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Observer sampling of deepwater fisheries: reporting methods

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PLAIN LANGUAGE SUMMARY

Standardised reports of the quantity and representativeness of observer sampling were developed for all deepwater stocks, and the key fisheries for each of these stocks. The reports are designed to be updated annually, with the methods described here.

Use of the observer reports will assist in planning stock assessment projects and identifying situations where further sampling is required. The reports should also promote more efficient tendering and delivery of stock assessment research because researchers will have a clearer picture of the available data.

A separate trip-level reporting template was also implemented, to assist the Observer Programme with monitoring of observer sampling at a finer scale.

EXECUTIVE SUMMARY

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***New Zealand Fisheries Assessment Report 2026/41*. 60 p.**

Observer sampling data are a key input for many assessments of the status of deepwater stocks. However, the quantity and quality of observer sampling has previously only been established when an assessment is attempted. Project OBS2025-01 has addressed this problem by implementing templates for routine reporting of observer sampling coverage, in a largely automated manner.

The key outputs of the project are:

- reports that summarise observer sampling at the trip level, intended primarily for Fisheries New Zealand internal use (illustrated in Appendix B); and
- annual sampling reports that examine observer coverage on a stock and fishery basis. The first iteration of these reports, for 1989–90 to 2024–25 is provided in Middleton (2026a, 2026b).

The reporting formats are primarily graphical, intended to assist the reader in identifying the specific reasons why coverage has not been representative of the full commercial fishery. Nevertheless, two statistics that aim to summarise representativeness were investigated, and are used to summarise temporal trends in sampling coverage.

In most cases, reports were implemented for the relevant Quota Management Areas for a species; however, for hoki, hake, and ling the reporting areas are aligned to those that are routinely used in stock assessments. The annual reporting has been implemented in terms of October fishing years, even for southern blue whiting stocks that are managed with an April fishing year. Because sampling is an ongoing process, the year chosen for reporting is somewhat arbitrary.

The report templates should be easily updatable if required. Data from the ling potting fishery is not yet fully available in the Centralised Observer Database, and the pot fishery sampling reports included in Middleton (2026a) are likely to be incomplete.

[1] Pisces Research, Wellington, New Zealand

1. INTRODUCTION

In New Zealand, fisheries observers—deployed on commercial fishing vessels—play a key role in collecting data used in stock assessments and a range of other monitoring programmes. Data collected by observers include:

Catch by species for each fishing event Observed data typically include catch quantities of *all* species caught, whereas event-level fisher-reported estimated catches need not include all species.[2] Catch data include quantities of fish species, and any protected species or benthic organisms, caught.

Catch composition information Observers sample within the species caught, collecting data on the size and/or weight composition of the catch, and may collect samples (e.g., of fish otoliths) that allow the age composition to be described.

Gear and vessel information Observers may collect information on the fishing gear and bycatch mitigation devices deployed.

Data on catch composition are the key observer data used in stock assessments although, in some fisheries, catch per unit effort (CPUE) analyses of observer catch data are used as the primary means of monitoring stock abundance.

While fisher-reported data provide information on all commercial fishing events, observer data are not comprehensive because observers are only placed on a subset of fishing trips. Users of observer catch sampling data must therefore consider whether the data collected are *representative* of the fishery; if not, then the data may need to be analysed in appropriate strata, or rescaled via modelling.

Information on the *quantity* of observer samples taken per species and year has been available online for some years[3]; however, information on the *representativeness* of sampling has typically only become available when a stock assessment is attempted. The lack of prior information on the quality of sampling creates inefficiencies, especially when new stock assessments are attempted: researchers must make assumptions about the samples that are available, and be prepared to deal with whatever they find. This may mean that additional analyses are required, or that the intended assessment methods cannot, in fact, be implemented.

This report aims to address this deficiency by developing comprehensive summaries of the observer sampling undertaken for all deepwater stocks, and the representativeness of that sampling. Detailed species and stock level reports are provided in Middleton (2026a, 2026b); these have been implemented in a manner that should allow for annual updating with minimal overhead.

Standardised graphics are the primary means used to illustrate the quantity and representativeness of observer sampling over time. However, tables provide the number of fishing events and fish sampled, and statistics that aim to quantify the representativeness of sampling are also presented. The nature and performance of these statistics is discussed in this report.

In addition, this project has implemented trip-level reporting of observer sampling. The trip level reports are primarily intended to be used internally by the Fisheries New Zealand Observer Programme; they aim to give observer managers an overview of the quantity and representativeness of sampling at the trip level, and may assist in spotting errors that were not obvious in the raw data. Between trip comparisons may also allow the Observer Programme to better monitor observer performance, identify training needs, etc. Three examples of trip level reports are provided in Appendix B.

[2] Estimated catches, reported by fishers per fishing event, may not include all species caught. Estimated catch reporting has varied depending on the reporting format. Historically, estimated catches for up to five species per event could be reported. Under the Electronic Reporting regime, at least eight species per event are reported (unless fewer are caught) and fisher reported landings and discards provide comprehensive catch data per fishing trip.

[3] for example, at https://marlin.niwa.co.nz/

2. METHODS

2.1 Stocks included

Sampling reports were constructed for the species/QMS stocks within the purview of the Deepwater Working Group (Fisheries New Zealand 2026, Table 1).

Table 1: Deepwater stocks included in this report. Observer sampling reports are organised by QMS species (or species group) and stock. Sample numbers are assessed based on the observer species codes associated with the QMS species (or species group). The sampling threshold is the minimum catch weight (kg, based on the vessel's estimated catch) required for a fishing event to be considered available for sampling (see subsection 2.5).

QMS species code	Deepwater stocks	Observer codes	Sampling threshold (kg)
BAR	BAR 4, BAR 5, BAR 7	BAR	50
BYX	BYX 1, BYX 2, BYX 3, BYX 7, BYX 8	BYX, BYS	10
CDL	CDL 1, CDL 2, CDL 3, CDL 4, CDL 5, CDL 6, CDL 7, CDL 8, CDL 9	CDL, EPT	30
EMA	EMA 3, EMA 7	EMA	20
FRO	FRO 3, FRO 4, FRO 5, FRO 6, FRO 7, FRO 8, FRO 9	FRO	30
GSH	GSH 4, GSH 5, GSH 6	GSH	10
GSP	GSP 1, GSP 5, GSP 7	GSP	20
HAK	HAK 1, HAK 4, HAK 7	HAK	70
HOK	HOK 1NW, HOK 1NE, HOK 1WC, HOK 1CS, HOK 1CR, HOK 1PU, HOK 1MC, HOK 1SA	HOK	70
JMA	JMA 3, JMA 7	JMA, JMD, JMM, JMN	120
LDO	LDO 1, LDO 3	LDO	10
LIN	LIN 1, LIN 2, LIN 3&4, LIN 5&6, LIN 6B, LIN 7WC, LIN 7CK	LIN	40
OEO (BOE)	OEO 1, OEO 3A, OEO 4, OEO 6	BOE	30
OEO (SSO)	OEO 1, OEO 3A, OEO 4, OEO 6	SSO	30
ORH	ORH 1, ORH 2A, ORH 2B, OEO 3A, ORH 3B, OEO 7A, OEO 7B	ORH	40
RBT	RBT 1, RBT 3, RBT 7	RBT	10
RBY	RBY 1, RBY 2, RBY 3, RBY 4, RBY 5, RBY 6, RBY 7, RBY 8, RBY 9	RBY	40
RIB	RIB 3, RIB 4, RIB 5, RIB 6, RIB 7, RIB 8	RIB	20
SBW	SBW 1, SBW 6A, SBW 6B, SBW 6I, SBW 6R	SBW	150
SCI	SCI 1, SCI 2, SCI 3, SCI 4A, SCI 5, SCI 6A, SCI 6B, SCI 7, SCI 8, SCI 9	SCI	20
SKI	SKI 3, SKI 7	SKI	20
SPD	SPD 4, SPD 5	SPD	30
SPE	SPE 3, SPE 4, SPE 5, SPE 6, SPE 7	SPE, HPA, HPC	10
SQU	SQU 1, SQU 6T	SQU, NOG, NOS, SQX	110
SWA	SWA 1, SWA 3, SWA 4	SWA	20
WWA	WWA 1, WWA 2, WWA 3, WWA 4, WWA 5B, WWA 7, WWA 8, WWA 9	WWA	20

2.2 Spatial stratification

For the majority of the species involved, the spatial stratification used in reporting was the Quota Management System (QMS) stock (i.e., the Quota Management Area, QMA). For hake and ling, however, representativeness was reported in terms of the biological stock areas that have been adopted for stock assessments (Fisheries New Zealand 2026). In the case of hoki, reporting used a "fishery" stratification that has commonly been used for characterising the hoki fishery. Comparisons between the Quota Management Areas for these species and the reporting strata used in this report are provided in Appendix A.

2.3 Species groups

Some "species" managed in the Quota Management System are actually groups of related species. Where the species are readily distinguishable, efforts have been made to implement reporting by species. In the deepwater fisheries, species groups include:

- alfonsino (BYX) stocks include both *Beryx splendens* and *B. decadactylus*. However, the alfonsino catch is usually assumed to be made up almost entirely of *Beryx splendens* (BYS);
- jack mackerels (JMA) include *Trachurus declivis* (JMD), *T. novaezelandiae* (JMN), and *T. murphyi* (JMM). These are not distinguished in fisher reporting and observer samples are required to assess species composition in the catch.
- oreo (OEO) stocks include *Pseudocyttus maculatus* (SSO), *Allocyttus niger* (BOE), *Neocyttus rhomboidalis* (SOR), and *Allocyttus verucosus* (WOE). For oreos, comprehensive, species-level reporting has been in place since the 2008 fishing year (Figure 1). The species most commonly caught are SSO (smooth oreo) and BOE (black oreo).
- sea perch (SPE) comprises *Helicolenus percoides* and *H. barathri*. These are not distinguished in fisher reporting and observer samples are required to assess species composition in the catch.
- squid (SQU) stocks comprise two arrow squid species: *Nototodarus gouldi* and *N. sloanii*. These are not distinguished in fisher reporting and observer samples are required to assess species composition in the catch, although the species are quite well separated spatially.

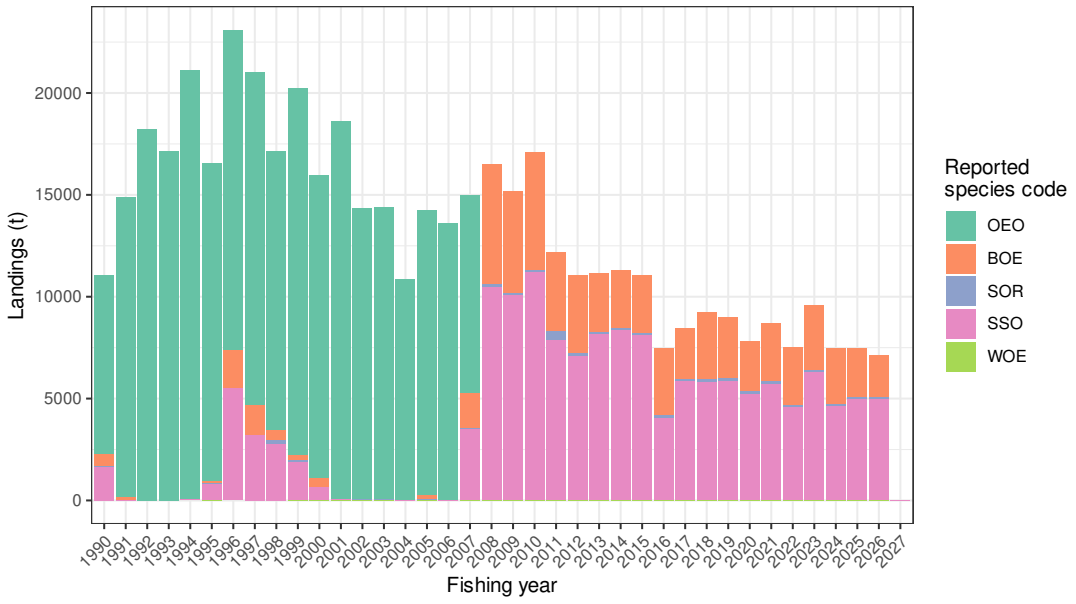


Figure 1: Catches of oreos categorised according to the species code used in the landings data.

Reporting of oreos pioneered the approach adopted more recently for several other species groups (including flatfish and groper) via the *Fisheries (E-logbook Users Instructions and Codes) Circular 2021*. The general solution was to remove the group code (OEO) as a valid species code, and require individual species codes to be used in all reporting, other than Monthly Harvest Returns. In particular, landings must be recorded to pseudo-fishstocks, such as BOE 4 or SSO 4, rather than OEO 4. In this report, the sampling of key oreo species (black oreo, BOE, and smooth oreo, SSO) is reported separately, with reporting starting from the 2008 fishing year and the pseudo-stock codes used to identify the fisheries.

2.4 Sampled fisheries

Following a species-level overview (restricted to the deepwater stocks of a species), sampling was evaluated at the fishery level, where fisheries were defined by stock (i.e., the spatial strata) and fishing method. For the purposes of evaluating observer sampling, some fishing methods were grouped. Fishing effort where the primary method used was BT, PRB, MW, PRM, BPT, MPT, or PSH[4] was coded as *Trawl* fishing, effort recorded using the BLL, DL, or TL codes was classified as *Line* fishing, and CP, FP, SCP, or POT events were coded as *Pot* fishing (the individual method codes are detailed in Appendix E).

Fishery-level sampling reports were prepared for the key stocks and fisheries for each deepwater species:

key stocks were (i) the stocks that accounted for at least 95% of the overall deepwater catch of the species,[5] or (ii) stocks where the mean annual catch exceeded 200 t; and

key fisheries were either (i) the principal method used to catch a stock over the data series, or (ii) methods accounting for at least 15% of the overall deepwater catch of a key stock within any five year period beginning in 2000 and with a mean annual catch exceeding 100 t.

2.5 Sampling thresholds

For assessing the representativeness of sampling, fishing events were considered to be available for sampling if the catch of the species of interest exceeded a minimum threshold weight. Because species vary in average size, the sampling thresholds must be species dependent (Table 1).

Here, thresholds were determined empirically by examining the catch weight of sampled fishing events and the number of individuals that were sampled from an event. The sampling threshold was set by identifying fishing events from which observers had previously sampled at least 20 individuals of the species of interest; the threshold was then set at the lower 1% quantile of catch weights of these events, rounded to the nearest kilogram.

For each of the species of interest, the distribution of catch weights and sample numbers in the observer dataset, and the resulting sampling threshold, is illustrated in Appendix C. Sampling thresholds were determined using data collected by observers, including the observer-recorded catch weight. When assessing representativeness, the resulting thresholds were applied to the estimated catch recorded by the vessel.

It is anticipated that these thresholds, evaluated using data from the 1990 to 2025 fishing years, will remain in place for future updates of the representativeness reports unless there is a specific need to

[4] PSH includes effort identified as using the Precision Seafood Harvesting gear before the PRB and PRM codes were introduced

[5] Strictly, the *smallest set* of stocks that accounted for at least 95% of the overall deepwater catch of the species; i.e., stocks were ranked by catch before the threshold was applied.

change. Any changes in the thresholds will impact how representative sampling is considered to have been over time.

2.6 Assessing representativeness

Assessing the representativeness of sampling data has typically involved comparing the proportions of samples over a set of strata with the proportion of fishing effort in those strata. Graphical comparisons of these proportions, including the use of cumulative distribution plots, are instructive in assessing the overall representativeness of sampling and identifying where sampling is lacking or over-represented.

Graphical comparisons are the primary approach employed for each deepwater stock in Middleton (2026a, 2026b). However, statistics that summarise the representativeness of coverage are also useful, especially when assessing the extent to which coverage has changed over time.

2.6.1 Representativeness statistics

This report employs two representativeness statistics, one based on the cumulative distribution—suitable when the data or strata are naturally ordered—and a second that is applicable to any set of strata. Both statistics provide an index of representativeness ranging from 0 (no match between sampling and fishing distributions) and 1 (a perfect match between sampling and fishing). The statistical significance of the differences is not assessed, although in some circumstances it may be useful to do this. Examples of extreme mismatches in coverage are used to illustrate the impact on the statistics.

2.6.1.1 The Kolmogorov-Smirnov statistic

The Kolmogorov-Smirnov test is often used to assess whether two sets of samples came from the same distribution. A range of tests are available for such comparisons (see, for example, Büning 2002), and the Kolmogorov-Smirnov test is not recommended in all circumstances. Here, we define the representativeness statistic

$$D = 1 - max|F_s - F_f| \tag{1}$$

where F_s and F_f are the cumulative distributions of sampling and fishing, respectively. In other words, the statistic is the maximum absolute difference between the two cumulative distributions (the usual Kolmogorov-Smirnov test statistic), but subtracted from one to provide the required 0 ...1 scale.

2.6.1.2 Manhattan distance

The second statistic considered is the overlap statistic

$$S = 1 - \sum_{i=1}^{n} \frac{|p_{s,i} - p_{f,i}|}{2} \tag{2}$$

proposed by Dunn (2011). Here $p_{s,i}$ and $p_{f,i}$ are the proportions of samples and fishing events, respectively, in stratum i of the n strata over which the sampling and fishing proportions each sum to one.

This statistic is the Manhattan block distance, divided by the maximum possible distance of two, and again subtracted from one to provide the required 0 ...1 range with the interpretation noted above.

2.6.2 Examples

The performance of the two statistics is illustrated here using intentionally extreme examples, applied to discrete strata. The number of strata used in each example is chosen for simplicity. Examples are considered where the proportion of fishing effort in a stratum is zero while the proportion of sampling is one; clearly this could not (quite) arise in practice, because sampling requires fishing.

The strata used for illustration can be thought of as months, or as latitude or longitude bins. However, there are cases (e.g., statistical areas, or *ad hoc* sampling areas) where the strata may not be naturally ordered.

2.6.2.1 Complete mismatch

In this example, all the fishing effort occurs in stratum 1 while sampling is restricted to stratum 5 (Table 2). Both representativeness statistics have a value of zero, indicating the complete mismatch between the sampling and fishing activity (Figure 2).

Table 2: Sampling and fishery proportions for an illustrative example with a complete mismatch of sampling and fishing.

	Proportion of	
Stratum	fishing	sampling
1	1	0
2	0	0
3	0	0
4	0	0
5	0	1

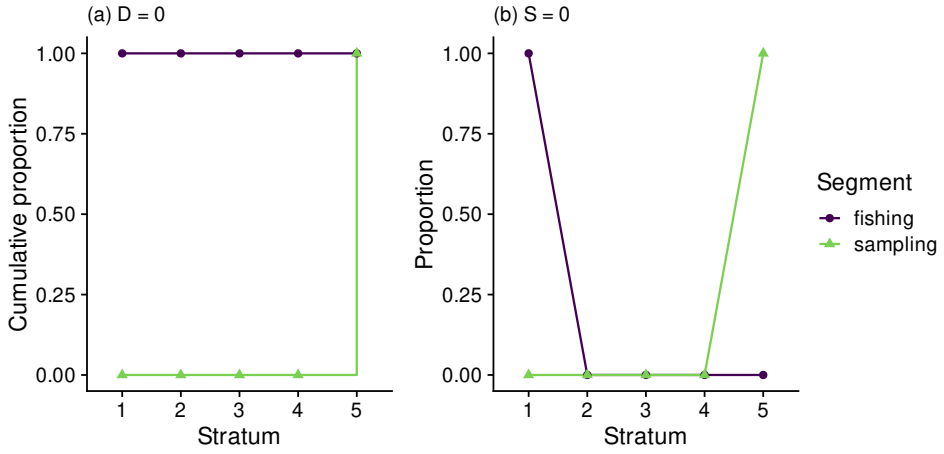


Figure 2: Sampling and fishery (a) cumulative proportions and (b) proportions for the illustrative case with a complete mismatch of sampling and fishing (Table 2).

2.6.2.2 Symmetric mismatch

Here, all of the fishing effort happens in stratum 4 ("the middle of the year") while sampling is split between strata 1 and 7 ("the ends of the year"; Table 3). While the Manhattan distance statistic again has a value of zero, because there is still no overlap between the sampling and fishing activity, the KS statistic has a value of 0.5, reflecting the fact that the cumulative distributions of sampling proportions are closer (Figure 3).

Table 3: Sampling and fishery proportions for an illustrative example with a symmetric mismatch of sampling and fishing.

	Proportion of	
Stratum	fishing	sampling
1	0	0.5
2	0	0.0
3	0	0.0
4	1	0.0
5	0	0.0
6	0	0.0
7	0	0.5

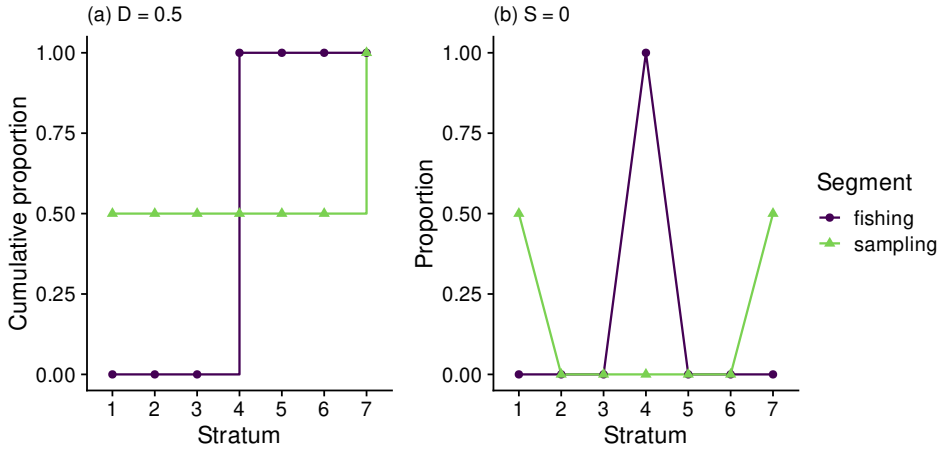


Figure 3: Sampling and fishery (a) cumulative proportions and (b) proportions for the illustrative case with a symmetric mismatch of sampling and fishing (Table 3).

2.6.2.3 Ordering matters

In the third example, all of the fishing effort again happens in stratum 4 ("the middle of the year") and the sampling is again split between two strata; however, the sampling has been reordered and occurs prior to the fishery (Table 4). In this case, both representativeness statistics revert to a value of zero (Figure 4).

Table 4: Sampling and fishery proportions for an illustrative example with the same values as the symmetric mismatch case (Table 3), but reordered.

	Proportion of	
Stratum	fishing	sampling
1	0	0.5
2	0	0.0
3	0	0.5
4	1	0.0
5	0	0.0
6	0	0.0
7	0	0.0

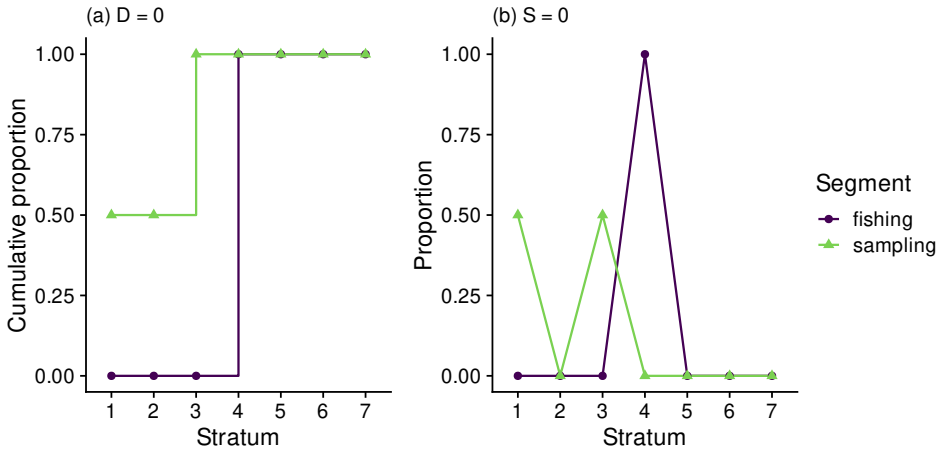


Figure 4: Sampling and fishery (a) cumulative proportions and (b) proportions for the illustrative case with a reordered mismatch of sampling and fishing (Table 4).

2.6.2.4 Alternating mismatch

Finally, we consider an example where sampling is interspersed with the fishery but, because of the strata boundaries, does not occur in the same strata (Table 5). Here, the Manhattan statistic continues to indicate a complete lack of overlap between the fishery and sampling, with a value of zero, while the KS statistic reaches a value of 0.8 reflecting the closer cumulative distributions (Figure 5).

Table 5: Sampling and fishery proportions for an illustrative example with an alternating mismatch of sampling and fishing.

