 | 21 | 1.40 |
| 19 | 16 | 17 | 1.28 |
| 28 | 24 | 6 | 1.19 |
| 29 | 25 | 5 | 1.33 |
| 30 | 26 | 5 | 1.21 |
| 56 | 54 | 11 | 1.28 |
| 63 | 62 | 2 | 1.37 |
| 72 | 72 | 1 | 1.50 |
| 73 | 73 | 1 | 1.24 |

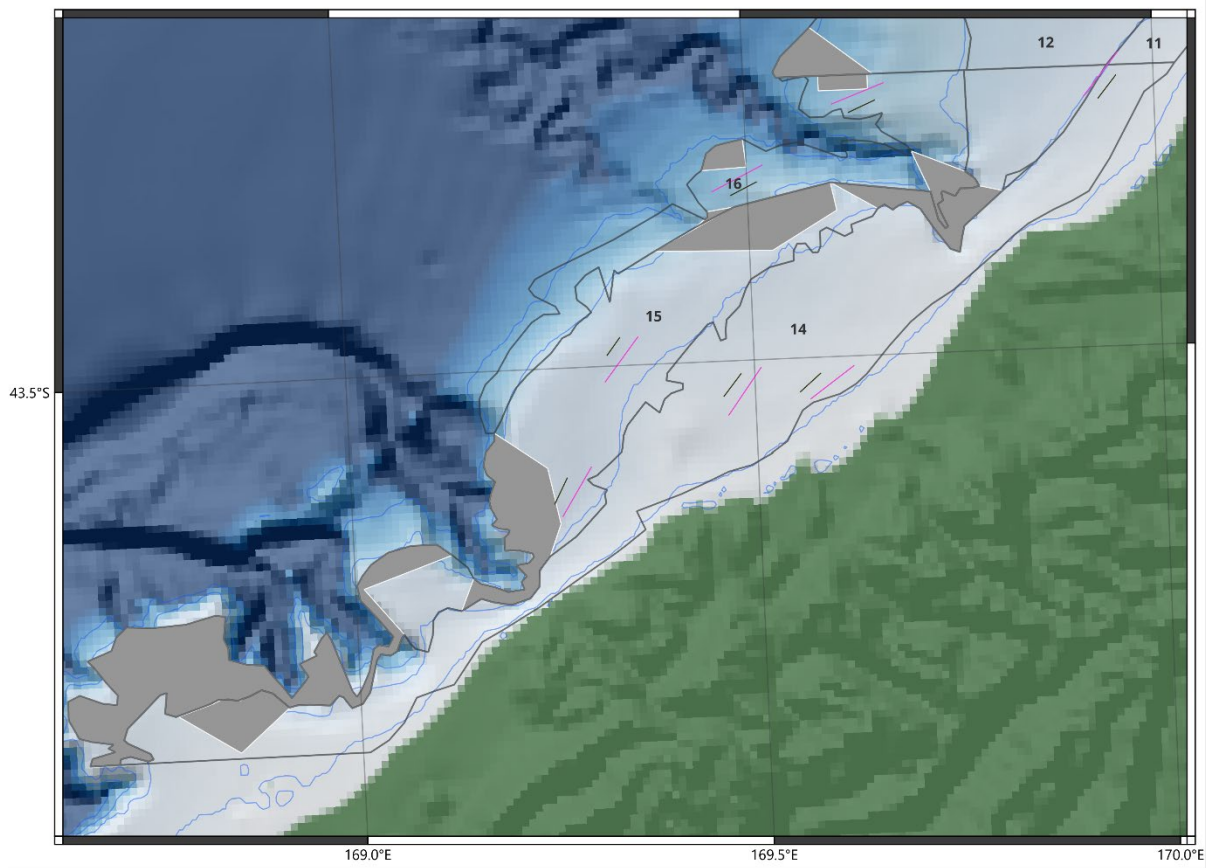
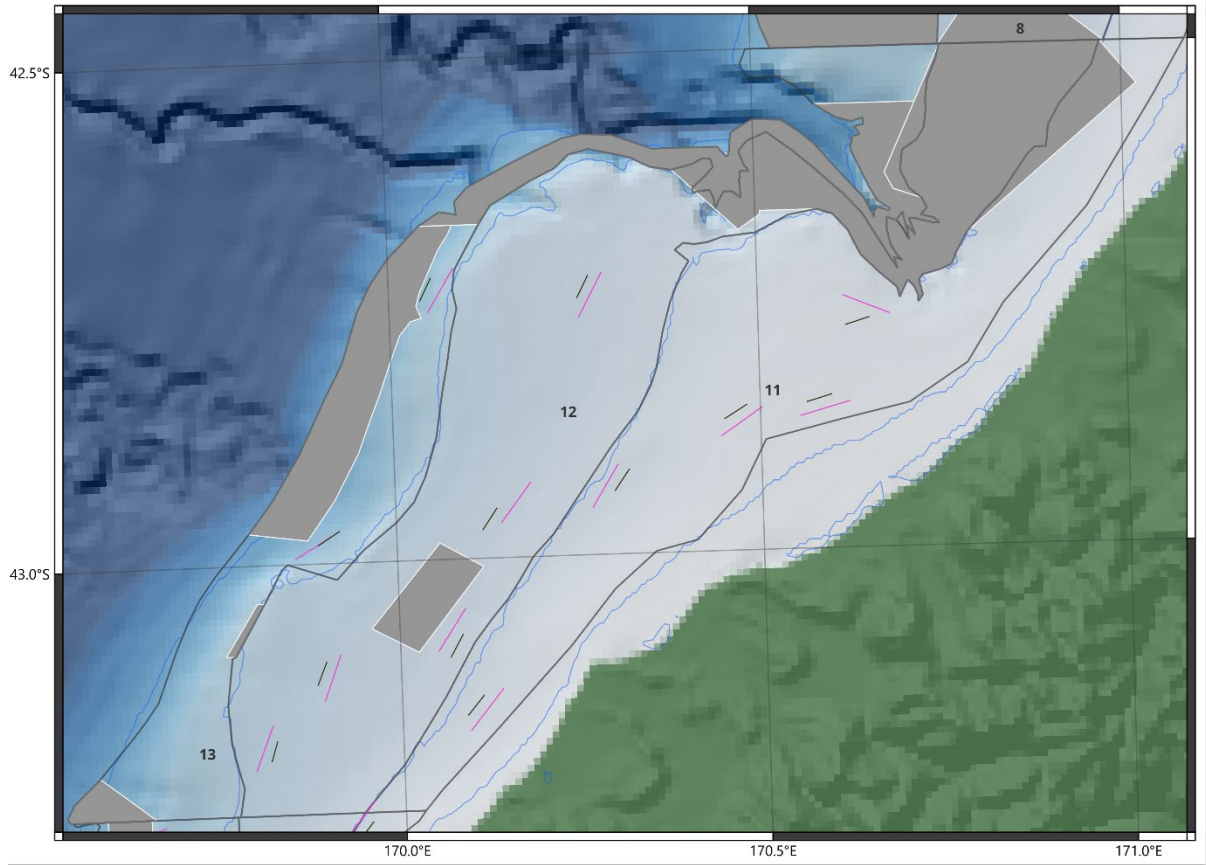
Appendix 3 Plots of paired intercalibration tows

Plots of paired intercalibration tows during the WCSI survey, where the tow path of *Kaharoa* is in pink and *Kaharoa II* is in black. Grey polygons indicate foul areas and numbers indicate stratum labels. Depth contours in strata 17–21 (TBGB) indicate 10, 20, 50, and 70 m, and on the WCSI, 20, 100, 200, and 400 m.









Appendix 4 Distributions of gear parameters

Histograms of distance fished (km), net doorspread (m), net headline height (m), average speed over ground, swept area (km²; distance fished × doorspread) for the *Kaharoa* and *Kaharoa II*, and for only *Kaharoa II*, wingspread (m), average speed through water (knots), and wingspread swept area (m²; distance fished × wingspread).



Appendix 5 Biomass ratios for species caught by both vessels

Estimated biomass (including lower and upper bounds, +/- 2 standard errors), coefficient of variation (CV), catch ratio (include 95% confidence intervals), and number of stations (No. stns) that registered catch by vessel for species caught during the WCSI intercalibration between *Kaharoa* (K) and *Kaharoa II* (K2). Biomass was estimated from all valid stations, i.e., with satisfactory or better gear performance and including extra stations conducted by *Kaharoa II*. All fish and QMS invertebrates which were caught by both vessels are included.

