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Tini a Tangaroa

Characterisation, CPUE and length-composition analyses of the New Zealand albacore tuna fishery

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Plain language summary

Albacore are mostly caught by trolling on the west coast of New Zealand. Albacore catch is composed of three distinct sizes in most years, likely reflecting one- to three-year-old fish.

The present analysis updated previous catch-per-unit-effort (CPUE) analyses, showing low CPUE in 2023. Modeling of catch lengths showed that low CPUE was generally associated with low availability of the usually dominant two-year-old year-class.

It is likely that patterns in New Zealand Albacore troll CPUE and catch composition are reflective of environmentally driven availability to the fishery.

EXECUTIVE SUMMARY

Neubauer, P.[1]; Hill-Moana, T.[1] (2024). Characterisation, CPUE and length-composition analyses of the New Zealand albacore tuna fishery.

***New Zealand Fisheries Assessment Report 2024/38*. 184 p.**

Albacore within the New Zealand fishery waters are part of the South Pacific Ocean stock which is distributed from the equator south to about 50°S. The broader stock is managed by two Regional Fisheries Management Organisations (RFMOs); the Inter-American Tropical Tuna Commission (IATTC) manages the eastern part of the stock, while the western part is managed under the Western and Central Pacific Fisheries Commission (WCPFC). In the WCPFC Convention Area, albacore are landed in a number of fisheries but primarily from longline and troll fisheries, with over 75% of the troll catch coming from New Zealand waters. This report updates the characterisation and CPUE analyses for the New Zealand albacore (*Thunnus alalunga*) fishery presented in 2021, and provides additional analyses into drivers of variability of albacore cohorts and length compositions in New Zealand waters. This issue is particularly relevant due to recent concerns about length composition data from New Zealand's troll fishery contributing to potentially spurious signals of very low recruitment over 2015 and 2017, which drives a strong reduction in spawning biomass in projections from the 2021 South Pacific albacore stock assessment. The present analysis was undertaken to provide information for the regional stock assessment undertaken by the Pacific Community (SPC) and focuses primarily on the troll fishery which lands the bulk of the catch in New Zealand, but longline data are also included.

The present analysis describes the fisheries targeting and catching albacore in New Zealand, and undertakes a CPUE standardisation of the commercial troll fishery. Data for the fishery description included the catch and effort from 1990 to 2023 from albacore troll target sets, all other troll activity, and all trips where albacore was specified as the target or recorded as bycatch. In recent years, both unstandardised CPUE and landings have declined in the fishery. For the CPUE analysis, catch-effort data for albacore target trolling only were modelled using maximum-likelihood generalised linear models (GLMs) predicting the catch as a function of spatial, temporal and environmental predictors. The models without environmental predictors provided a minimal standardising effect, producing CPUE series that show little long-term trend. Overall, the series, which now extends 30 years, fluctuates without trend over the last two decades, but recent standardised CPUE is at an all-time low. Models with environmental predictors showed a strong standardising effect of the El-Nino Southern Oscillation on catch rates. The standardised CPUE index is likely a reflection of availability and/or catchability, rather than a representative signal of abundance.

Length compositions from New Zealand's troll fisheries were analysed in two separate ways to gain insights into drivers of variability in the length composition of troll-caught albacore in New Zealand waters. First, a mixture model was constructed that aimed to partition the length data into three apparent length-cohorts by year. Although the model did not provide an good fit to the data, it suggested that the presence in the catch of the first cohort (thought to be one-year old fish) is highly variable in space and time, and may be related to vessel selectivity: there was little consistency in months or areas where these fish appeared in a given year, and only a small influence from sea-surface temperature on cohort abundance.

A more flexible model was fitted that avoided the assumption of specific cohorts. The model was used to investigate if standardising length compositions for environmental conditions and time- and area of fishing trips would lead to materially different predicted length compositions across the New Zealand troll fisheries from the compositions that have been reported based on scaled catch-sampling. All analyses pointed to fishing vessels contributing substantially to variability in observed compositions, suggesting that catch sampling effort should be spread across as many vessels as possible to ensure

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representative length compositions can be achieved. This analysis also confirmed findings from the mixture model, suggesting that spatio-temporal patterns in length compositions are significant, but cannot be explained by sea-surface temperature alone. Nevertheless, predicted length-compositions for the total catch effort of the NZ troll fishery suggested that standardising compositions has a minor impact. Significantly, the 2018 length-compositions remain largely unchanged by the standardisation approach, confirming abnormally high proportions of one-year-old fish in that year, with correspondingly lower proportions of older fish. However, both catch and CPUE were high in 2018, and compositions scaled to catch suggest that the composition in 2018 may be a reflection of abnormally high abundance of young fish in New Zealand waters in 2018, rather than abnormally low abundance of other cohorts. The result highlights the importance of interpreting the information of local length compositions in the light of local availability and catch trends.

1. INTRODUCTION

Albacore (*Thunnus alalunga*) within New Zealand waters are part of the South Pacific Ocean stock which is distributed from the equator south to about 50°S, and from the Australian east coast to the South American west coast. The broader stock is managed by two Regional Fisheries Management Organisations (RFMOs); the Inter-American Tropical Tuna Commission (IATTC) manages the eastern part of the stock, while the western part is managed under the Western and Central Pacific Fisheries Commission (WCPFC).

The total catch of south Pacific albacore in 2022 was 91 741 t, of which 75% (69 570 t) came from the WCPFC convention area (WCPFC 2022); of that, 2519 t (~4%) was landed in New Zealand fisheries waters in 2022, and 1006 t in 2023, marking a steep decline from the 2021 peak catch of 3480 t (the latter was the highest catch since 2005). Although the majority (89%) of this catch still came from the troll fishery, the proportion of catch coming from the troll fishery also declined from 97% in 2021. In the WCPFC convention area, albacore were landed in a number of fisheries but primarily from longline (95.5%) and troll (4.1%) fisheries, with 66% of the troll catch and <1% of the longline catch coming from New Zealand fishery waters in 2022.

Juvenile albacore appear in New Zealand fishery waters in the austral summer and then appear to gradually disperse north from the southern latitudes as they grow. Longline catch data indicate that adults appear to migrate seasonally between tropical and subtropical waters. This predictable movement brings albacore to New Zealand fisheries waters annually where they are targeted. Albacore are thought to have been landed in New Zealand since the 1940s, but regular commercial tuna fisheries only began in the 1960s (Kendrick & Bentley (2010) and Kendrick (2021)) with catch reaching a peak in 2003 (Fisheries New Zealand 2019).

The broader south Pacific albacore stock is managed by the WCPFC, and New Zealand is responsible for ensuring that the management measures applied within New Zealand fisheries waters are compatible with those of the Commission (Fisheries New Zealand 2019). Within New Zealand, albacore are managed outside of the Quota Management System (QMS) and have not been allocated a total allowable catch (TAC), but rather the effort restrictions applied under WCPFC (2015) apply within New Zealand.

In New Zealand, albacore are landed to a single Fishery Management Area (FMA) ALB 1 (Figure 1). Landings peaked in 2003 at 6408 t but declined thereafter and have fluctuated around 2000 t to 3000 t since 2006 (Figure 2). Catch is attributed to a statistical area (Figure 3) based on where the catch was made, although a recent reporting change to electronic reporting systems (ERS) provides GPS-referenced fishing locations since 2020.

Due to the small size of the New Zealand catch and the large mobile nature of the stock, it is not possible to undertake a stock assessment of albacore within New Zealand. Triennial assessments are undertaken by the WCPFC through their science service provider the Pacific Community (SPC), with the most recent being undertaken by Castillo Jordan et al. (2021). An updated assessment will be presented to the Scientific Committee of the WCPFC in 2024. These assessments use information from the New Zealand troll fishery, which catches juvenile fish, to help inform recruitment trends in the assessment. The New Zealand fishery data, therefore, contributes a small but potentially influential data set to the assessment. In particular, the most recent assessment showed a strong decline in terminal biomass, in part due to low estimates of recruitment between 2014 and 2016, and an apparent near absence of the 2016 cohort in the model. That result that was at least partially informed by New Zealand troll size compositions (Scott et al. 2023), which also appeared to be difficult to reconcile with growth assumptions in the 2021 diagnostic model for South Pacific albacore (Castillo Jordan et al. 2021). Although potential causes of the ”big dip” in recruitment and resulting stock status for South Pacific Albacore have been investigated in some detail (Scott et al. 2023), no conclusive cause was identified, and the most likely driver appeared to be a combination of data and model assumptions.

The present paper attempts to i) update fishery characterisation and CPUE analyses presented in (Brouwer et al. 2021) and, ii) provide a model-based analysis of New Zealand troll-fishery CPUE and length compositions that can inform the upcoming assessment of South Pacific albacore about reasonable model assumptions for New Zealand troll-caught albacore data. CPUE models used in this report were based on generalised linear models (GLMs), mirroring methods previously used to standardise CPUE in Brouwer et al. (2021), predicting the catch as a function of spatial, temporal and environmental predictors. Length compositions were analysed using two approaches; a mixture model approach that aimed to explicitly model spatio-temporal changes in cohort make-up of length compositions (making assumptions about the number of cohorts present in the data) as a function of spatio-temporal predictors (statistical areas and year/month), as well as a more assumption-free approach to standardizing length compositions that aimed to provide a standardised set of length compositions that can be used for index fisheries in stock assessments, with standardisation carried out using environmental variables that were used in CPUE models.

It is important to note that all analyses in the present report refer to the New Zealand fishing year (Oct–Sept), and cover the seasonal summer troll fishery for albacore within a single fishing year. The reported year is conventionally the latter calendar year in the fishing year - a reference to December of the 2023 fishing year, for example, therefore refers to December of the 2022 calendar year. As the South Pacific albacore stock assessment uses calendar-year quarters, we also provide outputs at this resolution.

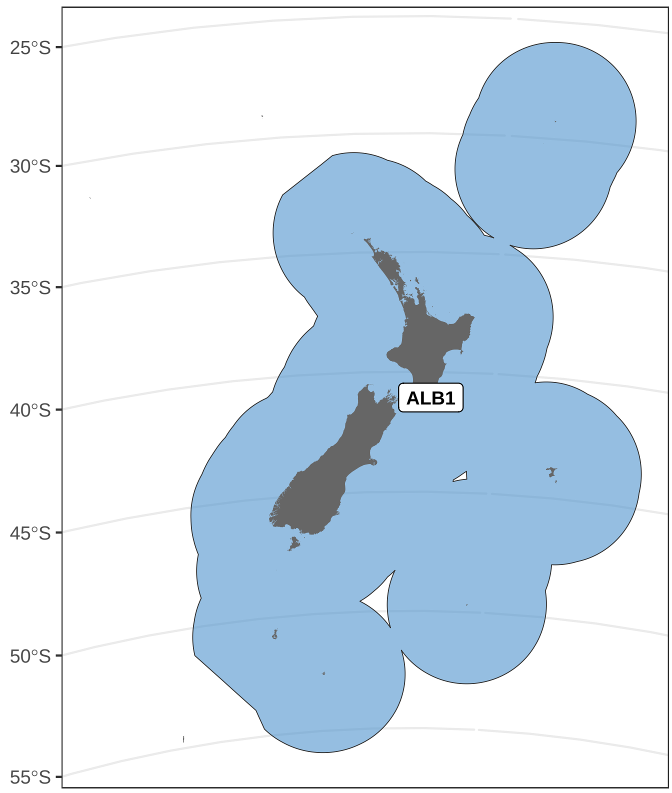

Figure 1: Fisheries Management Areas for albacore with ALB 1 highlighted.

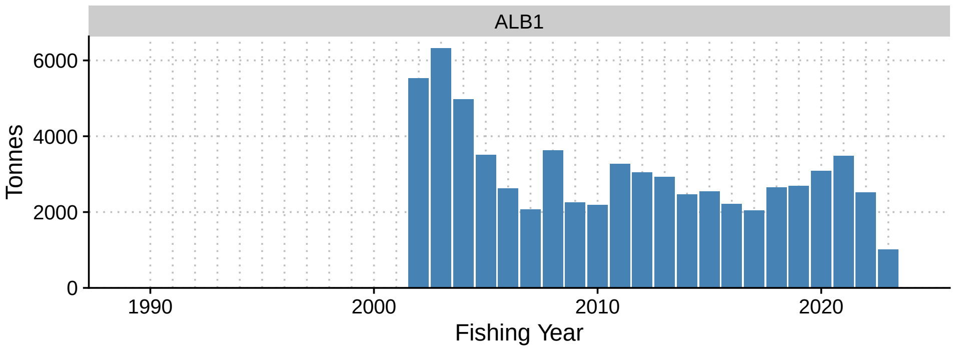

Figure 2: Monthly Harvest Return totals for ALB 1 from 2002 to 2023. Tabulated data are provided in Table C.1.

2. METHODS

Extracts (report logs 13159, 15894) of statutory commercial catch, effort, and landings data were provided by Fisheries New Zealand and processed using standardised grooming routines (Appendix B).

All years in this report refer to the normal New Zealand fishing year which runs from 1 October to 30 September. Fishing years are labelled using the later calendar year; thus, for example, 1990 refers to the fishing year 1 October 1989 to 30 September 1990.

For a full list of acronyms used in this report, please refer to Appendix I.

2.1 Terminology

In this report we use the term **catches** to refer to the catch of legally retainable fish. Catches include any legally retainable fish that are optionally returned to the sea (for example, schedule 6 returns) but exclude those fish that *must* be returned to the sea, such as fish below the minimum legal size (MLS). Catches include declared accidental losses of fish but do not include fish that escape capture, for example by escaping through the mesh of a trawl.

For species managed under the Quota Management System (QMS) we use the term **removals** to refer to the known mortality of fish; i.e., the legally retainable catches without those fish that are optionally returned to the sea and considered likely to survive. Any mortality suffered by these returned fish is not included in removals. However, in the case of non-QMS species we include returned fish as part of the removals.

2.2 Data sources

There are three types of statutory commercial data relevant to assessing catches and removals:

- Monthly Harvest Returns (MHRs) and their forerunner, Quota Management Reports (QMRs), which we refer to as the **MHR/QMR** data;
- landings and disposals, referred to as **landings** data; and
- the **estimated catches** recorded by fishers for individual fishing events.

MHR/QMR data are the key information used in the balancing of commercial catch against the Total Allowable Commercial Catch (TACC); however, they provide information at a relatively coarse resolution of client, stock, and month. QMRs provided a record of the total monthly catch of each QMS fishstock for each quota holder, by month from December 1986 to September 2001. MHRs replaced QMRs from October 2001 and record data on harvest of both QMS and non-QMS species.

The finest-scale catch information is provided by estimated catches, which are reported per species per fishing event. However, estimated catch data are not necessarily comprehensive or accurate; this is because not all species caught are required to be reported for each event, and the quantities reported are estimated rather than weighed.

Landings and disposals provide data on the catches of all stocks, generally at the fishing trip resolution, with quantities verified (where practicable; e.g., when landed) by weighing. Under the Electronic Reporting regime introduced by the Fisheries (Reporting) Regulations 2017, these data provide a comprehensive record of catches per trip, with the fate of those catches indicated by a destination code (Table 1). However, the set of available destinations has become more comprehensive as reporting regulations have evolved and the possibility that the landings data were less complete in the past must be considered.

In some cases, landings from a trip are first recorded to an interim destination. Because these fish should subsequently be reported to a final destination, the data for the initial, non-final landings are dropped from the landings dataset used in this report, together with any landings data for categories of fish that are not legally retainable.

The **catches** and **removals** used in the remainder of this report comprise the landings for final, legally retainable destinations (Table 1).

2.3 Allocation of catches to fishing events

As noted above, the landings data that define the catches and removals for a stock are generally reported at the resolution of the fishing trip. In some fisheries, trips are lengthy (exceeding a month) and carry out fishing over a wide area; as a result, catches are most usefully *allocated* to individual fishing events. Two allocation approaches are available: *trip-based allocation* and *annual scaling*. In this report, trip-based allocation was used for all stocks and methods.

The trip-based approach allocates the catches of ALB from a trip to the fishing event records from the trip using the hierarchical method of Starr (2007). If albacore were included in the estimated catch for at least one of the fishing event records on the trip, then catches were allocated in proportion to the estimated catch for each record (**Est. catch** allocation). If no estimated catch of albacore was recorded on the trip, but a single fishing method was used on the trip, then catches were allocated in proportion to the number of fishing events per record (**Effort no.** allocation). If neither of the previous approaches applied for a trip then catches were allocated equally across fishing effort records (**Equal** allocation).

2.4 Conversion factors

Catches and removals in this report are reported as greenweight. However, actual weighing of the catch may take place after processing, in which case the greenweight is derived by applying a conversion factor to the measured processed weight. The conversion factors used in the statutory commercial reporting are specified by Fisheries New Zealand, by species and processed state.

The regulated conversion factors may be updated at times; occasionally this is because the nature of processing a particular species or state has changed, but usually it is because sufficient data have been collected to provide a more reliable estimate of the appropriate conversion factor. In this report, we adjust historical landings data to the current conversion factor for the species and processed state:

$$gwt_{adj} = gwt_{rep} \frac{CF_{cur}}{CF_{rep}} \tag{1}$$

where gwt_{adj} is the adjusted greenweight, gwt_{rep} is the greenweight originally reported, CF_{cur} is the current conversion factor, and CF_{rep} is the conversion factor used when the data were reported.

Table 1: Destination codes used in reporting of landings and disposals, with introduction date for codes that were not defined in the original Fisheries (Reporting) Regulations 1990. The inclusion of the landing/disposal in subsequent MHR returns is indicated in circulars issued under the Fisheries (Reporting) Regulations 2017. Only categories that are legally retainable, and considered final, are included in the catches and removals for a stock. LFR = Licensed Fish Receiver.

		Date				Included in		
Code	Description	Introduced	Revoked	Final	Retainable	MHR	Catches	Removals
A	Accidental losses			Y	Y	Y	Y	Y
B	Retained for use as bait			Y	Y	Y	Y	Y
E	Catch eaten on board			Y	Y	Y	Y	Y
EOY	End of year landings	2017-10-01		Y	Y	Y	Y	Y
H	Losses from holding receptacles		2018-06-30	Y	Y	Y	Y	Y
HL	Losses from holding receptacles on land	2018-07-01		Y	Y	Y	Y	Y
HW	Losses from holding receptacles in the water	2018-07-01		Y	Y	Y	Y	Y
J	Observer or Fishery Officer authorised returns	2013-10-01		Y	Y	Y	Y	Y
L	Landings to an LFR			Y	Y	Y	Y	Y
LFL	Fish landed after being held live on land	2019-01-10		Y	Y	Y	Y	Y
LP	Final landing of fish from holding receptacles at sea	2018-07-01	2019-01-09	Y	Y	Y	Y	Y
LR	Final landing of retained fish	2017-10-01		Y	Y	Y	Y	Y
M	Sixth schedule returns (spiny dogfish)	2004-10-01		Y	Y	Y	Y	Y
O	Catch transported outside the EEZ			Y	Y	Y	Y	Y
PF	Predated fish	2018-07-01		Y	Y	Y	Y	Y
QL	Landings to an LFR after storing in a holding receptacle on land	2018-07-01		Y	Y	Y	Y	Y
S	Catch taken by a Fishery Officer or observer			Y	Y	Y	Y	Y
T	Transhipments		2018-06-30	Y	Y	Y	Y	Y
TL	Transhipments, reported as landed by the catching vessel	2018-07-01		Y	Y	Y	Y	Y
U	Used as bait			Y	Y	Y	Y	Y
W	Wharf sales			Y	Y	Y	Y	Y
Z	Returns to the sea (certain sharks, dead or near-dead)	2014-10-01		Y	Y	Y	Y	Y
BS	Biotoxin samples	2019-11-26		Y	Y	N	Y	Y
CS	Customary catch	2017-10-01	2019-11-25	Y	Y	N	Y	Y
D	Non-QMS returns			Y	Y	N	Y	Y
F	Landings as recreational entitlement	2002-07-11		Y	Y	N	Y	Y
I	Returns for safety of protected species	2022-11-01		Y	Y	N	Y	Y
V	Observer samples	2017-10-01		Y	Y	N	Y	Y
X	Permitted returns	2006-10-01		Y	Y	N	Y	N
C	Disposal to the Crown		2001-09-30	Y	Y		Y	Y
G	Returns above legal size	2018-07-01		Y	N	N	N	N
K	Lobster required returns (not sub-MLS)	2018-07-01		Y	N	N	N	N
Y	Sub-MLS returns	2017-10-01		Y	N	N	N	N
LF	Live fish held on land	2019-01-10		N	Y	N	N	N
N	Removals from holding receptacles at sea	2018-07-01		N	Y	N	N	N
P	Placed into a holding receptacle at sea			N	Y	N	N	N
Q	Placed into a holding receptacle on land		2018-06-30	N	Y	N	N	N
R	Landings retained on board			N	Y	N	N	N
TT	Transhipments, reported as landed by the receiving vessel	2017-10-01		N	Y	N	N	N

2.5 Characterisation dataset

A fishery characterisation dataset was prepared by identifying all trips with landings or estimated catches from ALB 1 and extracting the associated catch and effort data for fishing events within the ALB 1 Fisheries Management Area (Figure 1). Fishing events were selected based on start position (where available) or statistical area (Figure 3).

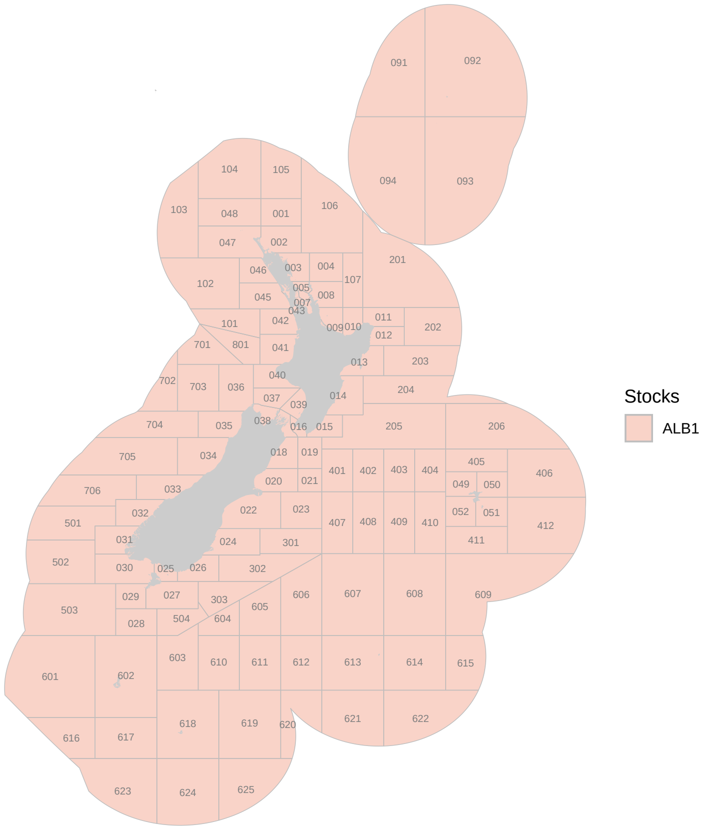

Figure 3: Statistical Areas that intersect the ALB 1 Fisheries Management Area.

Standard grooming drops some large landings in the early 1990s because the fish were reported as retained on board (Figure B.1). However, the size of these landings suggests that the quantity reported may also be in error. A significant quantity of landings in the mid-1990s were recorded to ALB 1 having been reported using other stock codes (Figure B.4); this arises when fishers have reported fish using a fishstock code constructed using the generic Fisheries Management Areas (e.g., ALB 8 for landings from generic FMA 8; Figure 4).