	Proportion of	
Stratum	fishing	sampling
1	0.2	0.0
2	0.0	0.2
3	0.2	0.0
4	0.0	0.2
5	0.2	0.0
6	0.0	0.2
7	0.2	0.0
8	0.0	0.2
9	0.2	0.0
10	0.0	0.2

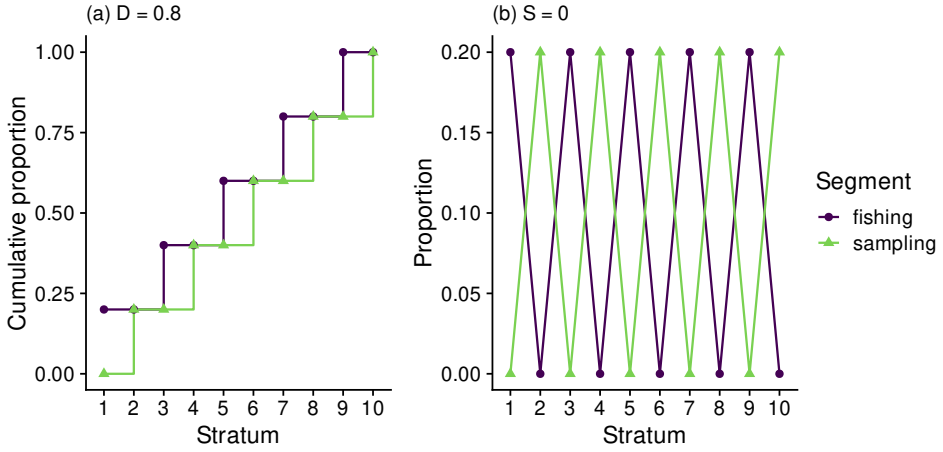


Figure 5: Sampling and fishery (a) cumulative proportions and (b) proportions for the illustrative case with an alternating mismatch of sampling and fishing (Table 5).

2.6.3 Impacts of discretisation on the KS statistic

In the examples above, both the KS statistic (*D*) and the Manhattan block statistics (*S*) were evaluated for data grouped into discrete strata. However, many of the dimensions over which representativeness might be assessed (for example, time, depth, latitude, longitude) are naturally continuous. Use of discretised bins, whether these are "natural" (for example, days/weeks/months/years) or arbitrary is often convenient, but the choice of these bins may impact on the apparent representativeness of sampling.

The impact of discretisation on the KS statistic was investigated for sampling of blue mackerel in EMA 7. The representativeness of sampling across the latitudinal range of the fishery was assessed by plotting the cumulative distributions of fishing effort and sampling, and calculating the KS statistic, for various latitudinal grids and without any division into latitudinal bins.

Over the 2016 to 2025 fishing years, the impact of discretisation on the KS statistic was small, but noticeable (Figure 6). For one fishing year (2023), the choice of bin impacted on the apparent trend in representativeness, as measured by the KS statistic (Figure 7); representativeness appeared higher for larger bins (0.25° to 1°) than for a smaller bin (0.1°) or without discretisation.

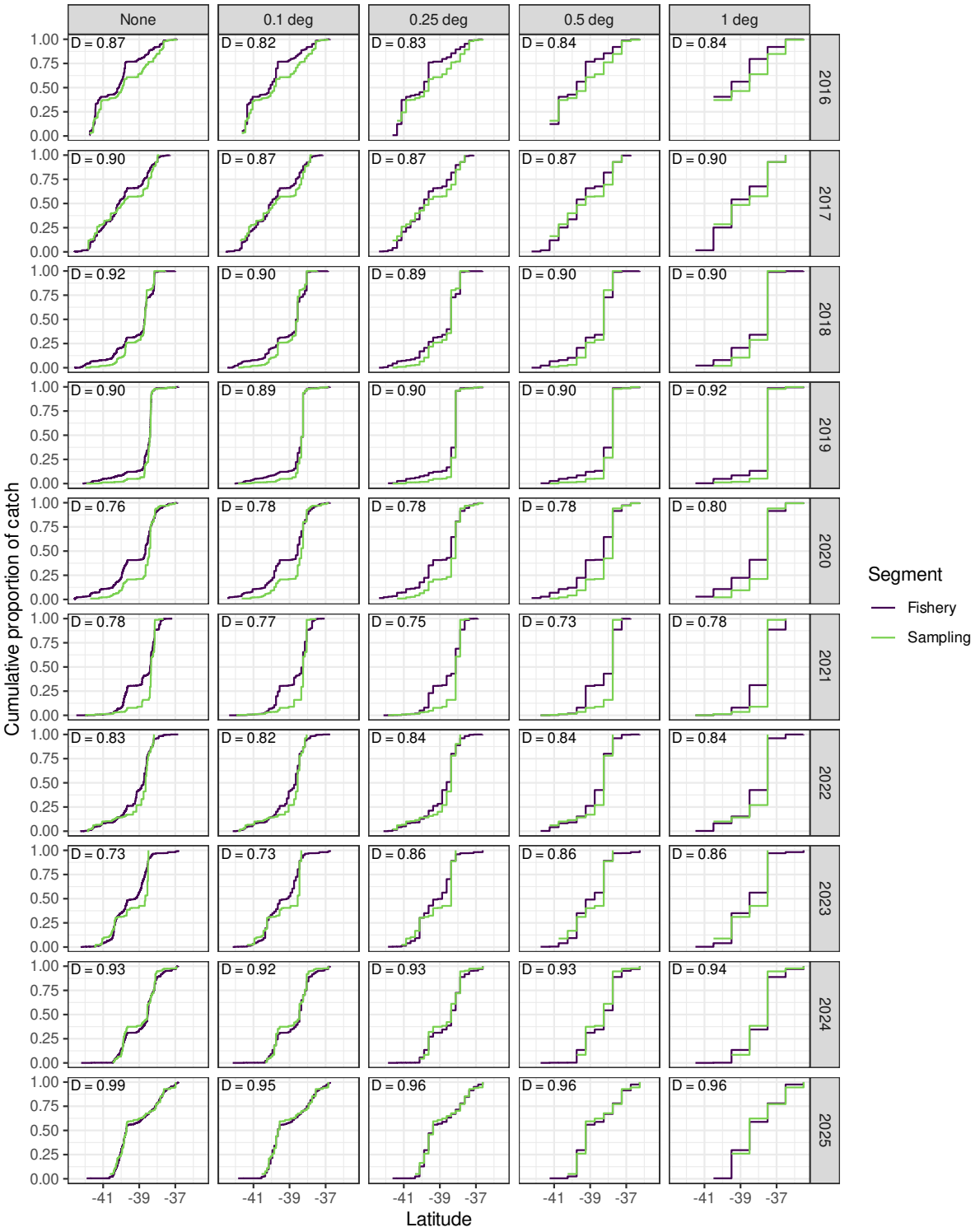


Figure 6: Cumulative proportions of overall and sampled catch for blue mackerel in EMA 7 in the 2016 to 2025 fishing years (plot rows), using different latitudinal bin sizes (plot columns). The KS representativeness statistic, *D*, is given in the top-right of each plot panel.

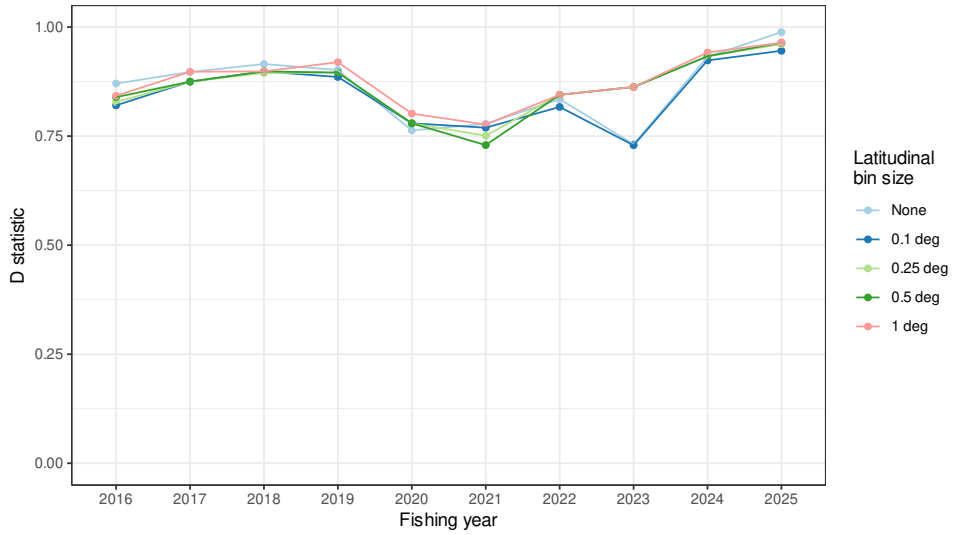


Figure 7: Temporal trends in the latitudinal representativeness of observer sampling of blue mackerel in EMA 7, assessed using the KS statistic, *D*, and calculated for different latitudinal bin sizes.

2.7 Evaluating the statistics

The two statistics considered here seem intuitively sensible for quantifying representativeness: the Kolmogorov-Smirnov distance is a standard approach for comparing cumulative distributions, while the Manhattan distance is a standard metric for assessing the distance between groups with the same dimensions. The extreme cases illustrated here indicate, however, that the two statistics can give differing impressions of sampling representativeness. In all the examples considered, the Manhattan statistic indicated a complete mismatch between sampling and fishing activity. However, the KS statistic suggested improved representativeness in cases where the sampling sequence better matched the fishing effort sequence. More generally, the KS statistic is always greater than, or equal to, the Manhattan statistic (Appendix D).

Both statistics are likely to be useful for quantitatively summarising representativeness. The KS statistic is useful when strata have a natural ordering (e.g., months of the year, latitude/longitude bins etc.); in the final example considered, the KS statistic gave "credit" for the similar ordering of sampling and fishing, despite the complete mismatch at the strata level. Circumstances where this credit is appropriate include cases where a continuous variable (i.e., time, space) is divided into somewhat arbitrary strata, yet where the closeness of sampling is helpful. For example, if the fishery is concentrated in June–July, then samples in May or August are likely to be more useful than sampling in December or January. It is also worth noting that assessing sampling representativeness by fishing year can create apparent mismatches: if the fishery is concentrated at the start of the year, then sampling at the end of the previous year is likely to be relevant.

The EMA 7 example illustrated that the value of the KS statistic can vary when continuous data are divided into discrete bins. The Manhattan statistic will also be affected by the particular stratification chosen: a single stratum would obviously show a perfect match between the fishery and sampling, but this is likely to deteriorate if the stratum is sub-divided.

In general, the graphical methods adopted in Middleton (2026a, 2026b) are considered to be the best approach for assessing the representativeness of sampling and identifying any deficiencies; this is illustrated in the following section. Nevertheless, the two representativeness statistics are useful for summarising temporal trends in representativeness, while recognising that the absolute values (and, in some cases, the trend) can be influenced by the stratification adopted.

3. OVERVIEW OF THE ANNUAL SAMPLING REPORTS

The sampling reports in Middleton (2026a, 2026b) are designed to be updated annually, providing a detailed summary of the quantity and representativeness of observer sampling from the 1989–90 fishing year to the most recent complete fishing year (2024–25 in the present report).

The reports are presented by species, but limited to the deepwater stocks of that species. The format of the reports is standardised to assist readers who are reviewing observer coverage for multiple species. The reports are structured as follows:

- An overview is presented at the **species** (or species-group) level. These overviews include:
  - a map of the Quota Management Areas (QMAs) for the deepwater stocks of the species. For hoki, hake, and ling the QMAs are replaced by the fishery or stock boundaries typically used in the assessment of these species;
  - plots showing the catch by method for each stock or area. These provide the context for the key fisheries to be sampled;
  - maps (by method) showing the difference in the proportion of sampled catch and total catch of the species on a 64 km grid; the colour scale indicates cells that are relatively over-sampled (blue) and under-sampled (red);
  - maps (by method) showing the difference in the proportion of sampled events and total qualifying events for the species on a 64 km grid;
  - plots showing the temporal trend in the spatial representativeness of sampling by method, assessed using the Manhattan distance metric (S) applied to 64 km grid cells for both the proportion of catch sampled and the proportion of positive events sampled; and
  - plots showing the temporal trend in the temporal representativeness of sampling by area and method, assessed using the KS statistic (D) applied to the start date-times (i.e., assessed without time bins) of all fishing events and all sampled fishing events, weighted by catch weight. The weighted KS test statistic is calculated using the `ks_test` function provided by the `Ecume` R package (Roux de Bezieux 2024).
- For each key **fishery** (area-method), a report section then presents:
  - a table detailing the annual number of positive fishing events (i.e., events where the catch met or exceeded the sampling threshold for the species), the number of events with length-frequency samples, the number of fish included in those samples, and the percentage of events sampled;
  - plots of the number and proportion of events with length-frequency samples by fishing year;
  - plots of the number and proportion of events with length-frequency samples by target species;
  - plots illustrating the annual representativeness of sampling by month, latitude, and longitude. Latitude and longitude are binned, and representativeness is illustrated by both cumulative distributions and using bubble plots of the proportions of sampling and fishing in a bin. Where the circle size for the sampling is larger than that of the commercial fishery, then the stratum has been over-sampled, and when the circle size for the sampling is smaller than that of the commercial fishery, then the stratum has been under-sampled. The representativeness plots are presented in terms of events (using a green/purple colour scheme) and catch (using a blue/orange colour scheme);
  - annual boxplots of the numbers of fish included in length-frequency samples of the species, together with an overall density (i.e., over all fishing years) for the length-frequency sample size;
  - a scatter plot showing the numbers of fish in length-frequency samples relative to the catch of the species, and density plots of the catch weights with and without length-frequency samples;

– a table detailing the annual number of positive fishing events, the number of events where ageing material was collected, the number of fish included in those samples, and the percentage of events sampled;
– plots showing the cumulative distribution, by fishing year, of the length of fish in length-frequency sampling, and the length of fish from which otoliths were collected; and
– a plot showing the methods used by observers to quantify the catch of the species in all observed events, by fishing year.

3.1 Illustrative examples

Examples from jack mackerel fisheries are used here to illustrate the differing roles of the representativeness statistics and the graphical summaries. The figures below are duplicated from Middleton (2026a).

3.1.1 Use of summary statistics and graphical summaries

The temporal trend in the spatial representativeness of length sampling of jack mackerels, at the EEZ level rather than by stock, is summarised using the Manhattan distance metric applied to 64 km grid cells (Figure 8). It is apparent that representativeness of sampling was variable in the early and mid 1990s but steadily improved during the late 1990s to mid 2000s, and has been generally consistent since.

The Manhattan statistic suggests that sampling of jack mackerels since 2011 has been somewhat more representative when evaluated in terms of catch, rather than in terms of positive events. Events catching jack mackerels (Figure 9) have been relatively under-sampled in the southern fishery (redder cells, in JMA 3, around the Stewart-Snares Shelf) and over-sampled off the west coast of the North Island (bluer cells, in the Taranaki Bight, part of JMA 7).

Expressed in terms of catch (Figure 10), the under-sampling is less apparent in JMA 3, where catches are smaller; instead fine-scale differences in representativeness are more apparent within the west coast fishery.

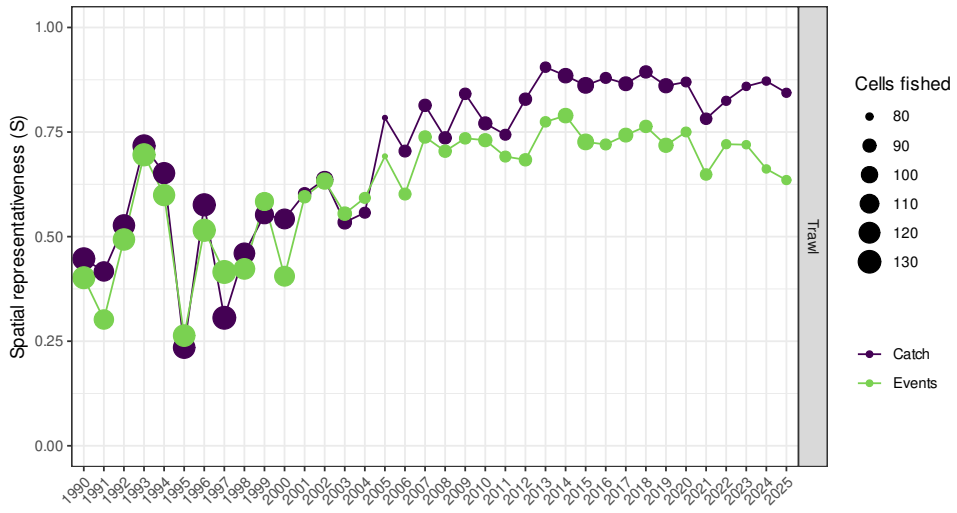


Figure 8: Spatial representativeness of observer sampling of jack mackerels by fishing year. Representativeness is assessed using the Manhattan distance metric (*S*) applied to 64 km grid cells, for both the proportion of catch sampled and the proportion of positive events sampled.

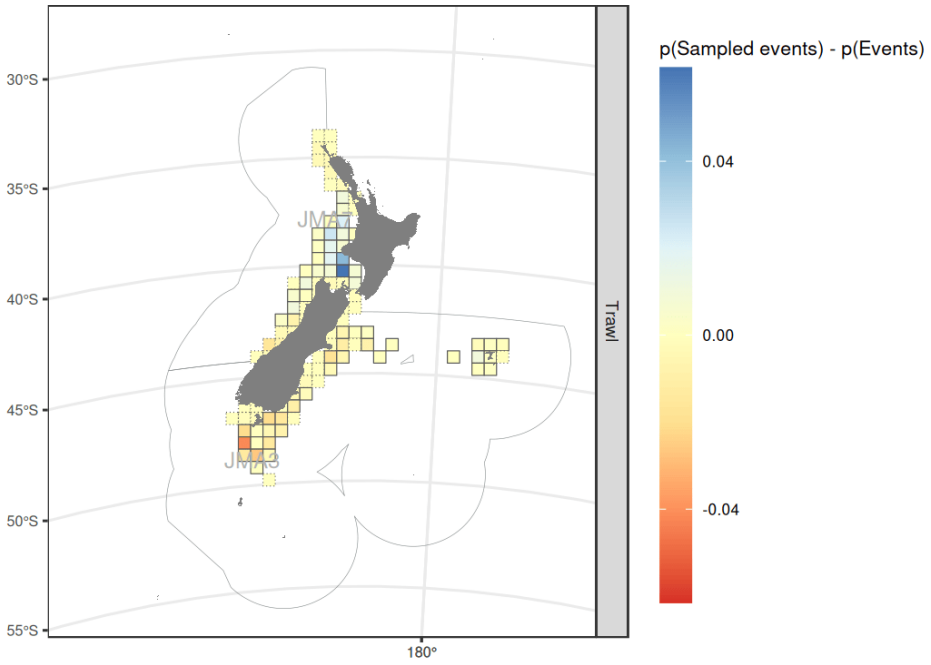


Figure 9: **Differences in the relative proportions of events meeting the sampling threshold and sampled events for jack mackerels during 2021–2025. Cells with a dotted border had no sampling.**

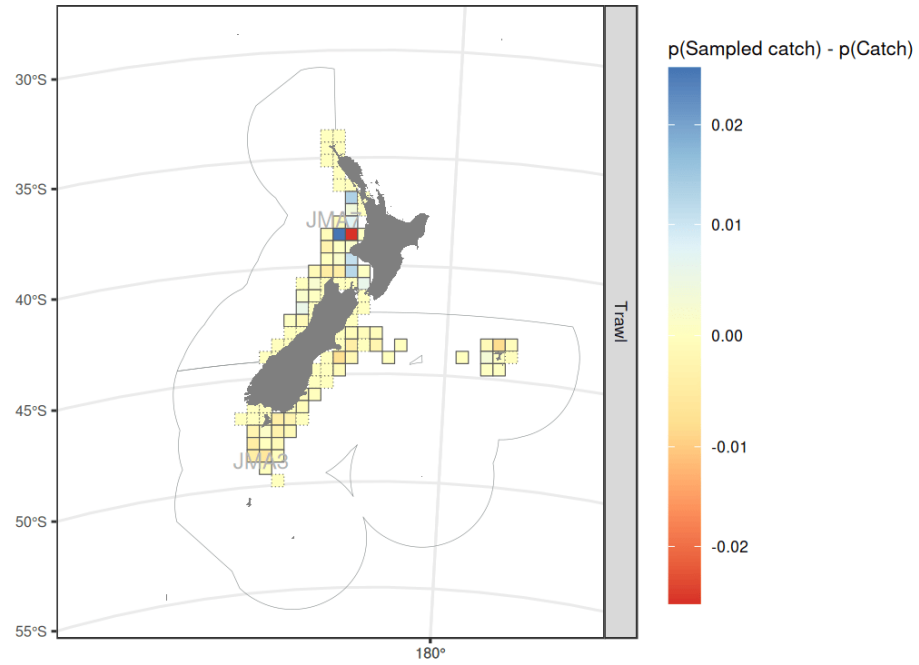


Figure 10: **Differences in the relative proportions of catch and sampled catch for jack mackerels during 2021–2025. Cells with a dotted border had no sampling.**

While the spatial representativeness of sampling can be visualised at the EEZ level, the temporal representativeness of sampling is more usefully assessed by stock/fishery; otherwise patterns in the larger fisheries mask those in the smaller fisheries. For jack mackerels, the temporal representativeness of sampling in the JMA 3 trawl fisheries has varied without a significant trend over the period from 1990 to 2025 (Figure 11). However, temporal representativeness of sampling in JMA 7 improved in the early 2000s and has been consistently high since 2013, with a slight dip in 2024.

Examining the temporal representativeness of sampling in JMA 7 in recent years (Figure 12) demonstrates that the reduced representativeness in 2024 is attributable to under-sampling in November and over-sampling in December and January, all peak months in the fishery. However, a potentially greater concern is the lack of sampling in April to May 2025. Because the JMA 7 catch in these months is relatively low, the overall representativeness statistics for 2023 and 2025 are similar, despite this "hole" in the 2025 sampling. This is immediately apparent in the graphical presentation of sampling and fishing effort in Figure 12, but not well captured by the summary statistics.

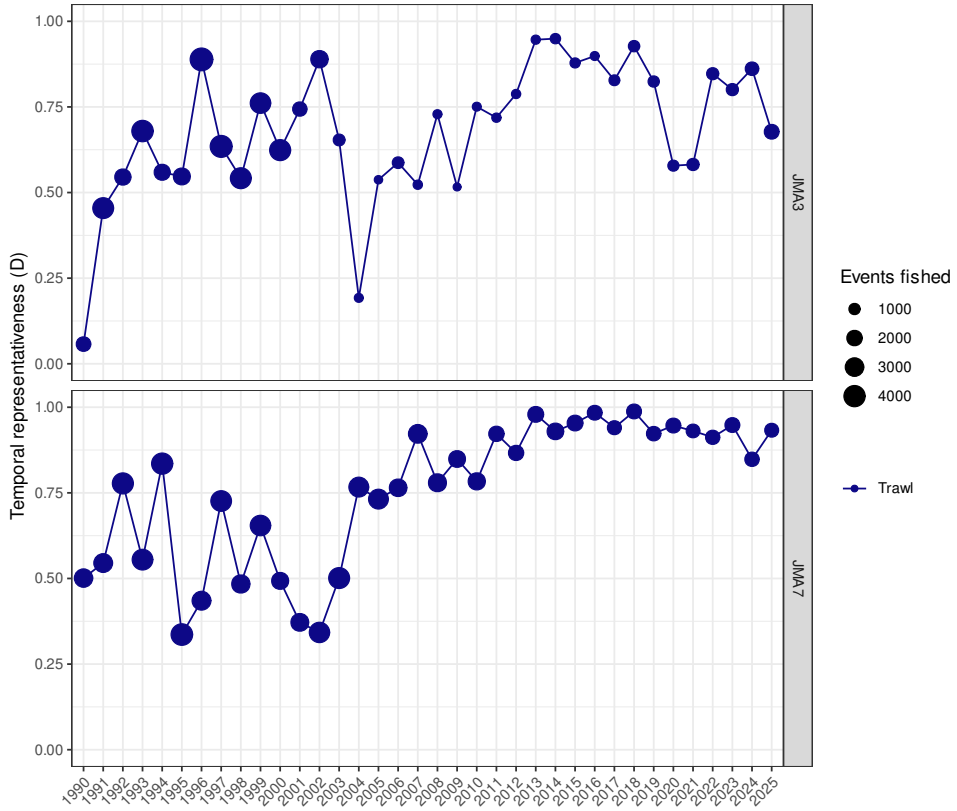


Figure 11: Temporal representativeness of observer sampling of jack mackerels by fishing year and area. Temporal representativeness is assessed using the KS statistic (*D*) applied to the start date-times of all fishing events and all sampled fishing events, weighted by catch weight.