| Species | Name | | <i>Kaharoa</i> (K) | | | | <i>Kaharoa II</i> (K2) | | | | K2 to K | | K to K2 | | | No. stns | | |
|--------------|---------------------|---|--------------------|---------|-------|----|------------------------|---------|-------|-----|---------|-------|---------|-------|-------|----------|----|----|
| | Common | Scientific | Lower | Biomass | Upper | CV | Lower | Biomass | Upper | CV | Lower | Ratio | Upper | Lower | Ratio | Upper | K | K2 |
| SNA | Snapper | <i>Pagrus auratus</i> <i>Chelidonichthys</i> | 3 326 | 4 453 | 5 579 | 13 | 3 275 | 4 736 | 6 198 | 15 | 0.97 | 1.06 | 1.16 | 0.86 | 0.94 | 1.03 | 41 | 44 |
| GUR | Red gurnard | <i>kumu</i> <i>Chelidonichthys</i> | 1 406 | 1 896 | 2 385 | 13 | 620 | 1 081 | 1 542 | 21 | 0.45 | 0.57 | 0.73 | 1.38 | 1.75 | 2.23 | 45 | 40 |
| GUR- TBGB | Red gurnard | <i>kumu</i> <i>Chelidonichthys</i> | 468 | 645 | 821 | 14 | 61 | 156 | 250 | 30 | 0.18 | 0.24 | 0.33 | 3.01 | 4.13 | 5.67 | 17 | 18 |
| GUR- WCSI | Red gurnard | <i>kumu</i> <i>Chelidonichthys</i> | 795 | 1 251 | 1 707 | 18 | 474 | 926 | 1 377 | 24 | 0.62 | 0.74 | 0.89 | 1.13 | 1.35 | 1.62 | 28 | 22 |
| GIZ | Giant stargazer | <i>Kathetostoma</i> <i>giganteum</i> <i>Nemadactylus</i> | 389 | 724 | 1 058 | 23 | 149 | 286 | 423 | 24 | 0.30 | 0.40 | 0.53 | 1.91 | 2.53 | 3.35 | 26 | 22 |
| NMP | Tarakihi | <i>macropterus</i> | 489 | 660 | 830 | 13 | 298 | 441 | 584 | 16 | 0.58 | 0.67 | 0.77 | 1.30 | 1.50 | 1.73 | 39 | 35 |
| JDO | John dory | <i>Zeus faber</i> <i>Pseudophycis</i> | 133 | 219 | 305 | 20 | 148 | 244 | 340 | 20 | 0.98 | 1.11 | 1.26 | 0.79 | 0.90 | 1.02 | 31 | 33 |
| RCO | Red cod | <i>bachus</i> | 331 | 879 | 1 427 | 31 | 0 | 401 | 856 | 57 | 0.26 | 0.46 | 0.81 | 1.23 | 2.19 | 3.89 | 30 | 26 |
| SPD | Spiny dogfish | <i>Squalus acanthias</i> | 845 | 2 662 | 4 480 | 34 | 318 | 2 554 | 4 790 | 44 | 0.70 | 0.96 | 1.31 | 0.76 | 1.04 | 1.42 | 42 | 40 |
| SCH | School shark | <i>Galeorhinus galeus</i> <i>Mustelus</i> | 188 | 467 | 747 | 30 | 84 | 206 | 328 | 30 | 0.29 | 0.44 | 0.68 | 1.48 | 2.27 | 3.49 | 36 | 26 |
| SPO | Rig | <i>lenticulatus</i> | 303 | 515 | 727 | 21 | 144 | 264 | 385 | 23 | 0.41 | 0.51 | 0.64 | 1.56 | 1.95 | 2.45 | 40 | 32 |
| ELE | Elephant fish | <i>Callorhynchus milii</i> <i>Hydrolagus</i> | 0 | 87 | 183 | 55 | 0 | 90 | 201 | 61 | 0.46 | 1.04 | 2.33 | 0.43 | 0.96 | 2.16 | 7 | 4 |
| GSH | Ghost shark | <i>novaezealandiae</i> | 156 | 587 | 1 019 | 37 | 50 | 209 | 368 | 38 | 0.28 | 0.36 | 0.46 | 2.20 | 2.81 | 3.58 | 24 | 18 |
| HBA | Bigeye sea perch | <i>Helicolenus</i> <i>barathri</i> <i>Helicolenus</i> | 16 | 42 | 68 | 31 | 24 | 46 | 69 | 24 | 0.93 | 1.10 | 1.31 | 0.77 | 0.91 | 1.08 | 12 | 13 |
| HPC | Sea perch | <i>percoides</i> <i>Helicolenus</i> <i>barathri</i> & <i>H.</i> | 7 | 28 | 49 | 37 | 0 | 7 | 14 | 55 | 0.08 | 0.23 | 0.69 | 1.44 | 4.30 | 12.82 | 16 | 11 |
| SPE | Sea perch | <i>percoides</i> | 35 | 71 | 106 | 25 | 29 | 53 | 77 | 23 | 0.65 | 0.75 | 0.86 | 1.16 | 1.33 | 1.53 | 23 | 17 |
| ANC | Anchovy | <i>Engraulis australis</i> | 0 | 2 | 6 | 82 | 1 | 3 | 4 | 28 | 0.24 | 1.19 | 6.01 | 0.17 | 0.84 | 4.27 | 5 | 11 |
| ATT | Kahawai | <i>Arripis trutta</i> | 10 | 45 | 81 | 39 | 9 | 39 | 70 | 39 | 0.35 | 0.87 | 2.15 | 0.47 | 1.16 | 2.87 | 17 | 15 |
| BAR | Barracouta | <i>Thyrsites atun</i> | 850 | 1 623 | 2 396 | 24 | 786 | 1 180 | 1 574 | 17 | 0.54 | 0.73 | 0.99 | 1.01 | 1.37 | 1.87 | 50 | 42 |
| BCO | Blue cod | <i>Parapercis colias</i> | 2 | 9 | 16 | 40 | 0 | 5 | 16 | 98 | 0.16 | 0.61 | 2.33 | 0.43 | 1.64 | 6.25 | 7 | 2 |
| BRI | Brill | <i>Colistium guntheri</i> | 0 | 4 | 10 | 92 | 0 | 1 | 2 | 100 | 0.15 | 0.20 | 0.26 | 3.89 | 4.92 | 6.22 | 2 | 1 |

| | | Name | Kaharoa (K) | | | | Kaharoa II (K2) | | | | K2 to K | | | K to K2 | | | No. stns | |
|-----|--------------------------|--------------------------------------|-------------|-----|-----|----|-----------------|-------|-------|-----|---------|------|-------|---------|------|-------|----------|----|
| CAR | Carpet shark | <i>Cephaloscyllium isabellum</i> | 237 | 329 | 421 | 14 | 83 | 138 | 192 | 20 | 0.35 | 0.42 | 0.50 | 2.00 | 2.39 | 2.85 | 36 | 21 |
| | Two saddle rattail | <i>Coelorinchus biclinozonalis</i> | 0 | 15 | 32 | 53 | 1 | 6 | 11 | 44 | 0.16 | 0.39 | 0.95 | 1.06 | 2.56 | 6.20 | 7 | 5 |
| CBI | Small banded rattail | <i>Coelorinchus parvifasciatus</i> | 0 | 12 | 24 | 51 | 0 | 5 | 12 | 64 | 0.29 | 0.46 | 0.72 | 1.39 | 2.18 | 3.41 | 7 | 4 |
| CCX | | <i>Capromimus abbreviatus</i> | 13 | 33 | 53 | 31 | 4 | 22 | 40 | 40 | 0.45 | 0.68 | 1.02 | 0.98 | 1.48 | 2.23 | 21 | 19 |
| CDO | Capro dory | | 13 | 31 | 49 | 29 | 0 | 11 | 31 | 98 | 0.07 | 0.34 | 1.66 | 0.60 | 2.94 | 14.35 | 10 | 2 |
| CON | Conger eel | <i>Conger</i> spp. | | | | | | | | | | | | | | | | |
| CUC | Cucumber fish | <i>Paraulopus nigripinnis</i> | 0 | 259 | 549 | 56 | 91 | 197 | 302 | 27 | 0.29 | 0.76 | 1.97 | 0.51 | 1.32 | 3.42 | 24 | 26 |
| | | <i>Myliobatis tenuicaudatus</i> | 11 | 29 | 47 | 31 | 1 | 36 | 71 | 48 | 0.58 | 1.26 | 2.75 | 0.36 | 0.79 | 1.73 | 9 | 10 |
| EGR | Eagle ray | | | | | | | | | | | | | | | | | |
| | Blue mackerel | <i>Scomber australasicus</i> | 0 | 2 | 5 | 94 | 0 | 1 | 2 | 51 | 0.08 | 0.49 | 3.07 | 0.33 | 2.04 | 12.76 | 4 | 7 |
| EMA | | | 0 | 19 | 40 | 55 | 0 | 10 | 25 | 81 | 0.07 | 0.51 | 3.91 | 0.26 | 1.95 | 14.88 | 5 | 2 |
| ERA | Electric ray | <i>Torpedo fairchildi</i> | | | | | | | | | | | | | | | | |
| | | <i>Peltorhamphus novaezeelandiae</i> | 0 | 22 | 45 | 52 | 0 | 8 | 18 | 57 | 0.15 | 0.38 | 0.99 | 1.02 | 2.64 | 6.86 | 8 | 7 |
| ESO | N.z. sole | <i>Euclichthys polynemus</i> | 0 | 2 | 4 | 80 | 0 | 2 | 4 | 50 | 0.69 | 1.23 | 2.20 | 0.46 | 0.82 | 1.45 | 2 | 3 |
| EUC | Eucla cod | | 34 | 110 | 186 | 35 | 0 | 234 | 499 | 56 | 1.33 | 2.13 | 3.42 | 0.29 | 0.47 | 0.75 | 17 | 19 |
| FRO | Frostfish | <i>Lepidopus caudatus</i> | | | | | | | | | | | | | | | | |
| HAK | Hake | <i>Merluccius australis</i> | 0 | 11 | 29 | 78 | 0 | 10 | 19 | 49 | 0.16 | 0.86 | 4.56 | 0.22 | 1.16 | 6.19 | 7 | 6 |
| | | <i>Macruronus novaezeelandiae</i> | 0 | 103 | 226 | 59 | 12 | 48 | 84 | 38 | 0.20 | 0.46 | 1.08 | 0.92 | 2.16 | 5.07 | 11 | 10 |
| HOK | Hoki | <i>Lepidorhynchus denticulatus</i> | 0 | 2 | 4 | 54 | 0 | 0 | 1 | 73 | 0.09 | 0.19 | 0.40 | 2.53 | 5.37 | 11.39 | 4 | 2 |
| JAV | Javelin fish | | 0 | 21 | 50 | 71 | 0 | 4 | 8 | 56 | 0.13 | 0.19 | 0.27 | 3.71 | 5.27 | 7.49 | 5 | 4 |
| JGU | Spotted gurnard | <i>Pterygotrigla picta</i> | | | | | | | | | | | | | | | | |
| | Greenback jack mackerel | <i>Trachurus declivis</i> | 0 | 430 | 959 | 61 | 0 | 655 | 1 326 | 51 | 0.83 | 1.52 | 2.77 | 0.36 | 0.66 | 1.20 | 25 | 32 |
| JMD | Yellowtail jack mackerel | <i>Trachurus novaezeelandiae</i> | 104 | 215 | 326 | 26 | 892 | 1 885 | 2 878 | 26 | 4.77 | 8.76 | 16.07 | 0.06 | 0.11 | 0.20 | 33 | 38 |
| JMN | | | 0 | 32 | 69 | 57 | 23 | 138 | 252 | 42 | 1.07 | 4.26 | 16.92 | 0.06 | 0.23 | 0.93 | 4 | 8 |
| KIN | Kingfish | <i>Seriola lalandi</i> | | | | | | | | | | | | | | | | |
| LEA | Leatherjacket | <i>Meuschenia scaber</i> | 25 | 66 | 108 | 31 | 9 | 47 | 84 | 41 | 0.56 | 0.70 | 0.87 | 1.14 | 1.42 | 1.76 | 10 | 6 |
| | | <i>Genypterus blacodes</i> | 10 | 64 | 118 | 42 | 3 | 11 | 19 | 37 | 0.08 | 0.17 | 0.35 | 2.79 | 5.75 | 11.83 | 15 | 8 |
| LIN | Ling | | 44 | 75 | 105 | 21 | 7 | 14 | 21 | 25 | 0.13 | 0.19 | 0.27 | 3.71 | 5.25 | 7.42 | 30 | 18 |
| LSO | Lemon sole | <i>Pelotretis flavilatus</i> | | | | | | | | | | | | | | | | |
| NSD | Northern spiny dogfish | <i>Squalus griffini</i> | 190 | 321 | 451 | 20 | 87 | 160 | 233 | 23 | 0.44 | 0.50 | 0.57 | 1.75 | 2.00 | 2.29 | 21 | 14 |
| | | <i>Pinnoctopus cordiformis</i> | 0 | 7 | 14 | 54 | 0 | 5 | 15 | 100 | 0.07 | 0.75 | 7.55 | 0.13 | 1.33 | 13.32 | 3 | 1 |
| OCT | Octopus | <i>Auchenoceros punctatus</i> | 0 | 0 | 0 | 71 | 0 | 0 | 0 | 100 | 0.13 | 0.54 | 2.27 | 0.44 | 1.85 | 7.77 | 2 | 1 |
| PCO | Ahuru | | 0 | 0 | 1 | 86 | 0 | 1 | 2 | 93 | 0.15 | 1.93 | 25.21 | 0.04 | 0.52 | 6.78 | 2 | 3 |
| PIL | Pilchard | <i>Sardinops sagax</i> | | | | | | | | | | | | | | | | |