2.6 Length composition data

Both the mixture and composition-standardisation models were based on the same albacore catch-sampling dataset (Table 2), which showed variable length compositions among years (Figure 5). Additional details on catch sampling data from New Zealand's fisheries are given in the Appendix as they are relevant to the assessment (Figure D.4). Some sampling has occurred from the longline fisheries, but most landings were samples from troll vessels in FMA 7 and FMA 9, with over 62 000 fish sampled in FMA 7 and 23 000 in FMA 9 (Figure 1). Only small numbers of samples have been taken from other FMAs and fisheries (Table D.1). Generally, the troll length data has three modes (Figure D.1 and Figure D.2). The cumulative length frequency data are most similar in FMAs 1 and 9, with fish samples in FMA 8 being the smallest. Year class and tracking modal progression is possible

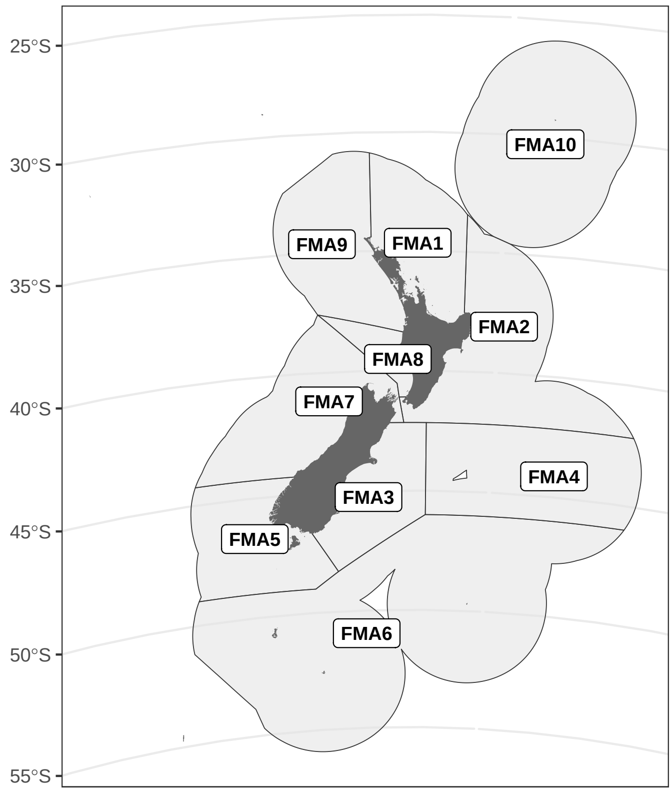

Figure 4: General New Zealand Fisheries Management Areas.

and strong year classes are noticeable for up to three years e.g. the ∼50cm mode in 2000 can be seen appearing in 2001 (∼60cm) and 2002 (∼75cm) as a strong year class in FMAs 1, 7 and 9 (Figure D.4). The sampling has been most consistent in FMAs 7 and 9, with FMAs 1 and 8 being sampled infrequently. These data are provided to SPC as part of the New Zealand annual data provision.

Additional length composition data are available from observer records from the troll fishery (Appendix E). The main observer effort occurred between 2006 and 2013, but length compositions are only available for the last three years in that period, with a small number of records collected in more recent years (2020 and 2021 fishing years).

While there were more than 12 500 fish measured during that time, there are few recent data from this sampling programme (e.g., only 12 fishing events in 2022). Nevertheless, because these data were recorded at the level of fishing events (i.e., a daily troll record), they potentially hold more detailed information on the relationship of albacore catch composition with temperature.

2.7 Mixture model for cohort mixture

A key feature of the length compositions of New Zealand troll-caught albacore is its tri-modal composition, presumably corresponding to (approximately) one-year-old to three-year-old fish. If the position (i.e., mean length and standard deviation) of these modes is approximately constant between years, then the relative contribution of each cohort to length compositions can be estimated using a mixture model that simultaneously estimates the location of the length modes, and the contribution of each cohort to individual sampled landings.

Each sampled landing is obtained from a fishing trip that can be associated with a modal statistical area, month and year (sampled fishing trips can, in theory, span more than one month, statistical area or year).

Table 2: New Zealand catch sampling data used for mixture and composition modelling.

Fishing year	Stat areas	Landings	Vessels	Measurements	SST range
1997	3	18	17	2283	11.9–20.48
1998	5	16	16	2955	10.42–21.83
1999	3	15	15	2568	11.98–17.78
2000	4	17	17	3158	11.53–17.35
2001	8	27	23	4505	11.83–21.74
2002	7	25	21	4226	11.31–18.24
2003	4	24	22	4808	10.45–17.93
2004	6	24	22	4485	12.3–18.46
2005	5	29	27	5502	11.63–18.26
2006	6	22	19	4270	12.05–18.97
2007	5	19	13	3800	11.9–20.11
2008	6	30	22	4364	11.45–19.93
2010	4	38	30	4185	11.71–18.25
2011	3	44	32	4384	13.01–14.77
2012	4	45	30	4500	11.34–13.45
2013	6	48	30	5348	11.39–17.46
2014	7	48	33	5631	10.83–18.46
2015	6	42	30	5216	12.35–18.8
2016	9	45	28	4850	10.92–20.23
2017	6	29	16	3369	12.1–18.09
2018	5	40	26	3963	13.13–18.8
2019	5	48	34	4806	11.91–18.49
2020	6	37	28	3696	12.21–16.86
2021	7	39	27	4338	11.64–18.04
2022	5	41	27	3600	11.05–13.87
2023	7	45	23	4506	11.65–14.42

Each observation (an individual fish) in the dataset has a measured length l_i, which can be attributed to one of three cohorts with mixture probabilities θ.

Conceptually, the model is most straightforwardly represented in terms of latent discrete parameters $\hat{s}_i$, which represent the estimated cohort label for fish i, given mean mixture proportions θ. This relationship can be represented as

$$\begin{aligned} \hat{s}_i &\sim categorical(\theta_i) \\ \theta_{i,s} &= \begin{cases} logit^{-1}(\bar{\theta}_s + \beta_s X_i + \gamma_s Z_i) & \text{if } s = 1,3, \text{ and} \\ 1 - \sum_{s'=1,3} \theta_{i,s'} & \text{if } s = 2 \end{cases} \end{aligned} \tag{2}$$

where X_i and Z_i are design matrices for fixed and random effects, respectively, and β_s and γ_s are estimated fixed and random effects. Conditional on the estimated species label $\hat{s}_i$, each observed fish length is then modeled as coming from a length distribution:

$$l_i \sim normal(\nu_{[\hat{s}_i]}, \sigma_{[\hat{s}_i]}) \tag{3}$$

where $\nu_{[\hat{s}_i]}$ is the mean length of cohort s assigned to sample i, with cohort growth estimated as $\nu_{[\hat{s}_i]} = \mu_{[\hat{s}_i]} + \zeta_s smonth_i$, with ζ_s the growth coefficient by which the size of cohort s increases each season-month (smonth). November was taken as the first season-month and coded as zero, such that $\mu_{[\hat{s}_i]}$ is the mean cohort length at the start of the fishing season. For simplicity, we assumed a fixed standard deviation across cohorts.

We investigated drivers of cohort presence in New Zealand waters by random effects for vessel, statistical area, month, fishing year and two and three way interactions for the latter three effects. In addition, we

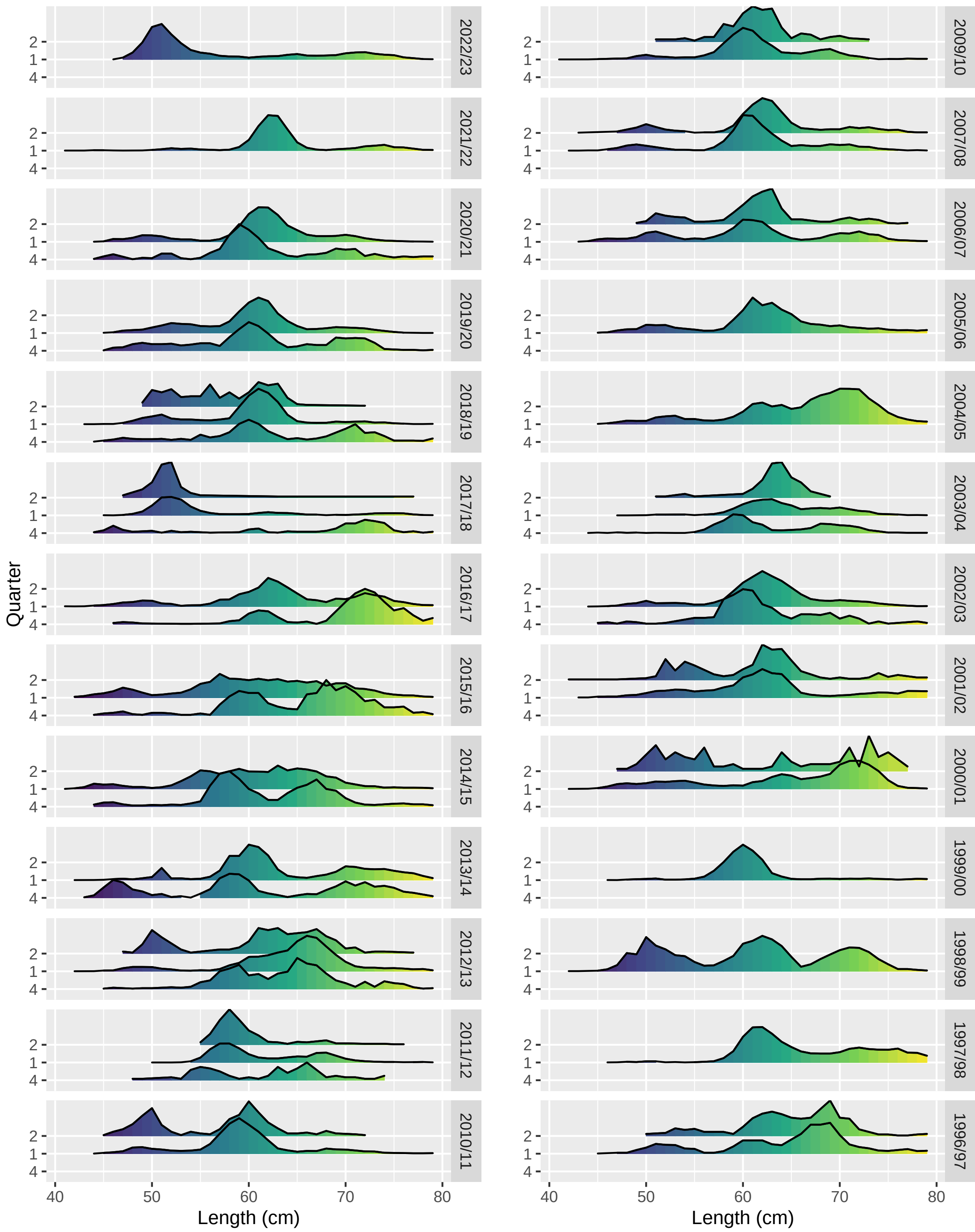

Figure 5: Unscaled length composition data for ALB by fishing year from the Aotearoa/New Zealand catch sampling programme.

assigned sea-surface temperature to modal statistical area to investigate if the proportional presence of cohorts is driven by oceanographic conditions. The latter was estimated as a fixed effect. Models were formulated such that linear predictors in equation 2 correspond to the presence of age one and age three fish relative to the presence of age two fish, as the latter tends to be the dominant cohort in New Zealand waters. The models were fitted using the `brms` package (Burkner 2017).

2.8 Size composition analysis using Possion-factorised multinomial regression

A large number of vessels participate in New Zealand troll fisheries, and catch-sampling can only reasonably cover a small proportion of trips and landings. Although catch sampling is designed to cover the range of landing ports, it is currently unclear how representative sampled length compositions are of the wider fishery. This poses a problem in that the lack of representative sampling across key sources of variability can lead to biased estimates of catch compositions. Biased compositions can, in turn, lead to false signals if composition data is not reflective of biological processes represented in the assessment model (Minte-Vera et al. 2017), and even down-weighting composition data may not be sufficient to eliminate such signals (Wang & Maunder 2017). It is therefore important to get an unbiased representation of composition data that corrects for biased sampling and appropriately scales composition data.

The present study used a standardisation model for composition data collected from catch sampling and observer data, the latter being provided for information only due to a limited number of years and areas covered. The model is similar to the one developed in Neubauer et al. (2023). The procedure adjusts the length-frequency samples based on spatial and temporal variability, similar to CPUE standardisation. However, unlike CPUE, rather than removing variation across strata, it predicts length-compositions across catch (or CPUE for index fisheries). This procedure effectively filters variance from length-frequency distributions that result from non-representative sampling. Random effects formulations ensure the sharing of information across strata.

The formulation is an extension of the multinomial GLM, which was developed for estimating length frequencies of New Zealand rock lobster removals (Webber 2022). The extension here was achieved by factorising the multinomial distribution into independent Poisson distributions for total measurements (N_s) in sample s, and a second Poisson distribution with mean $\lambda_{i,s}$ over draws $n_{i,s}$ for the number of fish in length category i in sample s. Length proportions π can then be recovered by setting $\pi_i = \lambda_i / \sum_j(\lambda_j)$. This setting allows the formulation as a straightforward Poisson GLM, using the total counts N_s in sample s as an offset term.

We implemented four distinct models that differed in the formulation for spatio-temporal terms. The base model (shown below) included effects for vessel, statistical area, month, and fishing year. Alternative models included ENSO (El Niño-Southern Oscillation), or sea-surface temperature, or excluded spatio-temporal interactions. The model was implemented in brms and run via:

```
bf(n ~ (1|bin) +
       s(MEIV,bin, k=c(10,5)) +
       (1|bin:month) +
       (1|bin:fishing-year) +
       (1|bin:fishing-year:month) +
       (1|bin:statistical-area) +
       (1|bin:statistical-area:fishing-year) +
       (1|bin:statistical-area:month) +
       (1|bin:statistical-area:fishing-year:month) +
       (1|bin:vessel_id) +
       offset(log(N)))
```

where the continuous effects for MEIV (ENSO) or SST were each included only in the relevant model. The best model was selected using pseudo leave-one-out (loo) cross validation via the expected log posterior predictive distribution (Vehtari et al. 2016, 2017). The fitted model can be used to obtain predictions for corresponding strata in catch or CPUE data, and scaled using relative catch (or CPUE) in each stratum when aggregating to larger scales. For example, predictions and scaling can be achieved at a month-year stratum level for all effort in these strata, and can therefore help correct non-representative sampling of the catch.

In addition to providing standardised estimates of removals, the ENSO-standardised length composition (analogous to the CPUE standardised for environmentally mediated availability) can be estimated as the length compositions that would have resulted at average ENSO conditions (i.e., MEIV2=0).

2.9 CPUE standardisation using Generalised linear models

CPUE standardisations in this analysis were prepared using two approaches: catch prepared from pseudo catch effort landing return aggregated daily (ALB 1 T pseudoCELR), with catch in numbers of fish per record; and data collated at the trip level (ALB 1 T CELR trip) from catch effort landing return (CEL) forms, with catch in landed weight per record. Both series are based on troll catch and effort data only.

A filtering process for anomalous data was run on each dataset, screening and removing records with:

- no recorded fishing duration;
- non-positive fishing duration;
- fishing duration >20 hours (ALB 1 T pseudoCELR only);
- total fishing duration >180 hours (ALB 1 T CELR trip only);
- season start day occuring outside the months November to April in each fishing year;
- no recorded ALB catch; and
- no inferred numbers of fish (ALB 1 T pseudoCELR only).

Both CPUE datasets were restricted to a core fleet, defined as those vessels that carried out at least a minimum qualifying number of fishing trips (3) within each of a minimum number of qualifying fishing years (4). Previous analyses condicted by Brouwer et al. (2021) showed that the exact numbers chosen for this filtering step have a minor impact on CPUE indices.

Finally, environmental variables were added to each dataset for sea surface temperature (SST) and the mulivariate El Niño/Southern Oscillation (ENSO) index (MEI). SST and MEI data was sourced from NOAA Physical Laboratory at https://psl.noaa.gov. The SST data were derived from weekly optimum interpolation (OI) sea surface temperature on a one degree grid (OISST.v2) linearly interpolated to daily values that were then averaged over a month. The monthly average OISST.v2 was matched to ALB 1 T dataset records by year, month and statistical area. The MEI data combines oceanic and atmospheric variables in a single index (sea level pressure, sea surface temperature, zonal and meridian components of surface wind, and outgoing longwave radiation over the Pacific basin). Monthly MEI.v2 records were matched to ALB 1 T model dataset records by year and month.

For albacore, estimated catches from trolling or longlining have normally been reported as numbers of fish. CPUE analyses using event based or daily data therefore used the number of fish as the response variable. However, trip-resolution CPUE analyses modelled the landed catch weight. Four CPUE analyses were investigated, two based on the trip resolution data and two based on the daily resolution data. While it is standard practice when analysing CPUE for New Zealand fisheries to use a combined model, which integrates annual abundance coefficients from a binomial model of zero catches with those from the model of positive catches, we have used a postive catch model only for trip based indices due to the paucity of zero catches in the albacore target troll fishery.

The same set of seven explanatory variables were offered to each of the four generalised linear models: fishing year (`fyear`), fishing vessel (`vessel_key`), statistical area (`stat_area`), month (`month`), fishing duration (`log(total_fishing_duration)` in the trip dataset and `log(fishing_duration)` in the daily dataset), sea surface temperature (`SST`) and the multivariate ENSO index (`meiv2`). Fishing year, vessel and statistical area were included as categorical variables. Statistical area and month were included in the model as an interaction term (`stat_area*month`). The log of fishing duration, sea surface temperature and the multivariate ENSO index (MEI; meiv2 in models) were included as continuous variables, and formulated as cubic splines with three degrees of freedom.

The generalised linear model was fitted to the trip resolution data with the formula:

$$log(landkg) \sim fyear + vessel\_key + modal\_stat\_area * modal\_month + ns(log(total\_fishing\_duration), 3) + ns(SST, 3) + ns(meiv2, 3)$$

and to the daily resolution data with the formula:

$$log(nfish) \sim fyear + vessel\_key + stat\_area * month + ns(log(fishing\_duration), 3) + ns(SST, 3) + ns(meiv2, 3)$$

For each of the two datasets, log(catch) was regressed against the full set of explanatory variables. For the trip based analysis, trips can overlap month and statistical areas, and the modal value (i.e., the month or statistical areas with most effort) was used as a predictor. For both the trip and daily resolution datasets, two sets of models were tested: first, a model where environmental explanatory variables (SST and MEIV) were excluded; and second, the full model. For the latter, the most recent datapoint included in the analysis was from January 15th 2023 as the sea-surface temperature product used for the analysis was not available after this date; the 2023 NZ fishing year was therefore incomplete and includes only 57.9% of catch by trips and 54% of all catch by fishing events for 2023.

Alternative assumed error distributions were explored for each model: the negative binomial and the poisson distributions where the catch in numbers was the response variable, and the lognormal, gamma, and Weibull distributions where the catch in weight (tonnes) was the response variable. The set of models constructed in this analysis are listed in Table 3. Analyses were run using the New Zealand fishing year (Oct–Sept).

Table 3: Summary of models constructed for CPUE standardisation. The primary models are highlighted in darker grey and supporting diagnostics are included below. Diagnostics for secondary models, highlighted in lighter grey, are included in Appendix A.

Series name	Data resolution	Response variable	Explanatory variable selection process	Core fleet years	Core fleet trips	Assumed error distribution
ALB 1 T pseudoCELR	daily	nfish	All selected	4	3	negative-binomial
ALB 1 T pseudoCELR full	daily	nfish	All selected	4	3	negative-binomial
ALB 1 T CELR trip	trip	landkg	All selected	4	3	gamma
ALB 1 T CELR trip full	trip	landkg	All selected	4	3	gamma

3. FISHERY CHARACTERISATION

Landings data were provided for all trips that landed ALB 1 at least once. Each landing was reported in green weight (kg) along with a processed state, any conversion factors used and a destination code. Almost all fish (99%) were landed to destination code “L” (landed to a Licensed Fish Receiver) with the remaining 1% being landed to a number (22) of other codes, mostly prior to 2006 (Figure 6). The other codes included fish that were consumed or used as bait, lost etc. The initial dataset corresponded closely with the QMR/MHR totals with very little catch being lost.

Albacore tend to be landed whole (green), with a very small fraction being landed to a number of processed states, mostly as fish meal (MEA) prior to 2017 (Figure 7). As most fish are landed whole there is little need for conversion factors, but for those that are processed there are a number of current conversion factors in use (Figure 8), with GGO (gilled, gutted, tail on) and SKF (fillets, skin-off) being the most commonly used in the most recent three years. The code definitions used in the report text and figures can be found in the Glossary - Appendix I (Table I.1). There have been no changes to conversion factors since 1990.

Nearly all landings were retained in the characterisation dataset (Figure 9). Prior to 2020, most landed catch was recorded on CEL forms, with around a quarter of fishing event records and 16% of landings reported on TUN forms. The form type code definitions used in the report text and figures can be found in the Glossary - Appendix I (Table I.2). In 2020, just over half the records (51%) and almost all the catch (94%) was reported on “ERS - Other Lining” forms (Figure 10). Prior to 1996, most records were reported on CEL forms (average 85%), that dropped steadily to 41% in 2010 with a higher proportion of records being reported on TUN forms (up to 35%). From 2010-2017 around 40% of records were being reported on TCP and TUN forms along with a number of other form types. The majority of the catch was reported on CEL forms from 2004 onwards. In the most recent year there was an almost total shift to electronic reporting with the catch being reported on “ERS - Other Lining” forms.

The majority of the albacore catch was landed by troll gear, and from 1998 to 2004 there was a shift from catch being landed by troll gear to longline. Prior to that period the longline fishery landed <20% of the catch. This increased to 36-45%, but declined again after 2004 and has remained below 20%, with 87% of the catch since 2004 being landed by troll gear (Figure 11).

In the surface longline fishery, prior to 2004, the albacore catch was landed primarily in sets targeting bigeye tuna, with only about 13% of the catch coming from sets targeting albacore. After 2004, landings from albacore target sets declined sharply, averaging just 2% of target declarations from 2004-2020 (Figure 12). There was also a distinct switch to targeting southern bluefin tuna where 21% of albacore catch was made in southern bluefin tuna sets prior to 2004 and 46% thereafter. Almost 100% of the troll catch came from albacore target sets. Other gears caught few albacore, and only 15% of other gears were albacore target sets. Prior to 2005, albacore made up the bulk of the surface longline catch, but from 2005 to 2010 blue sharks and swordfish were the dominant species.

In the surface longline fishery, most of the catch records were reported on TUN forms prior to the switch to ERS in 2019-20. Also, prior to 2005, when targeted, albacore have typically been ranked first in the estimated catch from a surface longline fishing event (Figure 13). From 2005, albacore were not generally targeted in the surface longline fishery, and the estimated albacore catch usually ranked above 2. On CEL forms for troll, in all set types the average rank of albacore in the estimated catch was 1.

On average vessels reported just over one record per day on all form types. There was some variation for CEL forms, but from the mid-1990s most surface longline trips reported one record per day, and most (but not all) troll trips report one record per day (averageing around 1.01 records per day). Landings reported on TUN forms occured in all years for the surface longline fishery and reported on average just over one record per day (~1.05). Since 2020, “ERS - Tuna Lining” and “ERS - Other Lining” forms have been in use (with a small amount of ERS data reported in 2019) and, on average, just over one record was reported per day for both surface longline and troll gear (Figure 14).