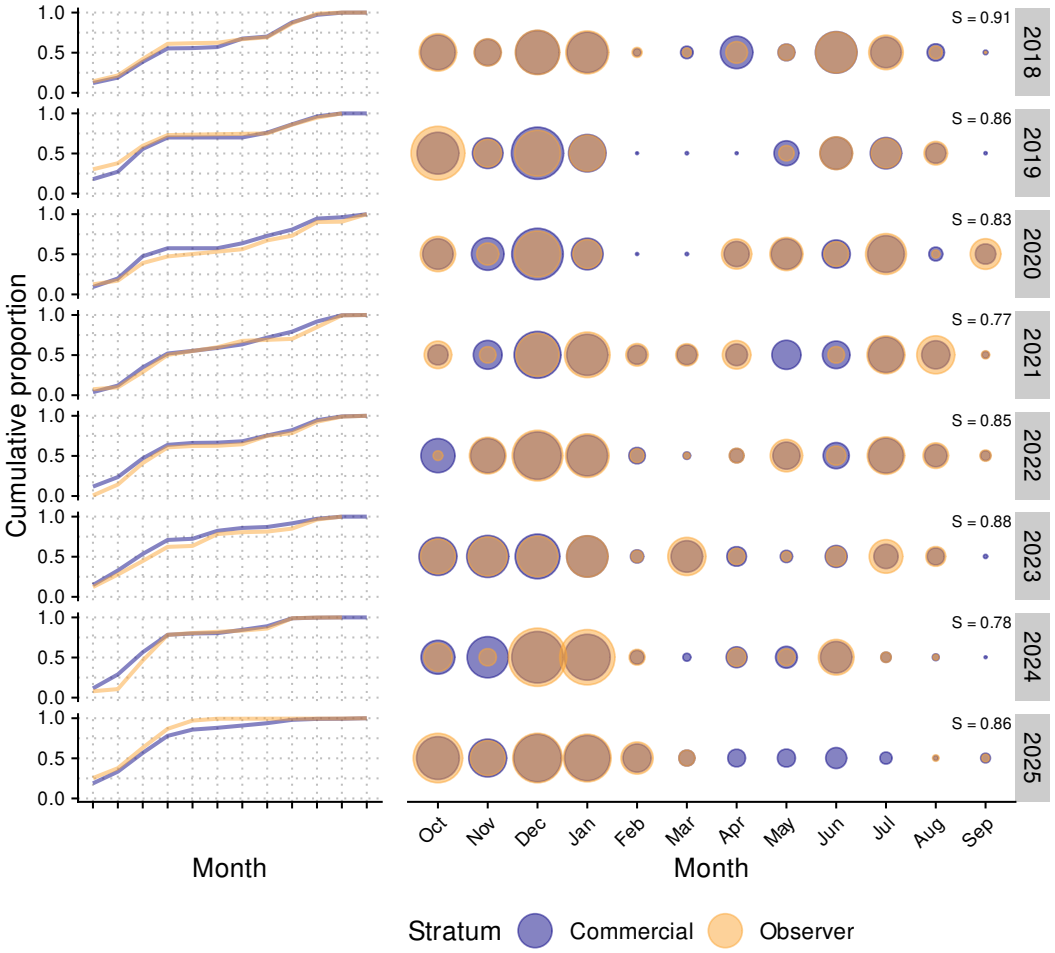


Figure 12: Monthly representativeness of observer sampling coverage of Trawl catch in JMA 7, from events where the jack mackerels catch exceeded the 120kg threshold, in 2018 to 2025. Observer data are for observed events with length sampling. Circle area is proportional to the proportion of catch in a month, with proportions summing to one within each fishing year. S: Manhattan block distance.

3.1.2 The importance of adequate sampling

The temporal representativeness of sampling in JMA 3 was clearly more variable than that in JMA 7, in terms of the summary Kolmogorov-Smirnov summary statistic (Figure 11), although it was also apparent that there was less consistent effort in JMA 3.

A graphical presentation of temporal representativeness of sampling in JMA 3 demonstrates that there has been a tendency to miss sampling the JMA 3 trawl fishery during May in most recent years (Figure 13); however, most other months with reasonable catches have been sampled.

A key conclusion for JMA 3, however, is that while the *representativeness* of sampling has generally been adequate, the *amount* of sampling has been too low. This is apparent from an examination of the proportion of the observer events that are sampled: in JMA 7 observers have typically sampled at least a quarter of observed events in recent years (Figure 14), whereas in JMA 3 less than 10% of observed events have been sampled (Figure 15). This is of particular concern for jack mackerels where length frequency sampling by observers provides species composition data in addition to length composition (Middleton & Neubauer 2025).

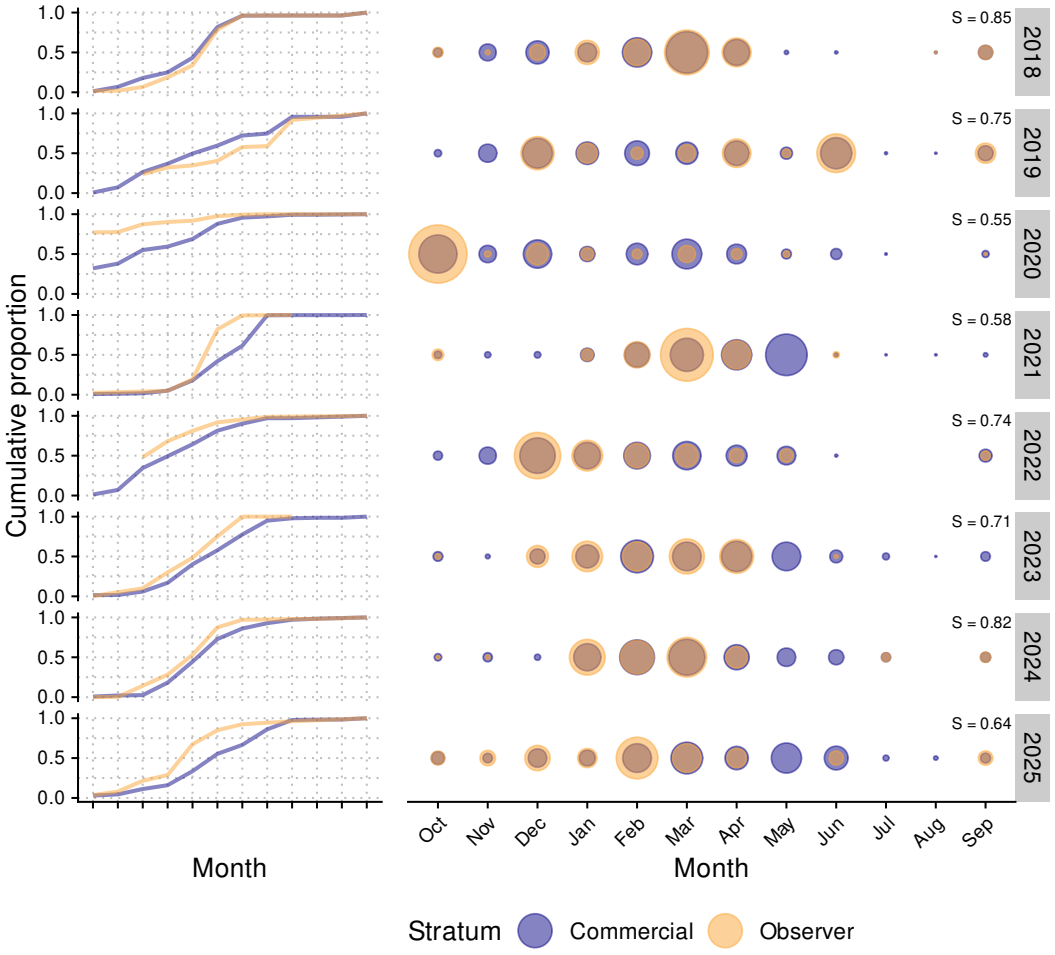


Figure 13: Monthly representativeness of observer sampling coverage of Trawl catch in JMA 3, from events where the jack mackerels catch exceeded the 120kg threshold, in 2018 to 2025. Observer data are for observed events with length sampling. Circle area is proportional to the proportion of catch in a month, with proportions summing to one within each fishing year. S: Manhattan block distance.

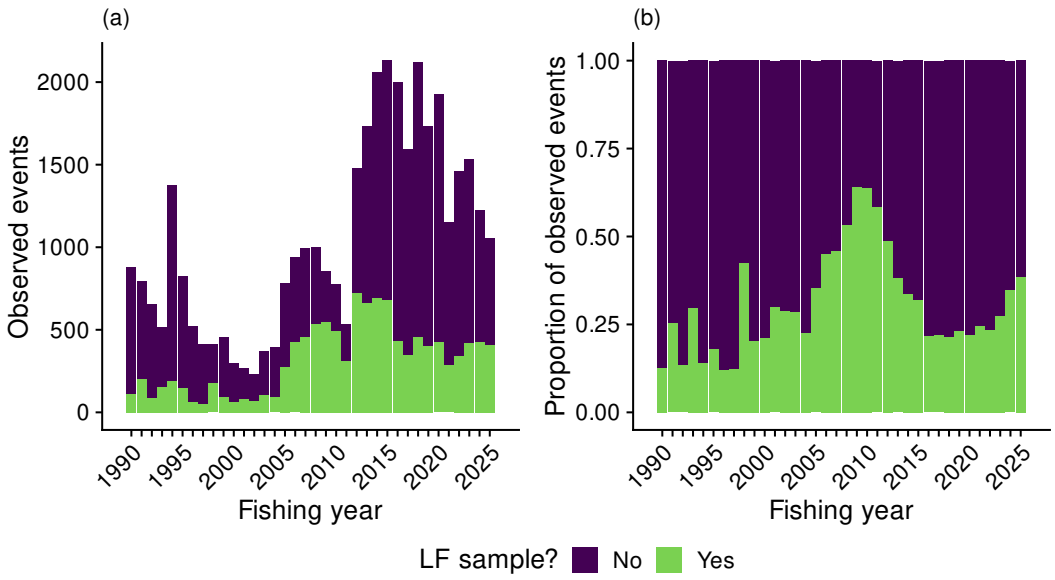


Figure 14: **(a) Observed Trawl fishing events, and (b) proportion of observed events, in JMA 7 where the jack mackerel catch exceeded the 120 kg threshold, with and without length-frequency sampling.**

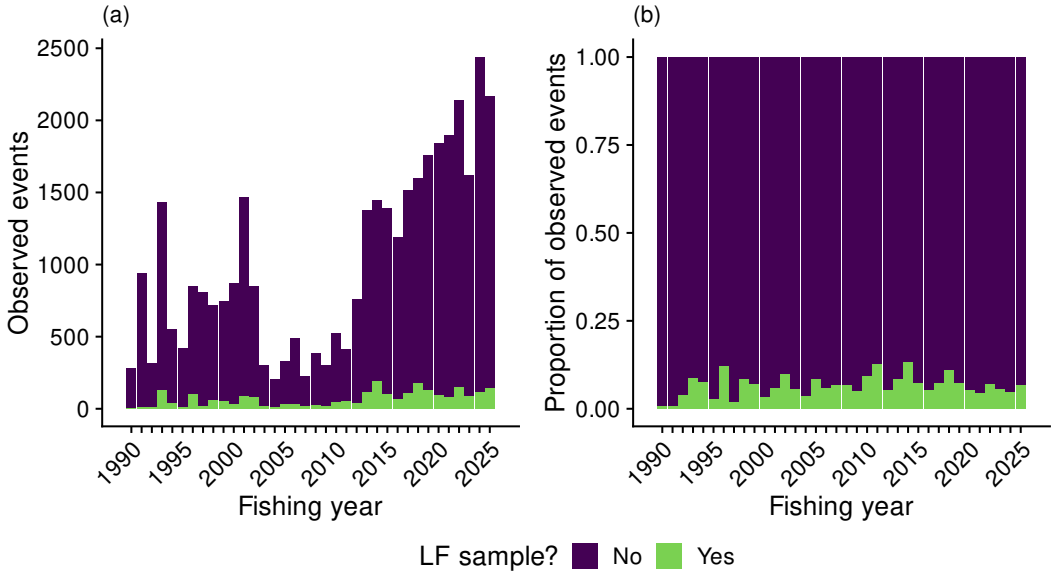


Figure 15: **(a) Observed Trawl fishing events, and (b) proportion of observed events, in JMA 3 where the jack mackerel catch exceeded the 120 kg threshold, with and without length-frequency sampling.**

3.1.3 Otolith subsampling

Catch at age data for assessments are produced by estimating the age of fish from otoliths. Two general approaches are in use: (i) ageing of fish selected **at random** from the catch, and (ii) transforming a length-frequency distribution into an age-frequency distribution through the application of an **age-length key**. The former approach relies on the collection of otoliths from fish selected at random from the catch, whereas the latter approach may intentionally oversample rarer fish sizes (typically the smallest and largest fish) to improve precision.

For random age-frequency sampling, the extent to which otolith sampling is genuinely random is usually assessed by comparing the size distribution of the fish from which otoliths were collected with the (usually much larger) sample of fish that were simply measured. Cumulative size frequency distributions allow discrepancies to be assessed visually: if the cumulative length distribution for the otolith subsample matches (overlays) that of the larger length sample then the otolith sampling is representative of the length sample. Likewise, intentional oversampling of the larger and/or smaller size categories will result in a systematic pattern where the cumulative length distribution of the otolith sample increases earlier than that of the length distribution, crosses the cumulative length curve, and asymptotes at a larger size.

For jack mackerels in JMA 7, where age distributions have typically been estimated using an age-length key (for example, Barnes et al. 2026), there is evidence that the otolith samples of *Trachurus declivis* (JMD) and *T. novaezelandiae* (JMN) generally oversample the larger fish, but not the smaller fish (Figure 16).

There is also clear evidence that—in many years—samples of *T. murphyi* (JMM) are "contaminated" by misidentified fish from the other species (or, at least, mislabelled fish). In 2020, the JMM cumulative distributions are similar for otolith and length samples, and only contain large fish. In 2022 and 2023 it is apparent that the length distribution is probably a mix of real JMM with a mode of smaller fish of one of the other species. In 2022, the otolith samples show the same mix, but in 2023 it appears that the otolith samples may be just larger JMM. In 2021 it is probable that few JMM are correctly identified in either the length or otolith samples.

3.1.4 Catch quantification

Observers use a range of approaches for estimating the catch of each species in all fishing events during a trip. Although observer catch and effort data may be used for catch per unit effort analyses, to complement analyses carried out using fisher reported data, the methods used by observers to estimate the catch are rarely considered. The catch quantification methods used by observers in the deepwater fisheries have been included in the observer representativeness reports primarily because of the lack of scrutiny of these data elsewhere: this presentation may prompt further consideration of the accuracy of different methods; alternatively, the methods used may be indicative of the observer workload or assigned priorities in a fishery.

In the examples from the JMA 7 (Figure 17) and JMA 3 (Figure 18) trawl fisheries, it is apparent that the coding system used for catch quantification methods changed in 2008 with the introduction of a new observer logbook for trawl effort. For the two jack mackerel fisheries, the methods used since 2008 are probably reflective of the nature of the catches: in JMA 7, jack mackerels comprise the majority of the catch and it is simplest for the observers to weight the other species and estimate the quantity of jack mackerels as the remainder of a total catch estimate. In JMA 3, catches are more mixed and a 'by eye' estimate of the species composition in a trawl is more common.

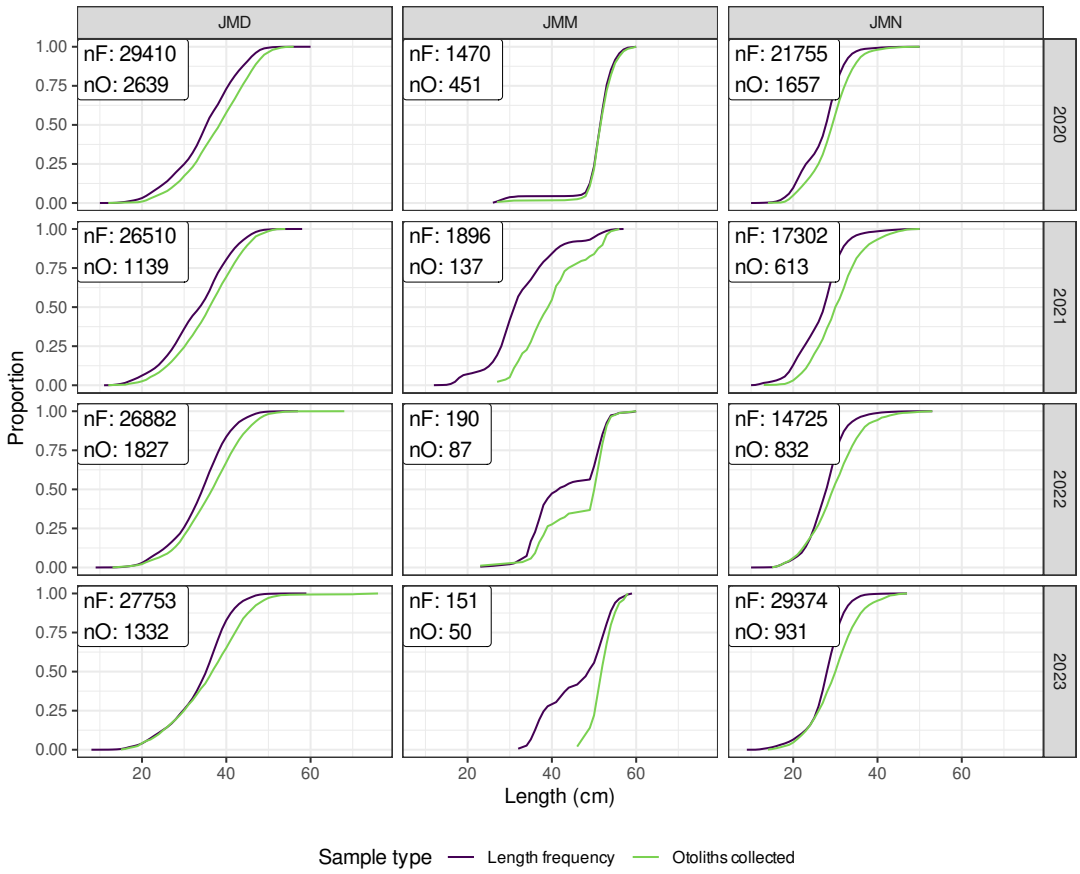


Figure 16: Cumulative distributions of the length of fish in the length frequency and otolith samples of jack mackerels in the JMA 7 Trawl fishery for the 2020 to 2023 fishing years. nF: number of fish in the length-frequency sample, nO: number of fish in the otolith sample.

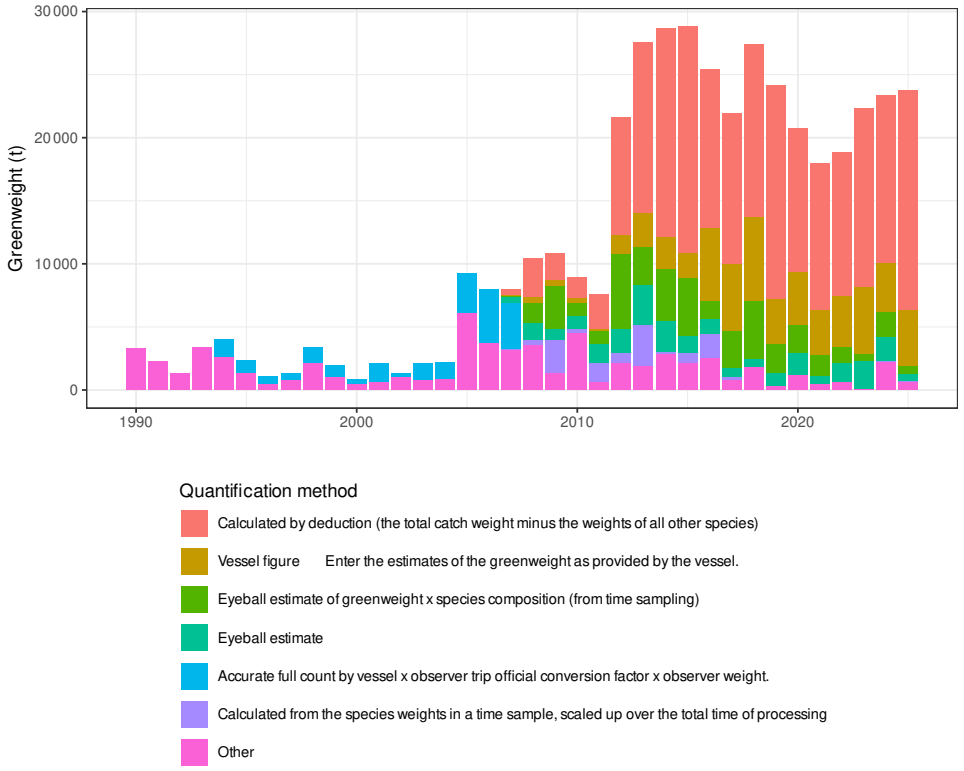


Figure 17: Methods used by observers to quantify the catch of jack mackerels in the JMA 7 Trawl fishery. The legend lists the methods used in descending order of total catch.

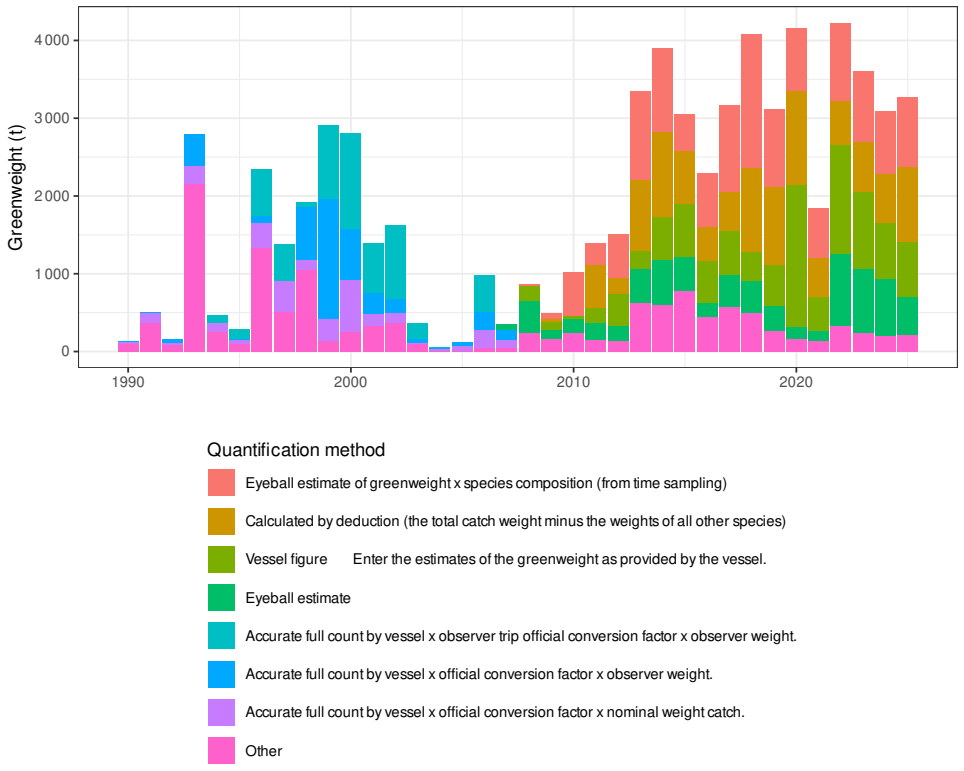


Figure 18: Methods used by observers to quantify the catch of jack mackerels in the JMA 3 Trawl fishery. The legend lists the methods used in descending order of total catch.

4. DISCUSSION

Observer sampling often provides key data used in the assessment of deepwater species. However, in the past, there have been limited resources to assist researchers in understanding the quantity and quality of observer sampling that has been carried out for a particular species, and for fisheries managers and science working groups to monitor trends in the quality of sampling over time.

The use of the kahawai reporting platform (Middleton et al. 2026) has allowed the implementation of standardised, detailed species and fishery reports for observer sampling of deepwater stocks. These reports (Middleton 2026a, 2026b) can be updated manually with minimal effort, and can be extended in the future if they are found to be missing information that would be useful. In addition, trip level reports (illustrated in Appendix B) have been implemented to assist the Observer Programme in monitoring observer performance at a fine scale, and to identify if observer workloads can be better balanced.

Both the annual and trip reports primarily use graphical methods to visualise the representativeness and quantity of observer sampling relative to the full commercial fishing effort for a stock. Some familiarity with the format of these plots is required to efficiently use these to identify where observer sampling has been less than ideal. However, similar graphics have been developed over many years of working group activity, and are therefore familiar to many working group participants.

In the past, reports of observer sampling have usually only been produced as part of an assessment project (e.g., Middleton & Neubauer 2025). Having the annual reports available in advance of stock assessment projects being tendered will allow those planning, and tendering for, projects to be more informed about the data that are available. Similarly, over time, it is anticipated that the trip reports will allow the observer programme to be more actively engaged in monitoring deepwater fisheries, for example, by identifying cases where existing protocols leave a significant part of the catch from a trip with only limited sampling.

Despite the focus on graphical methods, statistics for summarising representativeness as a single metric do have some value, primarily for assessing changes over time; i.e., indicating whether representativeness has improved or declined from year to year. Two statistics for quantifying representativeness were considered here. The Manhattan distance metric (S) can be applied to any group of strata, while the KS statistic (D) is applicable when data (or strata) are ordered. Apparent representativeness measured by these statistics will be dependent on the stratification chosen, although the KS statistic can be calculated for continuous data without discretisation. Other statistics for quantifying representativeness may be available. However, it is likely that the graphical methods will continue to be the key tool for understanding sampling coverage at a detailed level as these enable visualisation of where differences occur.

In future, the annual and trip reports may be more accessible if produced in alternative formats (e.g., HTML rather than PDF) and distributed via a website rather than as a monolithic document. The existing codebase should be easily adapted to such formats. Likewise, it is anticipated that—over time—researchers and working groups will identify new data presentations, and other sources of information, that could usefully be incorporated in these reports. The templates developed here should be easily extended to address such needs.

At the time of writing, sampling data from the recently expanded ling potting fishery (described by Middleton & Steele-Mortimer 2026) were not yet available in the Centralised Observer Database (COD) but work was underway to incorporate these. The observer sampling report for the ling potting fisheries are therefore likely to under-represent sampling from these fisheries. Future iterations of the reports should pick up these data, and may require slight adjustments to the code depending on the eventual storage format.

5. ACKNOWLEDGEMENTS

This work was funded by Fisheries New Zealand, under project OBS2025-01. Review and constructive suggestions made by the Deepwater Fisheries Assessment Working Group are gratefully acknowledged. Early implementations of the graphical methods used for assessing representativeness are attributable to Paul Starr (cumulative distributions) and Nokome Bentley (relative symbol sizes). Alistair Dunn employed the Manhattan distance statistic in a 2011 project associated with the development of the original deepwater 10 year research plan. Richard O'Driscoll noted the need to consider the effect of discretisation on the KS statistic. Data access was provided by the Fisheries New Zealand RDM team, and Adrian McNabb of the Fisheries Observer Programme provided helpful feedback on the trip reports and observer programme constraints. The project was managed by Gretchen Skea. Helpful science reviews were provided by Alexandra Northmore and Ian Blixt, with editorial review by Marianne Vignaux.