| | Name | | <i>Kaharoa</i> (K) | | | | <i>Kaharoa II</i> (K2) | | | | K2 to K | | | K to K2 | | | No. stns | |
|-----|----------------------|----------------------------------|--------------------|-----|-------|-----|------------------------|-----|-----|-----|---------|-------|--------|---------|-------|-------|----------|----|
| POP | Porcupine fish | <i>Allomycterus jaculiferus</i> | 173 | 348 | 523 | 25 | 57 | 253 | 449 | 39 | 0.46 | 0.73 | 1.15 | 0.87 | 1.37 | 2.16 | 20 | 13 |
| RHY | Common roughy | <i>Paratrachichthys trailli</i> | 0 | 1 | 4 | 91 | 0 | 92 | 276 | 100 | 5.12 | 67.14 | 881.10 | 0.00 | 0.01 | 0.25 | 2 | 1 |
| RMU | Red mullet | <i>Upeneichthys lineatus</i> | 0 | 3 | 10 | 98 | 0 | 0 | 1 | 100 | 0.08 | 0.09 | 0.10 | 9.92 | 10.60 | 11.32 | 2 | 1 |
| RSK | Rough skate | <i>Zearaja nasuta</i> | 19 | 128 | 236 | 43 | 9 | 35 | 61 | 38 | 0.12 | 0.27 | 0.63 | 1.57 | 3.64 | 8.43 | 16 | 9 |
| RSO | Gemfish | <i>Rexea solandri</i> | 327 | 922 | 1 517 | 32 | 242 | 472 | 702 | 24 | 0.30 | 0.51 | 0.87 | 1.14 | 1.95 | 3.34 | 29 | 23 |
| SCA | Scallop | <i>Pecten novaezealandiae</i> | 0 | 0 | 1 | 68 | 0 | 1 | 1 | 56 | 0.51 | 1.75 | 5.99 | 0.17 | 0.57 | 1.96 | 3 | 5 |
| SCG | Scaly gurnard | <i>Lepidotrigla brachyoptera</i> | 41 | 75 | 109 | 23 | 17 | 29 | 42 | 21 | 0.29 | 0.39 | 0.53 | 1.87 | 2.55 | 3.47 | 36 | 32 |
| SDO | Silver dory | <i>Cyttus novaezealandiae</i> | 1 | 2 | 3 | 29 | 0 | 16 | 45 | 86 | 1.40 | 9.02 | 58.31 | 0.02 | 0.11 | 0.71 | 13 | 12 |
| SFL | Sand flounder | <i>Rhombosolea plebeia</i> | 10 | 43 | 76 | 39 | 1 | 7 | 14 | 42 | 0.13 | 0.17 | 0.22 | 4.51 | 5.84 | 7.57 | 15 | 9 |
| SPA | Slender sprat | <i>Sprattus antipodum</i> | 0 | 0 | 0 | 100 | 0 | 0 | 0 | 100 | 0.11 | 1.89 | 32.86 | 0.03 | 0.53 | 9.13 | 1 | 1 |
| SPZ | Spotted stargazer | <i>Genyagnus monopterygius</i> | 0 | 4 | 8 | 56 | 0 | 1 | 2 | 92 | 0.05 | 0.20 | 0.83 | 1.20 | 5.02 | 21.03 | 6 | 2 |
| SQU | Arrow squid | <i>Nototodarus sloanii</i> | 143 | 311 | 479 | 27 | 212 | 295 | 378 | 14 | 0.65 | 0.95 | 1.39 | 0.72 | 1.05 | 1.54 | 43 | 48 |
| SSH | Slender smooth-hound | <i>& N. gouldi</i> | 1 | 22 | 43 | 48 | 0 | 3 | 8 | 100 | 0.04 | 0.12 | 0.34 | 2.96 | 8.25 | 22.97 | 3 | 1 |
| SSI | Silverside | <i>Gollum attenuatus</i> | 3 | 5 | 7 | 21 | 0 | 2 | 3 | 39 | 0.24 | 0.39 | 0.64 | 1.57 | 2.59 | 4.27 | 23 | 11 |
| SSK | Smooth skate | <i>Argentina elongata</i> | 38 | 130 | 223 | 35 | 0 | 56 | 115 | 54 | 0.19 | 0.43 | 0.97 | 1.03 | 2.34 | 5.33 | 13 | 9 |
| STY | Spotty Silver | <i>Dipturus innominatus</i> | 0 | 3 | 6 | 50 | 0 | 0 | 1 | 87 | 0.03 | 0.12 | 0.42 | 2.39 | 8.21 | 28.19 | 7 | 3 |
| SWA | Warehou | <i>Notolabrus celidotus</i> | 1 | 4 | 6 | 33 | 1 | 2 | 3 | 24 | 0.41 | 0.58 | 0.82 | 1.22 | 1.72 | 2.42 | 9 | 9 |
| TOD | Dark toadfish | <i>Seriolella punctata</i> | 0 | 0 | 0 | 100 | 0 | 0 | 1 | 100 | 3.60 | 3.60 | 3.60 | 0.28 | 0.28 | 0.28 | 1 | 1 |
| TRE | Trevally | <i>Neophrynichthys latus</i> | 30 | 75 | 121 | 30 | 75 | 138 | 200 | 23 | 1.27 | 1.83 | 2.64 | 0.38 | 0.55 | 0.79 | 15 | 20 |
| TUR | Turbot | <i>Pseudocaranx georgianus</i> | 0 | 2 | 5 | 72 | 0 | 3 | 10 | 100 | 0.48 | 1.55 | 5.04 | 0.20 | 0.64 | 2.08 | 2 | 1 |
| WAR | Common warehou | <i>Colistium nudipinnis</i> | 0 | 125 | 309 | 73 | 2 | 28 | 53 | 46 | 0.04 | 0.22 | 1.17 | 0.85 | 4.51 | 23.81 | 14 | 12 |
| WIT | Witch Yellowbelly | <i>Seriolella brama</i> | 18 | 47 | 76 | 31 | 2 | 22 | 43 | 46 | 0.23 | 0.47 | 0.97 | 1.03 | 2.13 | 4.41 | 40 | 27 |
| YBF | flounder | <i>Arnoglossus scapha</i> | 0 | 3 | 5 | 42 | 0 | 0 | 0 | 61 | 0.02 | 0.03 | 0.05 | 19.61 | 28.88 | 42.53 | 4 | 2 |
| | | <i>Rhombosolea leporina</i> | | | | | | | | | | | | | | | | |

Appendix 6 Length frequency comparison plots

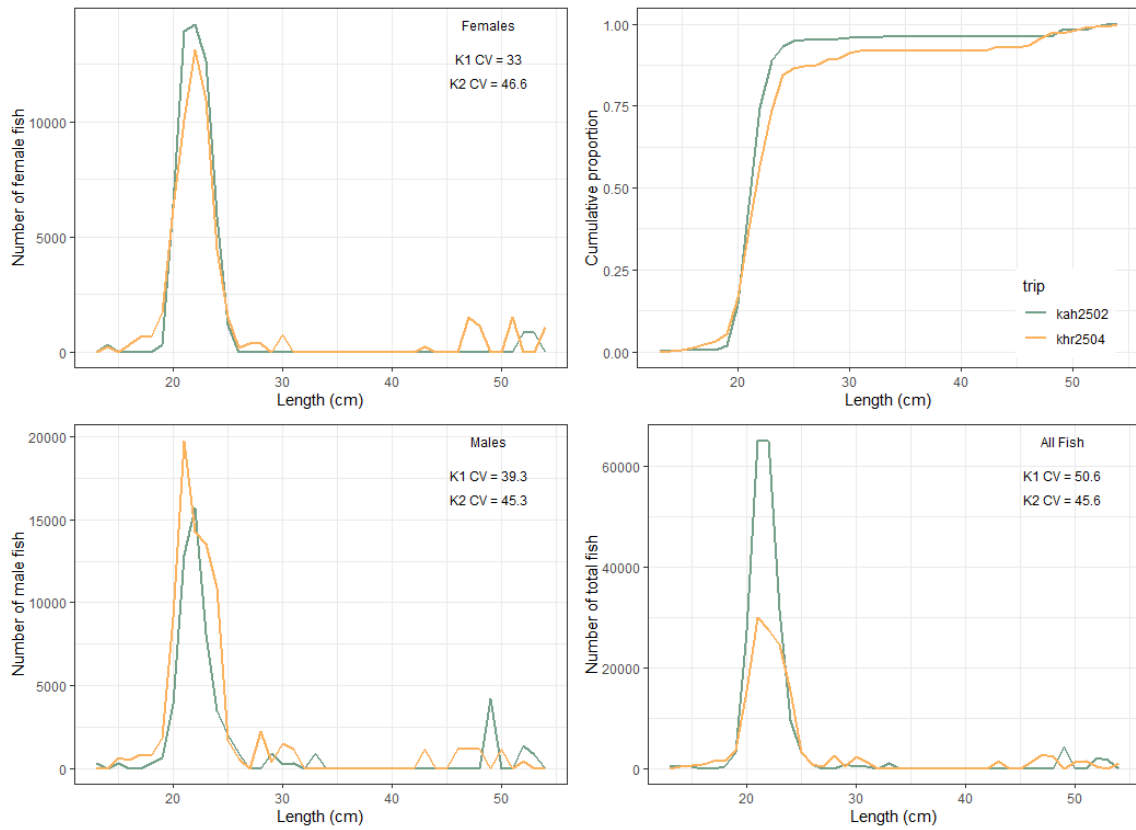


Figure A6-1: Kahawai scaled length frequency distributions for male (bottom left), female (top left), and all fish (bottom right), and cumulative proportion by length (top right) for *Kaharoa* (green line) and *Kaharoa II* (yellow line). The extra tows conducted by the *Kaharoa II* were included. CVs of the length distribution are included in the length frequency plots. Cumulative proportions were not scaled to total catch of both vessels.