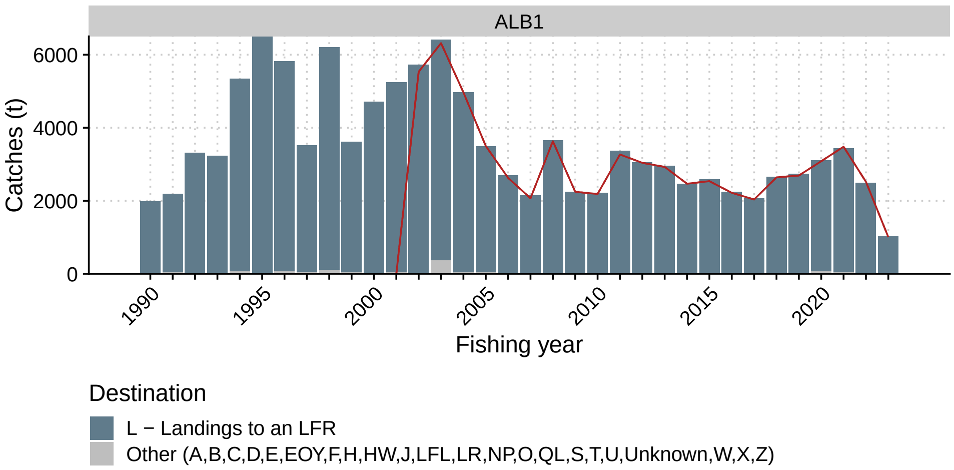

Figure 6: Catches of albacore by destination (bars), compared with Monthly Harvest Return / Quota Management Report (MHR/QMR) totals (line), for Fisheries Management Area ALB 1. Destination codes are defined in Table 1 and tabulated catches are given in Appendix C.

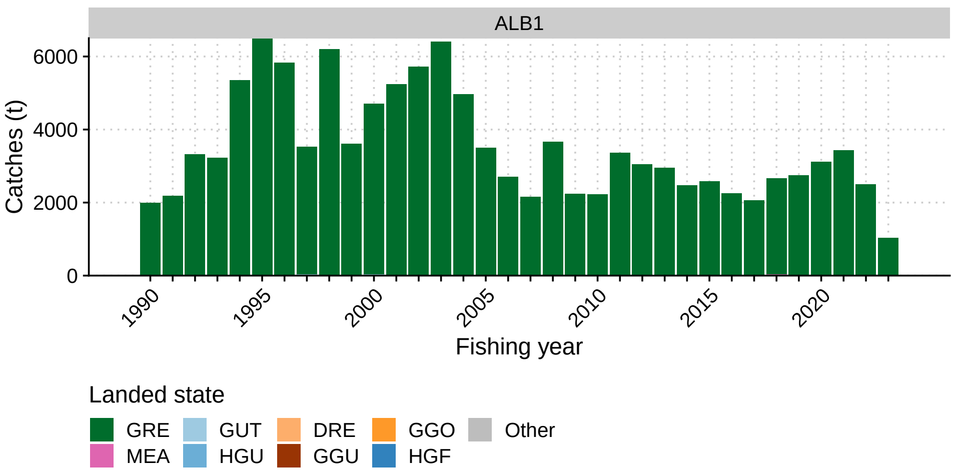

Figure 7: Landed state of albacore from Fisheries Management Area ALB 1. Catches are tabulated in Appendix C, and landed state codes are defined in the glossary Table I.1.

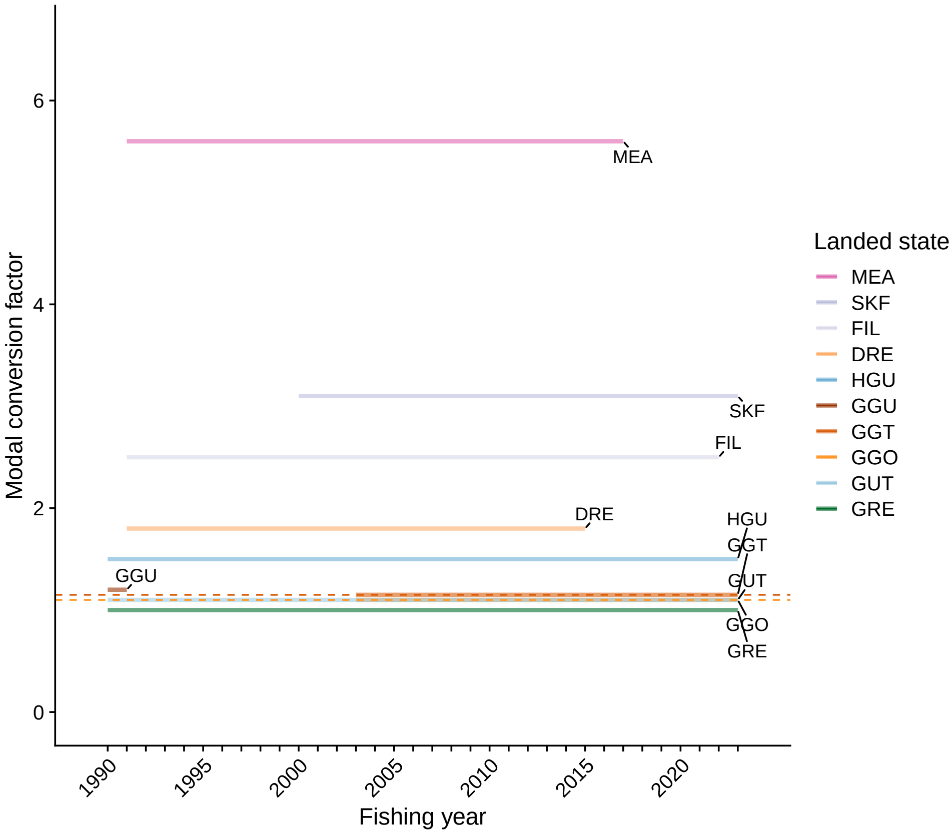

Figure 8: The modal annual conversion factor reported for the product states used in ALB 1 catches. The current statutory conversion factor is indicated by a dashed line for states where a species-specific value is defined. Tabulated results are provided in Table C.5, and landed state codes are defined in the glossary Table I.1.

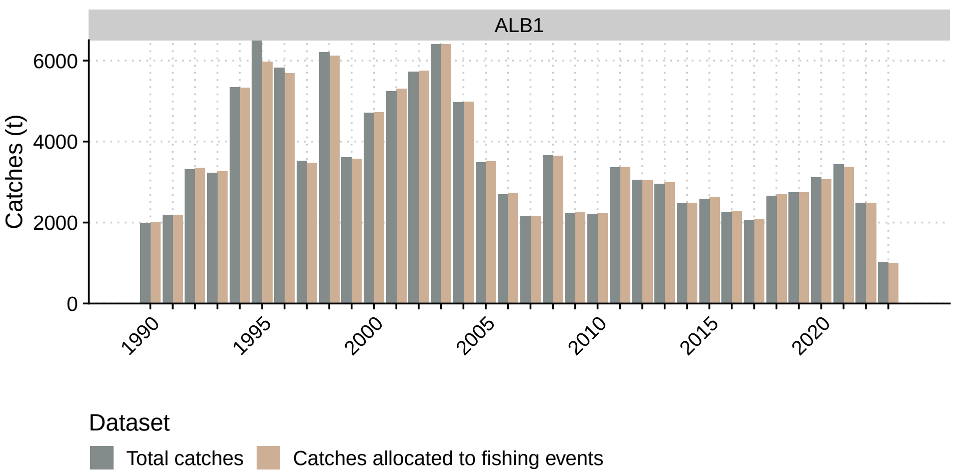

Figure 9: Total catches (t) of albacore from ALB 1 in comparison with catches allocated to fishing events in the characterisation dataset.

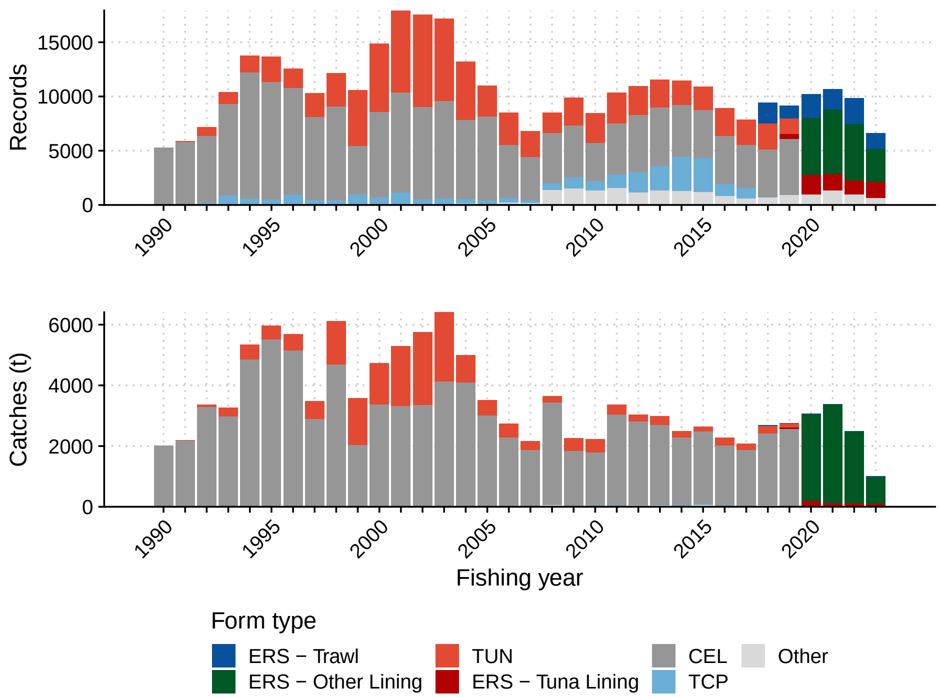

Figure 10: Reporting forms used on trips catching albacore within the ALB 1 Fisheries Management Area, in terms of fishing event records and catches. Tabulated results are available in Appendix C. Form types grouped as Other include: ERS - Diving, ERS - Lining, ERS - Netting, ERS - Potting, ERS - Seining, HCE, HLC, HTU, LCE, LTC, NCE, SJC, TCE. A list of the main form type codes is included in the glossary Table I.2.

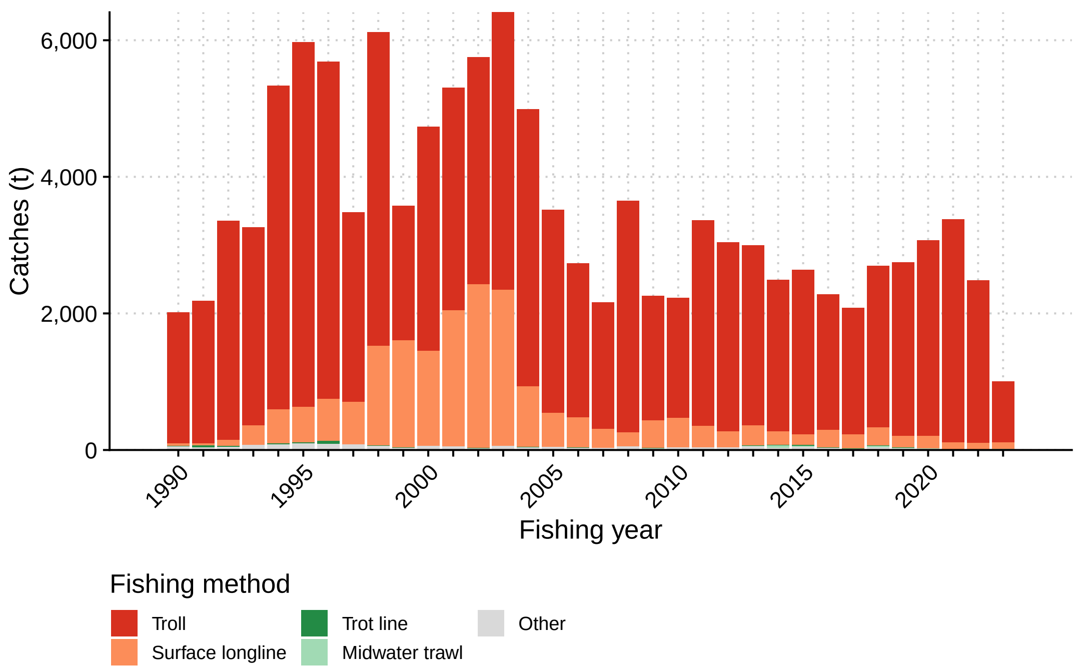

Figure 11: Catches of albacore by fishing method, for events within the ALB 1 Fisheries Management Area. Methods grouped as Other include: BLL, BPT, BS, BT, CP, CRP, D, DL, DN, DPN, DS, DV, FP, H, HL, L, MH, OCP, PL, POT, PRB, PRM, PS, RLP, RN, SCN, SJ, SN. Tabulated results are provided in Appendix C, and a list of the main fishing method code types is included in the glossary Table I.3.

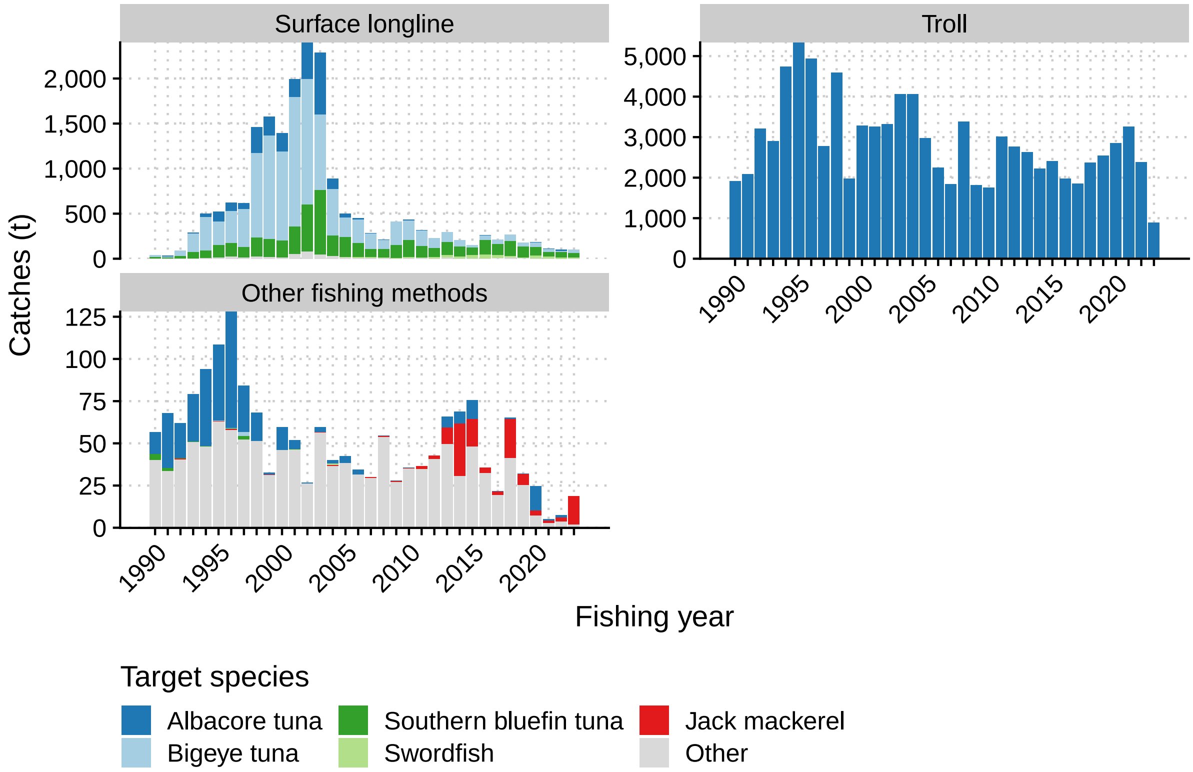

Figure 12: Catches of albacore by fishing method and declared target species, for events within the ALB 1 Fisheries Management Area. Fishing Methods grouped as Other include: BLL, BPT, BS, BT-PRB, CP, CRP, D, DL, DN, DPN, DS, DV, FP, H, HL, L, MH, MW-PRM, OCP, PL, POT, PS, RLP, RN, SCN, SJ, SN, TL. Species grouped as Other include target species with less than 1.5% of the albacore catch within the ALB 1 Fisheries Management Area in a fishing year.

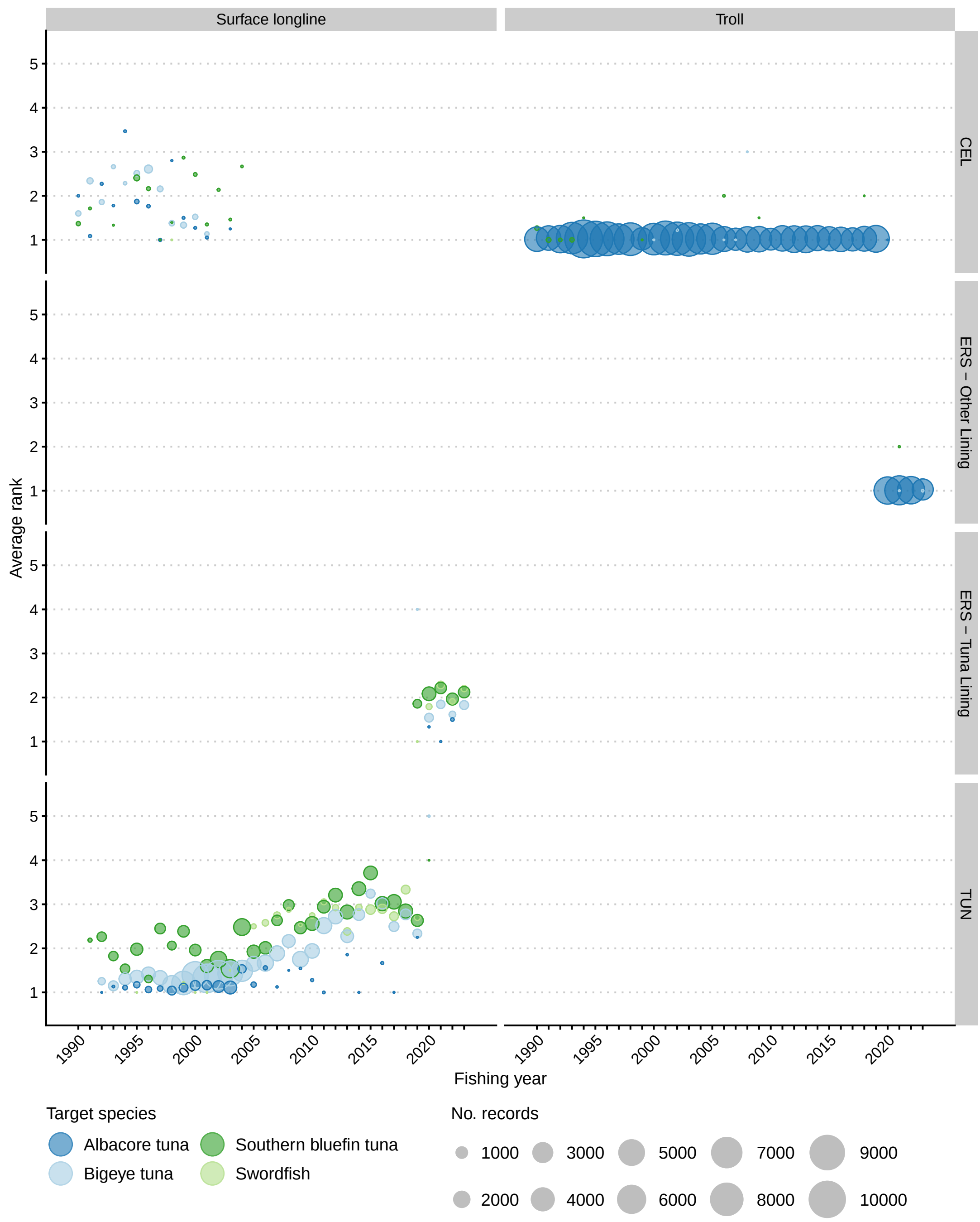

Figure 13: Average rank of albacore in the estimated catch, by fishing method, form type and declared target species, for events with estimated catches within the ALB 1 Fisheries Management Area. The area of the circles scales with the number of records.

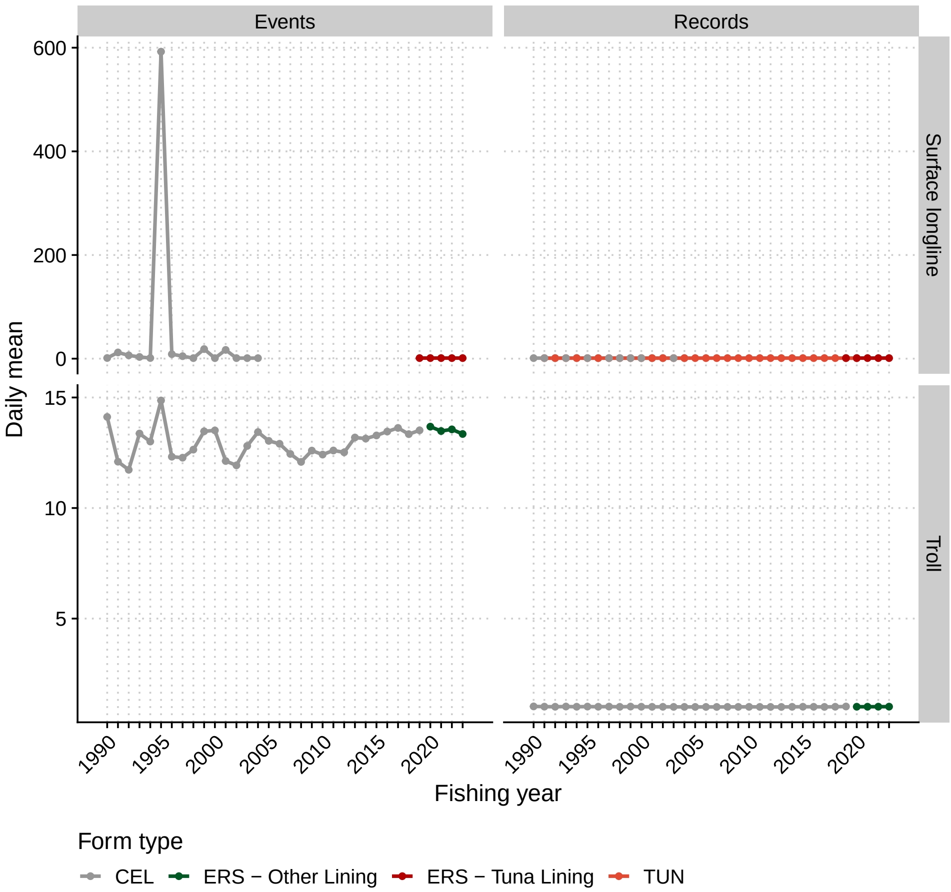

Figure 14: The mean number of fishing events and data records per vessel-day, by fishing method and reporting form, for effort within the ALB 1 FMA on trips landing catch from ALB 1. Data are included for years where a form was used on at least five vessel-days.

3.1 The troll fishery

Few (<20%) troll records prior to 2020 provided latitude and longitude information on the CEL forms. With the use of “ERS - Other Lining” forms since 2020, 100% of troll records reported latitude and longitude (Figure 15).