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APPENDIX A: SPATIAL STRATA FOR HOKI, HAKE AND LING

The reporting areas implemented for hake (Figure A-1) were defined by amalgamating Statistical Areas to recreate the biological stock areas illustrated by Dunn (2025, fig. 1). This approach results in areas that are similar, but not identical, to those illustrated by Holmes (2021, fig. 1). The codes used for the biological stocks are the same as those used for the QMS stocks despite the different spatial definitions.

The biological stocks for ling were also defined using Statistical Area boundaries; these were helpfully tabulated by Mormede et al. (2023, table 1). LIN 1 and LIN 2 were retained as separate reporting areas (Figure A-2), although the biological stock boundaries in these areas are less certain (Mormede et al. 2023, fig. 1).

Hoki is typically assessed as two biological stocks (western and eastern) that share a common juvenile ground on the Chatham Rise. Recent stock assessments have defined finer-scale spatial strata (McGregor-Tiatia & Langley 2026, fig. 1), but characterisations of the fishery typically use a series of regions and sub-fisheries (Ballara et al. 2025, table 1). For the purpose of reporting observer sampling representativeness, fishery areas were defined (Figure A-3) based on code used for assigning fishing events to areas for annual characterisations (S. Ballara, pers. comm.), but excluding a South Island east coast area that is defined for July to September only.

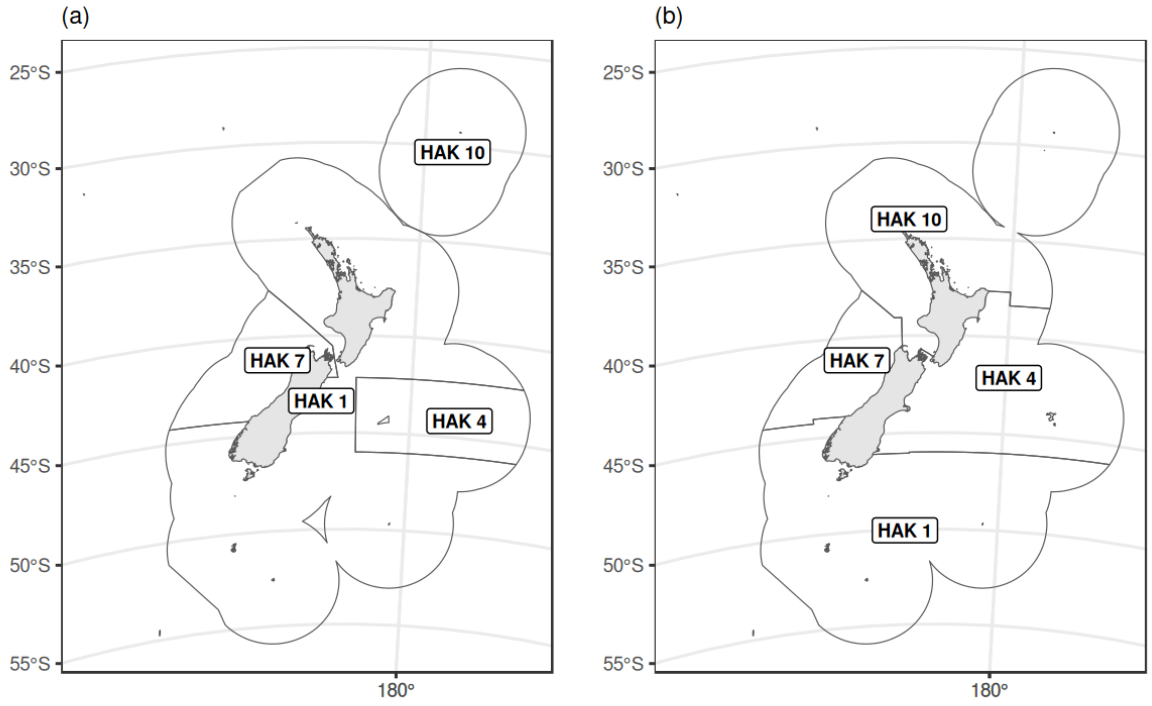


Figure A-1: The Quota Management Areas for hake (a), and the biological stocks (b) used for reporting the representativeness of observer sampling.

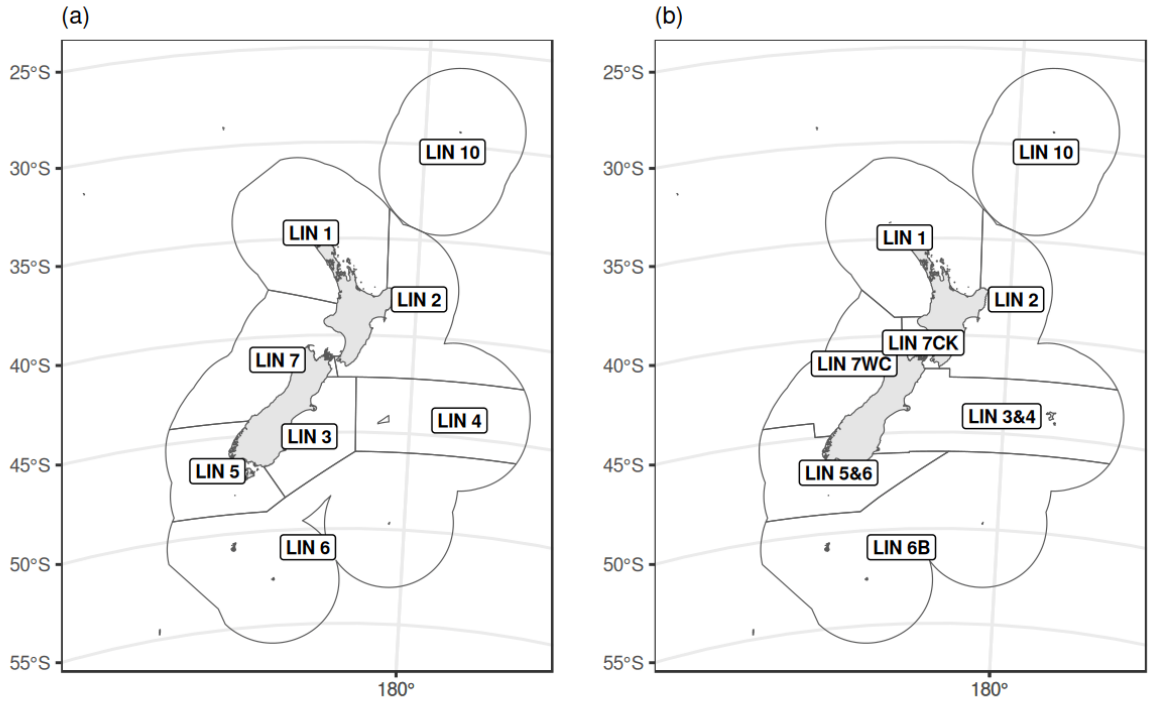


Figure A-2: The Quota Management Areas for ling (a), and the biological stocks (b) used for reporting the representativeness of observer sampling.

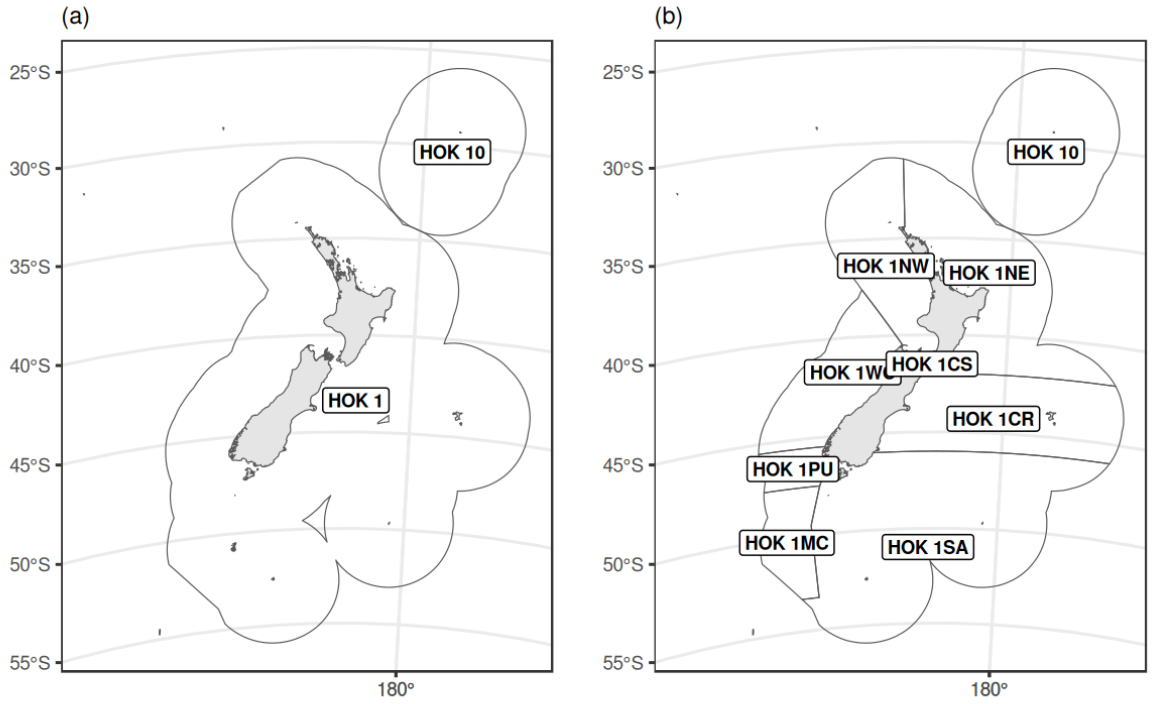


Figure A-3: The Quota Management Areas for hoki (a), and the fishery areas (b) used for reporting the representativeness of observer sampling.

APPENDIX B: EXAMPLES OF TRIP REPORTS

This appendix provides three examples of reports that enable sampling to be assessed for individual observer trips. The examples included here have been anonymised. The reports use a standardised, graphical format and include:

- Trip details, including the intended targets and areas, and a summary of realised fishing activity and sampling
- Plots of the fishing activity on the trip, as a timeline and a map
- Trip level catch and sampling by species, with the representativeness of sampling in terms of catch and positive events
- Cumulative distributions evaluating the representativeness of length-frequency, biological, and age sampling over the course of the trip
- Realised sample sizes by species, in relation to catches
- A table of samples by species

Fisheries New Zealand

Tini a Tangaroa

Observer trip 9999: sampling report

Last updated: 2026-10-01

Trip details

- Vessel: **ABCDEF** (99999)
- Trip dates: **YYYY-MM-DD** to **YYYY-MM-DD** (31 days, of which 25 were fished)
- Intended targets: BAR/ JMA
- Intended areas: CEW/ CHA/ SOE
- Fishing events: 64
- Number of observers: 1
- Sampled events (L-F): 25
- Otoliths collected (n. fish): 267

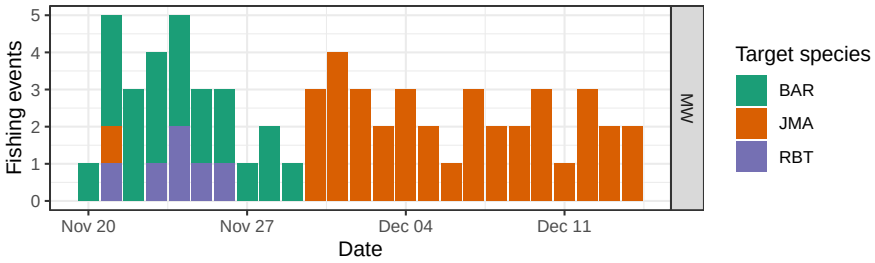


Figure 1: Daily fishing activity through the trip. Target species is as assigned by the observer.



Figure 2: Fishing event locations. Target species is as assigned by the observer.

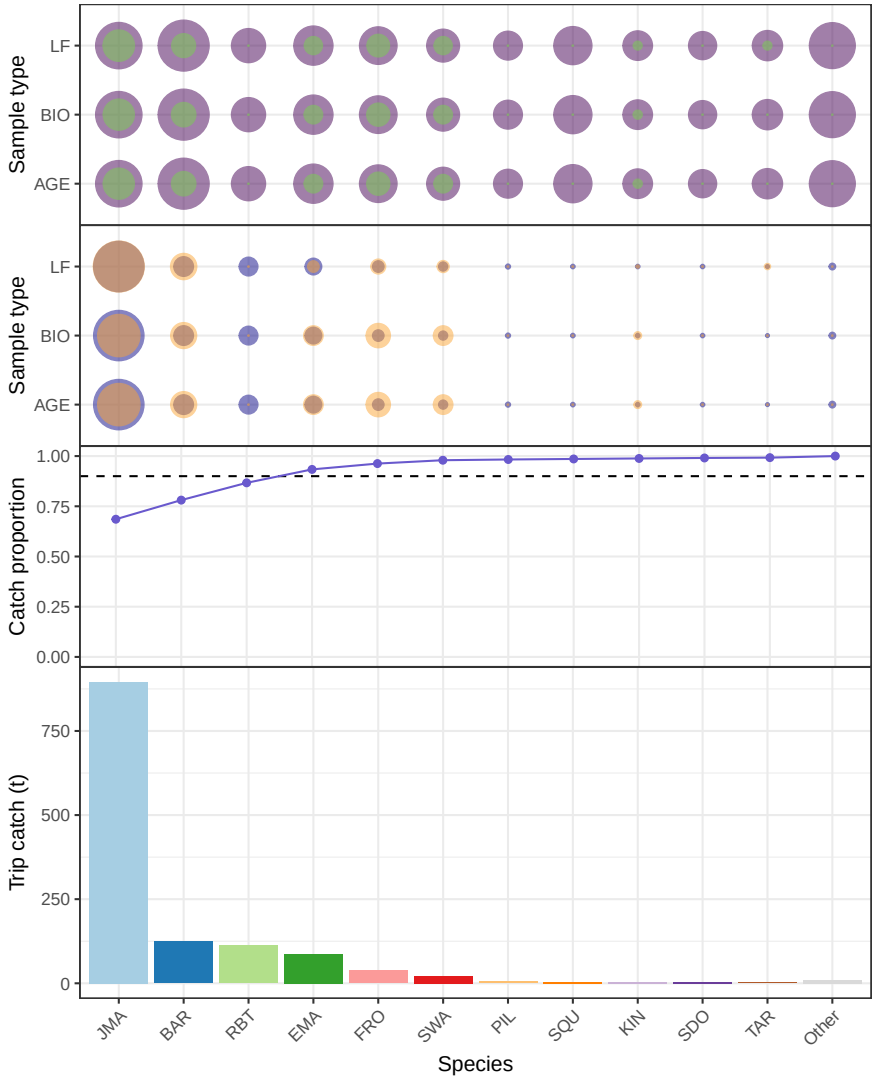


Figure 3: Trip catch by species (lower panel), cumulative proportion of trip catch across species (middle panel, with the dashed line representing 90%), and representativeness of sampling at the trip level (top panels). In the top panels, the blue circles show the proportion of catch weight by species, and the orange circles show the proportion of sample numbers, the purple circles show the proportion of events that caught a species, and the green circles show the proportions of events sampled. LF indicates length-frequency samples, BIO indicates individual biological samples, and AGE indicates biological samples with ageing material.

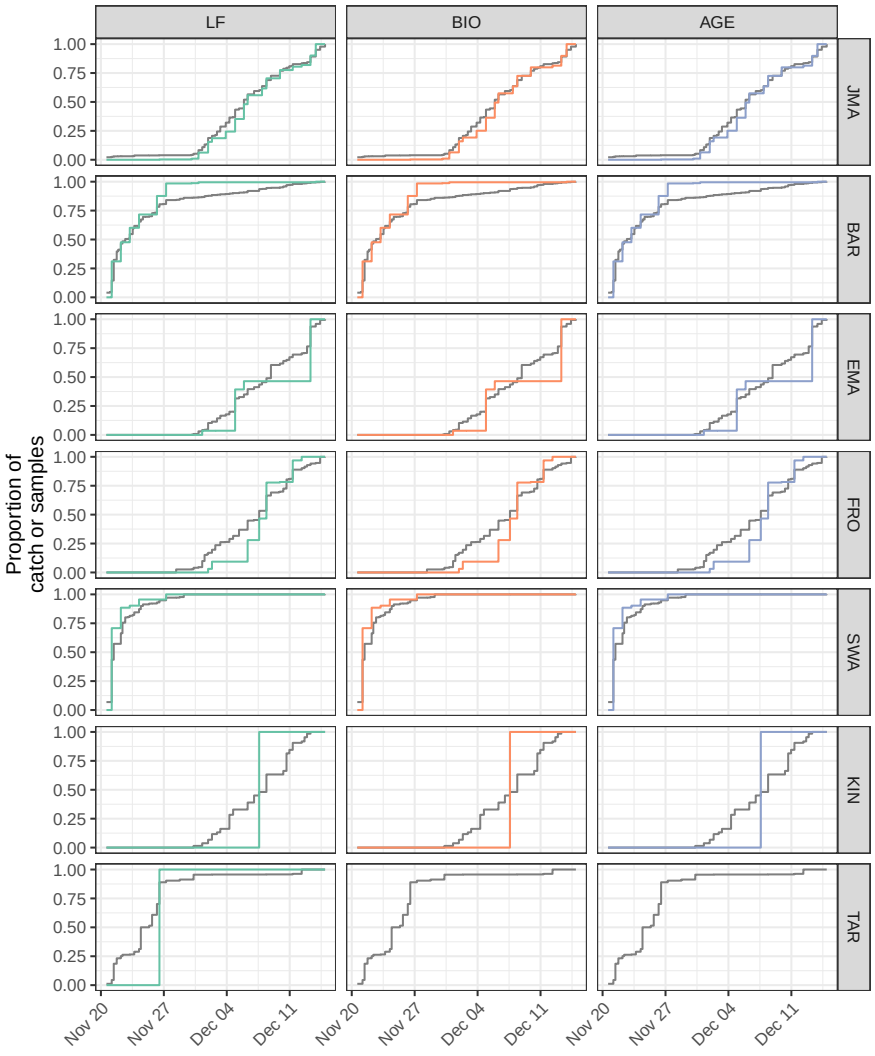


Figure 4: Sampling representativeness across trip fishing events; the cumulative proportion of catch sampled (coloured line) should be close to the cumulative proportion of catch (grey line). LF indicates length-frequency sampling, BIO indicates individual biological sampling, and AGE indicates biological sampling with ageing material.

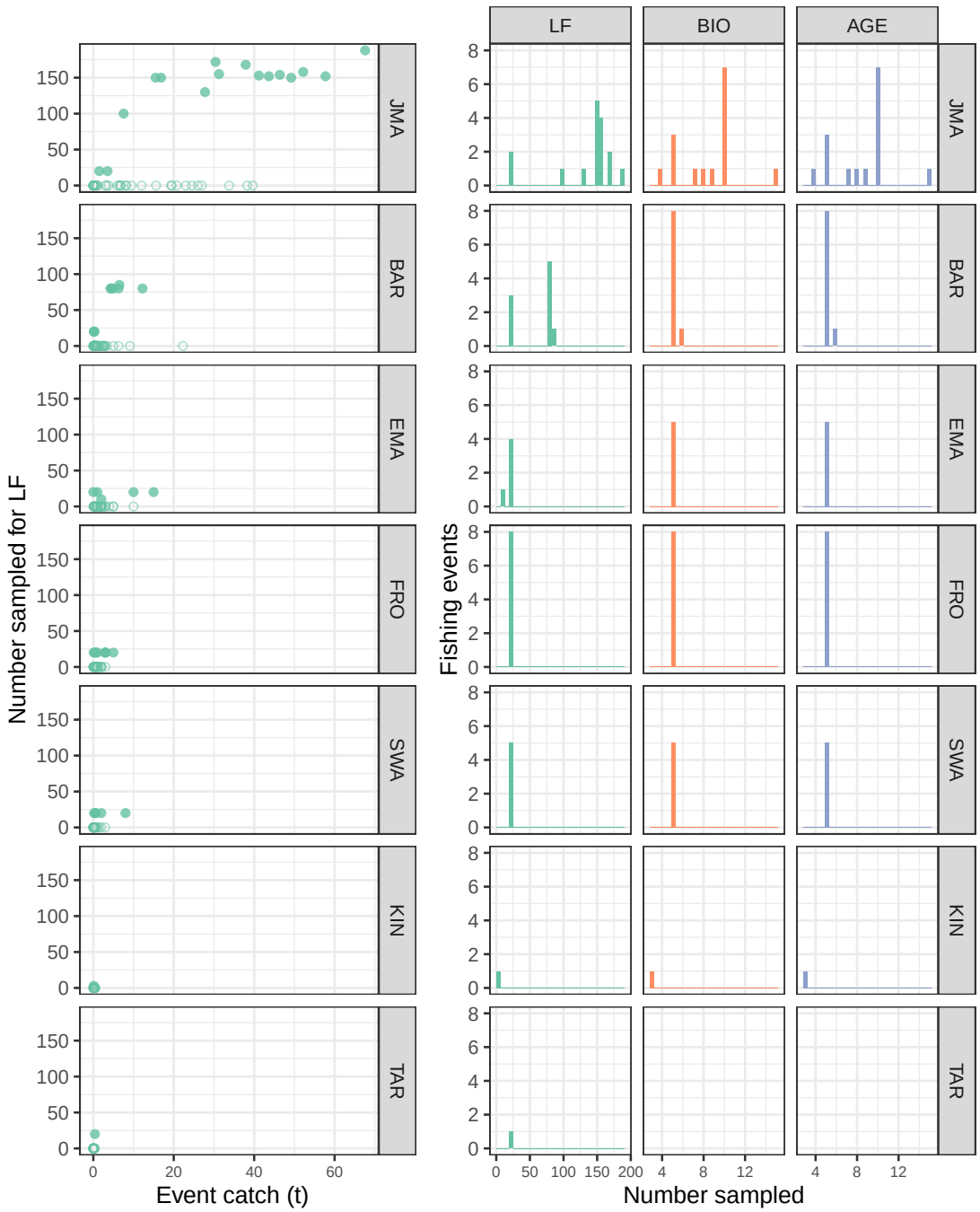


Figure 5: Length-frequency sample sizes relative to event catch (left) and histograms showing the number of events with different length-frequency, biological, and ageing sample sizes.

Table 1: Sampling by species. LF indicates length-frequency samples, BIO indicates individual biological samples, and AGE indicates biological samples with ageing material.

		Events sampled			Individuals sampled		
Species	Events caught	LF	BIO	AGE	LF	BIO	AGE
JMA	51	16	15	15	2172	128	128
BAR	62	9	9	9	545	46	46
EMA	36	5	5	5	90	25	25
FRO	33	8	8	8	160	40	40
SWA	25	5	5	5	100	25	25
KIN	20	1	1	1	3	3	3
TAR	21	1	-	-	20	-	-

Fisheries New Zealand
Tini a Tangaroa

Observer trip 9999: sampling report

Last updated: 2026-10-01

Trip details

- Vessel: **ABCDEF** (99999)
- Trip dates: **YYYY-MM-DD** to **YYYY-MM-DD** (45 days, of which 36 were fished)
- Intended targets: LIN - Ling
- Intended areas: FMA5 - SOU - Southland
- Fishing events: 84
- Number of observers: 1
- Sampled events (L-F): 54
- Otoliths collected (n. fish): 933

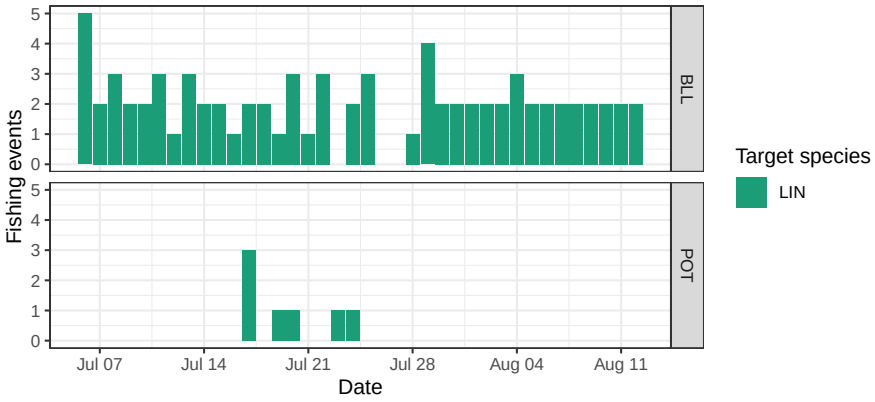


Figure 1: Daily fishing activity through the trip. Target species is as assigned by the observer.