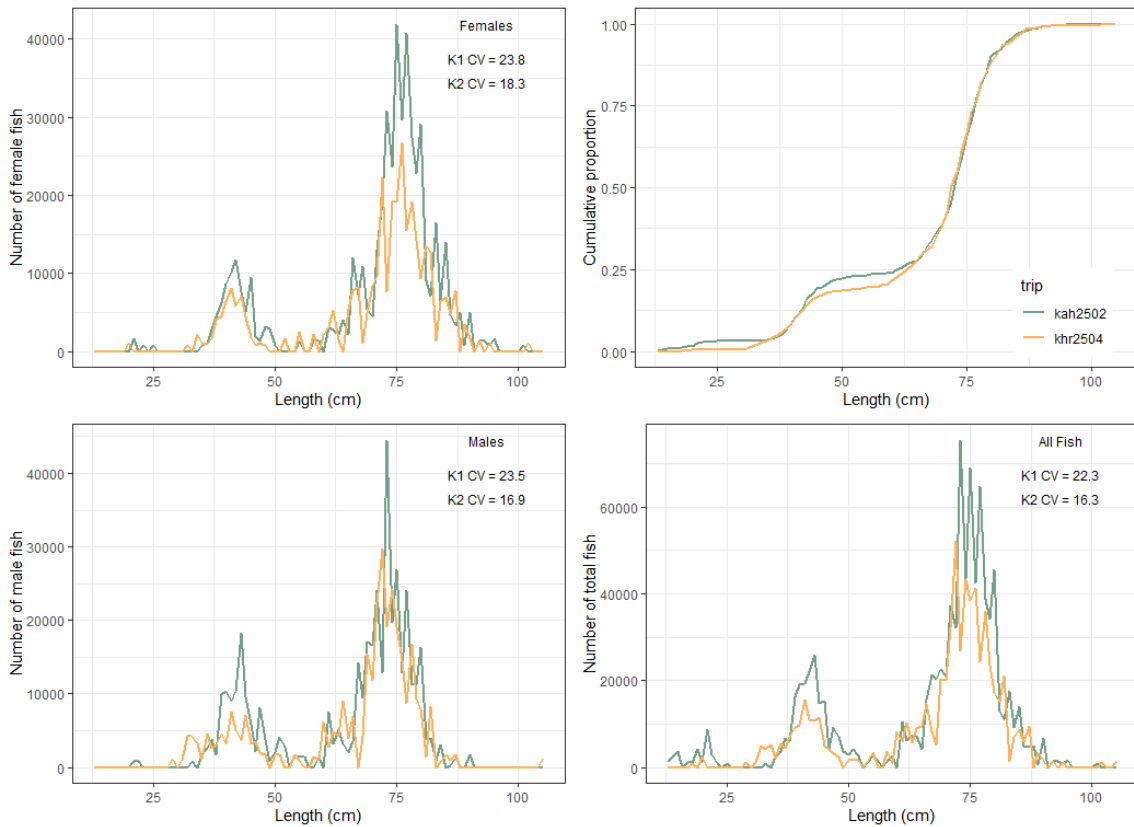


Figure A6-2: Barracouta scaled length frequency distributions for male (bottom left), female (top left), and all fish (bottom right), and cumulative proportion by length (top right) for *Kaharoa* (green line) and *Kaharoa II* (yellow line) (see Figure A6-1).

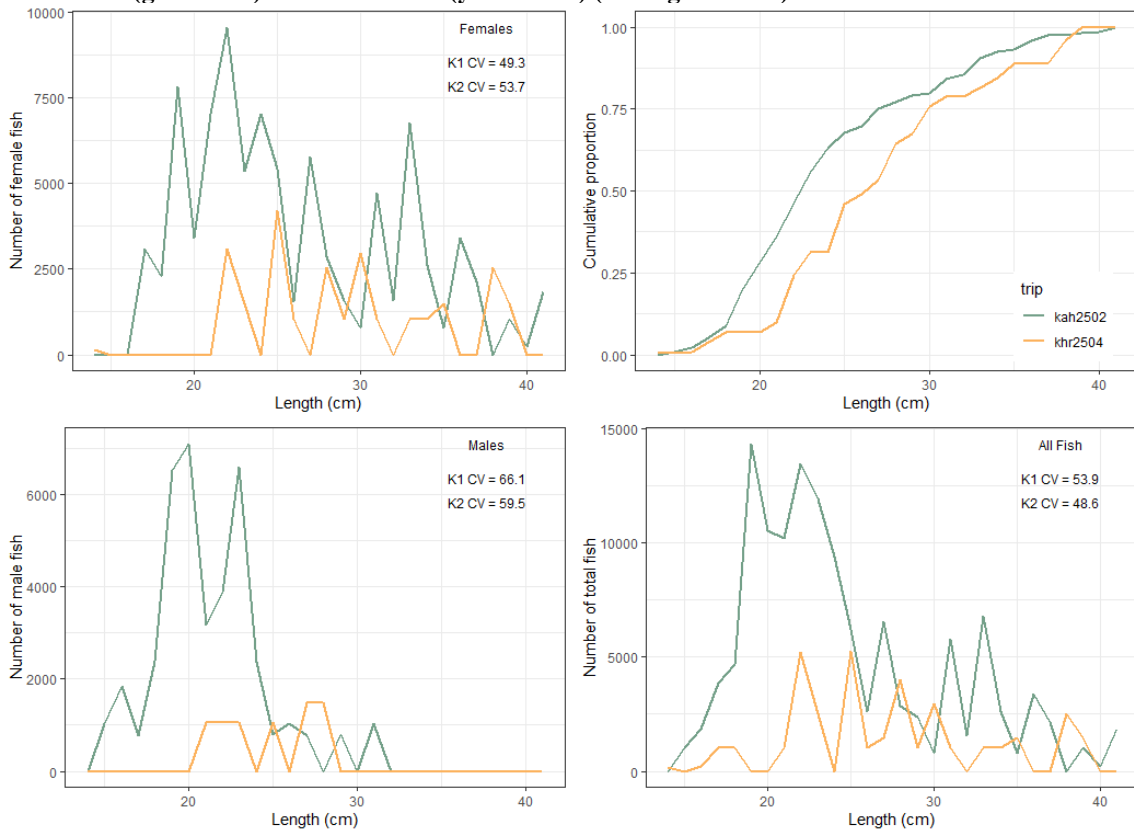


Figure A6-3: English sole scaled length frequency distributions for male (bottom left), female (top left), and all fish (bottom right), and cumulative proportion by length (top right) for *Kaharoa* (green line) and *Kaharoa II* (yellow line) (see Figure A6-1).

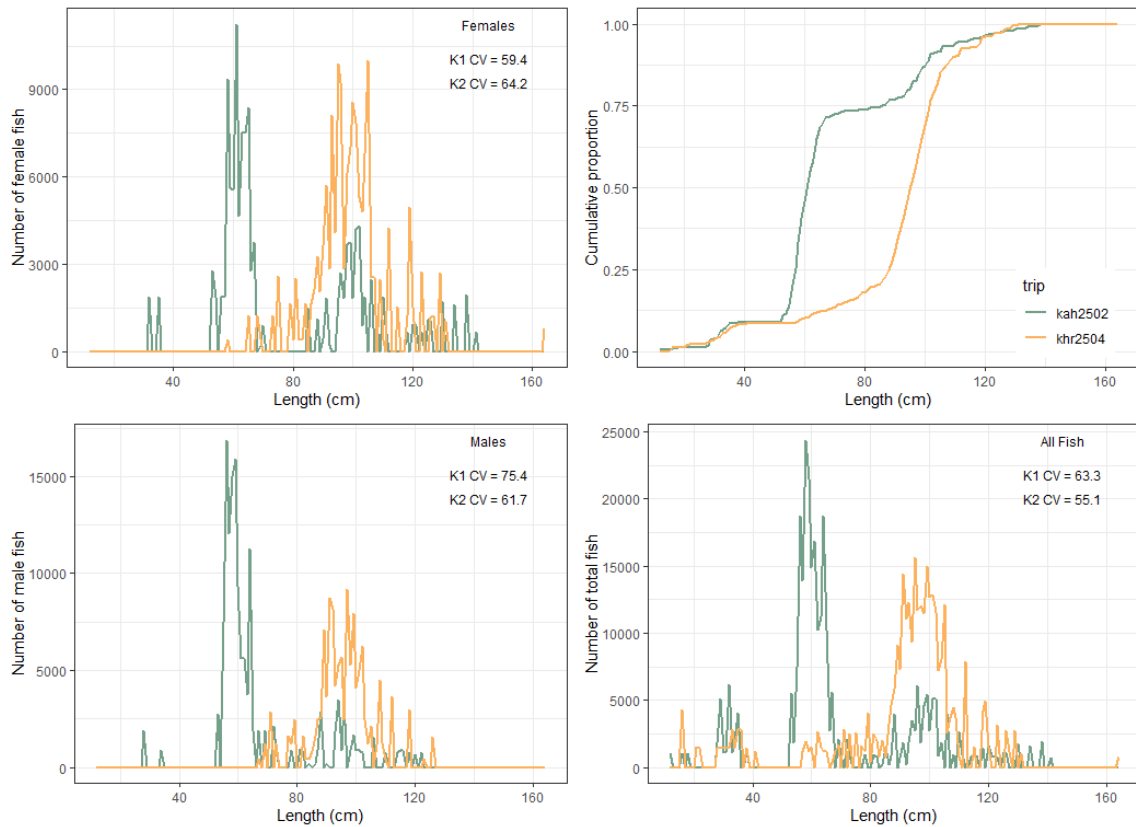


Figure A6-4: Frostfish scaled length frequency distributions for male (bottom left), female (top left), and all fish (bottom right), and cumulative proportion by length (top right) for *Kaharoa* (green line) and *Kaharoa II* (yellow line) (see Figure A6-1).