In the troll fishery, most of the catch and the highest catch rates occurred on the west coasts of both the North and South Islands (Figure 16, Figure 17). There were relatively high concentrations of catch and high catch rates in Statistical Areas 042 and 045 on the central west coast of the North Island. High catch was also made on the west coast of the South Island in Statistical Areas 033 to 036. A small amount of catch was taken on the east coast of the North Island, with the highest catch rates in Hawke Bay. Catch on the east coast of the South Island was negligible. Note however, prior to 2020 the spatial distribution of catch and cath rate is informed by less than <20% of fishing events.

The spatial distribution of the recent (2019–2023) troll catch increased rapidly in a relatively small area with about half the catch being taken in the first 50 grid cells fished (Figure 18), after which the area fished expands rapidly. This was probably as a result of the fleet moving south as the fishing season progresses, and the main fishing area was in about 100 cells. These data were, however, skewed by the limited latitude and longitude reporting prior to 2020. The early series is therefore constrained by the poor latitude and longitude reporting noted above. Overall, most of the catch came from three distinct areas, the west coast of the upper north Island, the north Taranaki Bight and the west coast of the South Island, with most of the landings coming from Statistical Areas 034 and 035 (Figure 19).

Most of the catch was made during the Austral summer. The troll fishery generally began in November or December, with small catches of albacore. Catches increased in December and were highest in January to March, with a small catch in April and little catch in May (Figure 21). While the catch mostly occurred during the period from January to March, unstandardised CPUE was relatively consistent from December through to April in most years (Figure 22). Trolling was almost entirely directed at albacore (Figure 20), and the rapid decline in catch during the autumn was likely a combination of the fish dispersing and the vessels switching gear to target more lucrative species such as southern bluefin tuna at that time of year.

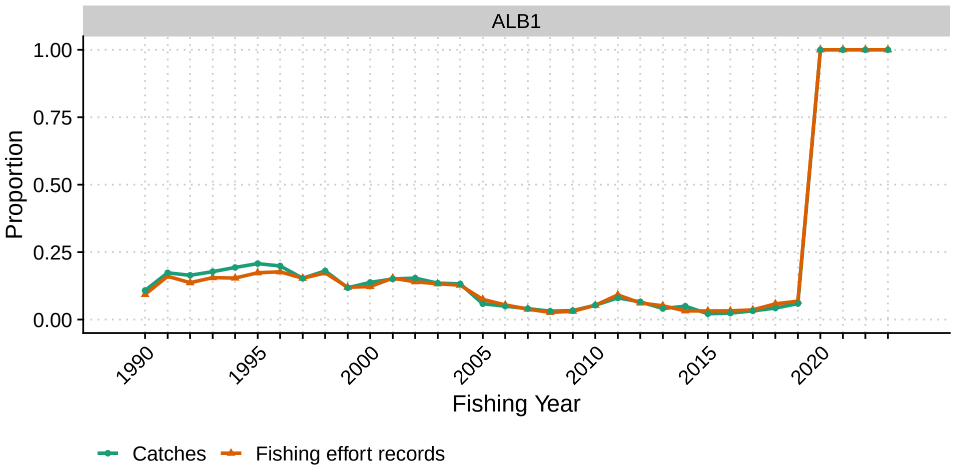

Figure 15: The proportion of records and catches reported with a latitude/longitude for the ALB 1 troll fishery.

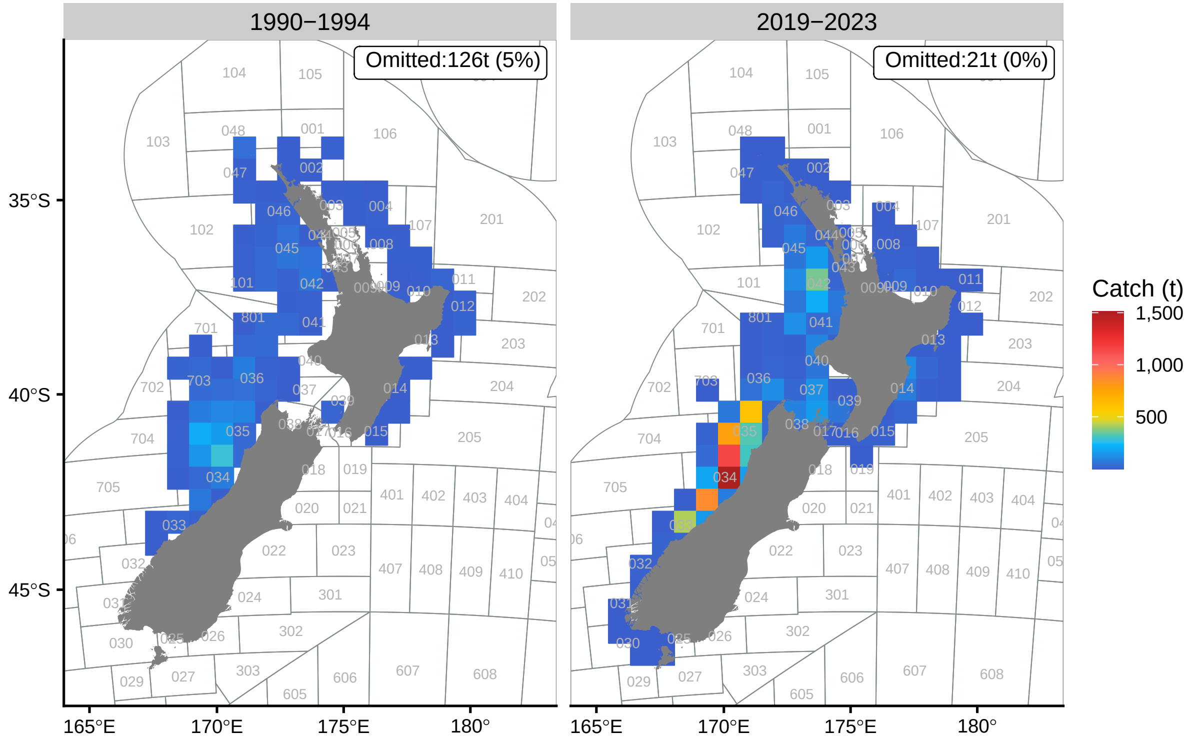

Figure 16: Catches (t) for the ALB 1 troll fishery, for 5-year periods within the era during which at least 5% of catch was reported with spatial positions. These plots use a 64 km grid and include records where catches were allocated in proportion to estimated catch. Cells with data from less than three vessels or permit holders are omitted; the quantity of catch affected is indicated on each panel.

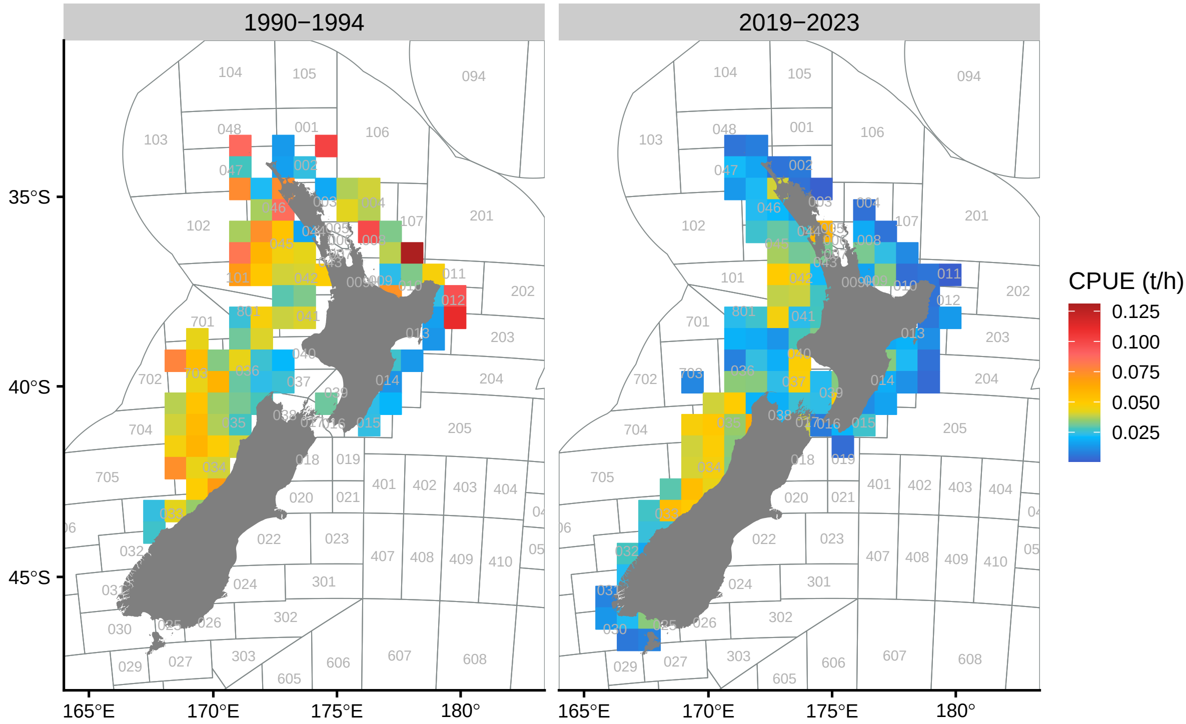

Figure 17: Raw aggregate CPUE (t/h) for the ALB 1 troll fishery, for 5-year periods within the era during which at least 5% of catch was reported with spatial positions. These plots use a 64 km grid and include records where catches were allocated in proportion to estimated catch. Cells with data from less than three vessels or permit holders are omitted.

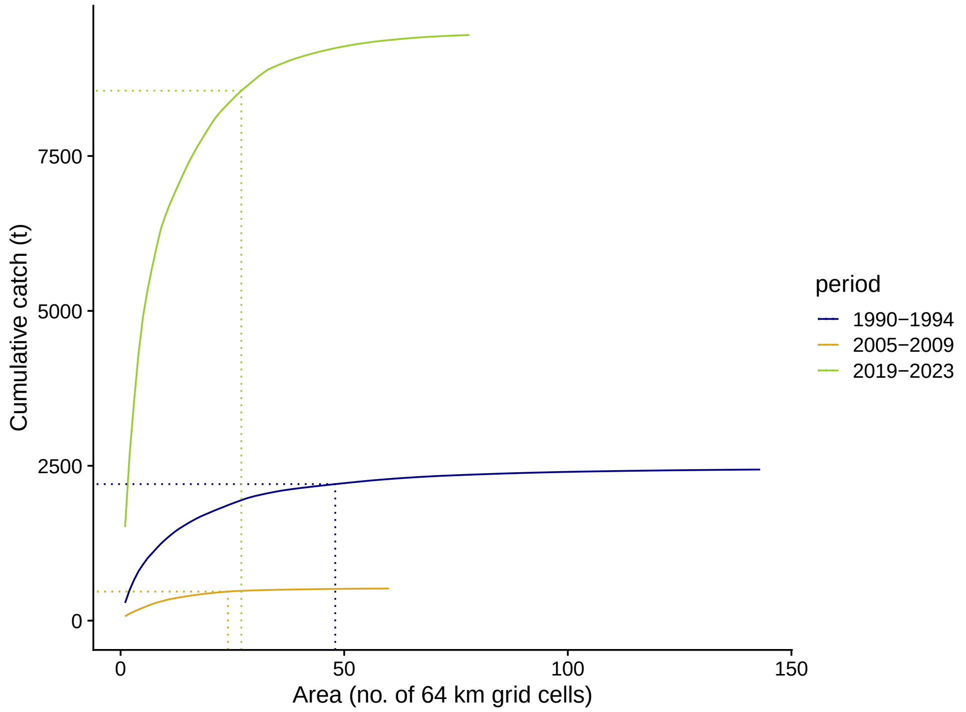

Figure 18: Cumulative ALB 1 catch by area (grid cells) for the troll fishery, aggregated for the first, middle, and last 5-year period of reporting. Dotted lines indicate the 90th percentile for the first, middle, and last 5-year period of reporting.

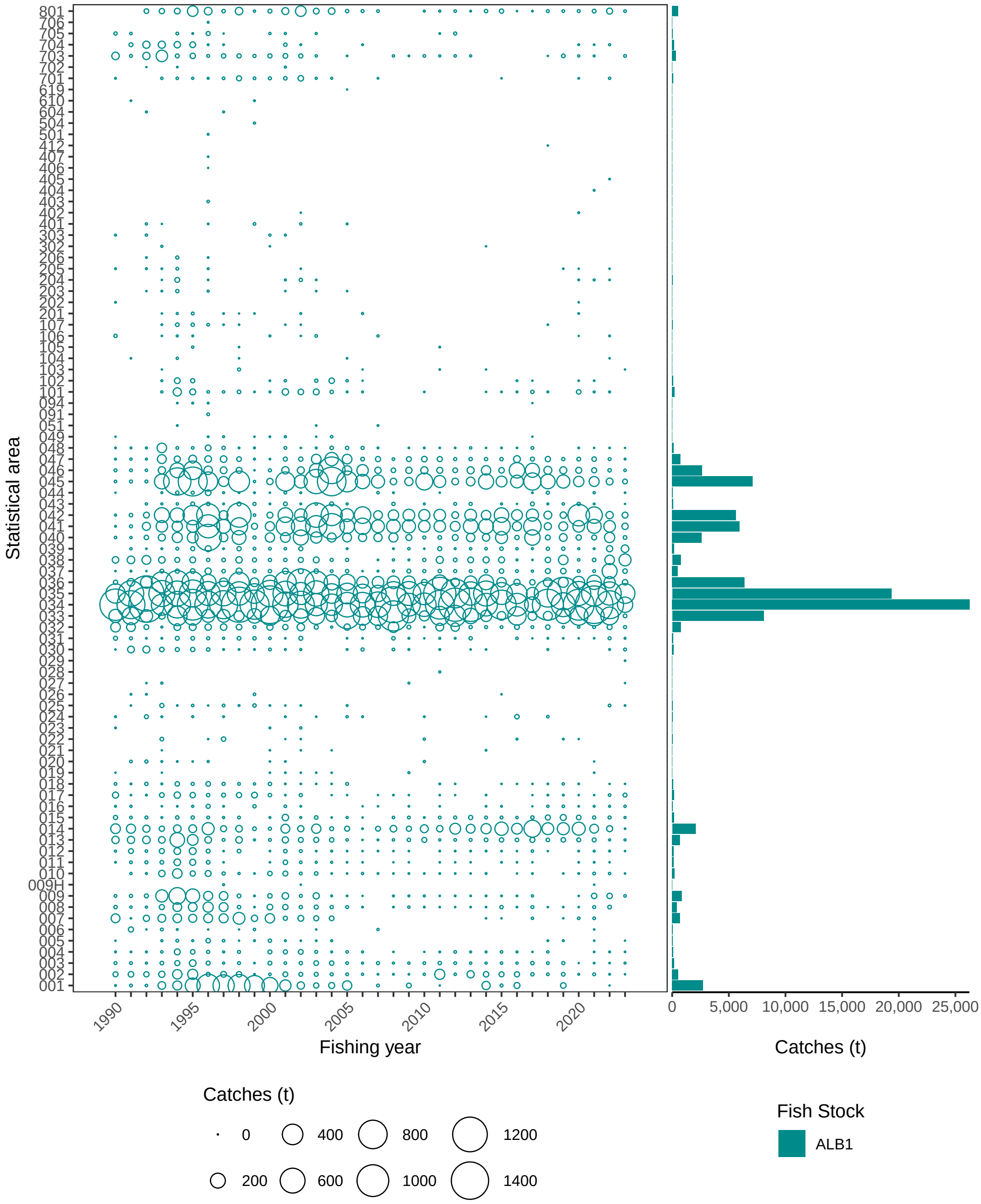

Figure 19: Annual ALB 1 catches (t) by statistical area for the troll fishery. The circle size scales with the catches by statistical area. The bar plot (right) shows the total catches of ALB 1 for each statistical area.

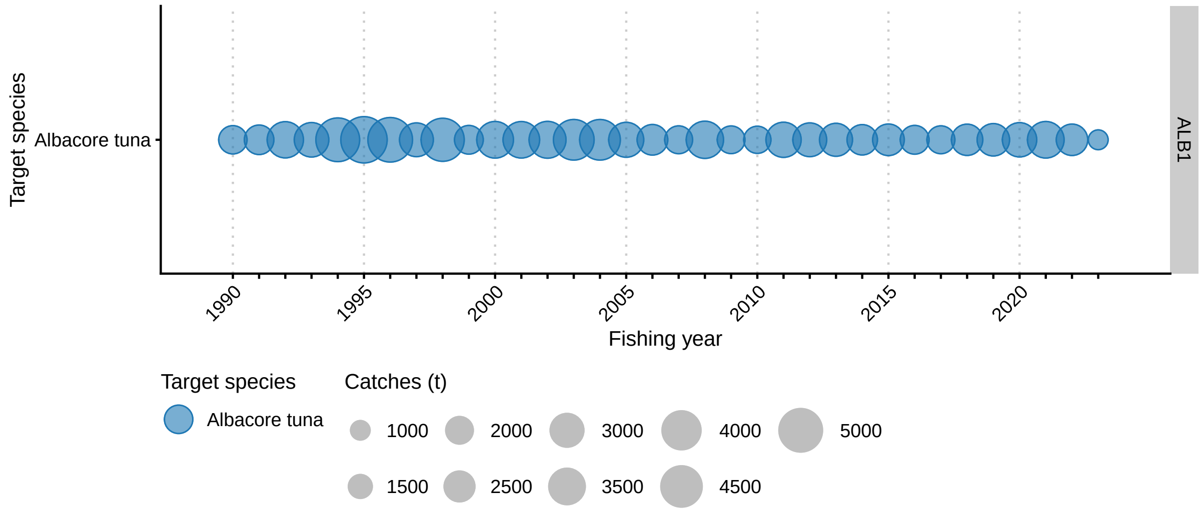

Figure 20: Albacore catches by fishing year and target species for the troll fishery. The area of the circle scales with the yearly catches.

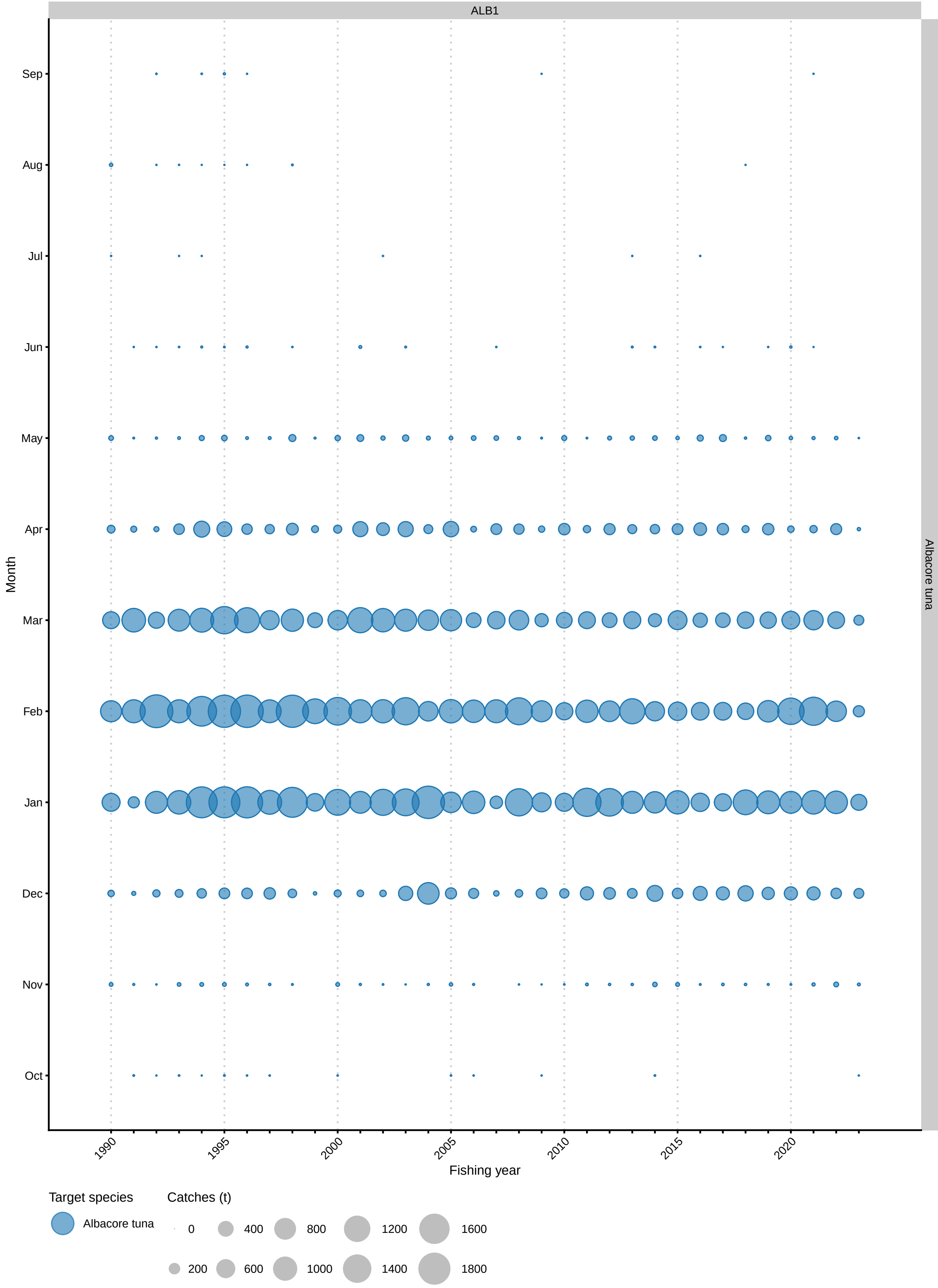

Figure 21: Seasonal distribution of ALB 1 catches by month and fishing year for the troll target fisheries. The area of the circle scales with the monthly catches.