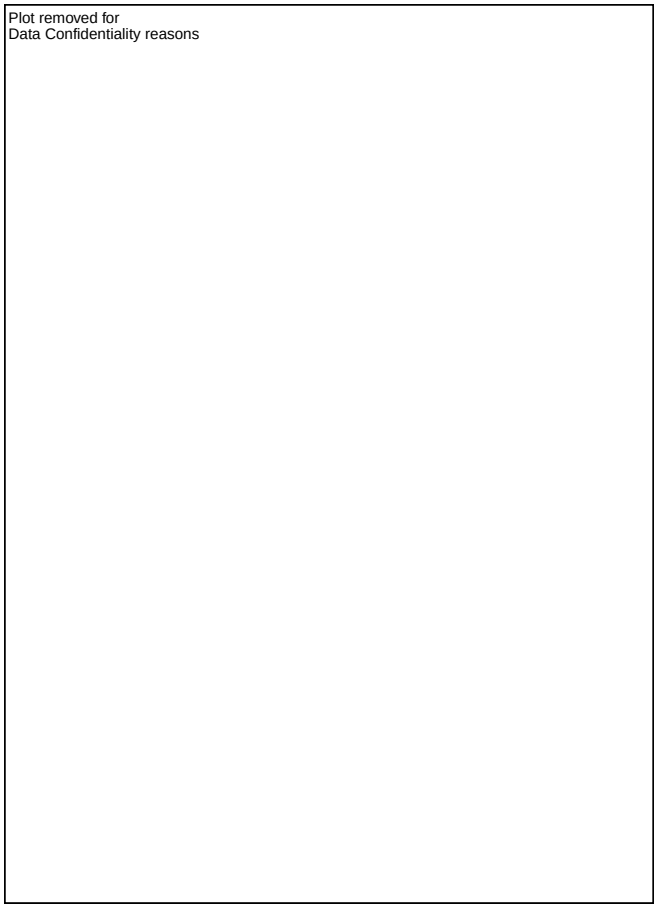


Figure 2: Fishing event locations. Target species is as assigned by the observer.

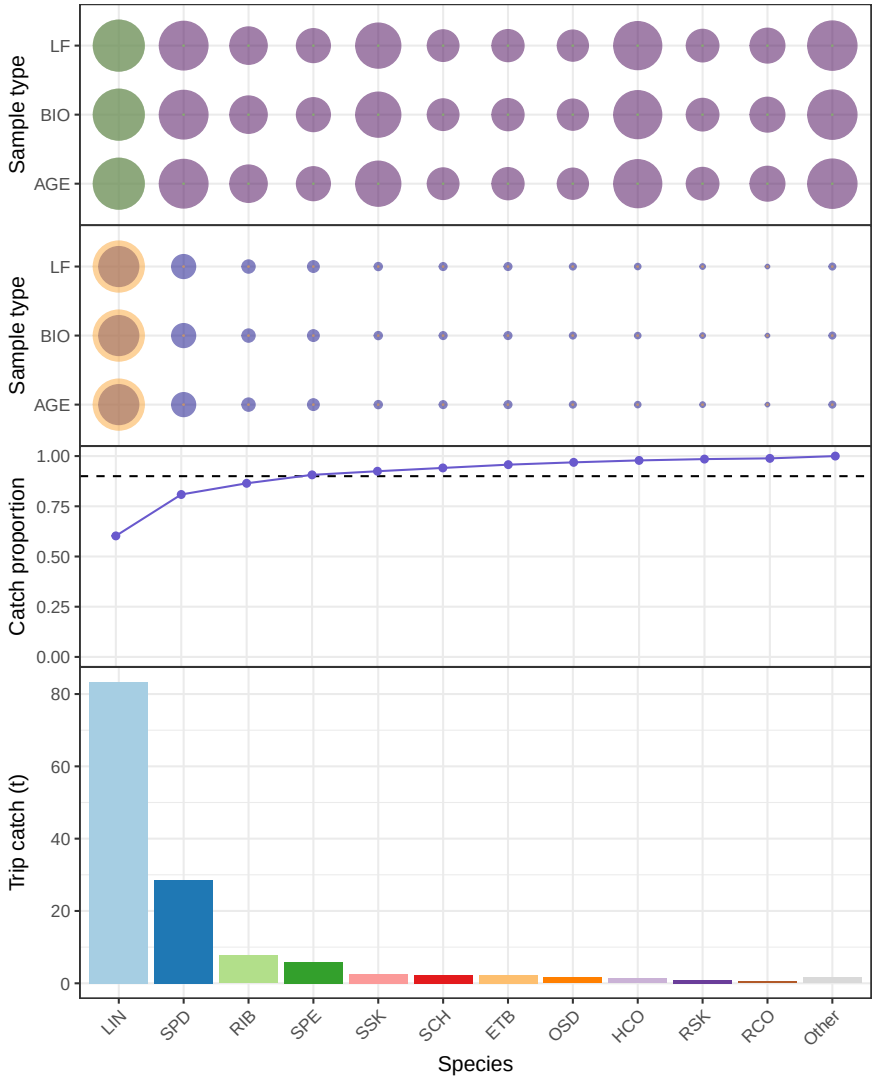


Figure 3: Trip catch by species (lower panel), cumulative proportion of trip catch across species (middle panel, with the dashed line representing 90%), and representativeness of sampling at the trip level (top panels). In the top panels, the blue circles show the proportion of catch weight by species, and the orange circles show the proportion of sample numbers, the purple circles show the proportion of events that caught a species, and the green circles show the proportions of events sampled. LF indicates length-frequency samples, BIO indicates individual biological samples, and AGE indicates biological samples with ageing material.

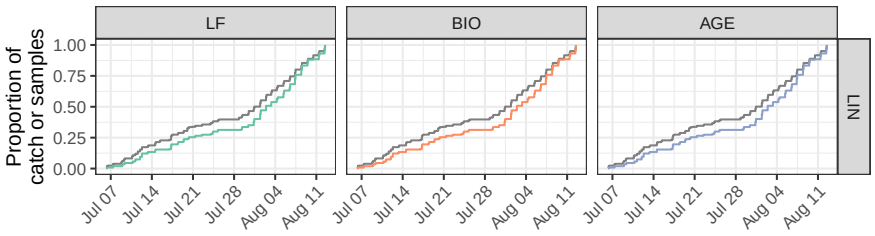


Figure 4: Sampling representativeness across trip fishing events; the cumulative proportion of catch sampled (coloured line) should be close to the cumulative proportion of catch (grey line). LF indicates length-frequency sampling, BIO indicates individual biological sampling, and AGE indicates biological sampling with ageing material.

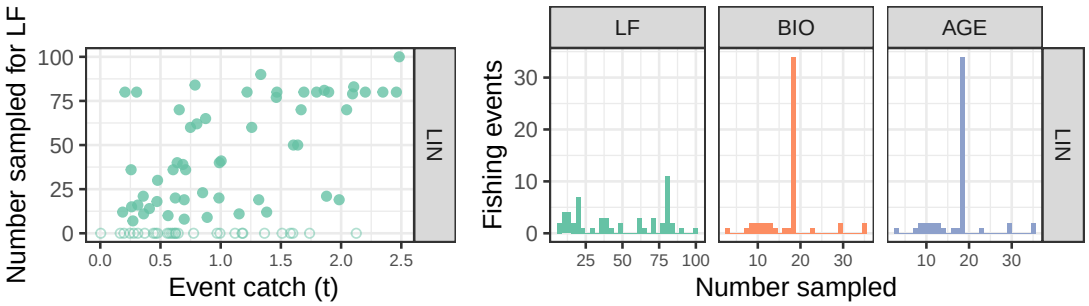


Figure 5: Length-frequency sample sizes relative to event catch (left) and histograms showing the number of events with different length-frequency, biological, and ageing sample sizes.

Table 1: Sampling by species. LF indicates length-frequency samples, BIO indicates individual biological samples, and AGE indicates biological samples with ageing material.

		Events sampled			Individuals sampled		
Species	Events caught	LF	BIO	AGE	LF	BIO	AGE
LIN	83	54	54	54	2554	933	933

Fisheries New Zealand

Tini a Tangaroa

Observer trip 9999: sampling report

Last updated: 2026-10-01

Trip details

- Vessel: **ABCDEF** (99999)
- Trip dates: **YYYY-MM-DD** to **YYYY-MM-DD** (61 days, of which 51 were fished)
- Intended targets: SQU
- Intended areas: SOI
- Fishing events: 122
- Number of observers: 1
- Sampled events (L-F): 51
- Otoliths collected (n. fish): 640

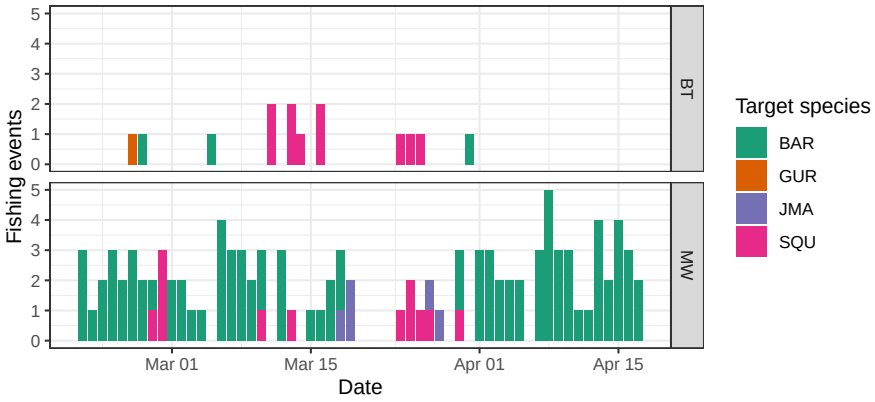


Figure 1: Daily fishing activity through the trip. Target species is as assigned by the observer.

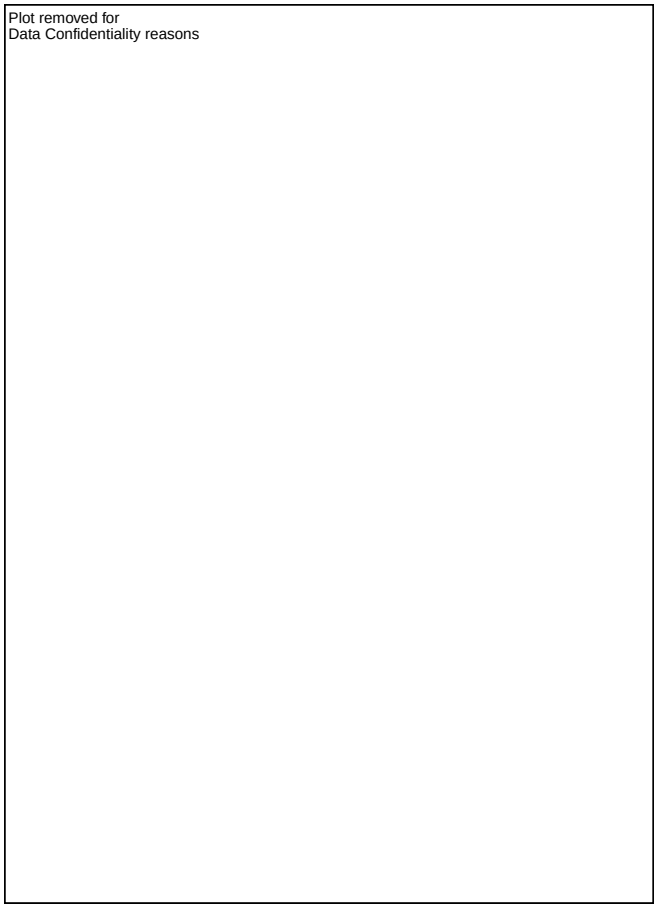


Figure 2: Fishing event locations. Target species is as assigned by the observer.

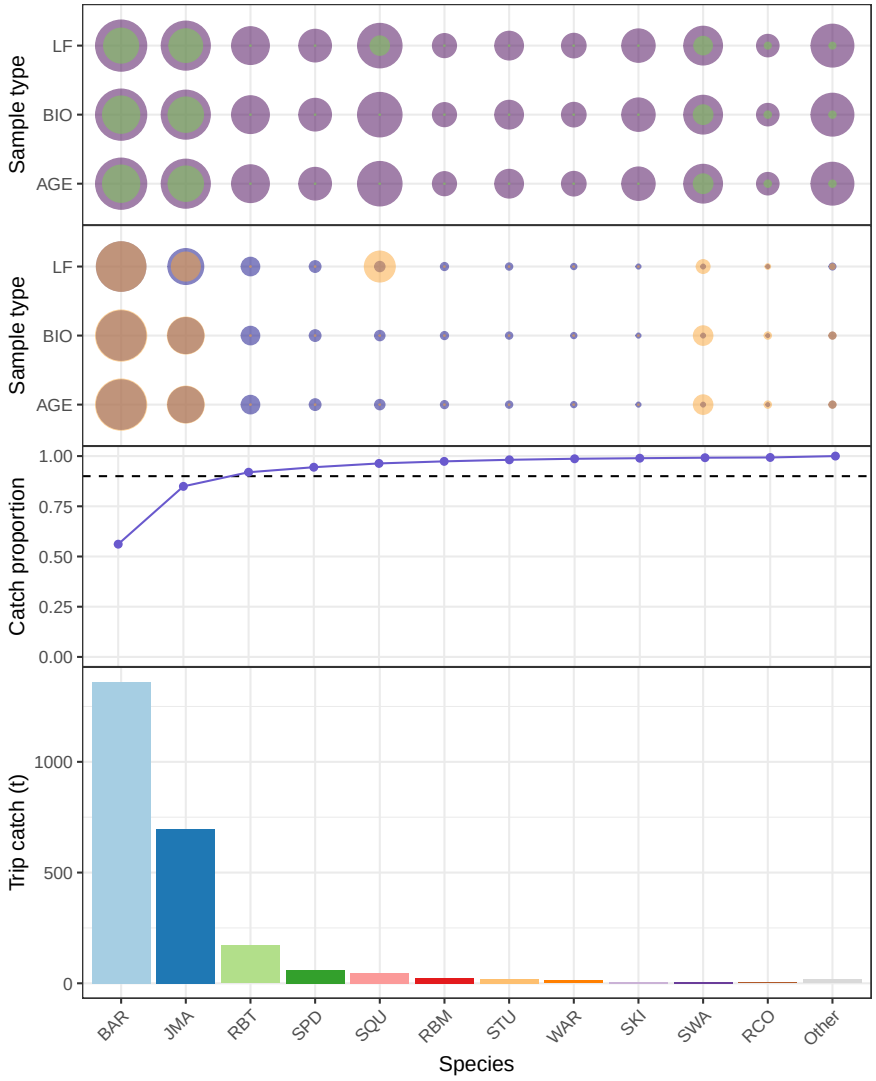


Figure 3: Trip catch by species (lower panel), cumulative proportion of trip catch across species (middle panel, with the dashed line representing 90%), and representativeness of sampling at the trip level (top panels). In the top panels, the blue circles show the proportion of catch weight by species, and the orange circles show the proportion of sample numbers, the purple circles show the proportion of events that caught a species, and the green circles show the proportions of events sampled. LF indicates length-frequency samples, BIO indicates individual biological samples, and AGE indicates biological samples with ageing material.

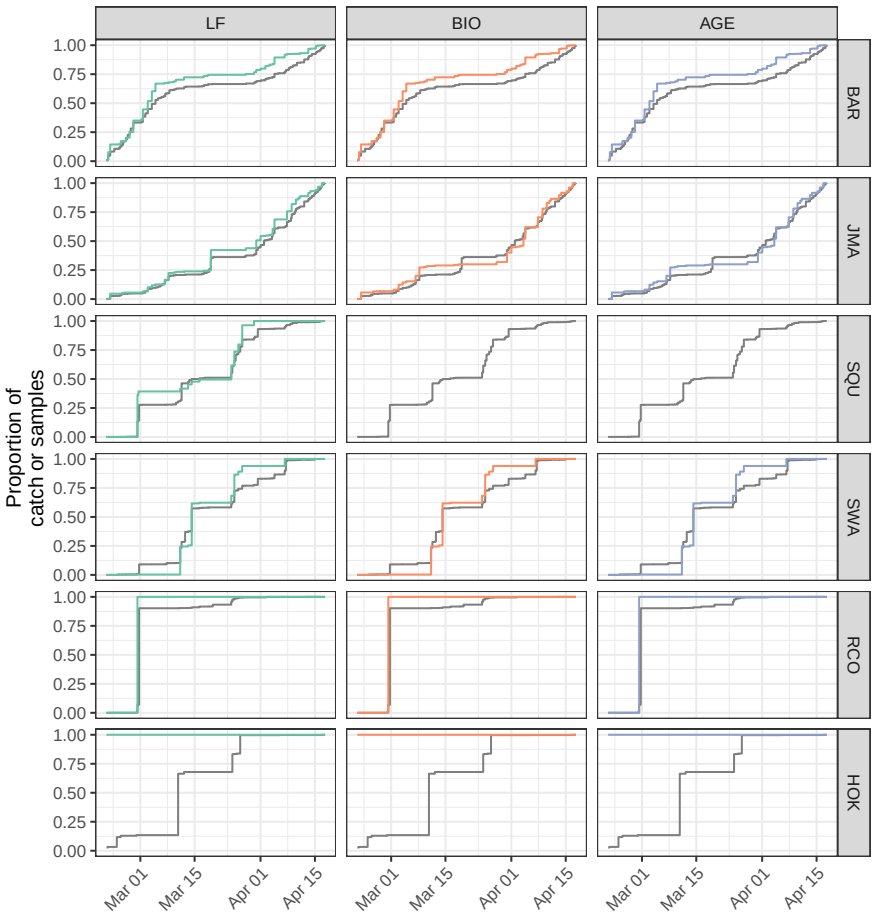


Figure 4: Sampling representativeness across trip fishing events; the cumulative proportion of catch sampled (coloured line) should be close to the cumulative proportion of catch (grey line). LF indicates length-frequency sampling, BIO indicates individual biological sampling, and AGE indicates biological sampling with ageing material.

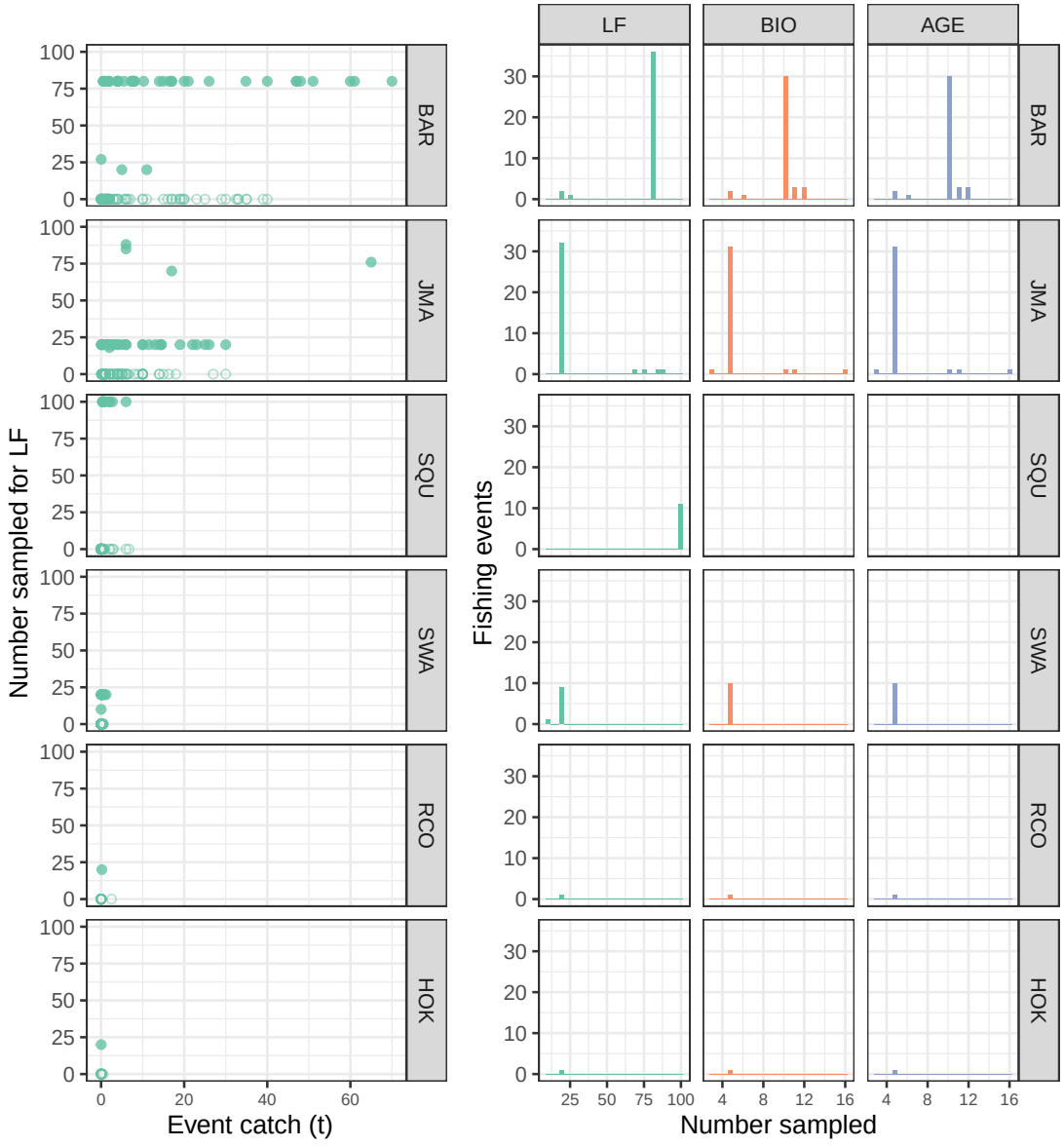


Figure 5: Length-frequency sample sizes relative to event catch (left) and histograms showing the number of events with different length-frequency, biological, and ageing sample sizes.

APPENDIX C: CATCH SIZES FOR SAMPLING

The scatter plots below show the realised length-frequency sample sizes (the number of fish sampled by observers) in relation to the total catch of a species from an event, for all deepwater species considered in this report (Table 1) and aggregated over fishing years up to 2024–25. Both sampled numbers and catch are plotted on log scales. The red dashed line indicates a sample size of 20 individuals, while the blue and green dotted lines indicate samples sizes of 30 and 100 individuals respectively. The red vertical line denotes the derived empirical threshold (see Section 2.5) for the catch weight, above which the event would be considered available for sampling. The threshold is also noted in the top-left of the main plot.

The marginal density plots illustrate the distribution of sampled and unsampled catch weights (x-axis), and of the length-frequency sample sizes for the species (y-axis).

In general, and ignoring outliers that are likely to be associated with errors in the recorded catch weight, the left 'edge' of the cloud of points identifies the minimum catch weight required for a particular sample size. For most species the sample size tends to increase with the quantity caught, asymptoting at sample sizes of around 100.

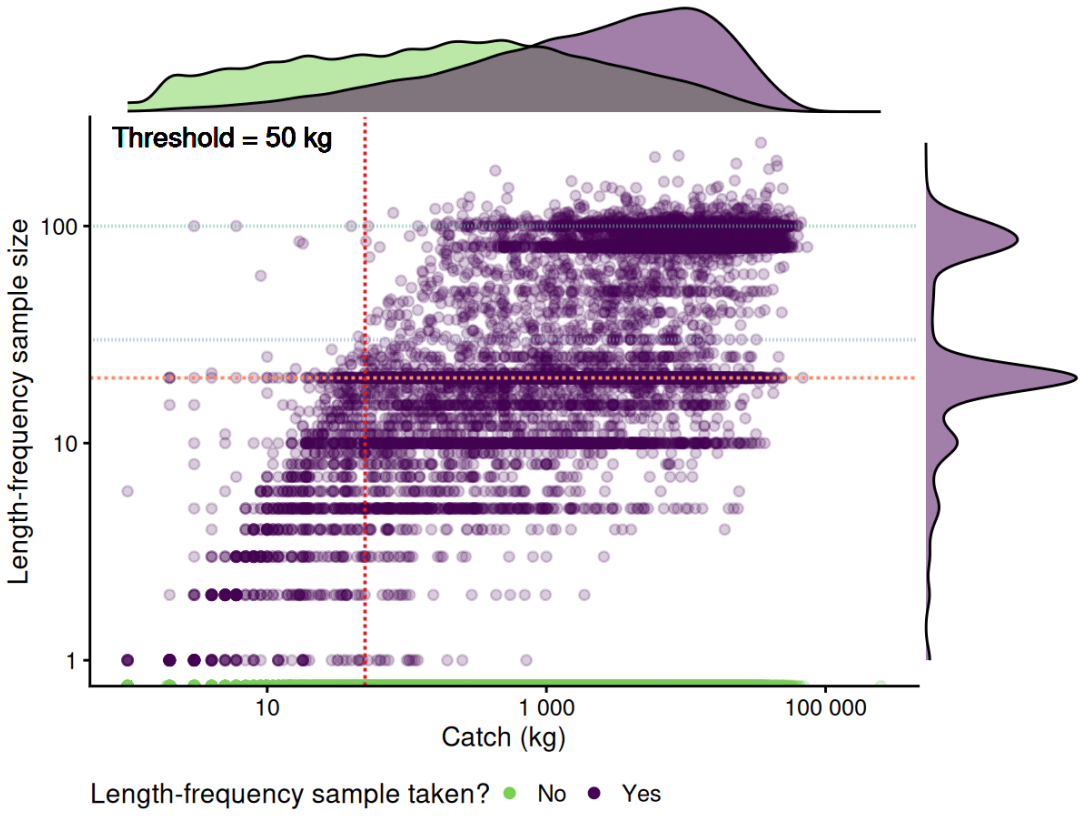


Figure C-1: Length-frequency sample sizes (number of fish sampled) in relation to the total BAR catch from an event.