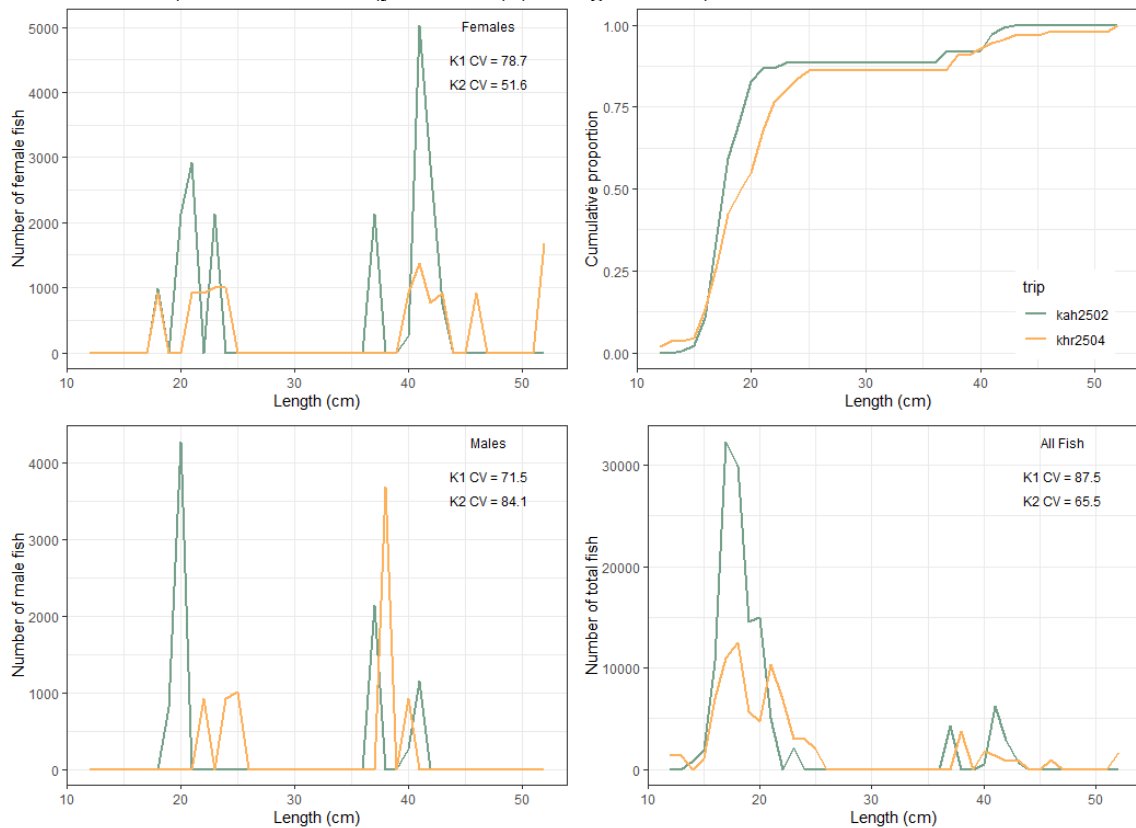


Figure A6-5: Hake scaled length frequency distributions for male (bottom left), female (top left), and all fish (bottom right), and cumulative proportion by length (top right) for *Kaharoa* (green line) and *Kaharoa II* (yellow line) (see Figure A6-1).

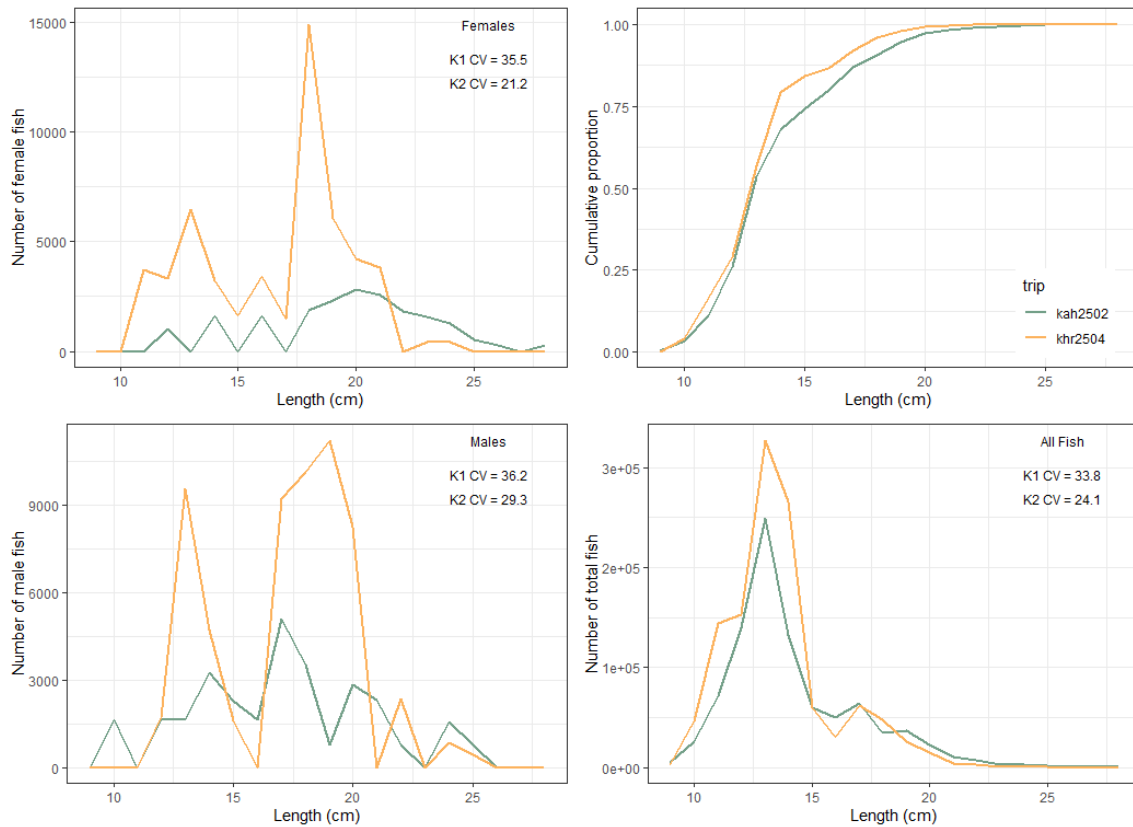


Figure A6-6: Bigeye sea perch (*Helicolenus barathri*) scaled length frequency distributions for male (bottom left), female (top left), and all fish (bottom right), and cumulative proportion by length (top right) for *Kaharoa* (green line) and *Kaharoa II* (yellow line) (see Figure A6-1).

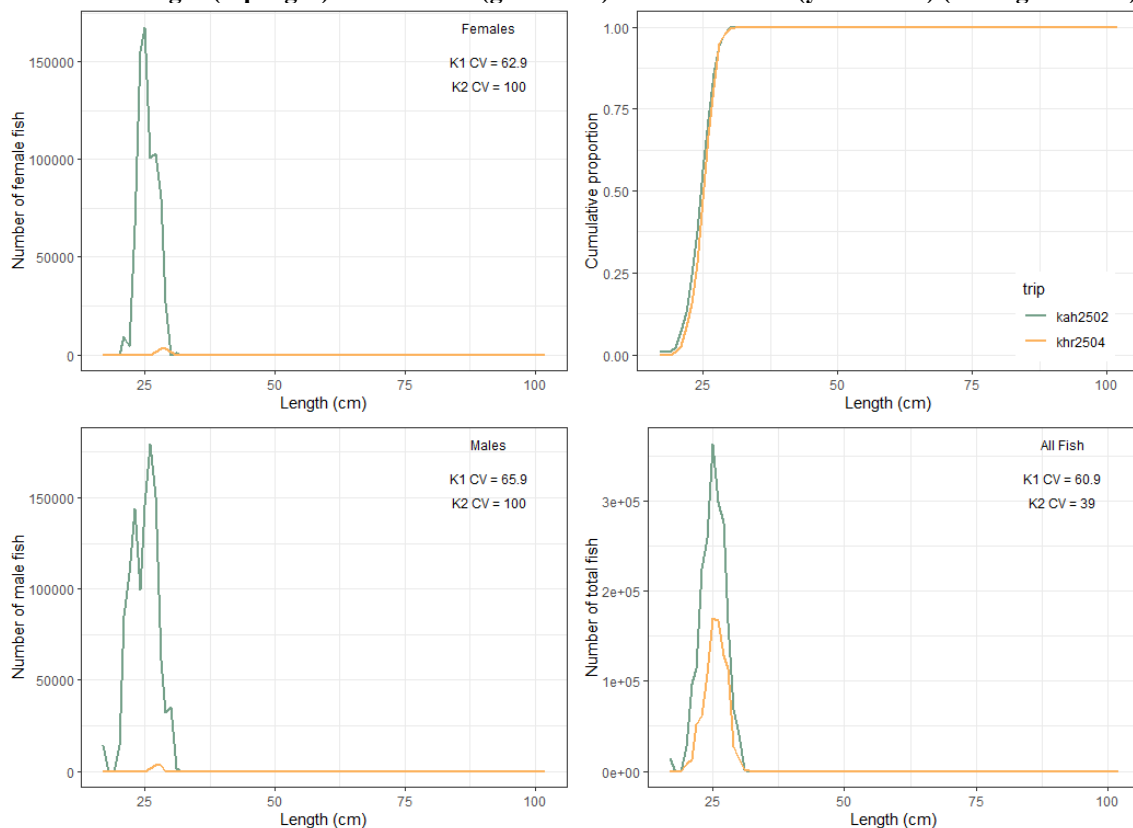


Figure A6-7: Hoki scaled length frequency distributions for male (bottom left), female (top left), and all fish (bottom right), and cumulative proportion by length (top right) for *Kaharoa* (green line) and *Kaharoa II* (yellow line) (see Figure A6-1).