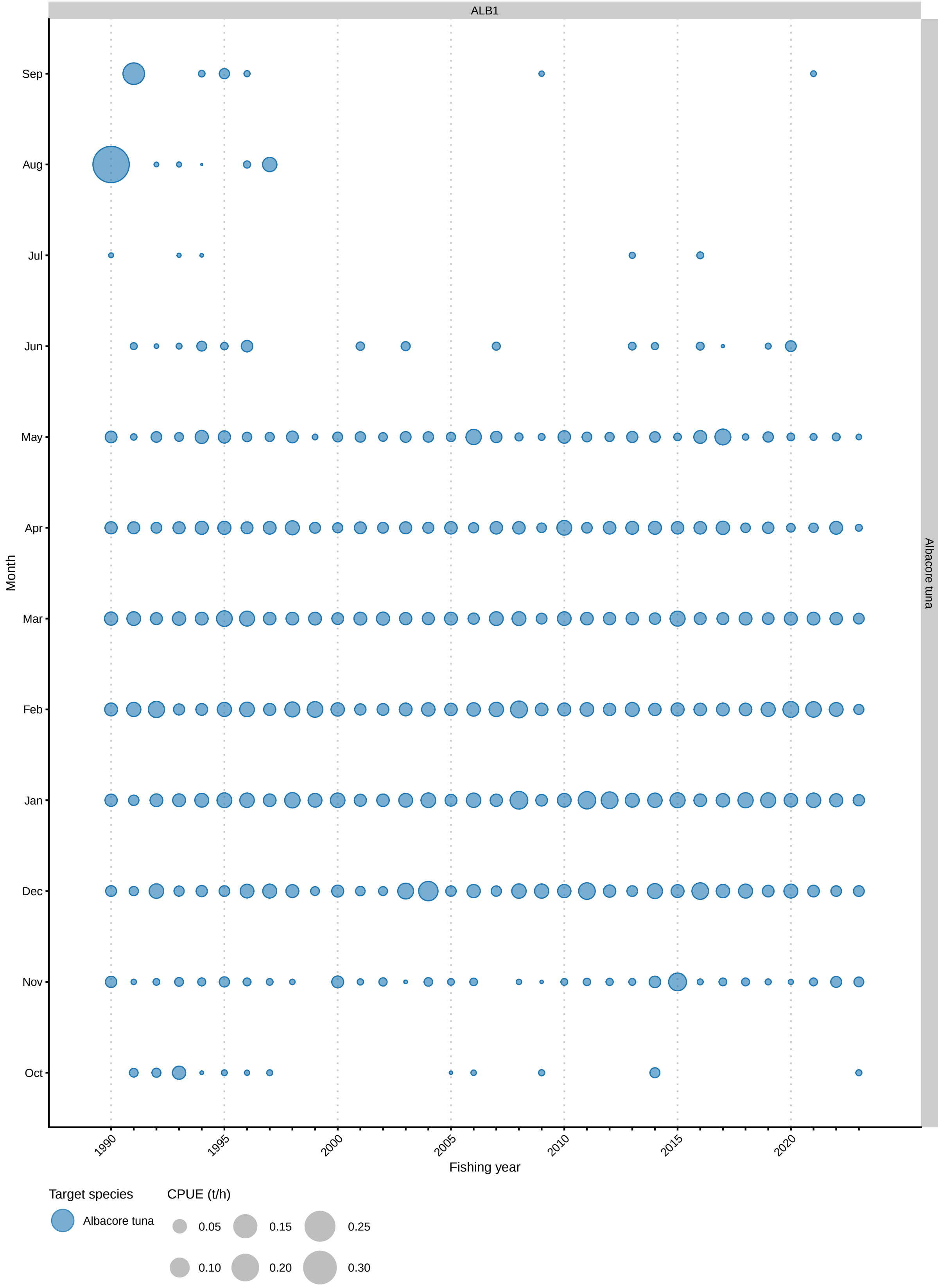

Figure 22: Seasonal distribution of ALB 1 raw aggregate CPUE (t/h) by month and fishing year for the troll target fisheries. The area of the circle scales with the monthly raw aggregate CPUE (t/h).

3.2 The surface longline fishery

The New Zealand surface longline fishery catches a number of species and has changed over the course of the last three decades. Prior to 2004 most of the catch was albacore with high catch of swordfish as well as bigeye tuna. From 2005 the catches of albacore and bigeye tuna declined substantially, while the catches of blue shark and southern bluefin tuna increased (Figure 23, Table H.1). There was a fairly abrupt change in surface longline albacore catches in the mid-2000s, when the albacore catches declined markedly (Figure 23, Table H.1). To some extent this can be attributed to a reduction in targeting of albacore and bigeye tuna and a slight increase in the targeting of swordfish after 2010. However, most of the reduction in albacore catch was attributed to a large reduction in surface longline fishing effort directed at bigeye and albacore tuna from 2003 to 2005, when the overall fishing effort declined by two thirds (Figure 24, Table H.2).

Since 1993 almost all surface longline records have reported latitude and longitude for sets catching ALB 1 (Figure 25). This trend was consistent between the TUN and “ERS - Other Lining” forms.

The troll fishery occurred mainly on the west coast of New Zealand and relatively close inshore, in contrast to the surface longline fishery where albacore catches occurred mostly on the east coast of the North Island (Figure 26). Albacore surface longline catches straddled the East Cape of New Zealand, and extended from Hawke Bay to north of Cape Reinga out to the boundary of the EEZ. Small amounts of catch occurred off the southeast coast of the South Island, and off the west coast of the North Island. In the earlier period (2003–2007), when the surface longline fishery was albacore focused, the catch distribution was broader than the more recent period when albacore target sets were less frequent. The spatial nature of records in the plots may be influenced by vessels dropping out due to the data grooming rules.

Surface longline sets targeting albacore are sparse, and occurred off the East Cape and northwest of the North Island. Albacore catch in sets targeting bigeye tuna occurred primarily off the east coast of the North Island from Hawke Bay north. There was a relatively high density of catches off the central west coast of the South Island where vessels were targeting primarily southern bluefin tuna, and the albacore catches off the southeast coast of the South Island were also in southern bluefin target sets (Figure 28).

The surface longline catch of albacore expanded in its spatial extent slower than the troll fishery. Nevertheless, in 2003–2007 the initial catch came from a few cells with around half the catch coming from about 50 cells and the second half coming from the remaining 500+ cells (Figure 29). In recent years (2019–2023), however, the area fished was smaller with most of the catch coming from <300 cells. Compared to the troll fishery, the surface longline catch was more widely distributed with high proportions of the catch coming from Statistical Areas 001–004, 008–014, 033–035, 041–048, and 105–205 (Figure 30). This was due to the dispersed nature of the fishery as well as the relatively high number of target pelagic longline fisheries that catch albacore as a bycatch.

Catch in albacore target sets was more pronounced in April to July across years (Figure 32), but albacore were relatively consistently caught in the more northerly bigeye tuna surface longline sets throughout the year (Figure 32). Catches of albacore in the southern bluefin tuna target fishery tended to occur from March to August. Swordfish target surface longline sets caught albacore year-round, but mostly in the first and second quarters. Targeting in the surface longline sets has changed considerably through the years since 1990. From 2010, catch and target were relatively consistent with swordfish and bigeye targeting throughout the year, southern bluefin tuna targeting through the Austral winter, with very little albacore targeting which tended to occur in the autumn months (Figure 32, Figure G.5). Assessing the monthly CPUE data from these target fisheries revealed that CPUE was higher prior to 1998 for both albacore and bigeye tuna target sets, thereafter CPUE data were sparse for the albacore target sets which dropped off after 2005. Albacore CPUE in bigeye target sets is relatively consistent throughout the year, but prior to 2000 and after 2015 CPUE was higher in March to August (Figures 33, G.6), a trend also apparent in the southern bluefin tuna target sets (Figures 33, G.7). Figure 31 also shows the increasing catch of albacore prior to 2005 followed by large reductions in albacore catch in albacore, bigeye and southern bluefin tuna target sets and an increase in swordfish target sets.

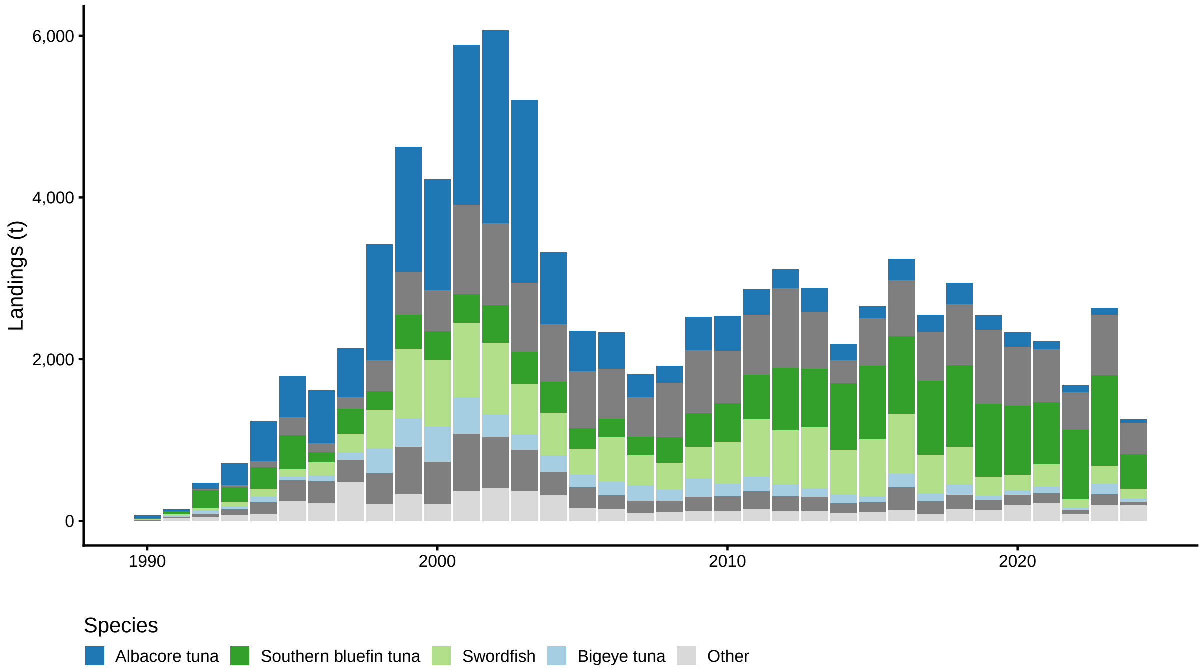

Figure 23: Landings by species and fishing year for the New Zealand surface longline fishery, for trips where the modal fishing method was surface longlining.

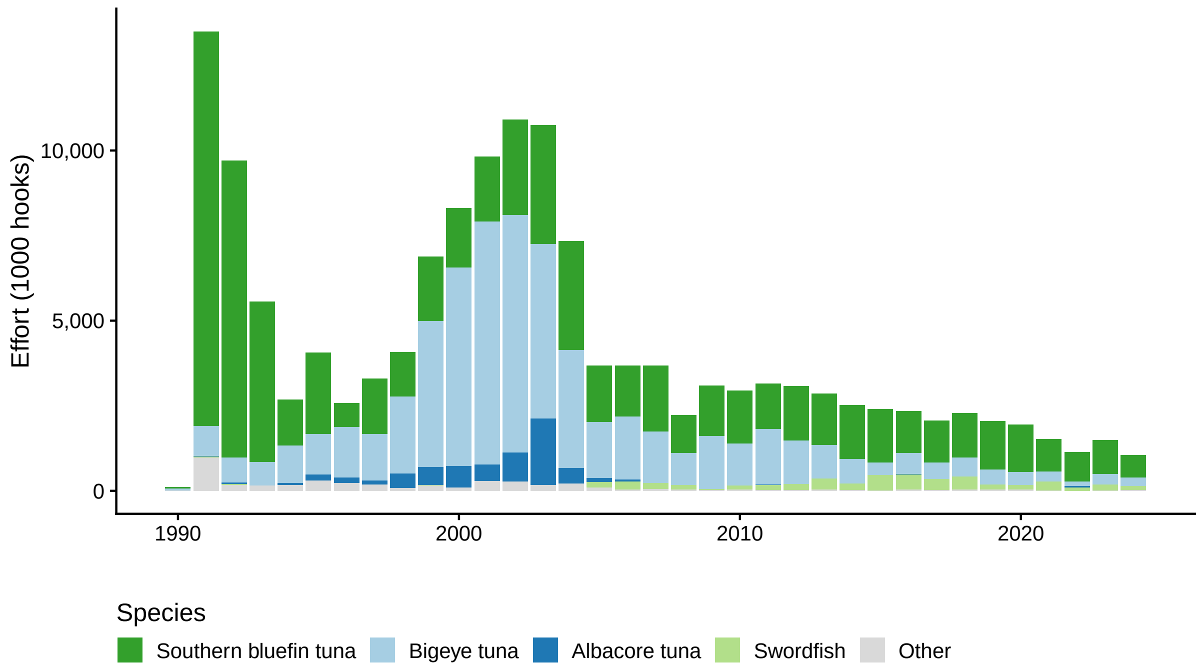

Figure 24: Total effort (no. hooks/1000) by species and fishing year for the New Zealand surface longline fishery, for trips where the modal fishing method was surface longlining.

Assessing the catch and CPUE seasonally in spaced suggests that the troll and surface longline fisheries do not generally overlap. The troll catch generally started in November inshore on the northwest coast of the North Island and then progressed south through the summer. By February and March most of the catch was being made inshore off the central and southern South Island west coast. The catch generally declined substantially in April and May (Figure G.1 and Figure G.2). This differs from the surface longline albacore catch that occured in October to December on the North Island east coast, moving further offshore and to the west coast and south along the east coast in January and February. By March, the catch was centered off Hawke Bay. Reasonable catch was being taken off the South Island's west coast. This shift in longline effort progressed and intensified through the second quarter of the year and into July. In August and September, the catch was taken from the northeast coast of the North Island (Figure G.3 and Figure G.4). While the troll catch was all albacore target driven, the surface longline catch was from sets directed at other species. Albacore target sets occurred off the south and central east coast of the North Island in the first half of the year with a slight shift north in the second quarter (Figure G.5). The bigeye tuna target fishery operated predominantly off the east coast of the North Island all year round but with some catch on the west coast of the North Island in the first quarter and into the second quarter of the year (Figure G.6). The southern bluefin tuna target sets began in March off the South Island west coast and continue there through the Austral winter while also expanding to the North Island east coast through winter and into spring (Figure G.7).

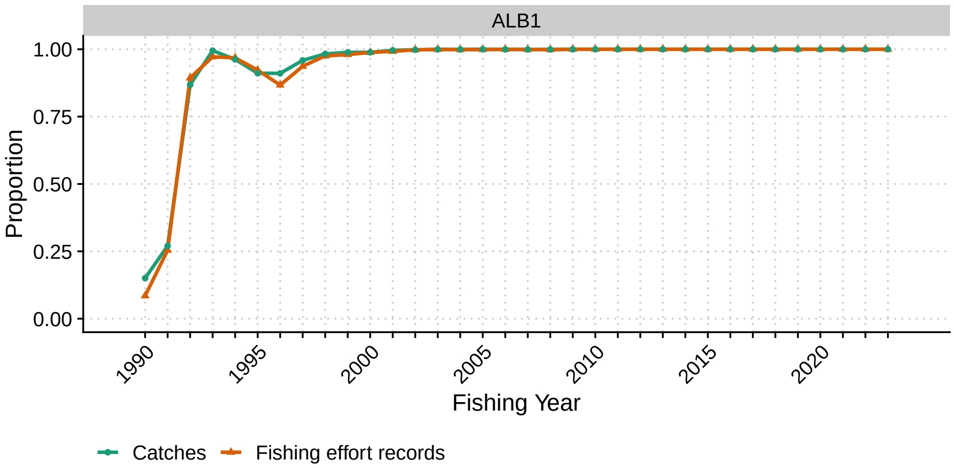

Figure 25: The proportion of records and catches reported with a latitude/longitude for the ALB 1 surface longline fishery.

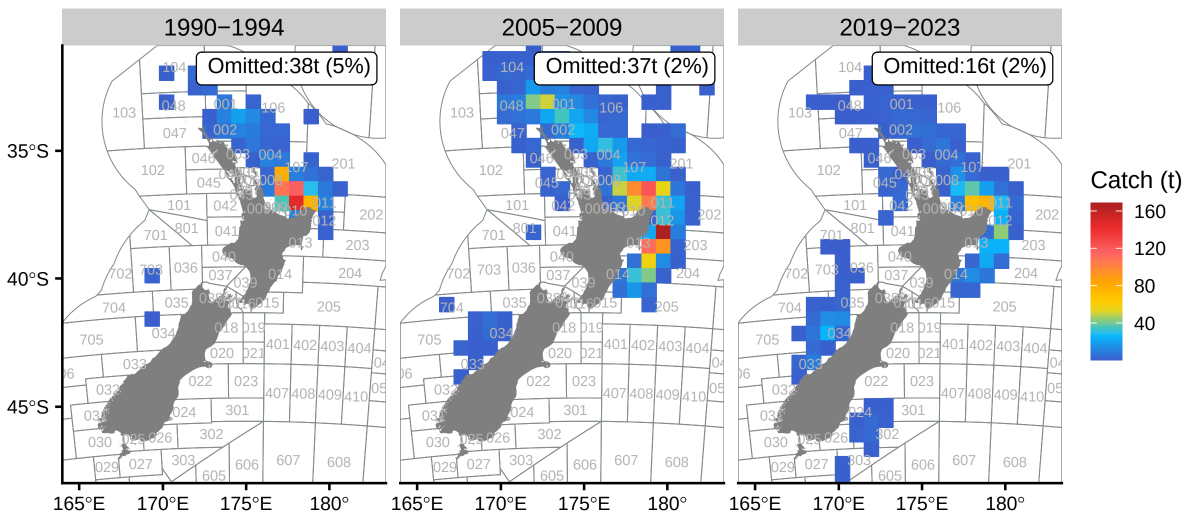

Figure 26: Catches (t) for the ALB 1 surface longline fishery, for 5-year periods within the era during which at least 5% of catch was reported with spatial positions. These plots use a 64 km grid and include records where catches were allocated in proportion to estimated catch. Cells with data from less than three vessels or permit holders are omitted; the quantity of catch affected is indicated on each panel.

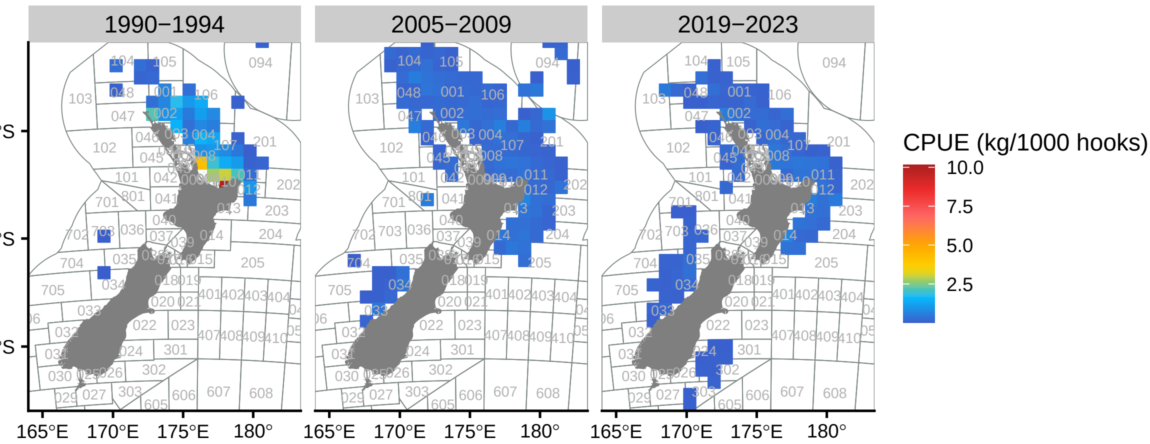

Figure 27: Raw aggregate CPUE (kg/1000 hooks) for the ALB 1 surface longline fishery, for 5-year periods within the era during which at least 5% of catch was reported with spatial positions. These plots use a 64 km grid and include records where catches were allocated in proportion to estimated catch. Cells with data from less than three vessels or permit holders are omitted.

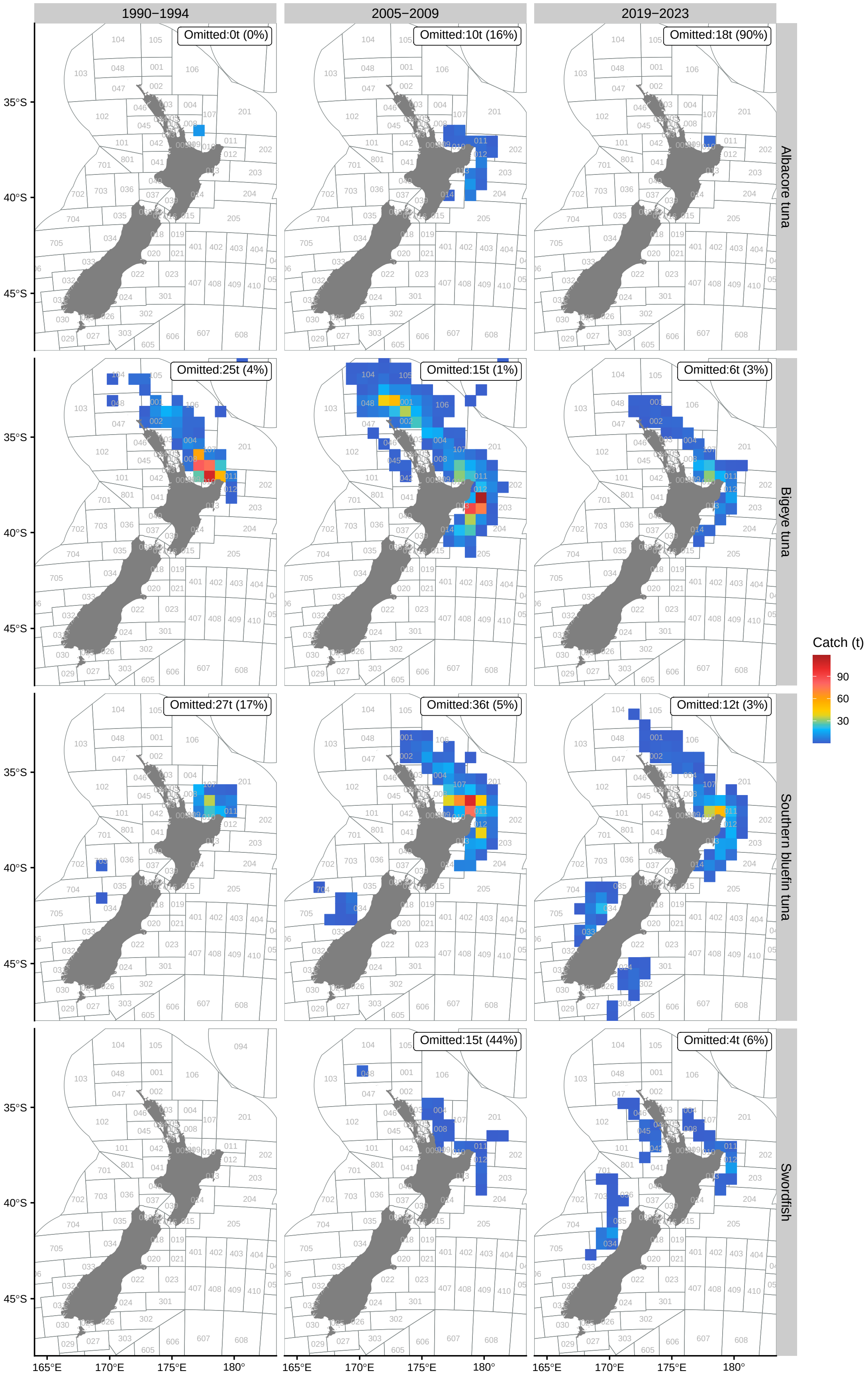

Figure 28: Catches of albacore from the surface longline fishery by key target species. These plots use a 64 km grid and include records where landings were allocated in proportion to estimated catch. Cells with data from less than three vessels or permit holders are omitted; the quantity of catch affected is indicated on each panel.