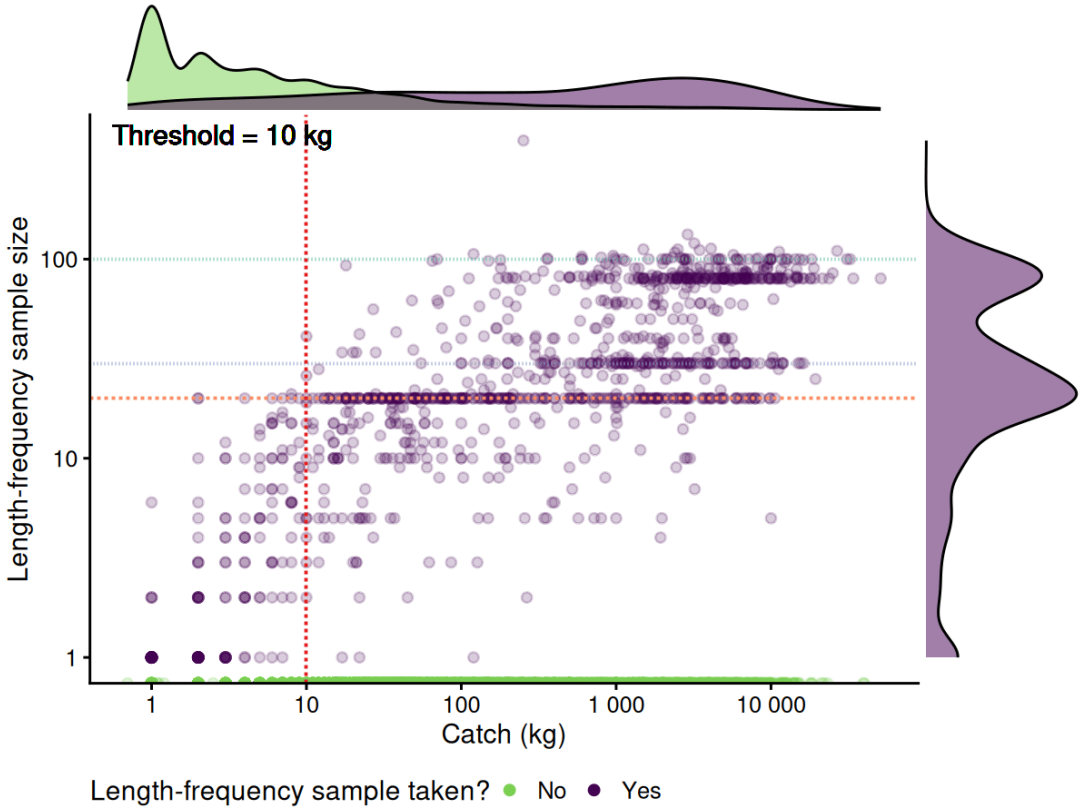


Figure C-2: Length-frequency sample sizes (number of fish sampled) in relation to the total BYX catch from an event.

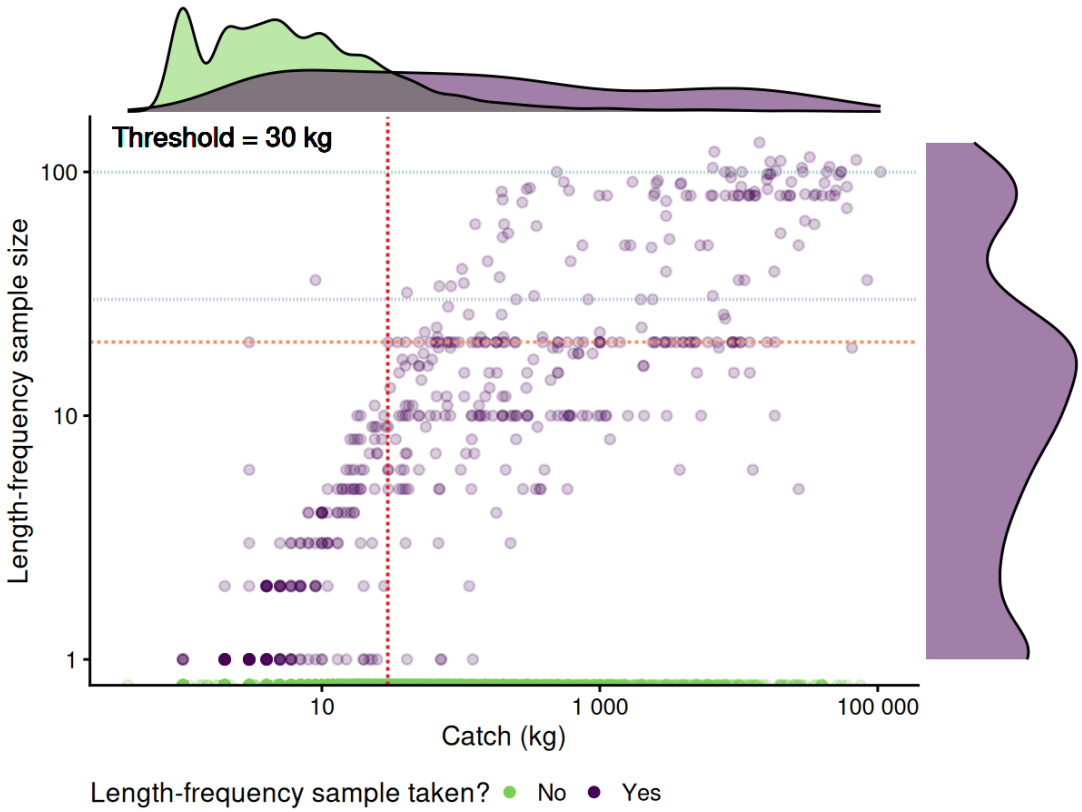


Figure C-3: Length-frequency sample sizes (number of fish sampled) in relation to the total CDL catch from an event.

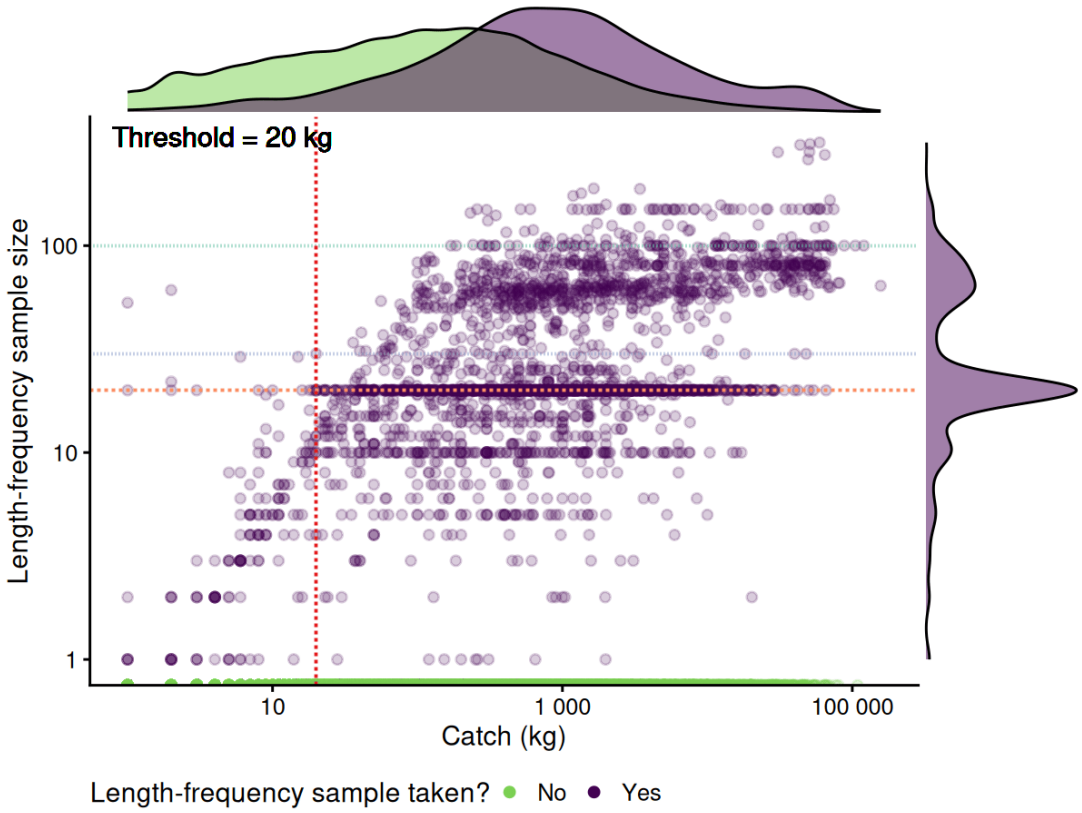


Figure C-4: Length-frequency sample sizes (number of fish sampled) in relation to the total EMA catch from an event.

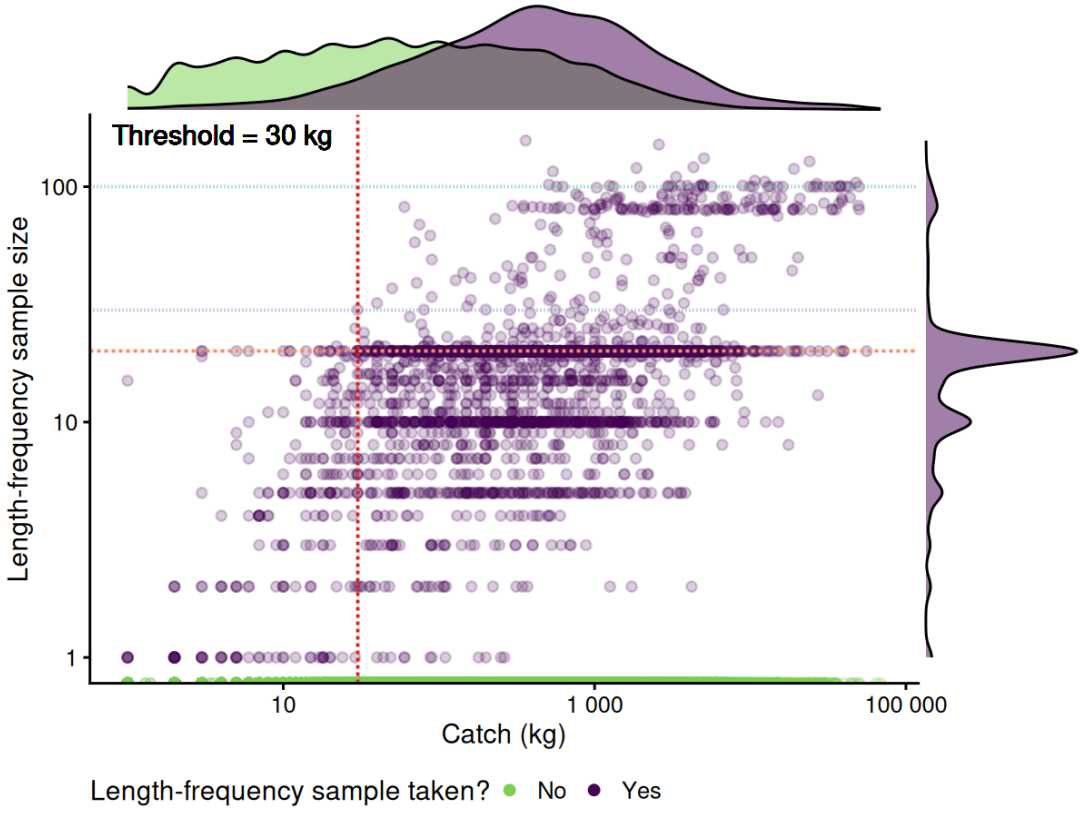


Figure C-5: Length-frequency sample sizes (number of fish sampled) in relation to the total FRO catch from an event.

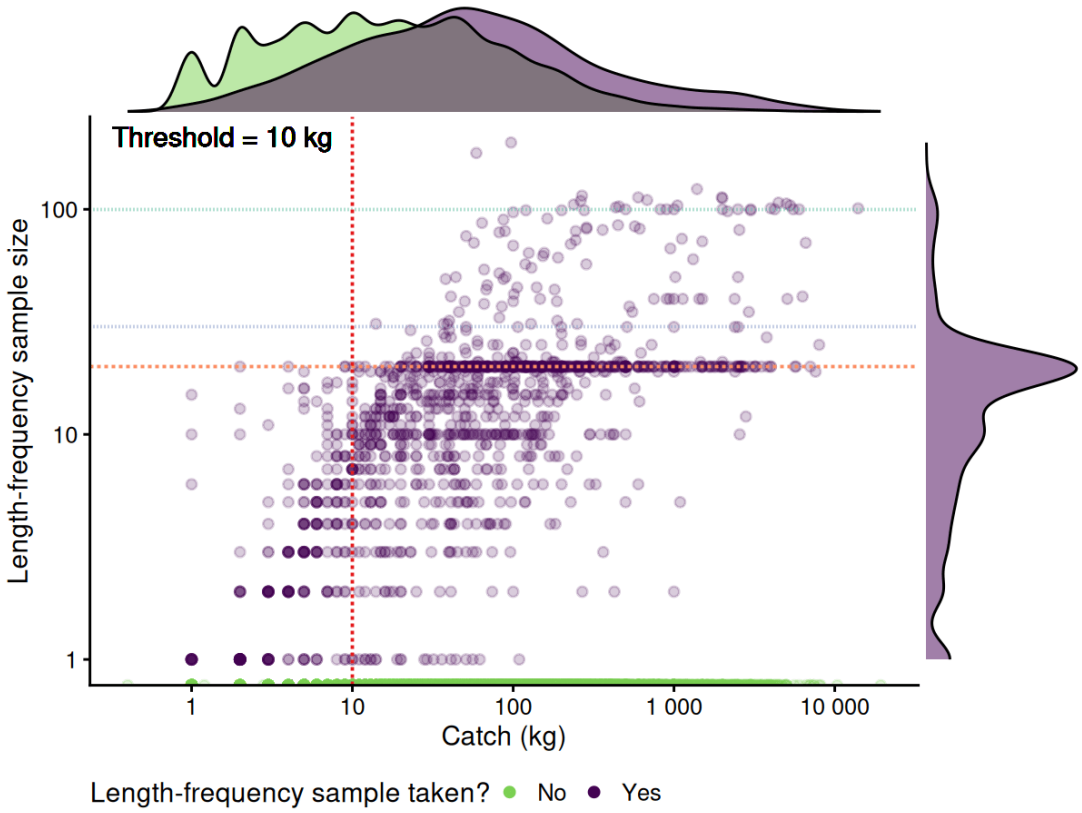


Figure C-6: Length-frequency sample sizes (number of fish sampled) in relation to the total GSH catch from an event.

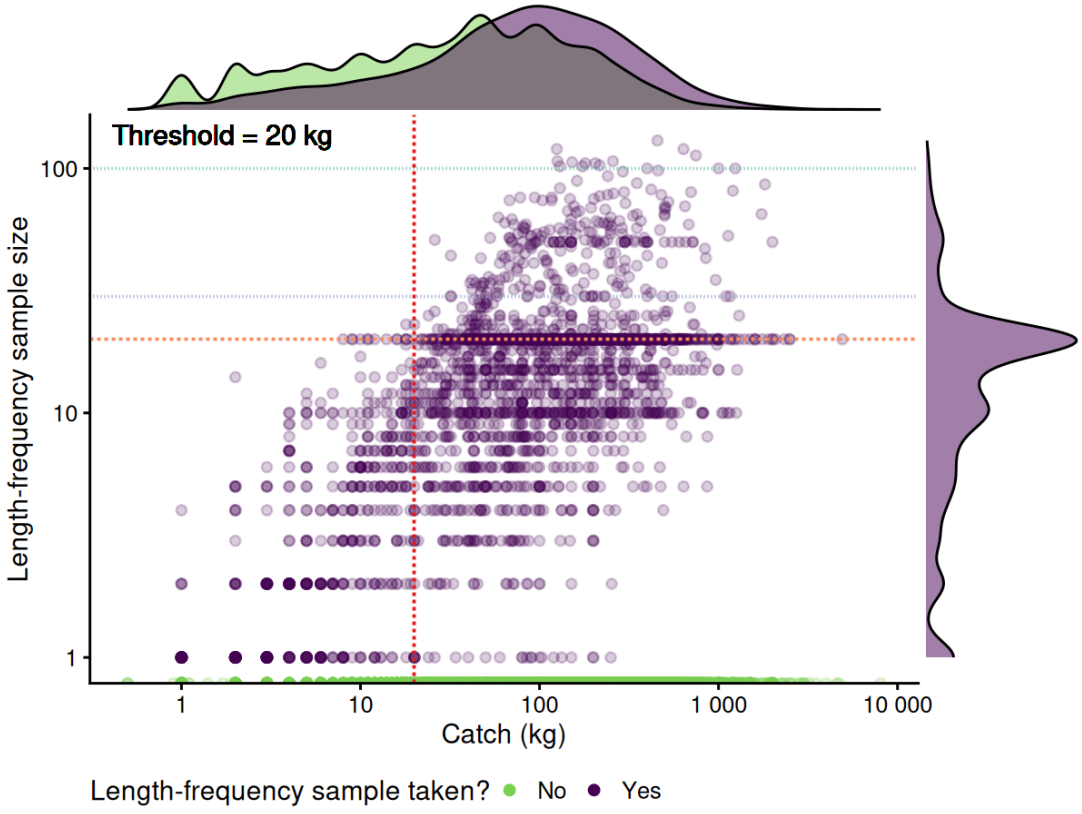


Figure C-7: Length-frequency sample sizes (number of fish sampled) in relation to the total GSP catch from an event.

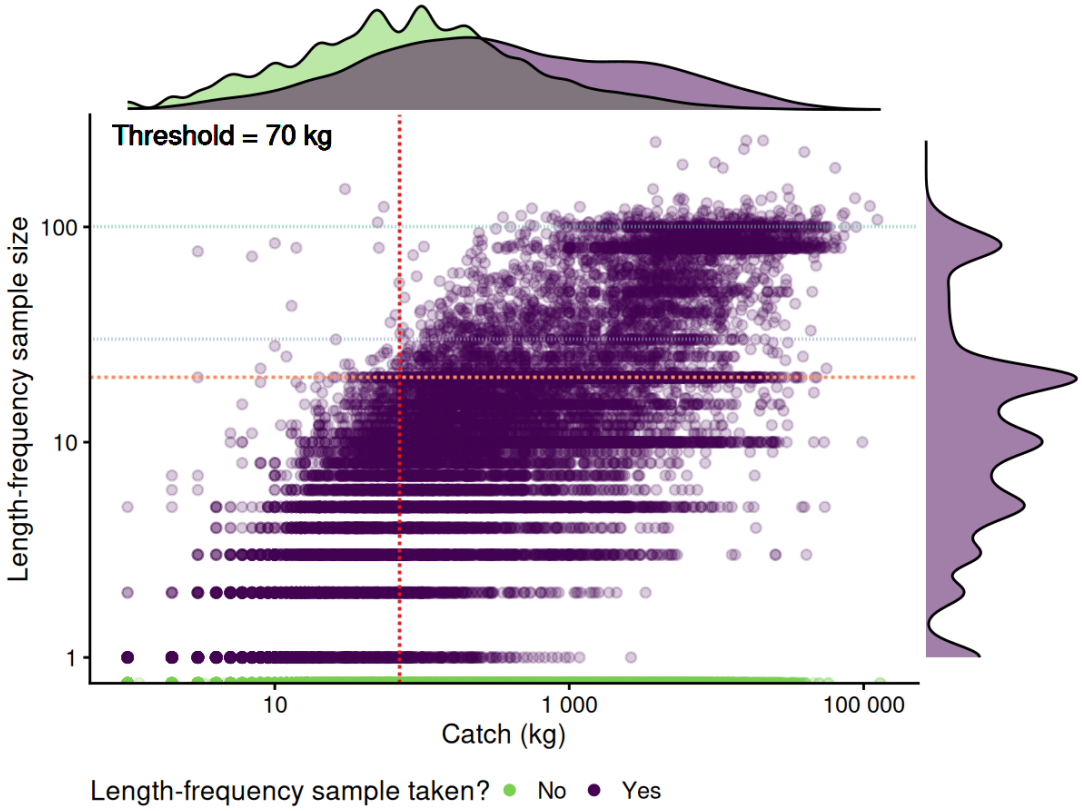


Figure C-8: Length-frequency sample sizes (number of fish sampled) in relation to the total HAK catch from an event.

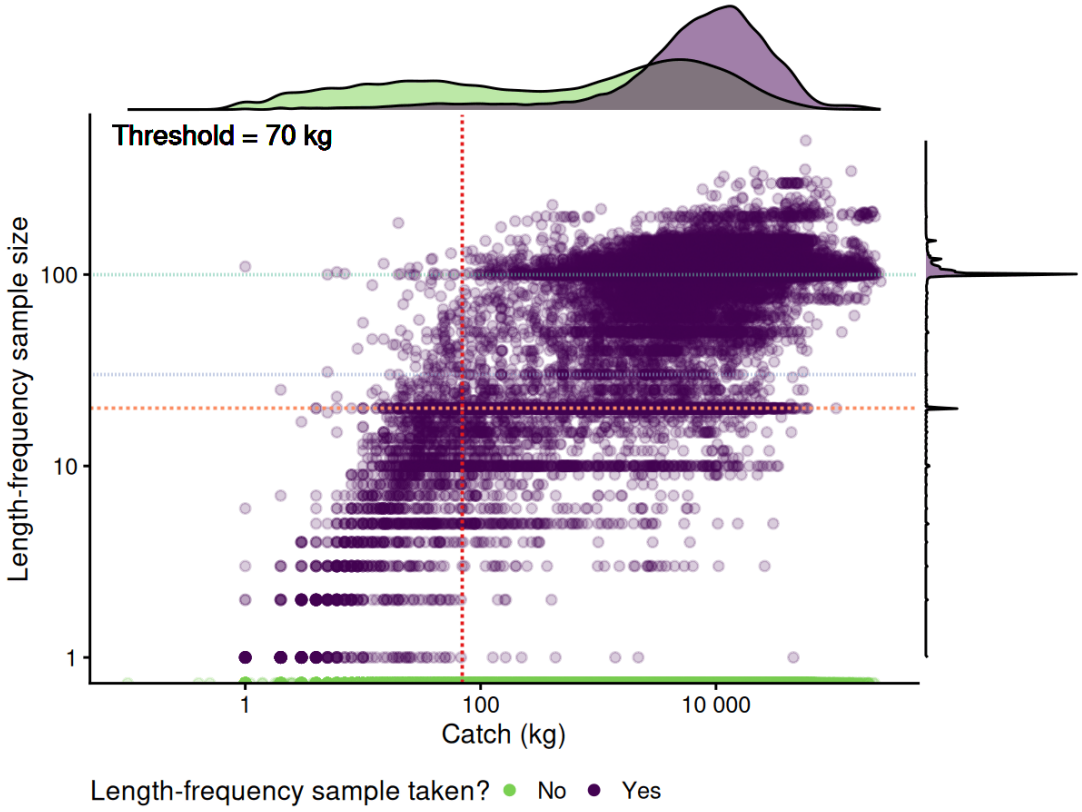


Figure C-9: Length-frequency sample sizes (number of fish sampled) in relation to the total HOK catch from an event.