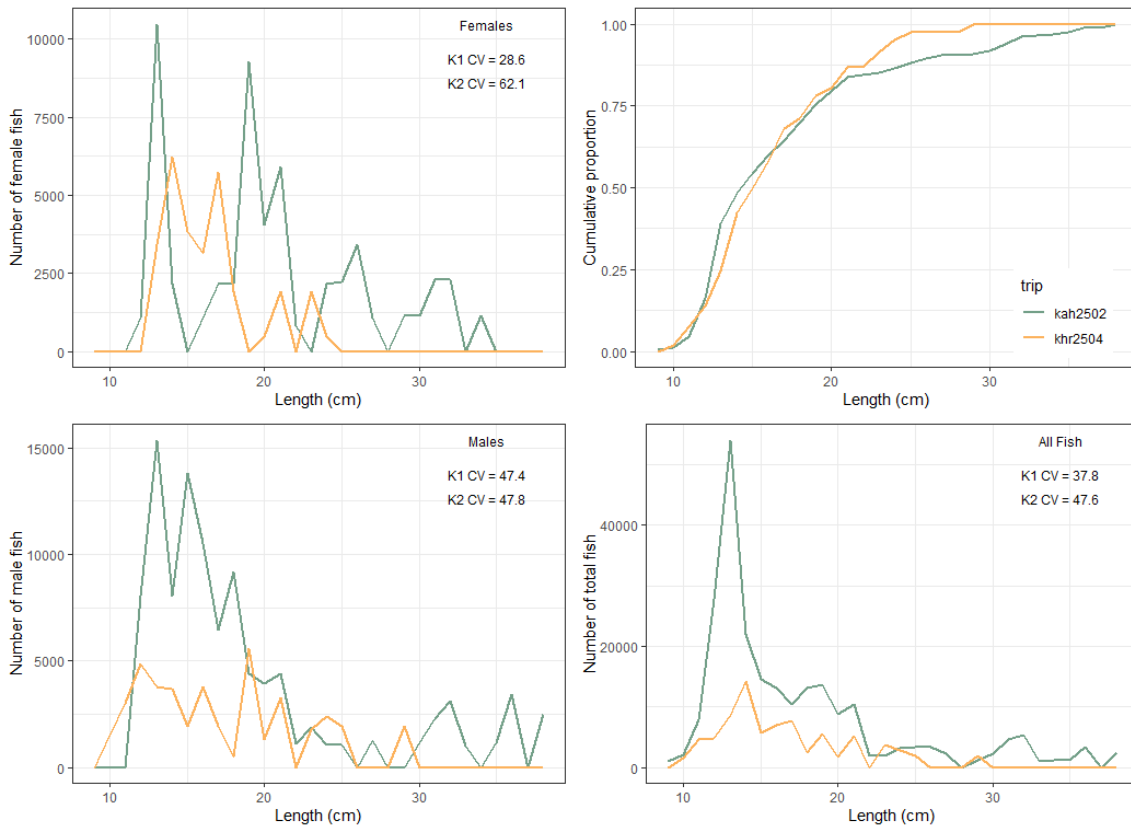


Figure A6-8: Sea perch (*Helicolenus percoides*) scaled length frequency distributions for male (bottom left), female (top left), and all fish (bottom right), and cumulative proportion by length (top right) for *Kaharoa* (green line) and *Kaharoa II* (yellow line) (see Figure A6-1).

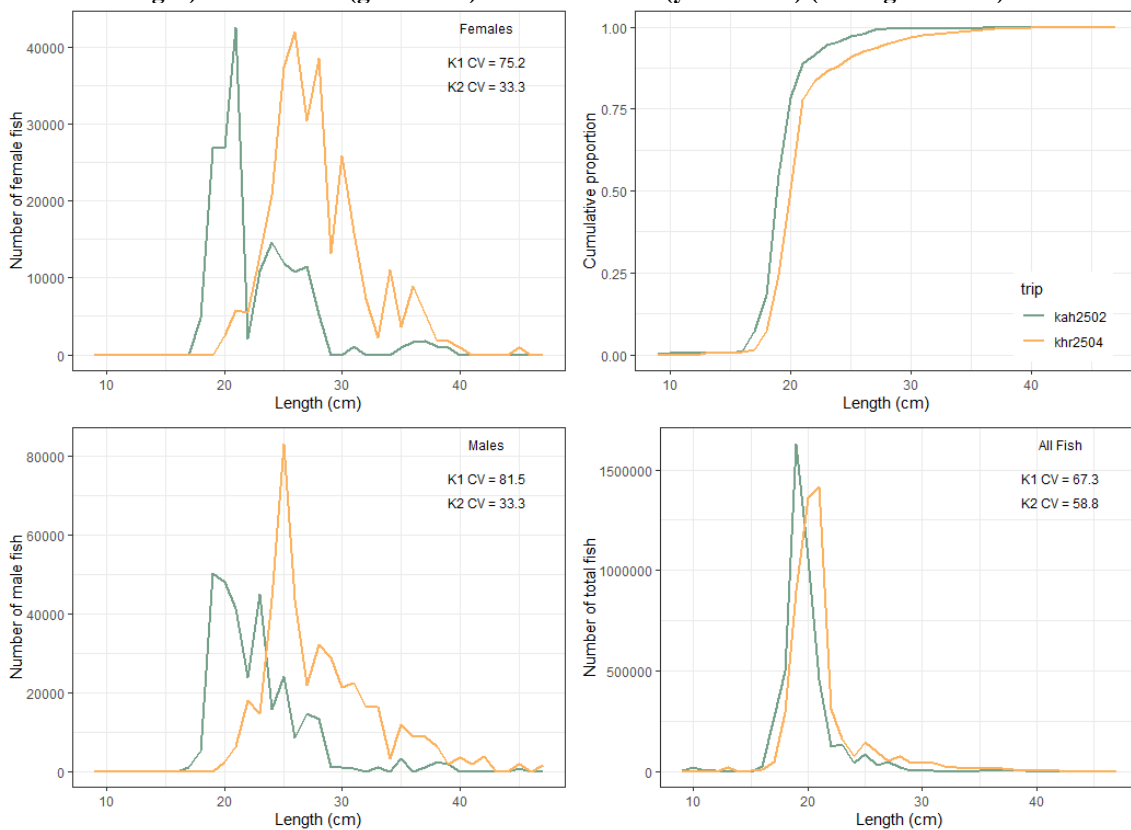


Figure A6-9: Greenback jack mackerel (*Trachurus declivis*) scaled length frequency distributions for male (bottom left), female (top left), and all fish (bottom right), and cumulative proportion by length (top right) for *Kaharoa* (green line) and *Kaharoa II* (yellow line) (see Figure A6-1).

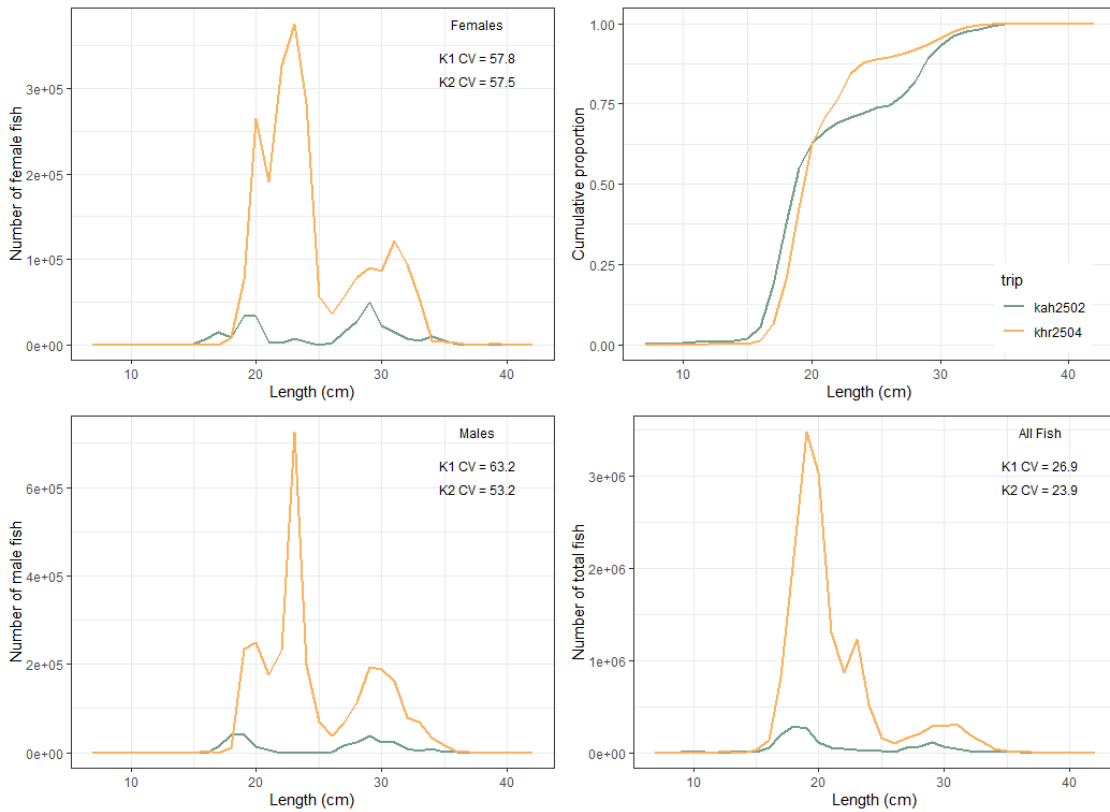


Figure A6-10: Yellowtail jack mackerel (*Trachurus novaezelandiae*) scaled length frequency distributions for male (bottom left), female (top left), and all fish (bottom right), and cumulative proportion by length (top right) for *Kaharoa* (green line) and *Kaharoa II* (yellow line) (see Figures A6-1).

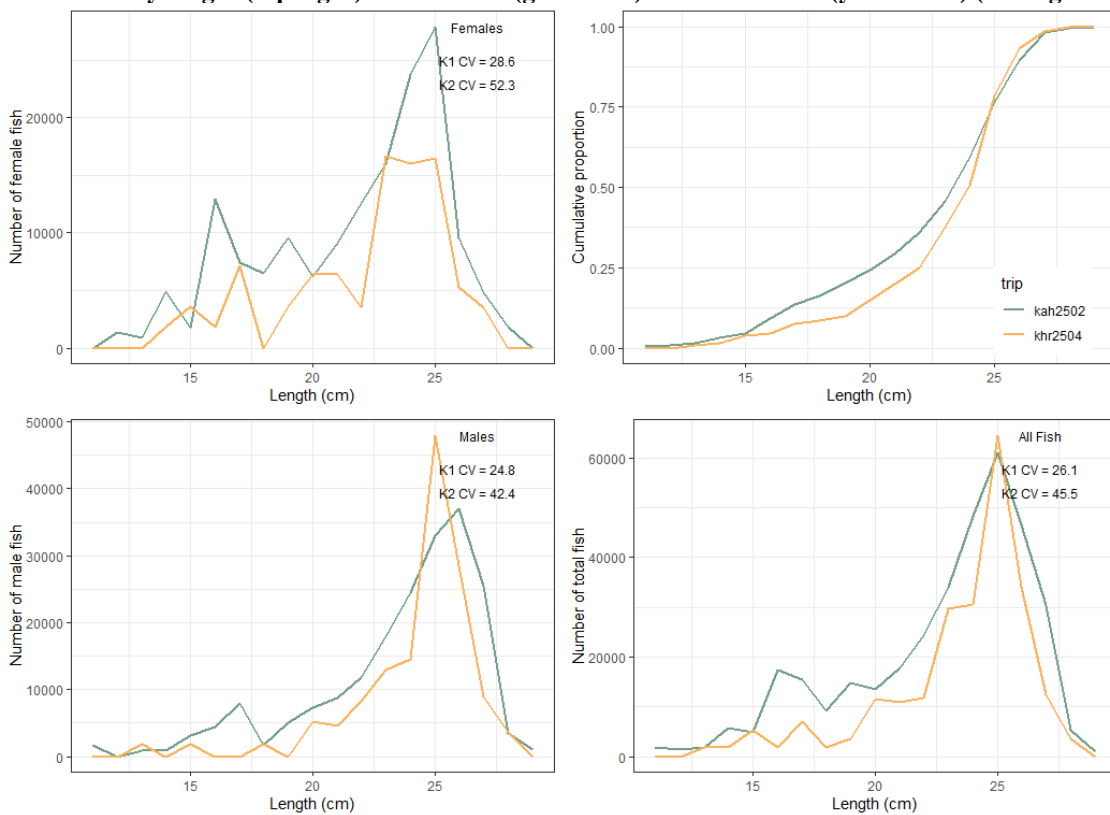


Figure A6-11: Leatherjacket scaled length frequency distributions for male (bottom left), female (top left), and all fish (bottom right), and cumulative proportion by length (top right) for *Kaharoa* (green line) and *Kaharoa II* (yellow line) (see Figure A6-1).