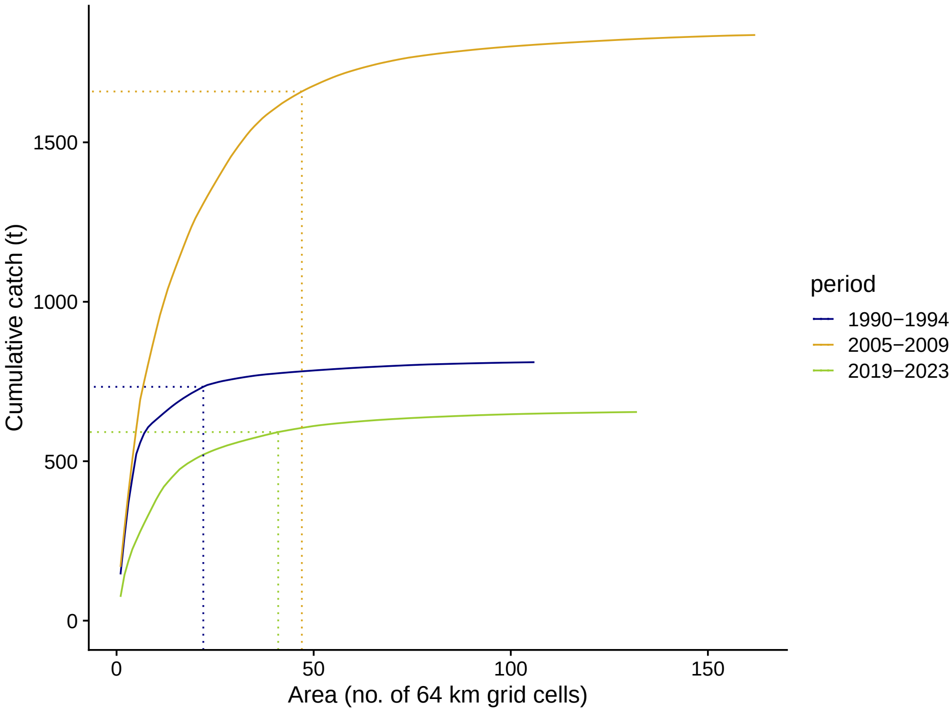

Figure 29: Cumulative ALB 1 catch by area (grid cells) for the surface longline fishery, aggregated for the first, middle, and last 5-year period of reporting. Dotted lines indicate the 90th percentile for the first, middle, and last 5-year period of reporting.

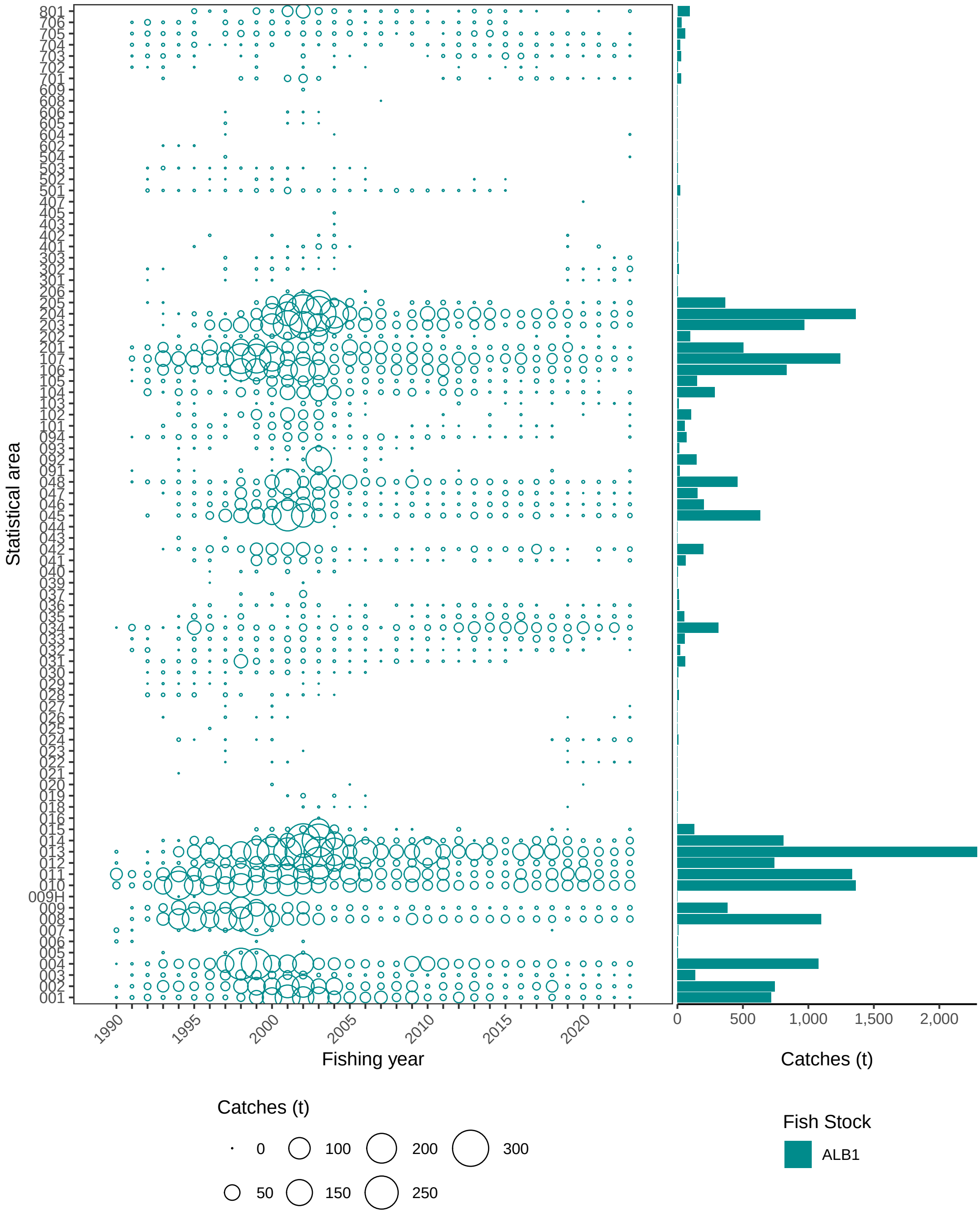

Figure 30: Annual ALB 1 catches (t) by statistical area for the surface longline fishery. The circle size scales with the catches by statistical area. The bar plot (right) shows the total catches of ALB 1 for each statistical area.

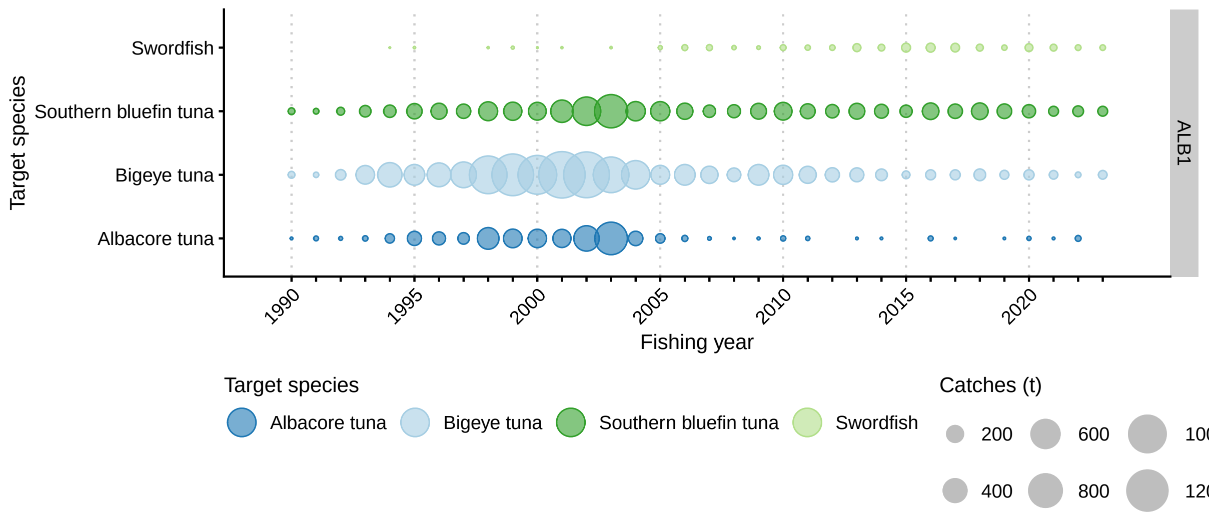

Figure 31: Albacore catches by fishing year and target species for the surface longline fishery. The area of the circle scales with the yearly catches.

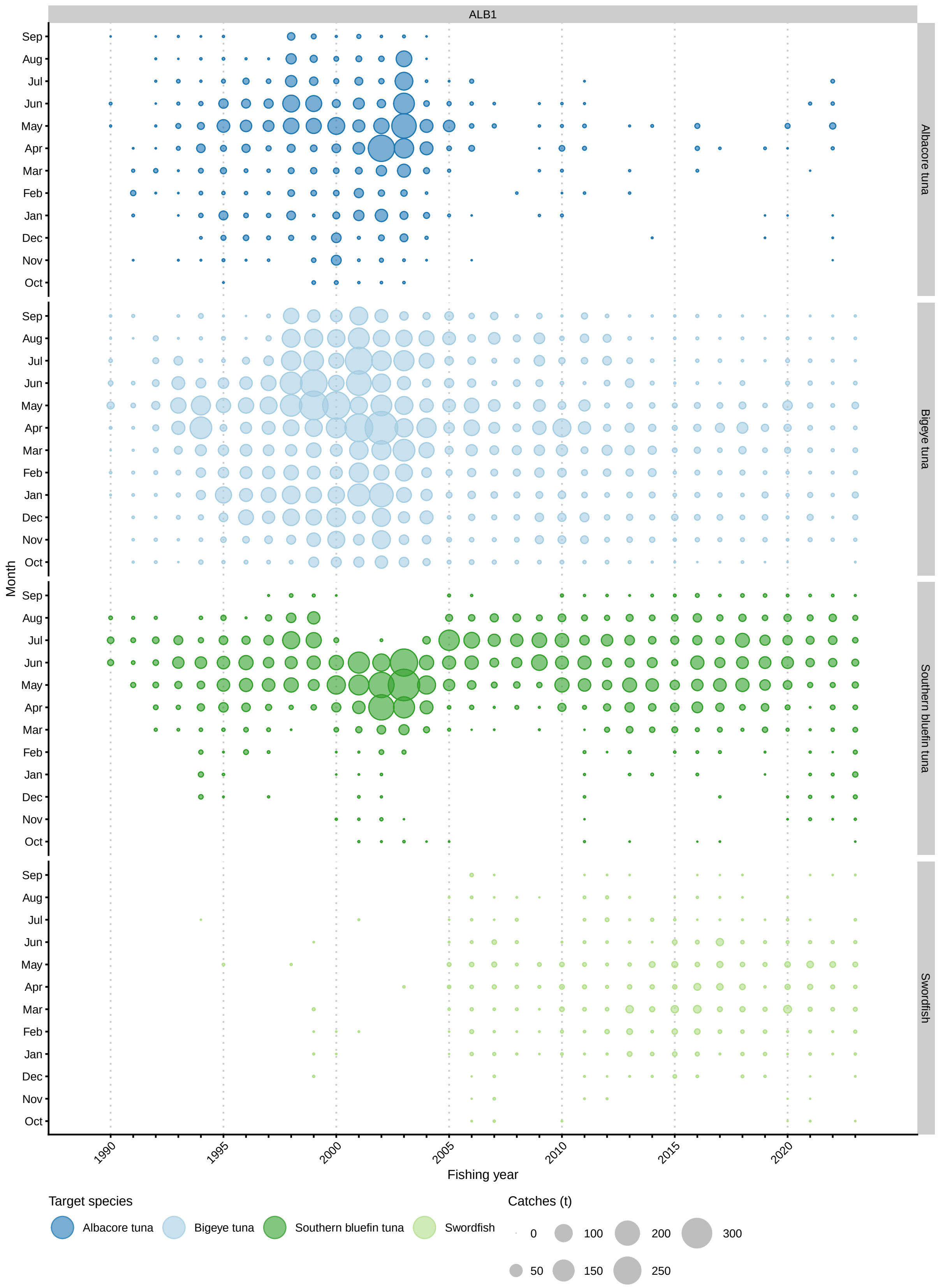

Figure 32: Seasonal distribution of ALB 1 catches by month and fishing year for the surface longline target fisheries. The area of the circle scales with the monthly catches.

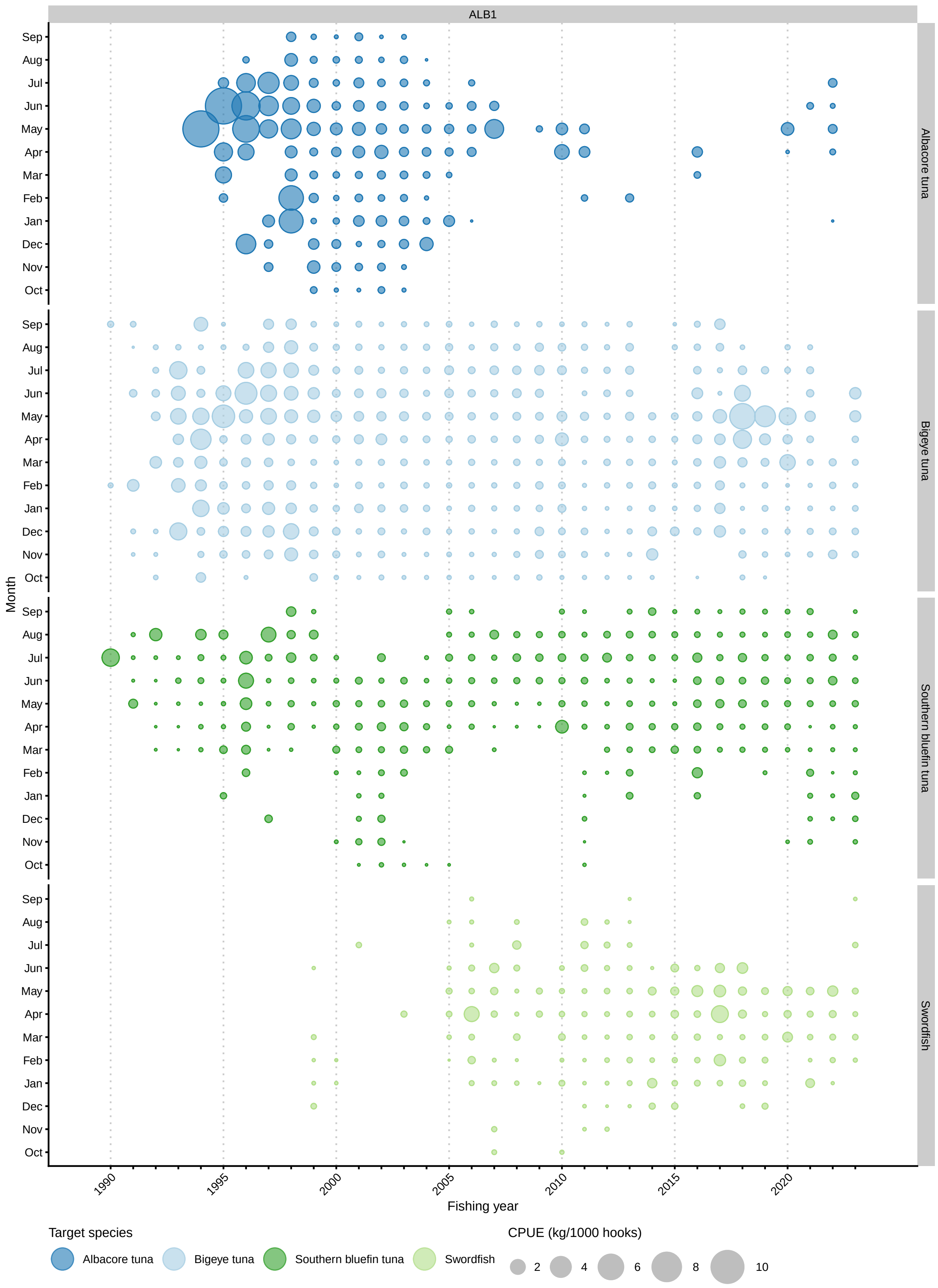

Figure 33: Seasonal distribution of ALB 1 raw aggregate CPUE (kg/1000 hooks) by month and fishing year for the surface longline target fisheries. The area of the circle scales with the monthly raw aggregate CPUE (kg/1000 hooks).

4. LENGTH COMPOSITIONS AND OCCURRENCE OF ALBACORE COHORTS IN AOTEROA/NEW ZEALAND'S WATERS

4.1 Cohort mixture analysis

The mixture model showed good convergence for all model parameters (Figure 34, Table 4), with cohort mean length estimated at 51.52 cm, 61.27 cm, and 71.11 cm for ages 1–3, respectively. Although model fit was below expectations (Figure 35), the presence of one-year-old and three-year-old fish was most strongly variable by year (Figure 36), with variability also attributed to the interaction between statistical area, month and year, as well as vessels. The latter was more strongly associated with the presence of small individuals (age 1) in the sample than for older fish, suggesting potential gear or vessel effects on the selectivity for small albacore. Effects for month, statistical, or their interaction without a year effect, were notably lower, suggesting limited spatial and temporal consistency in compositions between years (Figure 36). Temporally averaged spatial patterns are, therefore, reflective of average cohort proportions only, without strong consistent spatial patterns within cohort proportions (Figure 37). Estimates of the effect of sea-surface temperature on cohort presence overlapped zero and could not explain the presence, or not, of the different age classes in New Zealand waters (Table 4).

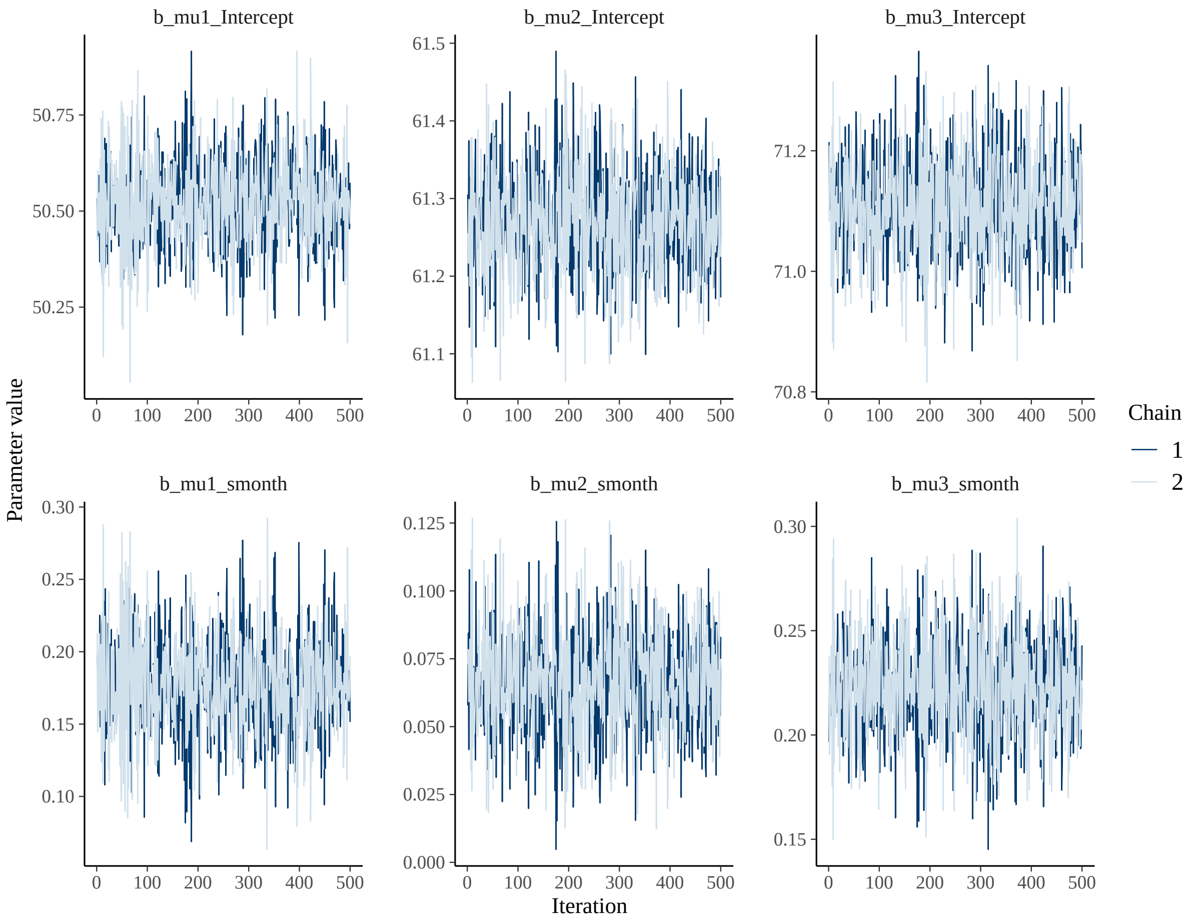

Figure 34: Markov Chain Monte Carlo traces for mixture components in the albacore cohort mixture model.

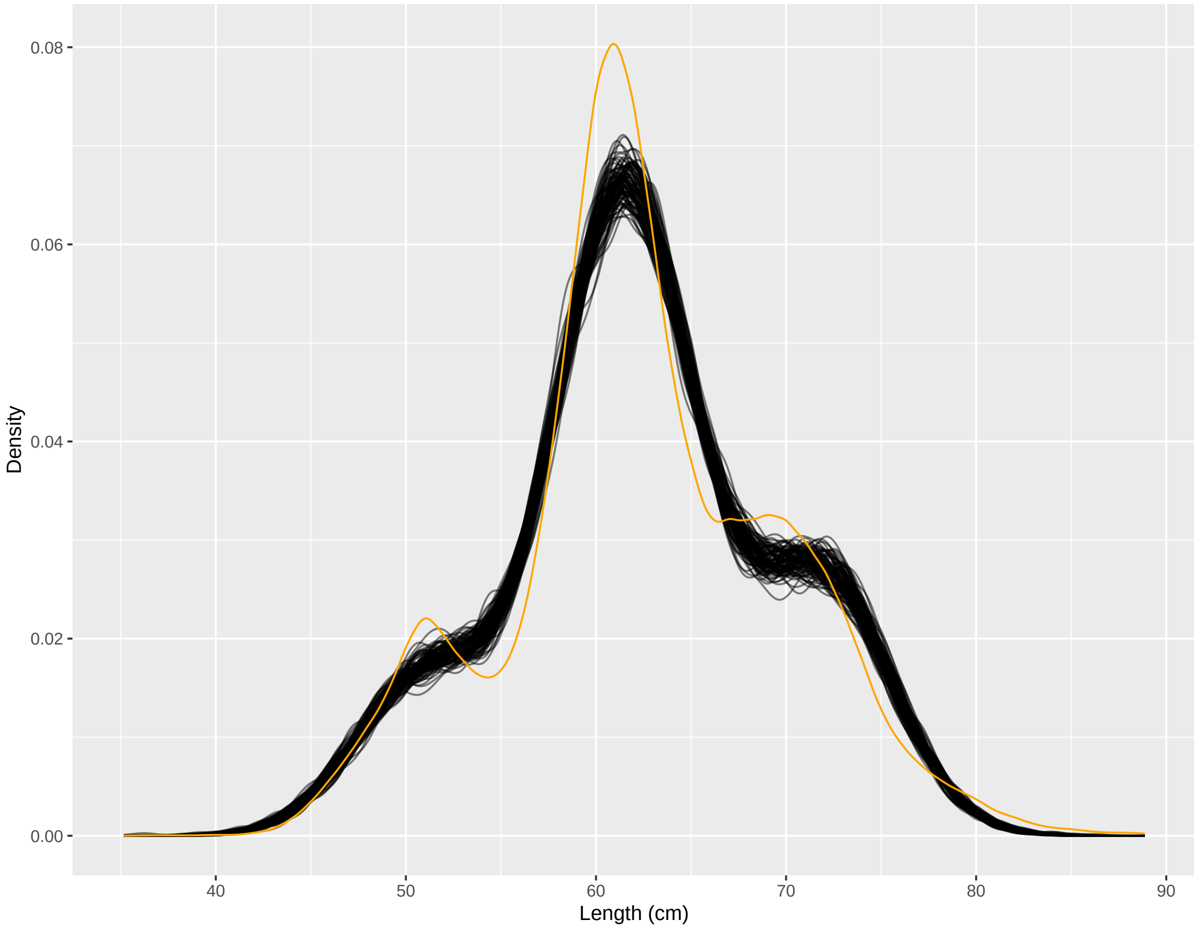

Figure 35: Posterior predictive plot for the mixture model, with replicates from the model drawn and summarised as densities (black lines; i.e., proportions of fish at length), relative to the density of the numbers at length found in the data used to fit the model (orange). A well-fitting model should be able to approximate the underlying data, but in this case, there are systematic devaitions between densities based on model replicates and the data, indicating a relatively poor fit.