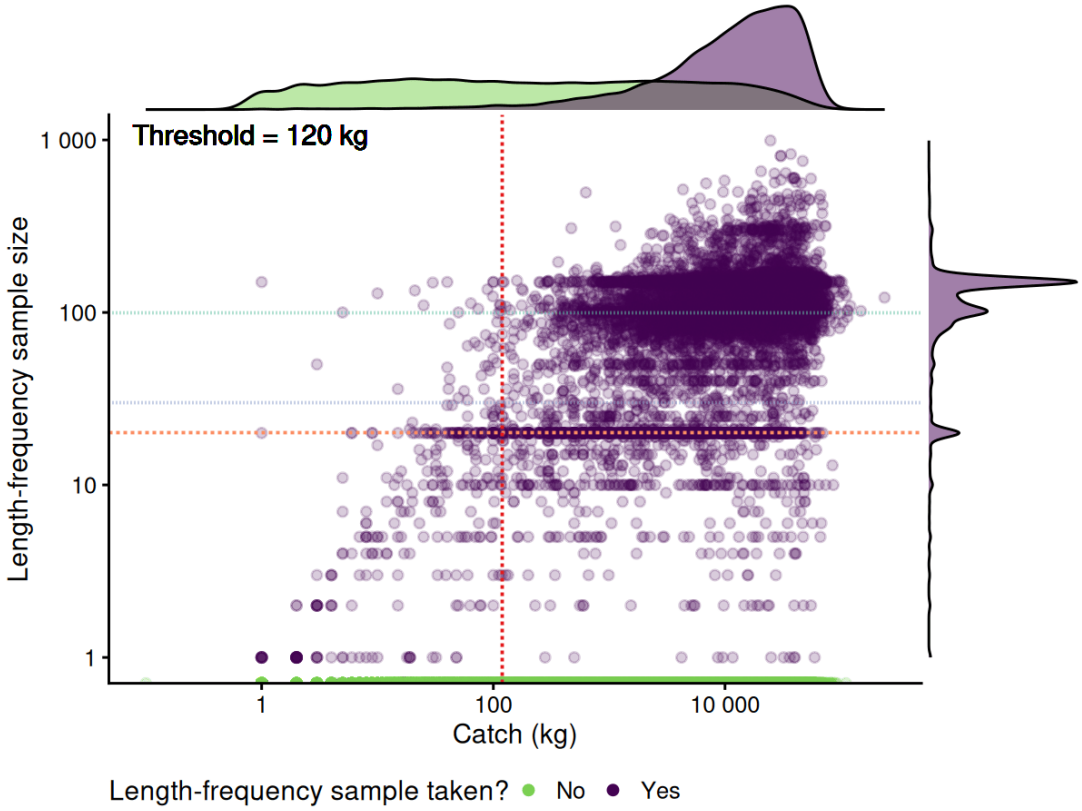


Figure C-10: **Length-frequency sample sizes (number of fish sampled) in relation to the total JMA catch from an event.**

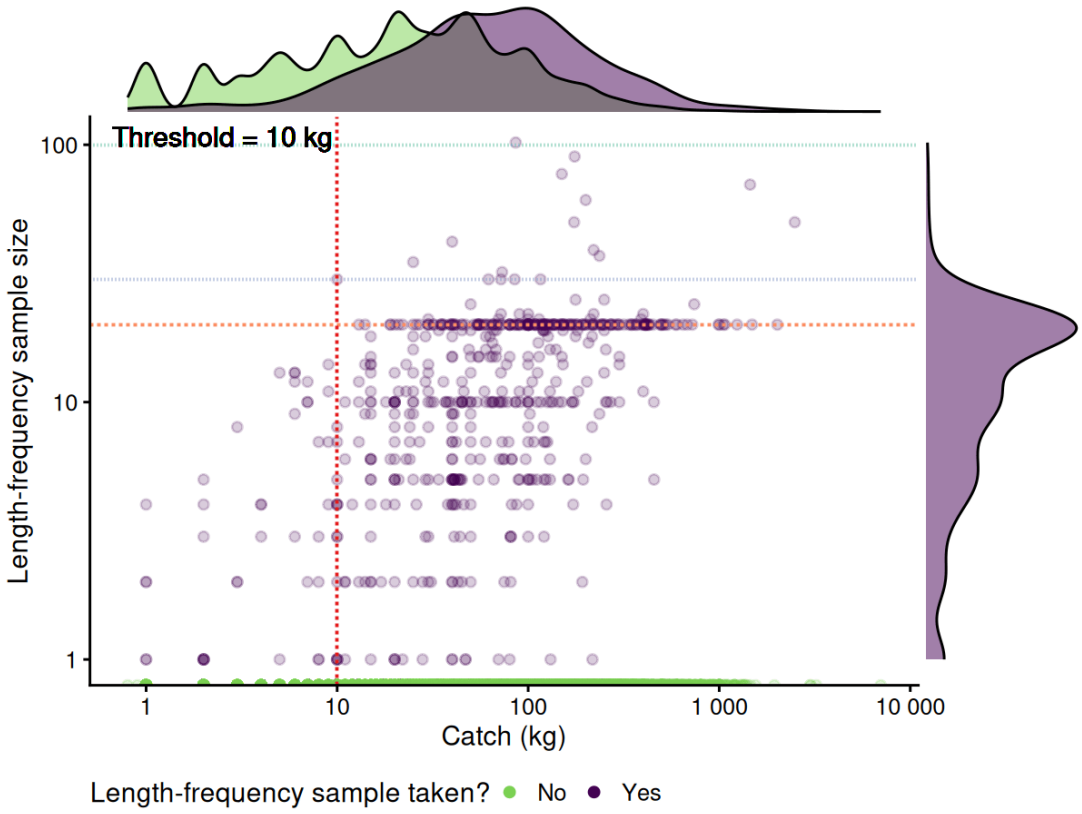


Figure C-11: **Length-frequency sample sizes (number of fish sampled) in relation to the total LDO catch from an event.**

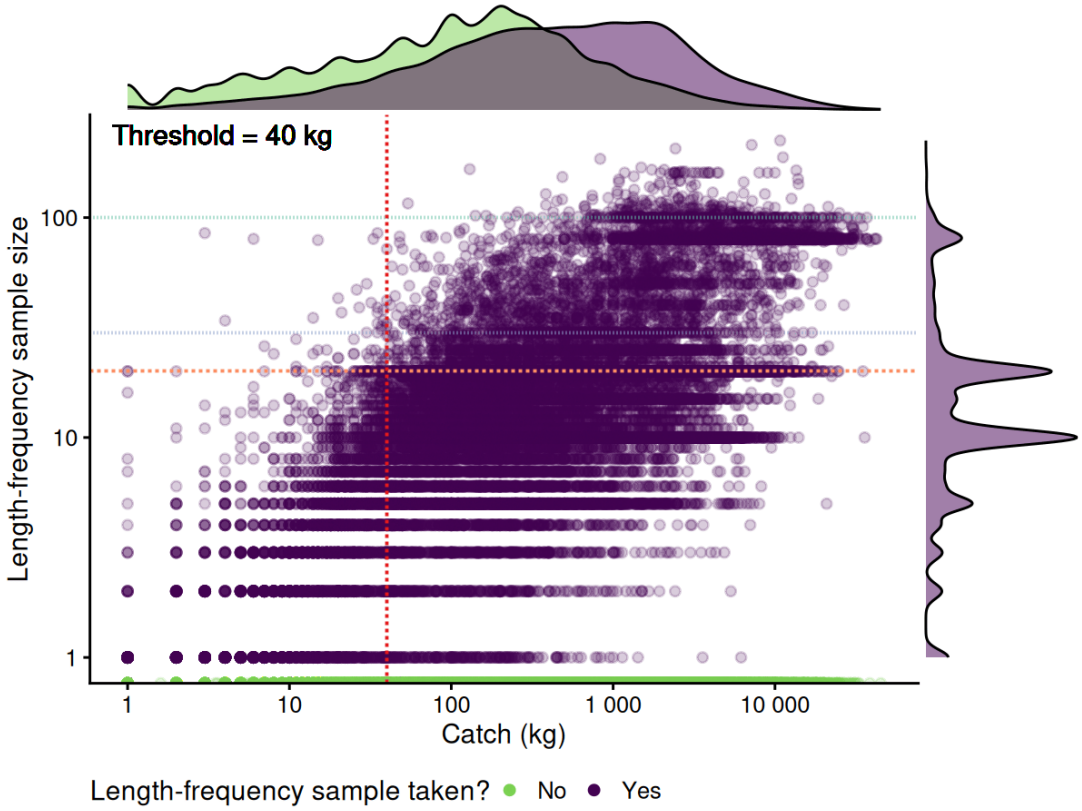


Figure C-12: Length-frequency sample sizes (number of fish sampled) in relation to the total LIN catch from an event.

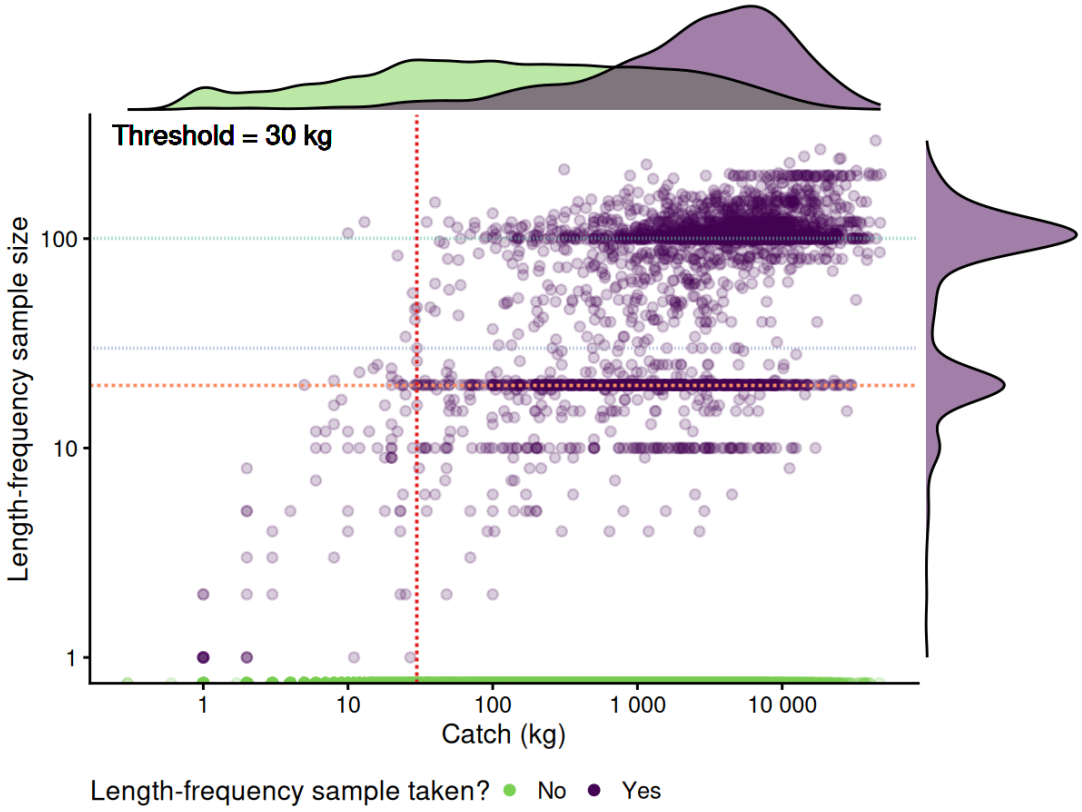


Figure C-13: Length-frequency sample sizes (number of fish sampled) in relation to the total BOE catch from an event.

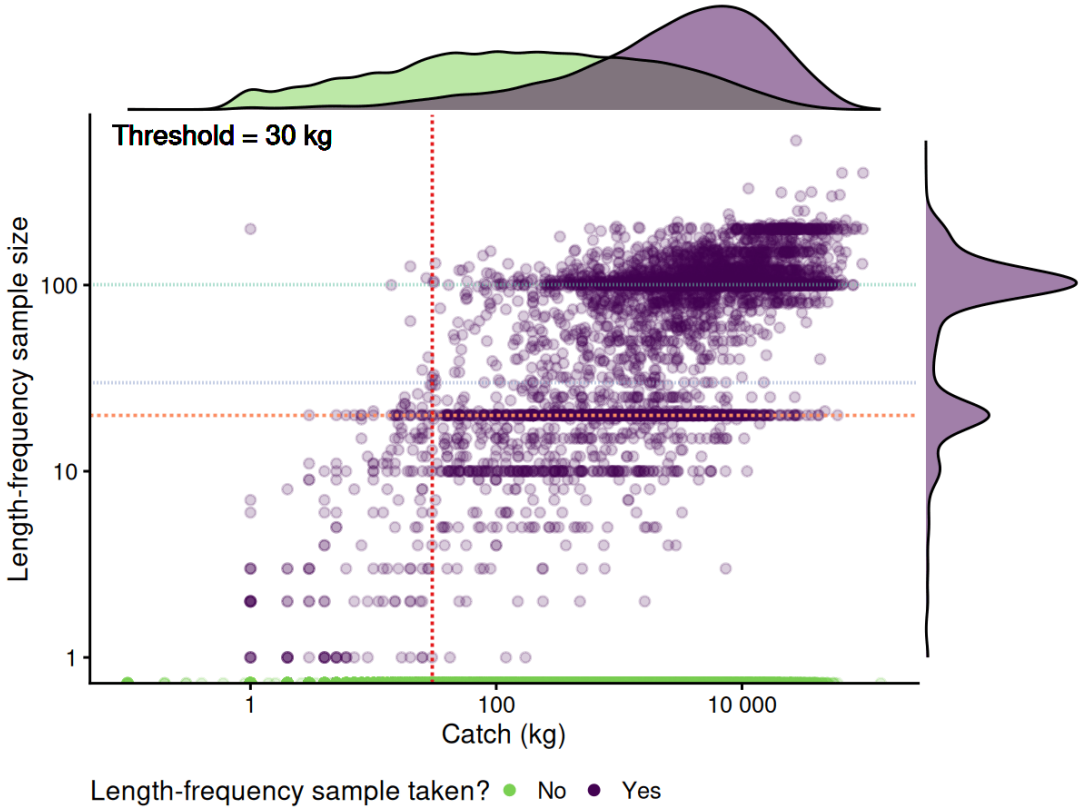


Figure C-14: Length-frequency sample sizes (number of fish sampled) in relation to the total SSO catch from an event.

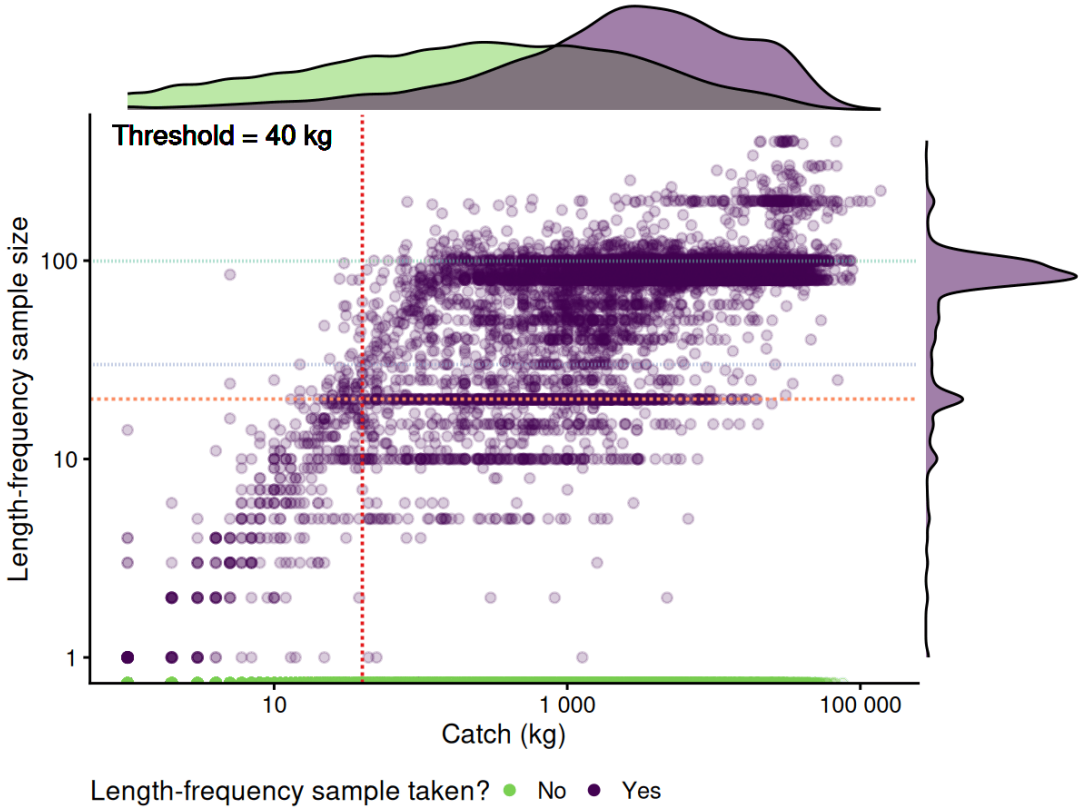


Figure C-15: Length-frequency sample sizes (number of fish sampled) in relation to the total ORH catch from an event.

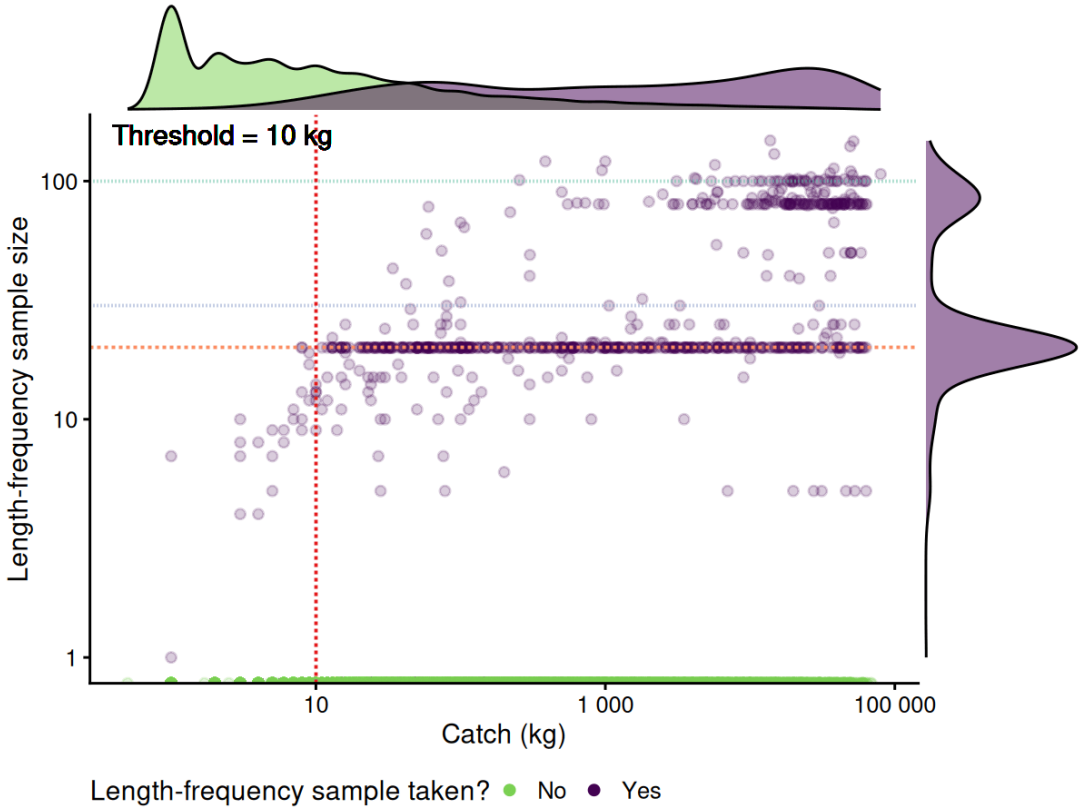


Figure C-16: Length-frequency sample sizes (number of fish sampled) in relation to the total RBT catch from an event.

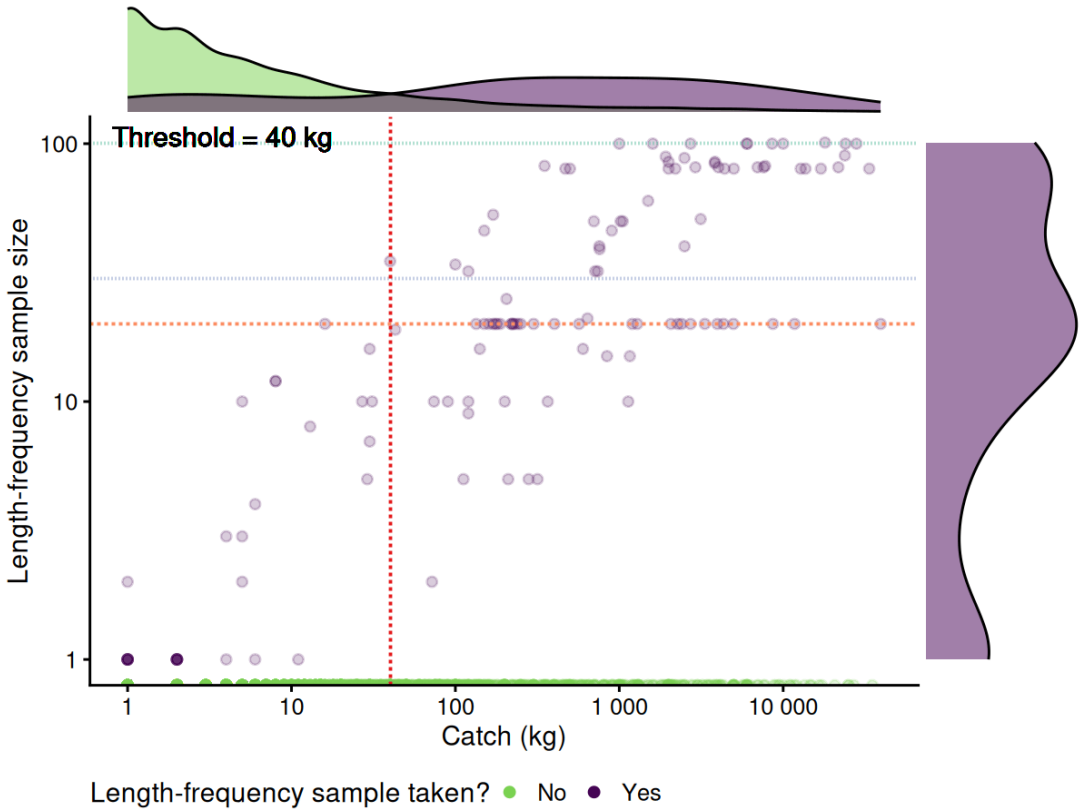


Figure C-17: Length-frequency sample sizes (number of fish sampled) in relation to the total RBY catch from an event.

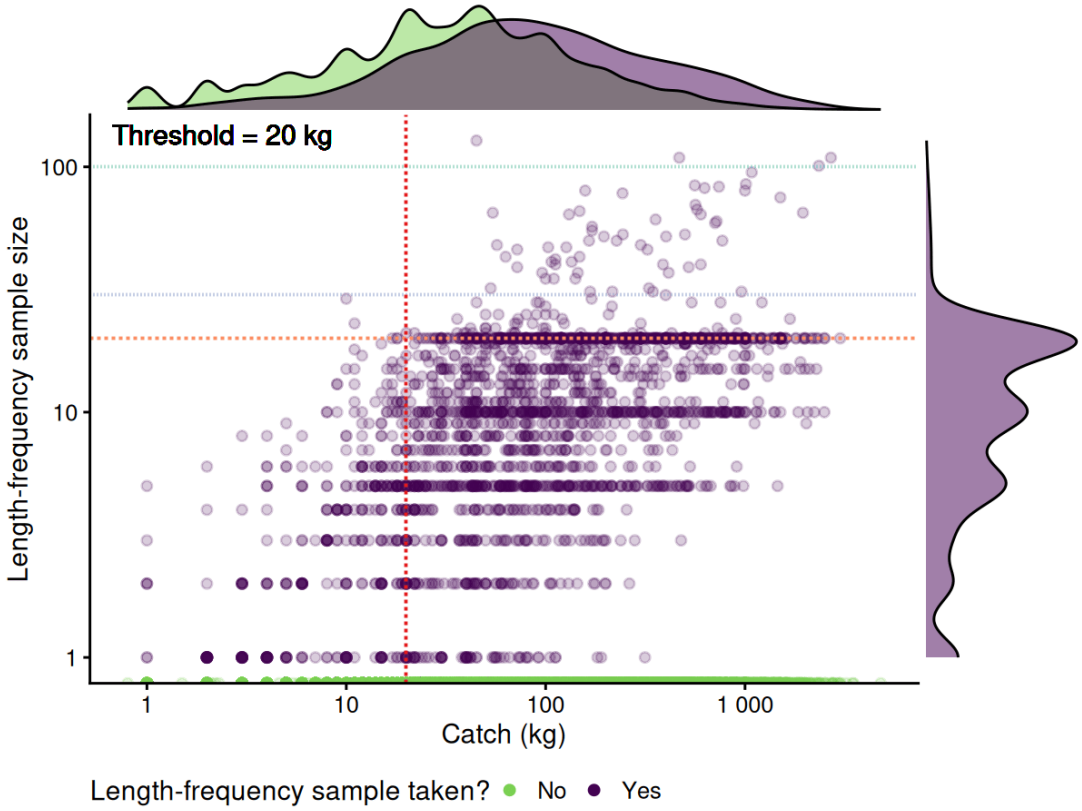


Figure C-18: **Length-frequency sample sizes (number of fish sampled) in relation to the total RIB catch from an event.**

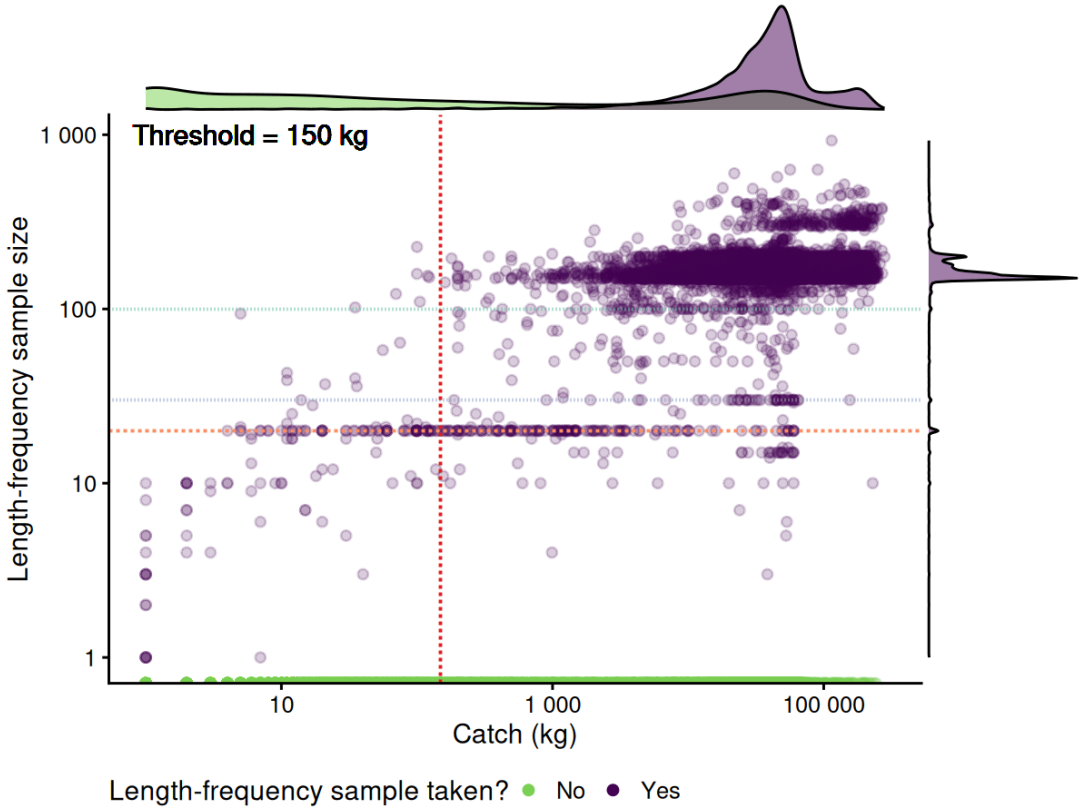


Figure C-19: **Length-frequency sample sizes (number of fish sampled) in relation to the total SBW catch from an event.**

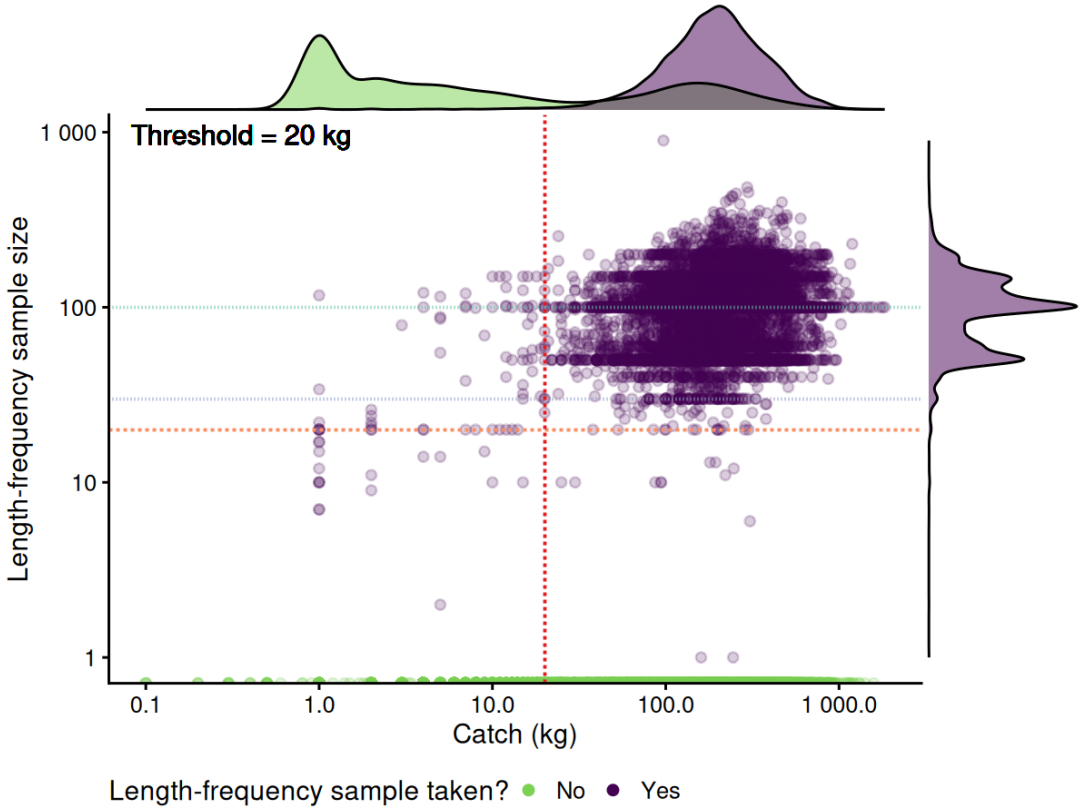


Figure C-20: Length-frequency sample sizes (number of fish sampled) in relation to the total SCI catch from an event.