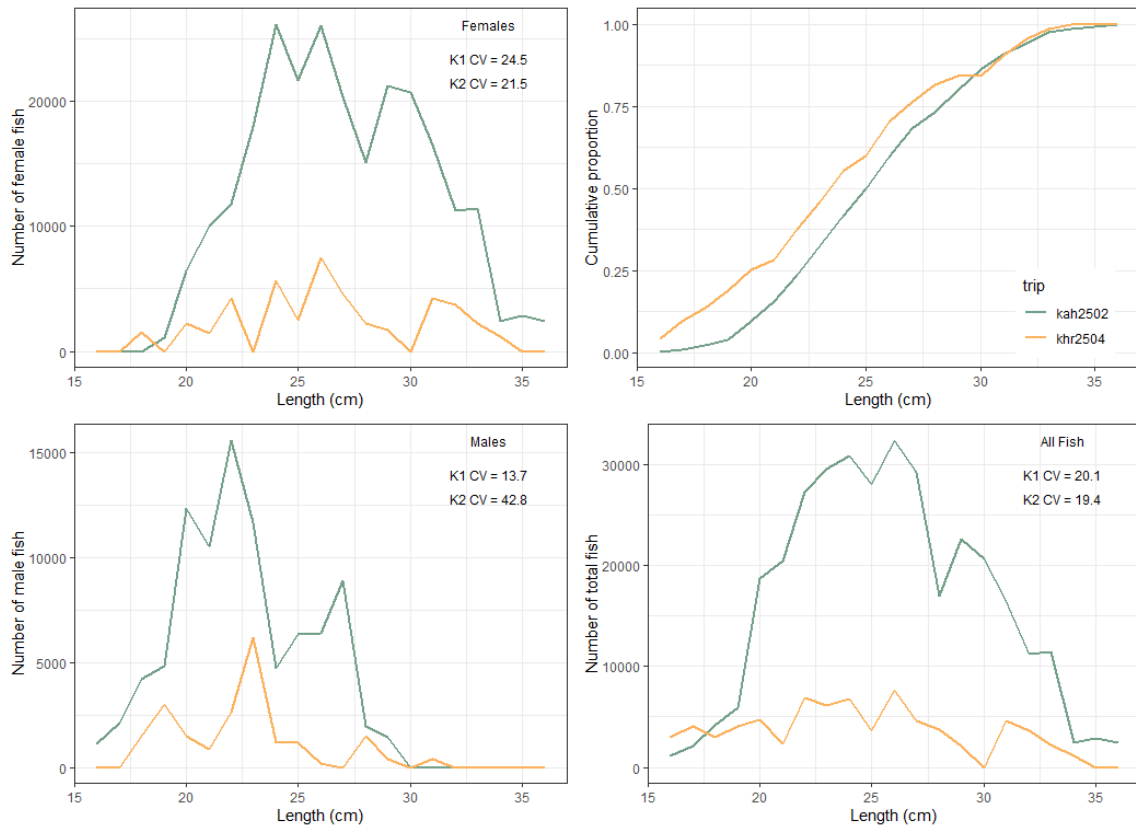


Figure A6-12: Lemon sole scaled length frequency distributions for male (bottom left), female (top left), and all fish (bottom right), and cumulative proportion by length (top right) for *Kaharoa* (green line) and *Kaharoa II* (yellow line) (see Figure A6-1).

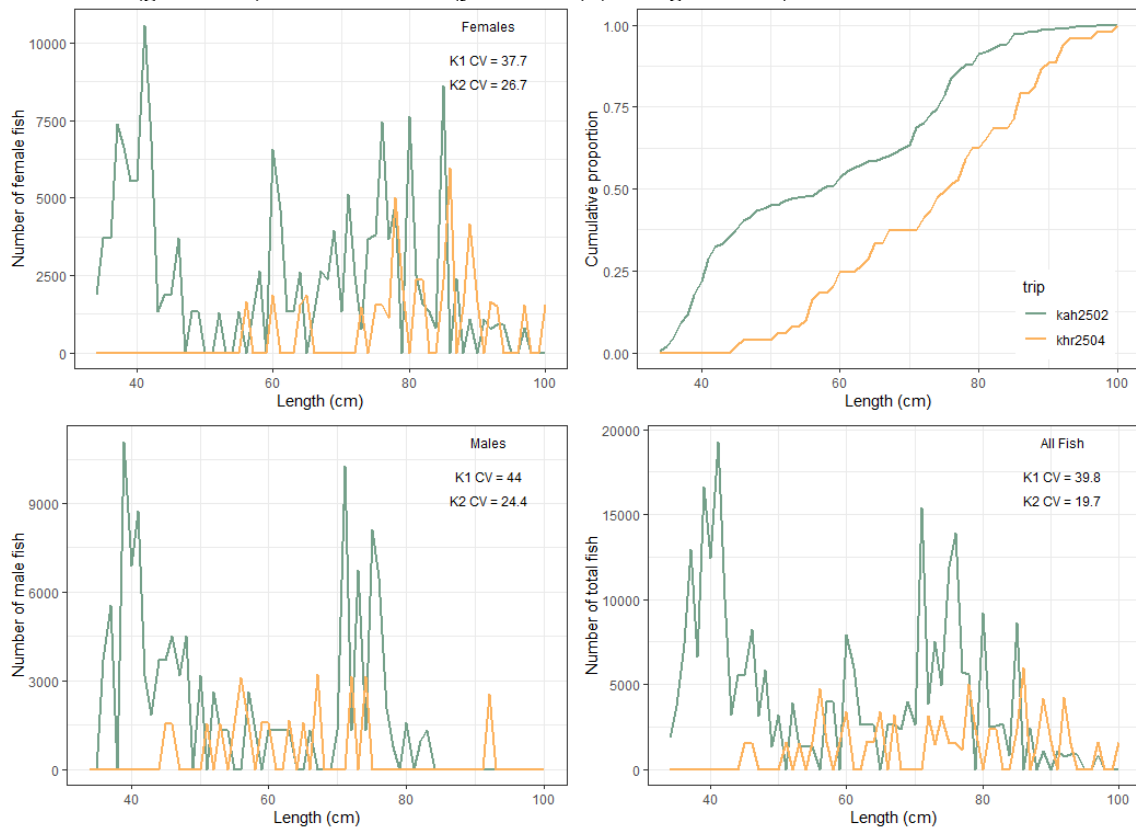


Figure A6-13: Northern spiny dogfish scaled length frequency distributions for male (bottom left), female (top left), and all fish (bottom right), and cumulative proportion by length (top right) for *Kaharoa* (green line) and *Kaharoa II* (yellow line) (see Figure A6-1).

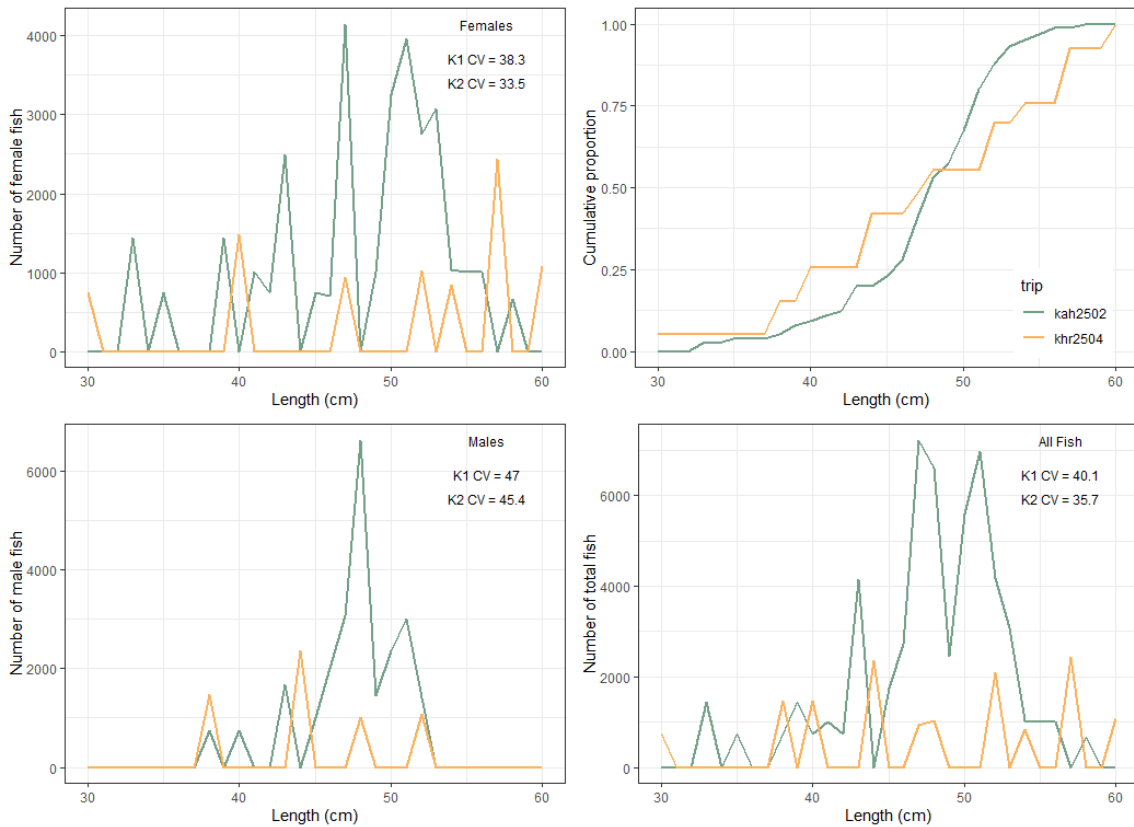


Figure A6-14: Rough skate scaled length frequency distributions for male (bottom left), female (top left), and all fish (bottom right), and cumulative proportion by length (top right) for *Kaharoa* (green line) and *Kaharoa II* (yellow line) (see Figure A6-1).