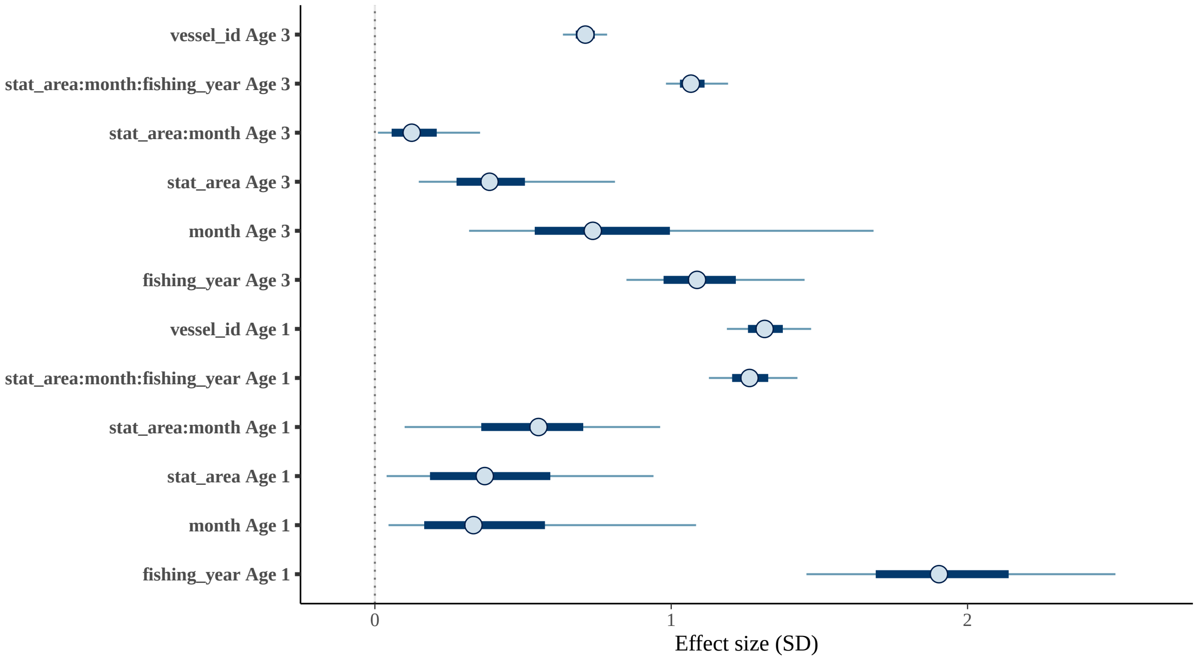

Figure 36: Estimated parameters for mixture proportions in the Albacore cohort mixture model.

Table 4: Parameter estimates for the mixture model of cohort contributions to albacore length compositions by year. Cohorts 1-3 in the model correspond to ages 1-3. rhat: convergence statistic; rhat close to 1 ($<$ 1.05) suggests model is converged) based on standard deviation within chains to standard deviation between chains. ESS: effective Markov Chain Monte Carlo sample size in the bulk and tail of the posterior distribution.

Variable	Mean	Median	SD	5th Perc.	95th Perc.	Rhat	Ess bulk	Ess tail
b mu1 Intercept	50.52	50.52	0.12	50.33	50.72	1	1460.18	671.62
b mu2 Intercept	61.27	61.27	0.07	61.16	61.38	1	1350.83	856.98
b mu3 Intercept	71.11	71.10	0.09	70.97	71.25	1	1580.38	889.25
b theta1 Intercept	-3.16	-3.17	1.18	-5.00	-1.16	1	519.90	488.92
b theta3 Intercept	-1.08	-1.15	0.89	-2.43	0.46	1	732.52	678.79
b sigmas Intercept	1.30	1.30	0.00	1.29	1.30	1	1036.88	823.32
b mu1 smonth	0.18	0.18	0.04	0.12	0.23	1	1430.66	570.21
b mu2 smonth	0.07	0.07	0.02	0.03	0.10	1	1393.49	799.13
b mu3 smonth	0.22	0.22	0.03	0.18	0.27	1	1894.08	818.71
b theta1 SST	0.08	0.08	0.07	-0.04	0.18	1	599.17	584.57
b theta3 SST	0.00	0.00	0.05	-0.09	0.07	1	773.65	730.13

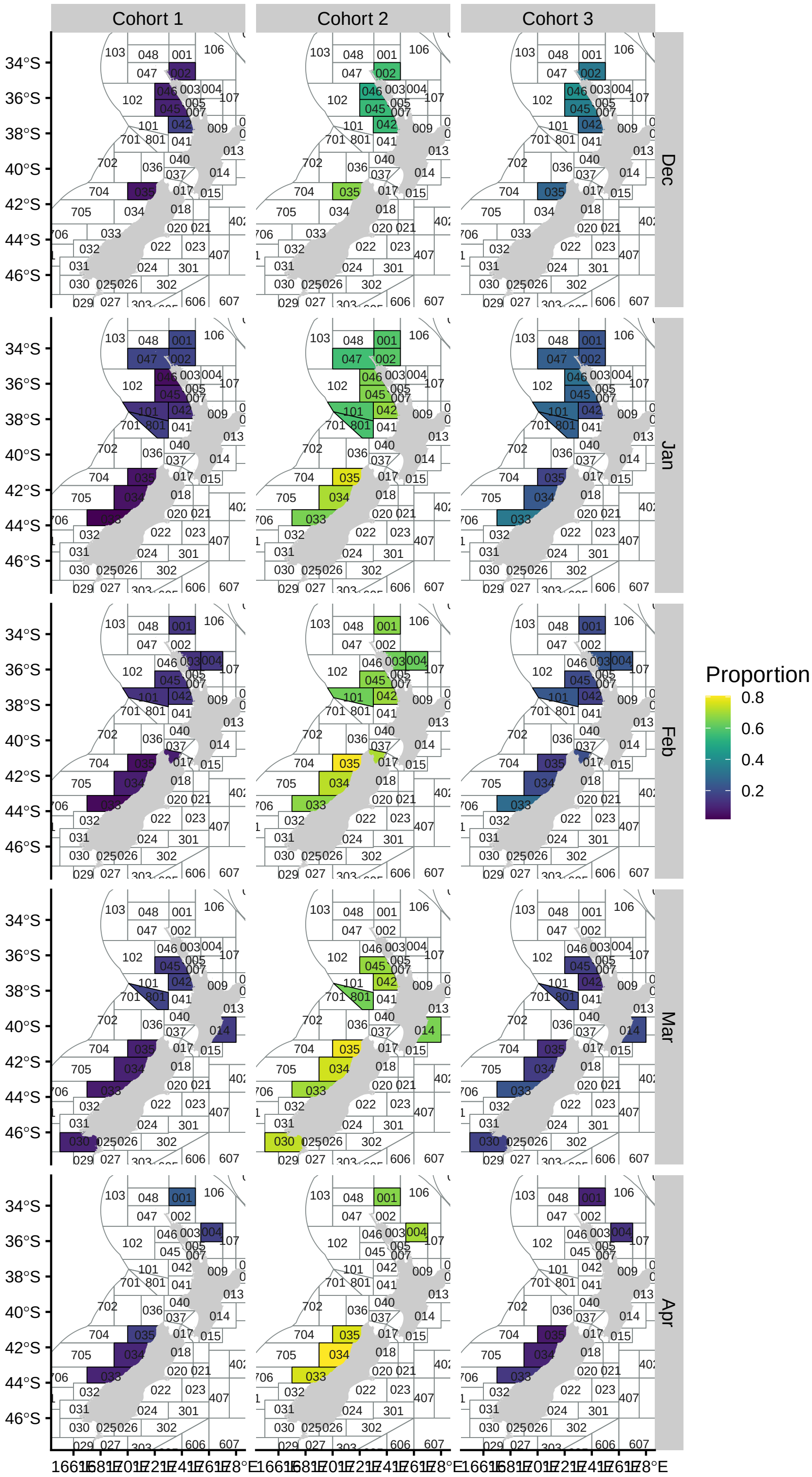

Figure 37: Estimated (posterior mean) mixing proportions by month and statistical area for cohorts 1-3 (ages 1-3) in the cohort mixture model for albacore in New Zealand waters.

4.2 Catch-sampling size composition analysis using Poisson-factorised multinomial regression

Model selection suggested that a model with statistical-area-month interaction effects in addition to effects for fishing-year, vessel, month and statistical area, best explained the data, relative to model that attempted to explain variability without the interaction term or environmental covariates (Table 5). The SST effect was very minor for the model with SST (Figure 38), however, despite a lower loo-IC score, the ENSO effect was more pronounced and suggested that small 1-year-olds are predominantly present during La-Niña conditions (negative MEIV2), whereas large age-3 fish are more likely to be present during El-Niño conditions (Figure 39). We therefore maintained this model to standardise compositions for ENSO effects, in accordance with the environmentally adjusted CPUE indices.

As for the mixture model, the greatest variability was attributed to variation among fishing years (Figure 40, Table 6). However, vessel ID also contributed to variation, and, notably, most vessels only have catch sampled in a single year (Figure 41). The effects of statistical area, month, and their interaction were relatively less important (Figure 40, Table 6).

Models fits were very good at aggregated levels (Figures 42,43, 44). Effect plots show strong year effects (Figure 45), with 10-fold increased or decreased relative proportions for given sets of size bins in many years. For instance, 2018 showed a >10-fold increase over average proportions of small fish. By contrast, effects for statistical areas were very minor (Figure 46), but month effects showed in-season growth (Figure 47).

Scaled compositions for catch reflected strong year effects, with little scaling effect (Figure 48) relative to sampled compositions. Standardisation for ENSO showed a standardisation effect in some years, with adjustments for compositions for the 2018 fishing year suggesting the dominance of small age 1 fish was possibly mediated by ENSO conditions (Figure 49).

4.3 Observer size composition analysis using Poisson-factorised multinomial regression

Similarly to the market sampling data, the model with explicit area-year effects was chosen (Table F.1), over the model with SST as a predictor. The latter showed a more noticeable pattern of composition changes with SST (Figure F.1), but those changes were predicted to be very small (on the order of 1% change). Given the uneven sampling through time and space of the observer length compositions, there was no further attempt to interpret these results.

Table 5: Expected log posterior density (elpd) and standard error (se) estimated from pseudo leave-one-out (loo) cross-validation, alongside estimated parameters (p), loo information criterion (ic) and elpd difference between models. Models are ordered from best to worst in terms of predictive performance (measured by highest elpd or lowest looic) for compositions. Models were fitted without spatio-temporal terms (no ST), with statistical-area (SA) month effects, and with ENSO (El Niño-Southern Oscillation) or sea surface temperature (SST) to explain spatio-temporal patterns in compositions.

	elpd loo	se elpd loo	p loo	se p loo	looic	se looic	elpd diff	se diff
SA month	-56335	297	10016	102	112669	594	0	0
w SST	-62675	366	10388	121	125351	733	-6341	182
w ENSO	-62684	367	10395	122	125368	734	-6349	182
no ST	-62880	368	10476	122	125761	737	-6546	183

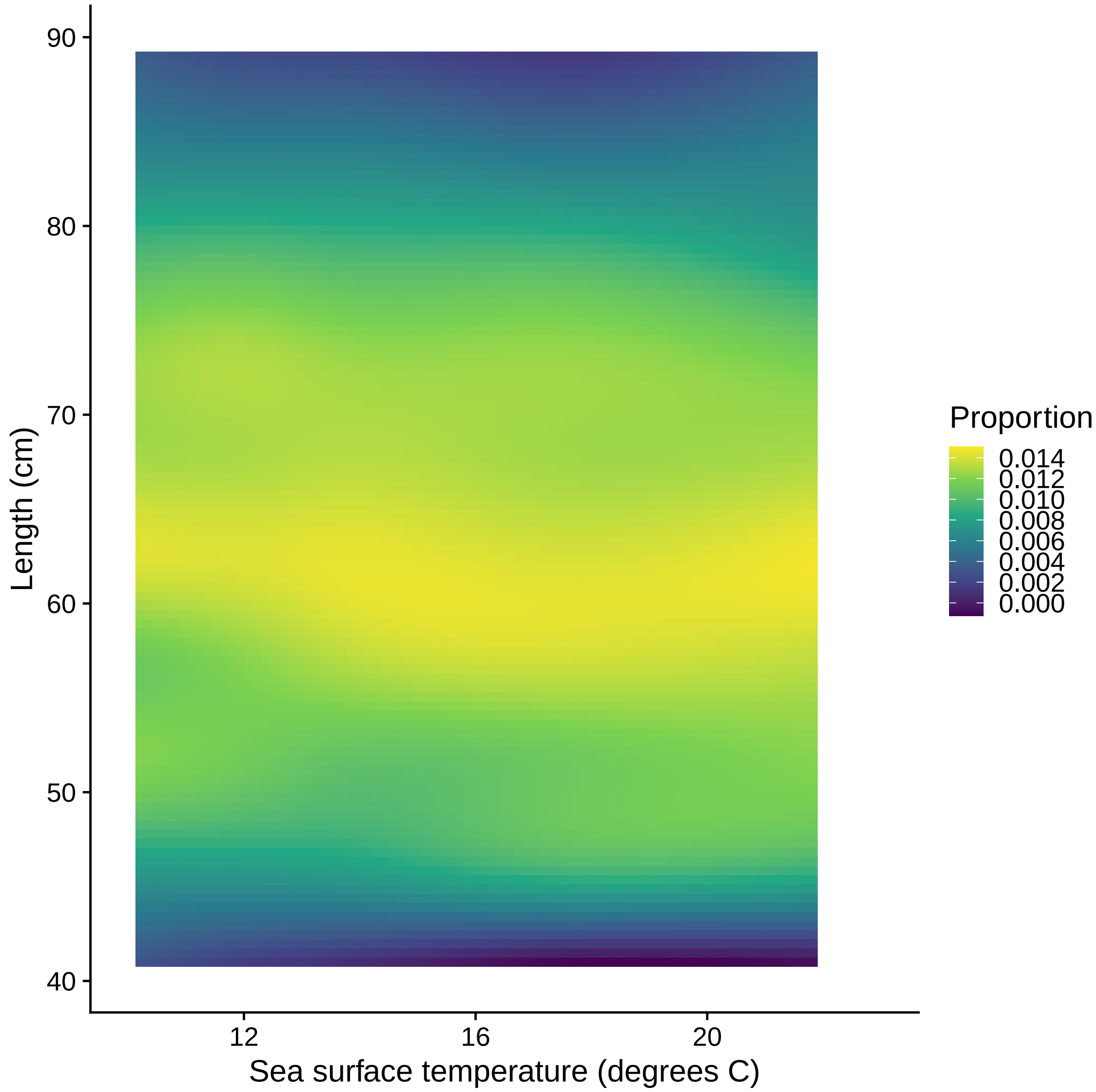

Figure 38: Effect of sea-surface temperature on the expected proportions at length in New Zealand troll-caught albacore.

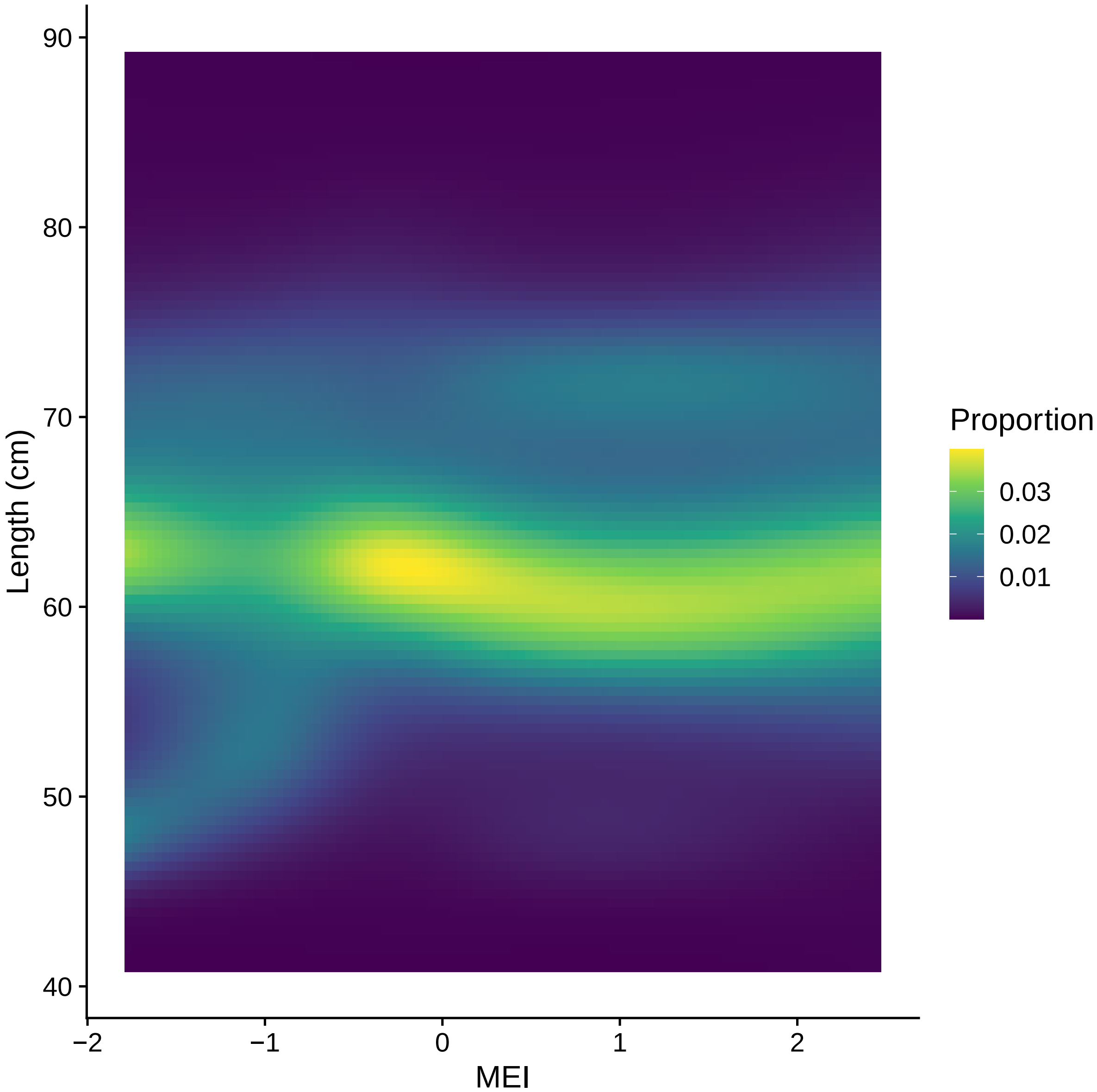

Figure 39: Effect of the multivariate ENSO (El Niño-Southern Oscillation) index (MEI-V2) on the expected proportions at length in New Zealand troll-caught albacore.

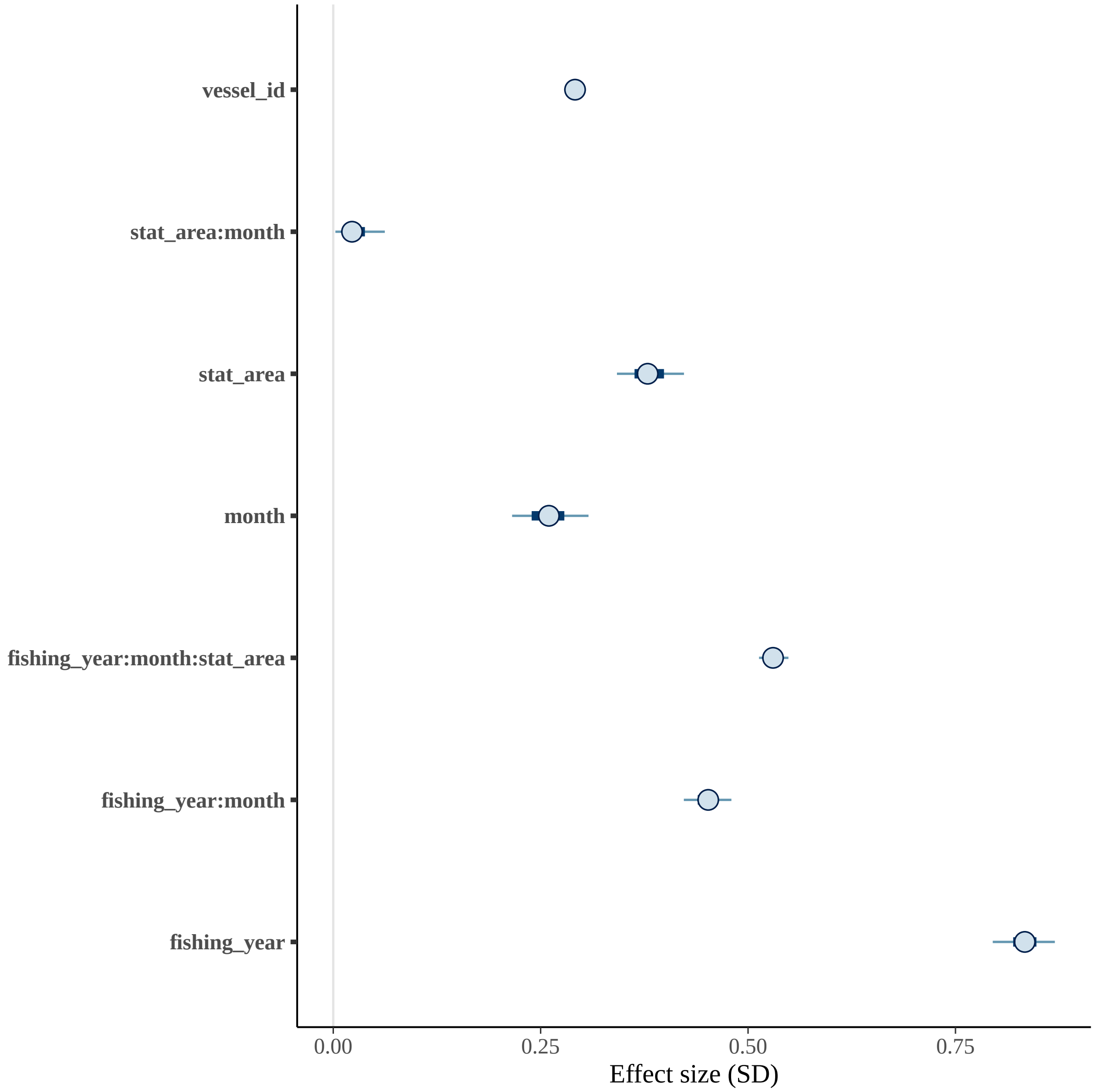

Figure 40: Effect size in terms of random effect standard deviations affecting proportions at length in New Zealand troll-caught albacore