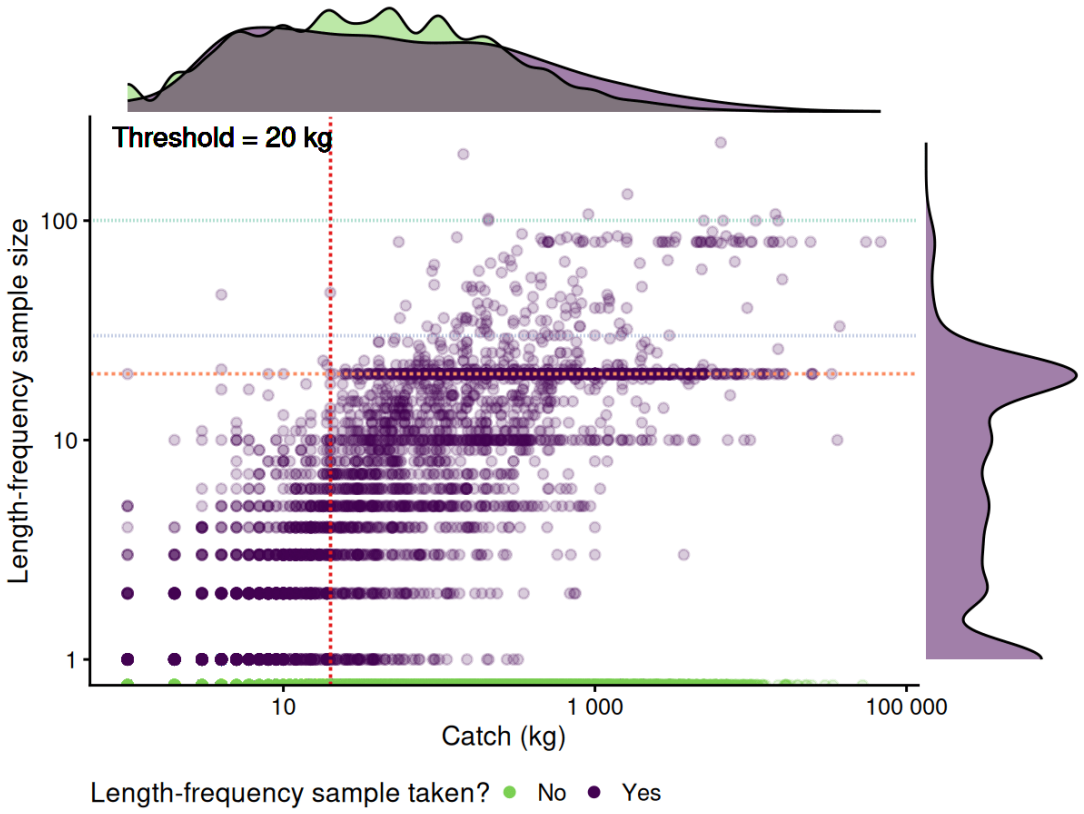


Figure C-21: Length-frequency sample sizes (number of fish sampled) in relation to the total SKI catch from an event.

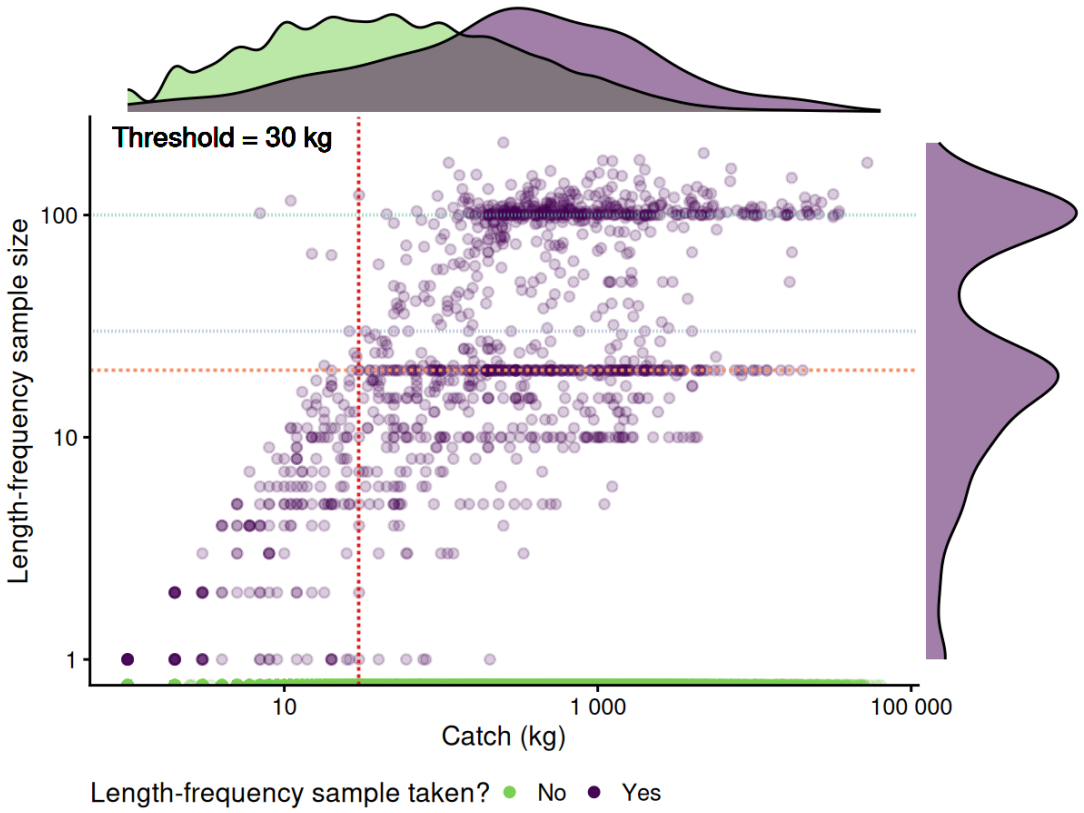


Figure C-22: Length-frequency sample sizes (number of fish sampled) in relation to the total SPD catch from an event.

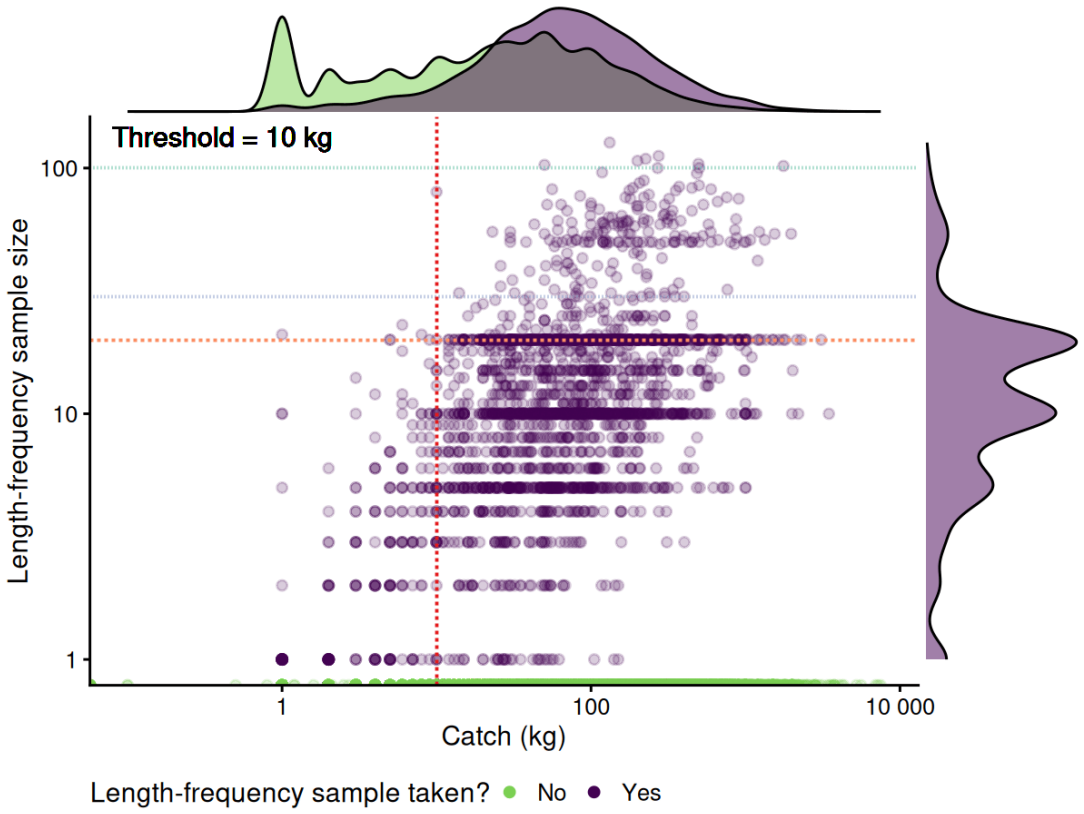


Figure C-23: Length-frequency sample sizes (number of fish sampled) in relation to the total SPE catch from an event.

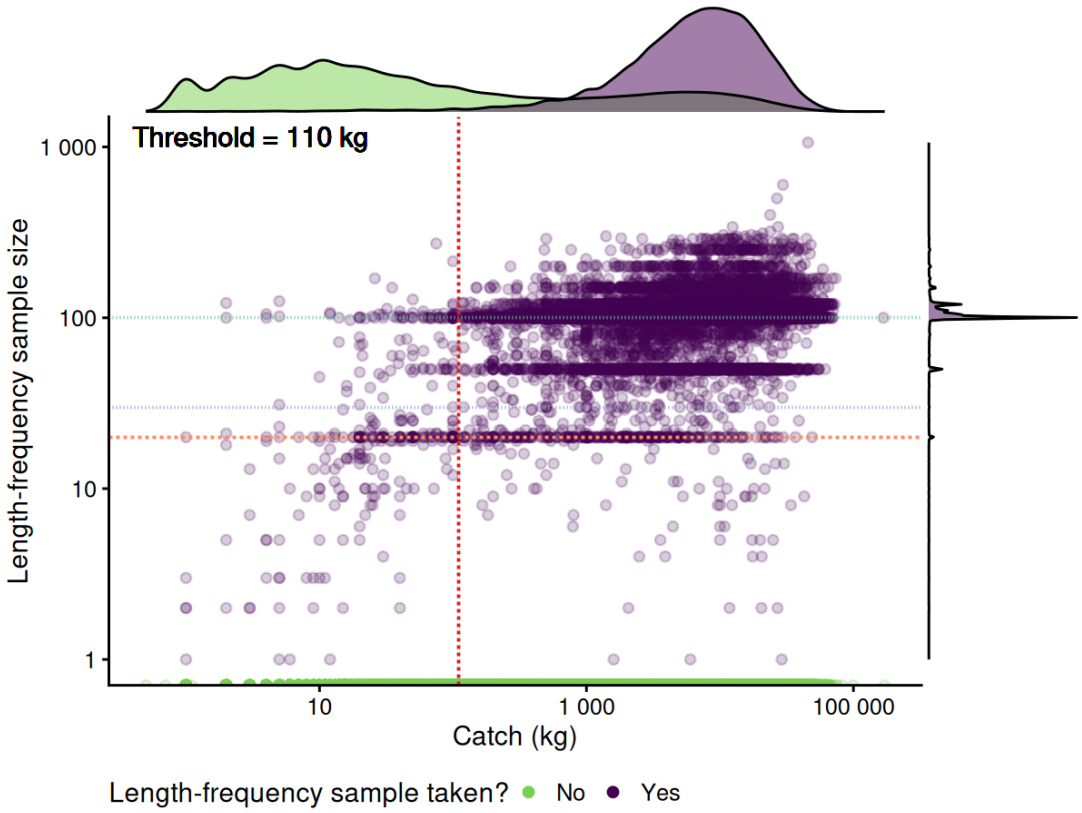


Figure C-24: Length-frequency sample sizes (number of fish sampled) in relation to the total SQU catch from an event.

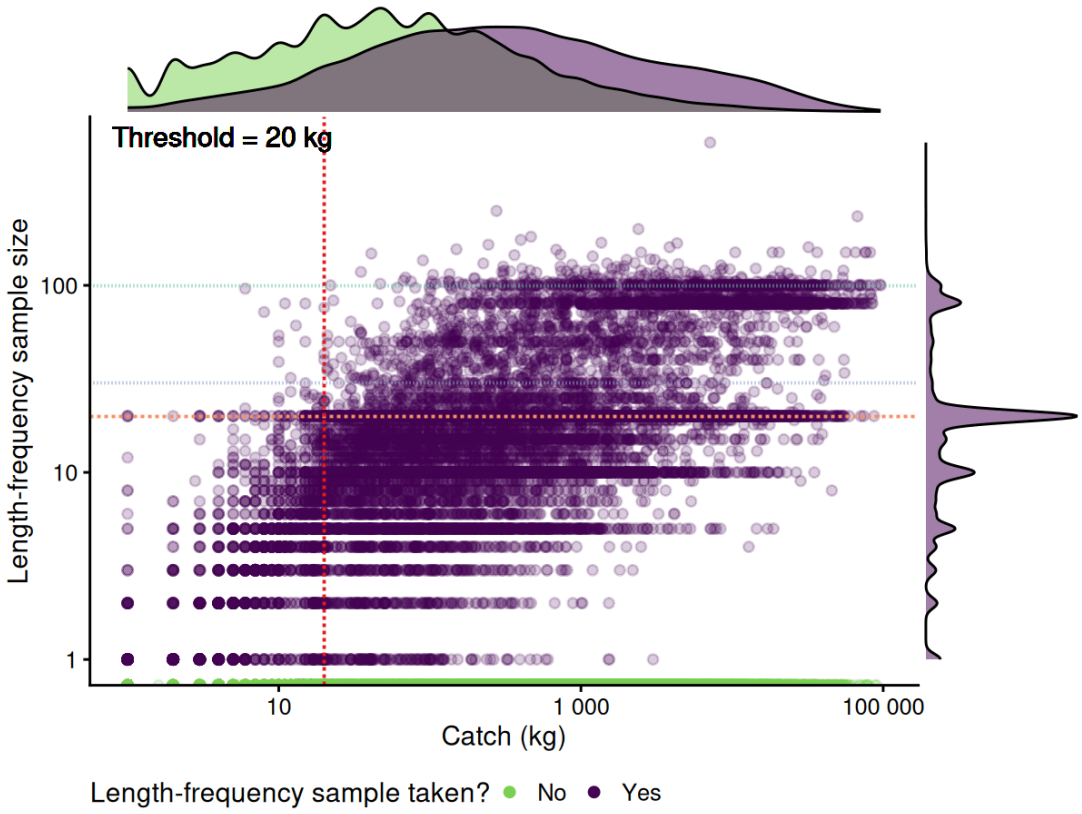


Figure C-25: Length-frequency sample sizes (number of fish sampled) in relation to the total SWA catch from an event.

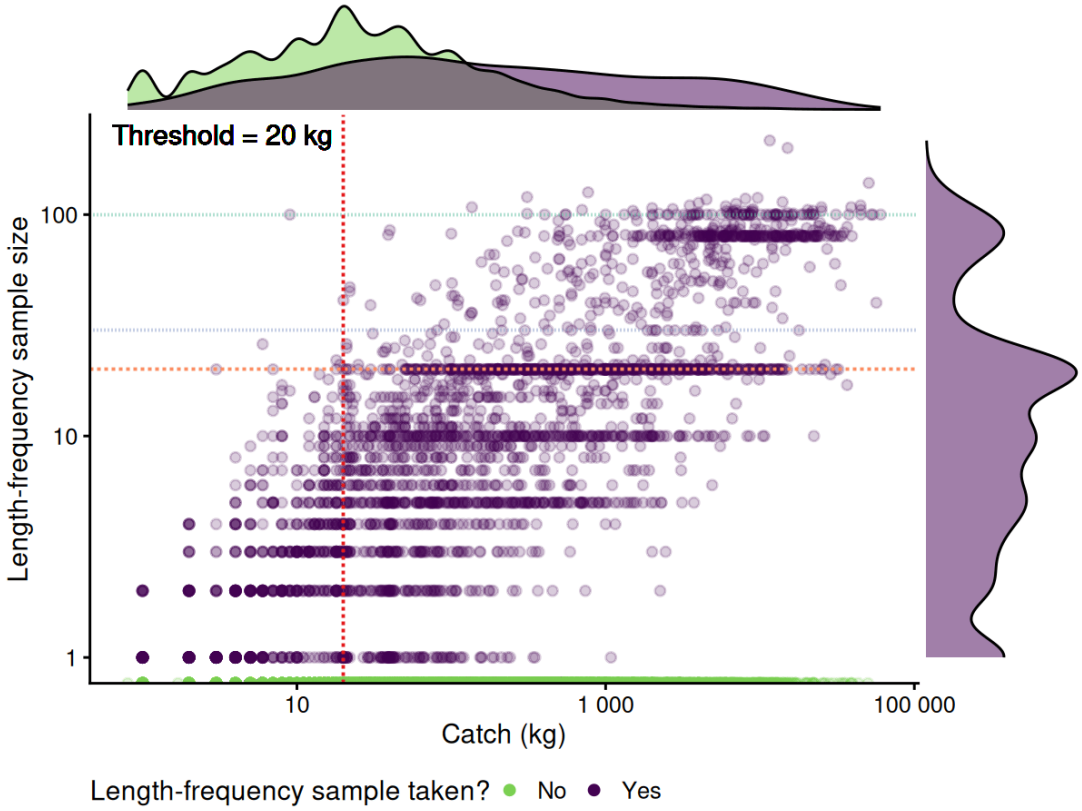


Figure C-26: Length-frequency sample sizes (number of fish sampled) in relation to the total WWA catch from an event.

APPENDIX D: PROOF THAT $S \leq D$

The following proof that the Manhattan-distance based representativeness statistic, S, is less than or equal to the Kolmogorov-Smirnov based representativeness statistic, D, was provided by Sam A. Middleton and improved after feedback from Ian Blixt and Marianne Vignaux.

Let A and B be the two distributions of interest (i.e., fishery proportions and sampling proportions) over the same ordered set of strata, $1...n$, with individual proportions $p_{A,i}$ and $p_{B,i}$, such that

$$\sum_{i=1}^{n} p_{Z,i} = 1 \tag{D-1}$$

where Z represents either A or B. The cumulative distribution is

$$F_{Z,i} = \sum_{j=1}^{i} p_{Z,j} \tag{D-2}$$

defining $F_{Z,0} = 0$, and noting that $F_{Z,n} = 1$ by Equation D-1.

The definition of the Kolmogorov-Smirnov based representativeness statistic, from Equation 1, can be rewritten by inserting the definition for the cumulative distributions, and combining the summations:

$$D = 1 - \max_{i \in \{1...n\}} |F_{A,i} - F_{B,i}| \tag{D-3}$$

$$= 1 - \max_{i \in \{1...n\}} \left| \sum_{j=1}^{i} p_{A,j} - \sum_{j=1}^{i} p_{B,j} \right| \tag{D-4}$$

$$= 1 - \max_{i \in \{1...n\}} \left| \sum_{j=1}^{i} (p_{A,j} - p_{B,j}) \right| \tag{D-5}$$

Thus, D is an absolute-sum-of-differences, whereas the Manhattan-distance based representativeness statistic involves half a sum-of-absolute-differences (Equation 2, repeated here for convenience):

$$S = 1 - \frac{1}{2} \sum_{i=1}^{n} |p_{A,i} - p_{B,i}| \tag{D-6}$$

Define $\delta_i = p_{A,i} - p_{B,i}$ and $\Delta_i = F_{A,i} - F_{B,i} = \sum_{j=1}^{i} \delta_i$. Let Δ^+ be the sum of all positive δ_i and Δ^- be the sum of all negative δ_i. We then have $\Delta^- \leq \Delta_i \leq \Delta^+$, with equality on one side if and only if all of the δ_j contributing to, for example, Δ^- have $j \leq i$ and none of those contributing to Δ^+ do.

Over the full set of n strata,

$$\Delta_n = \Delta^+ + \Delta^- = F_{A,n} - F_{B,n} \tag{D-7}$$

$$= 1 - 1 \tag{D-8}$$

$$= 0 \tag{D-9}$$

$$\Delta^- = -\Delta^+ \tag{D-10}$$

Therefore, $\max |\Delta_i| \leq \Delta^+$. Returning to the definition of S:

$$S = 1 - \frac{1}{2} \sum_{i=1}^{n} |p_{A,i} - p_{B,i}| \tag{D-11}$$

$$= 1 - \frac{1}{2} \sum_{i=1}^{n} |\delta_i| \tag{D-12}$$

$$= 1 - \frac{1}{2} \left(\Delta^+ + \left| \Delta^- \right| \right) \tag{D-13}$$

$$= 1 - \Delta^+ \tag{D-14}$$

$$\leq 1 - \max |\Delta_i| \tag{D-15}$$

$$\leq D \quad \square \tag{D-16}$$

APPENDIX E: GLOSSARY: FISHING METHOD CODES

Table E-1: Core deepwater fishing method codes and descriptions, with the grouping used in this report for the purposes of reporting observer coverage.

Method group	Code	Description
Line	BLL	Bottom longline
Line	DL	Drop/dahn line
Line	TL	Trot line
Pot	CP	Cod pot
Pot	FP	Fish trap
Pot	POT	Other pot
Pot	SCP	Scampi pot
Trawl	BPT	Bottom trawl - pair
Trawl	BT	Bottom trawl
Trawl	MPT	Midwater trawl - pair
Trawl	MW	Midwater trawl
Trawl	PRB	Precision bottom trawl
Trawl	PRM	Precision midwater trawl

Table E-2: Other fishing method codes and descriptions.

Method group	Code	Description
Other	BS	Beach Seine/Drag nets
Other	CRP	Crab pot
Other	D	Dredge
Other	DI	Diving
Other	DN	Inshore drift net
Other	DPN	Dip net
Other	DPS	Danish Seine - pair
Other	DS	Danish seine
Other	DSF	Spear fishing
Other	DV	Diving - combined
Other	EFN	Ellesmere fyke net
Other	EP	Eel pot
Other	FN	Fyke net
Other	H	Handgathering
Other	HL	Handline
Other	L	Lampara
Other	MH	Mechanical harvesting
Other	OCP	Octopus pot
Other	PL	Pole and line
Other	PS	Purse seine
Other	PSN	Pair set net
Other	RLP	Rock lobster pot
Other	RN	Ring net
Other	SCN	Scoop net
Other	SJ	Squid jig
Other	SLL	Surface longline
Other	SN	Set net
Other	T	Troll
Other	UBA	Diving utilising self-contained underwater breathing apparatus
Other	UBS	Diving utilising surface-supplied underwater breathing apparatus