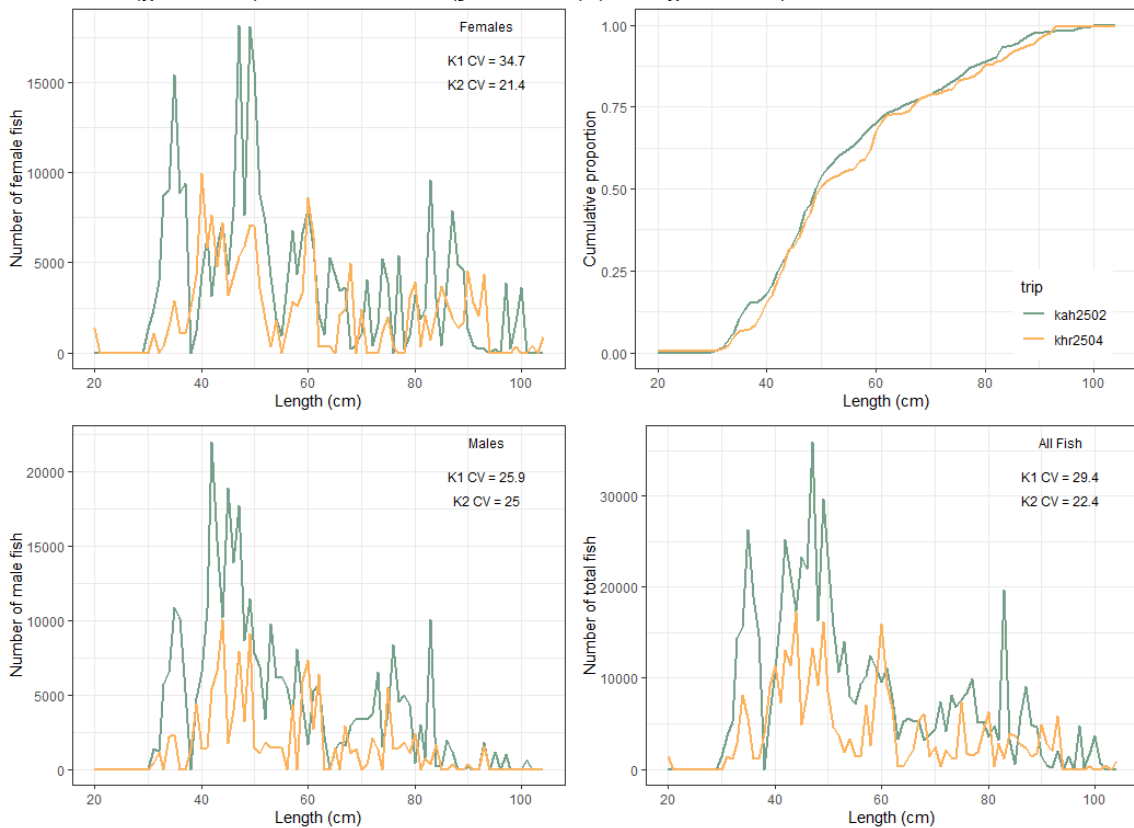


Figure A6-15: Gemfish scaled length frequency distributions for male (bottom left), female (top left), and all fish (bottom right), and cumulative proportion by length (top right) for *Kaharoa* (green line) and *Kaharoa II* (yellow line) (see Figure A6-1).

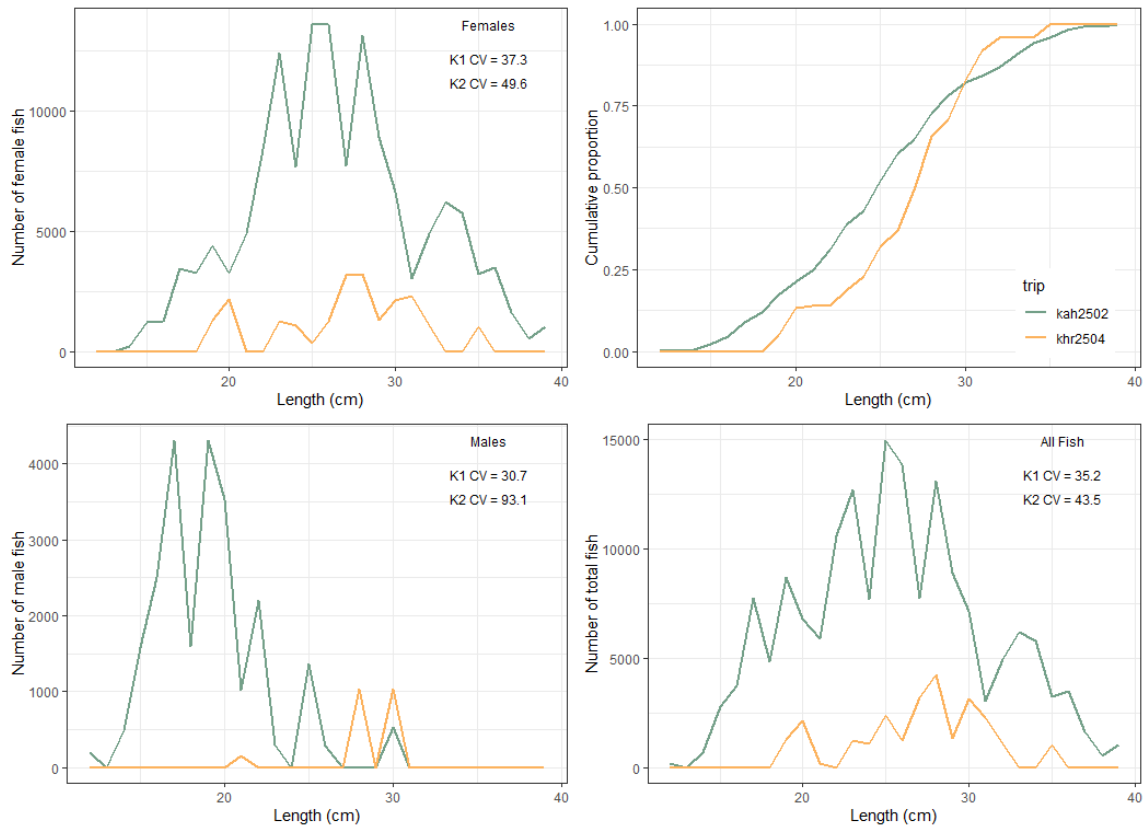


Figure A6-16: Sand flounder scaled length frequency distributions for male (bottom left), female (top left), and all fish (bottom right), and cumulative proportion by length (top right) for *Kaharoa* (green line) and *Kaharoa II* (yellow line) (see Figure A6-1).

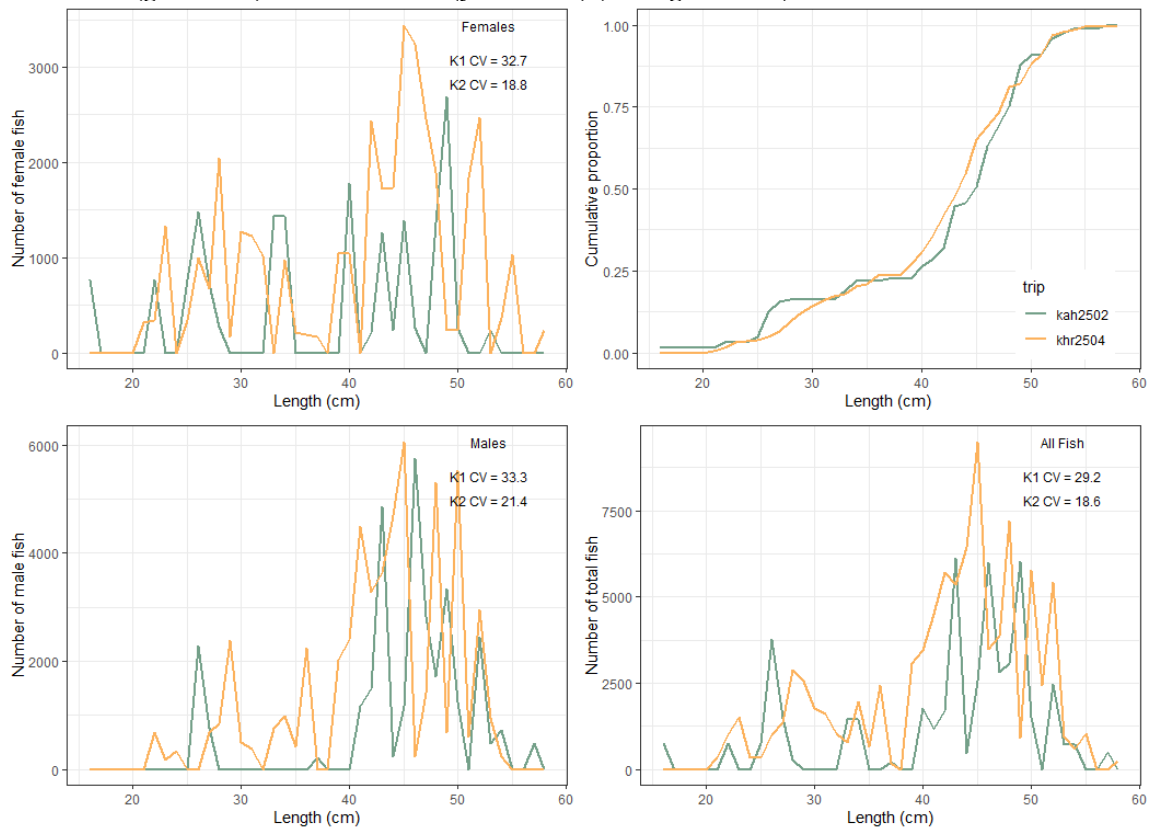


Figure A6-17: Trevally scaled length frequency distributions for male (bottom left), female (top left), and all fish (bottom right), and cumulative proportion by length (top right) for *Kaharoa* (green line) and *Kaharoa II* (yellow line) (see Figure A6-1).