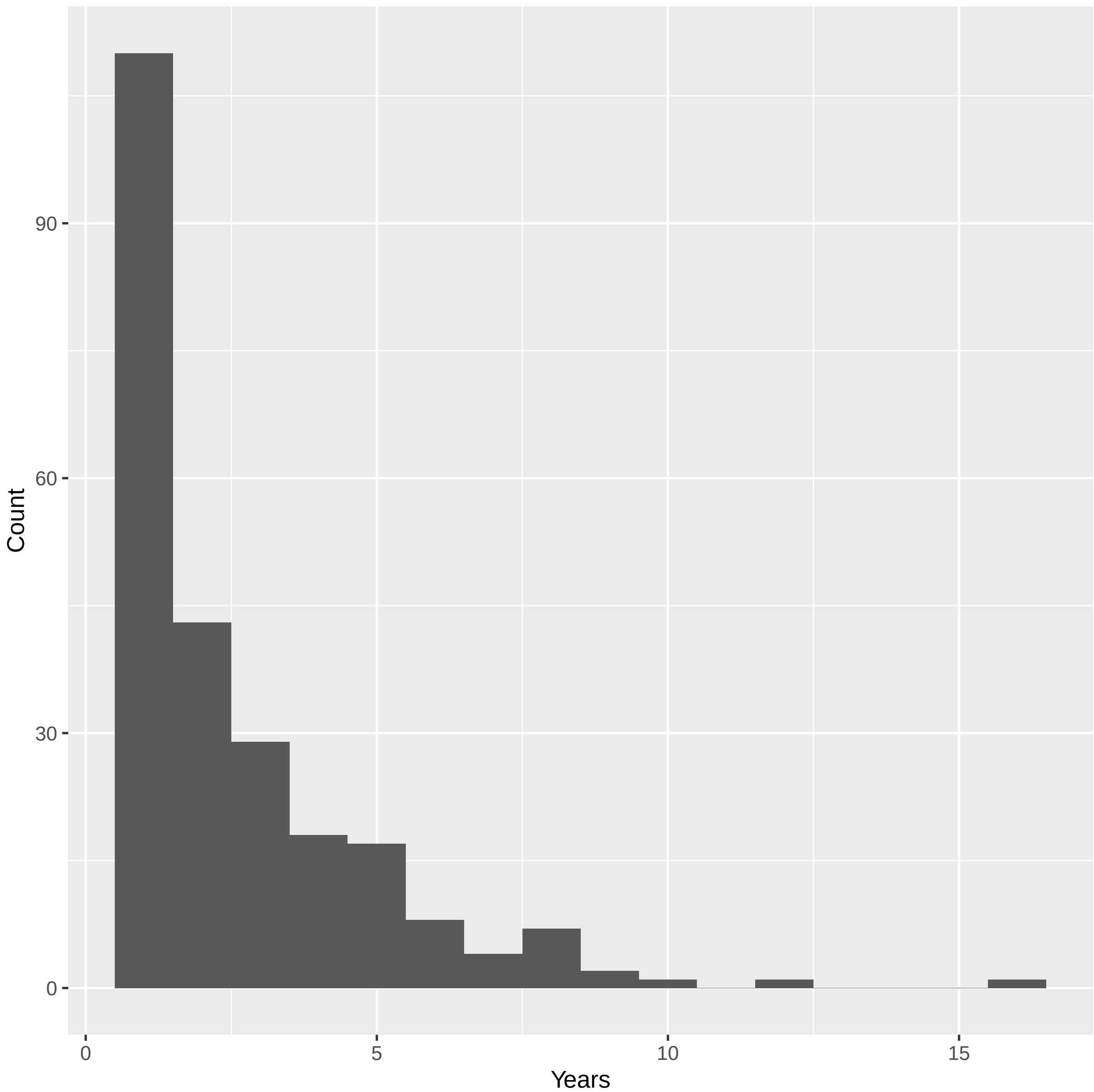

Figure 41: Number of fishing-years with sampling data for vessels occurring in the New Zealand albacore catch sampling data

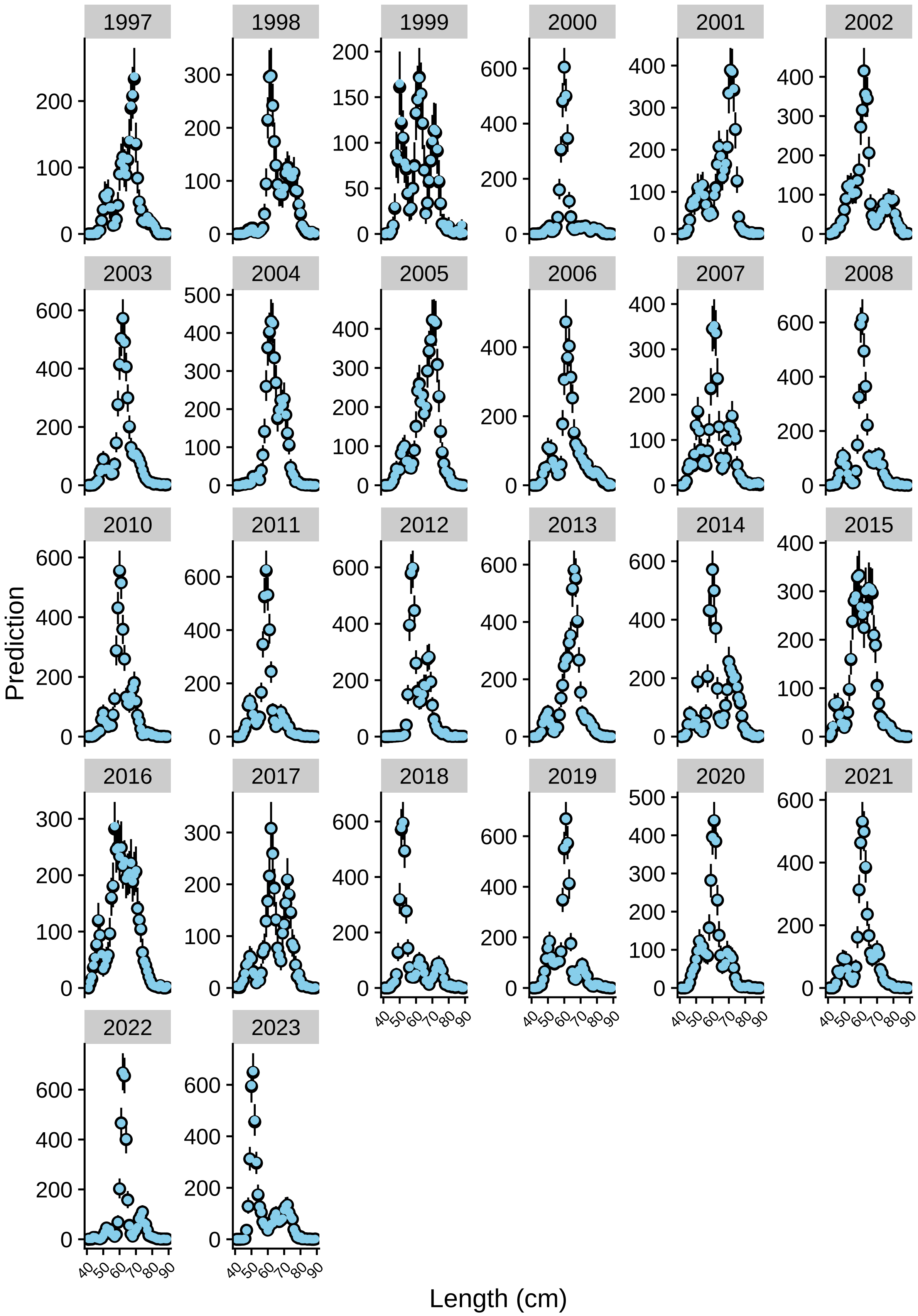

Figure 42: Length-composition standardisation model fit (black posterior median and 95 percent prediction interval) to the sampled numbers in each length bin (blue) by year for New Zealand troll-caught albacore.

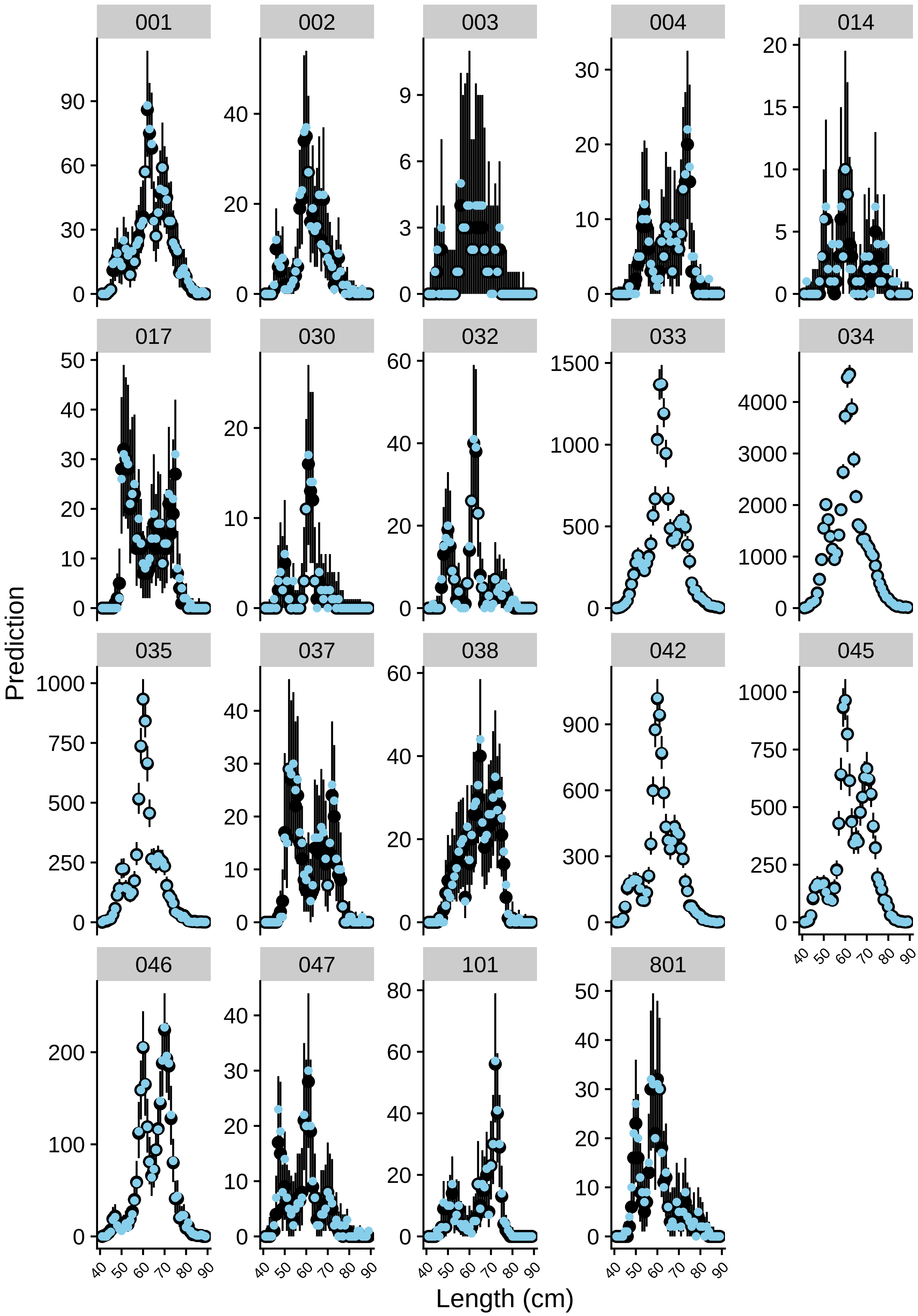

Figure 43: Length-composition standardisation model fit (black posterior median and 95 percent prediction interval) to the sampled numbers in each length bin (blue) by statistical area for New Zealand troll-caught albacore.

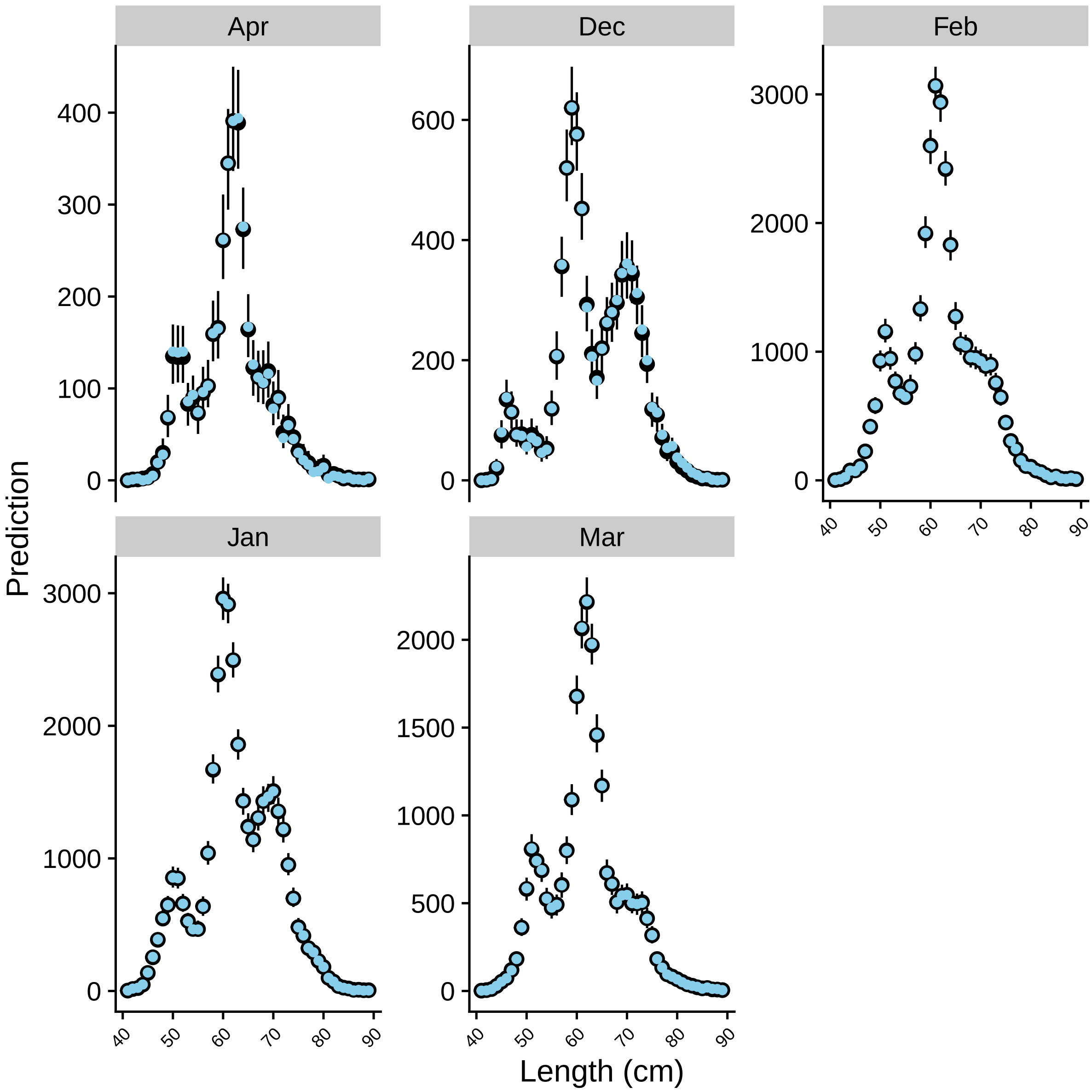

Figure 44: Length-composition standardisation model fit (black posterior median and 95 percent prediction interval) to the sampled numbers in each length bin (blue) by month for New Zealand troll-caught albacore.

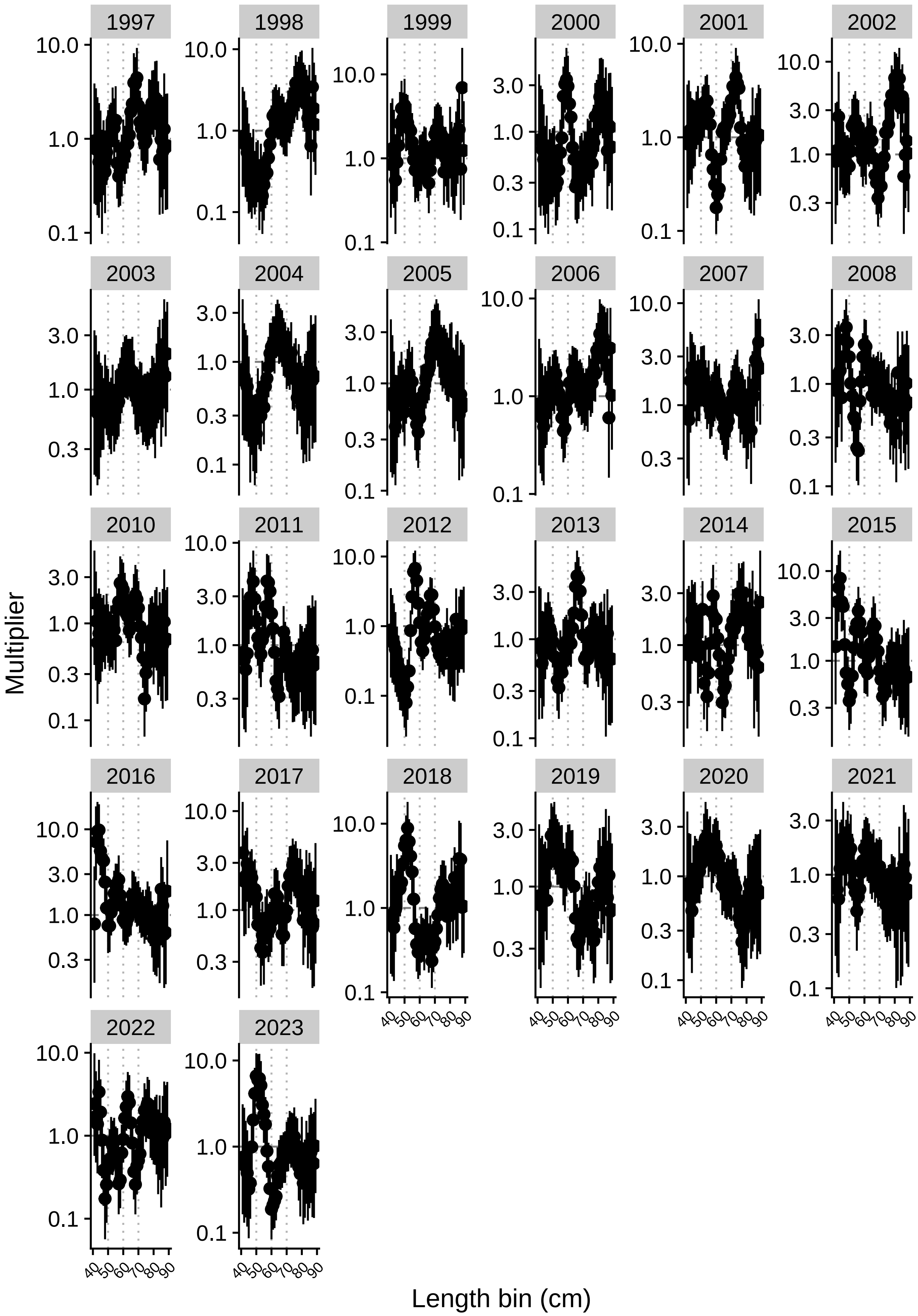

Figure 45: Year effect by length bin, relative to the over-all mean length composition for New Zealand troll-caught albacore, estimated by the length-composition standardisation model (black posterior median and 95 percent prediction interval).

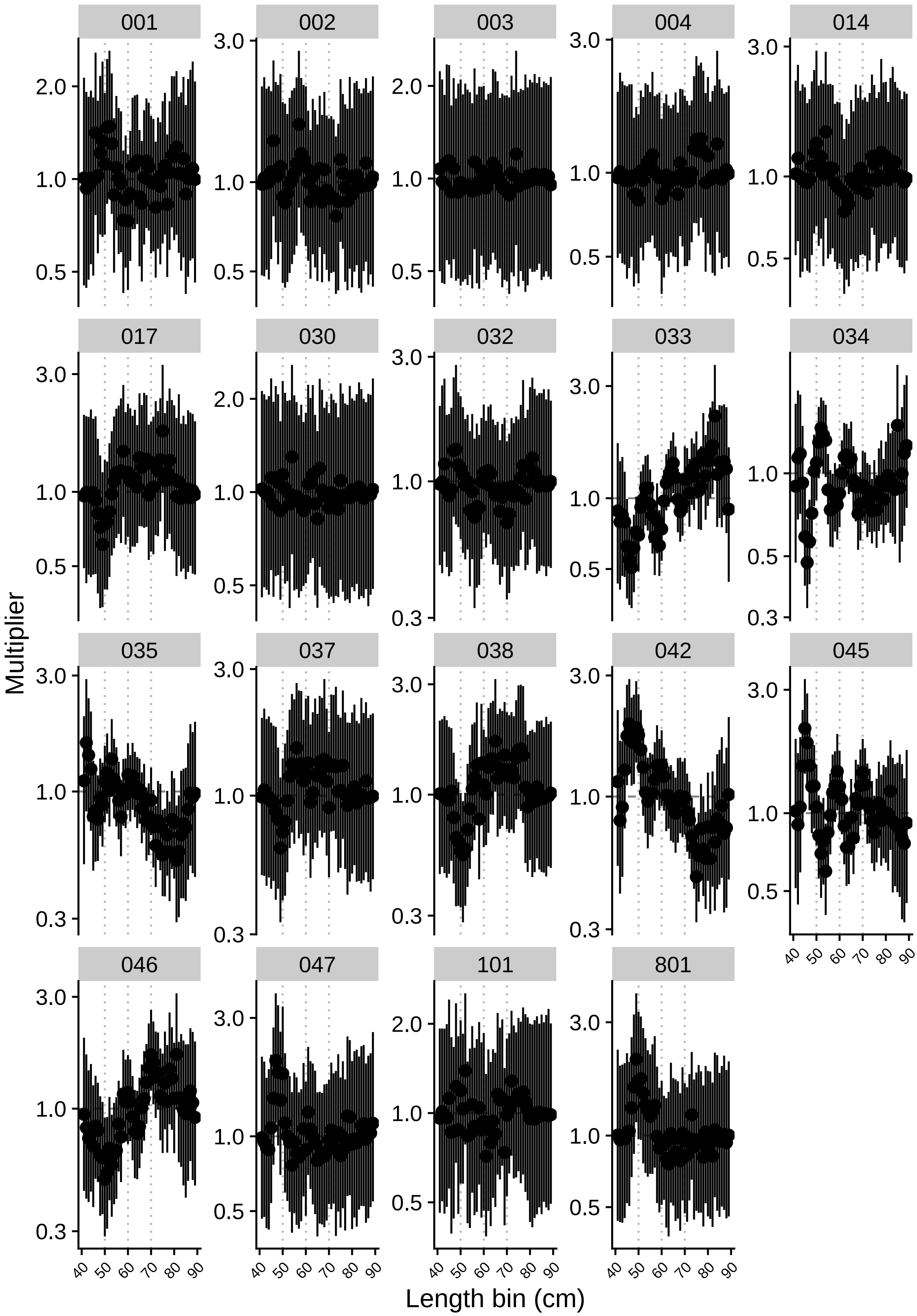

Figure 46: Statistical area effect by length bin, relative to the over-all mean length composition for New Zealand troll-caught albacore, estimated by the length-composition standardisation model (black posterior median and 95 percent prediction interval).

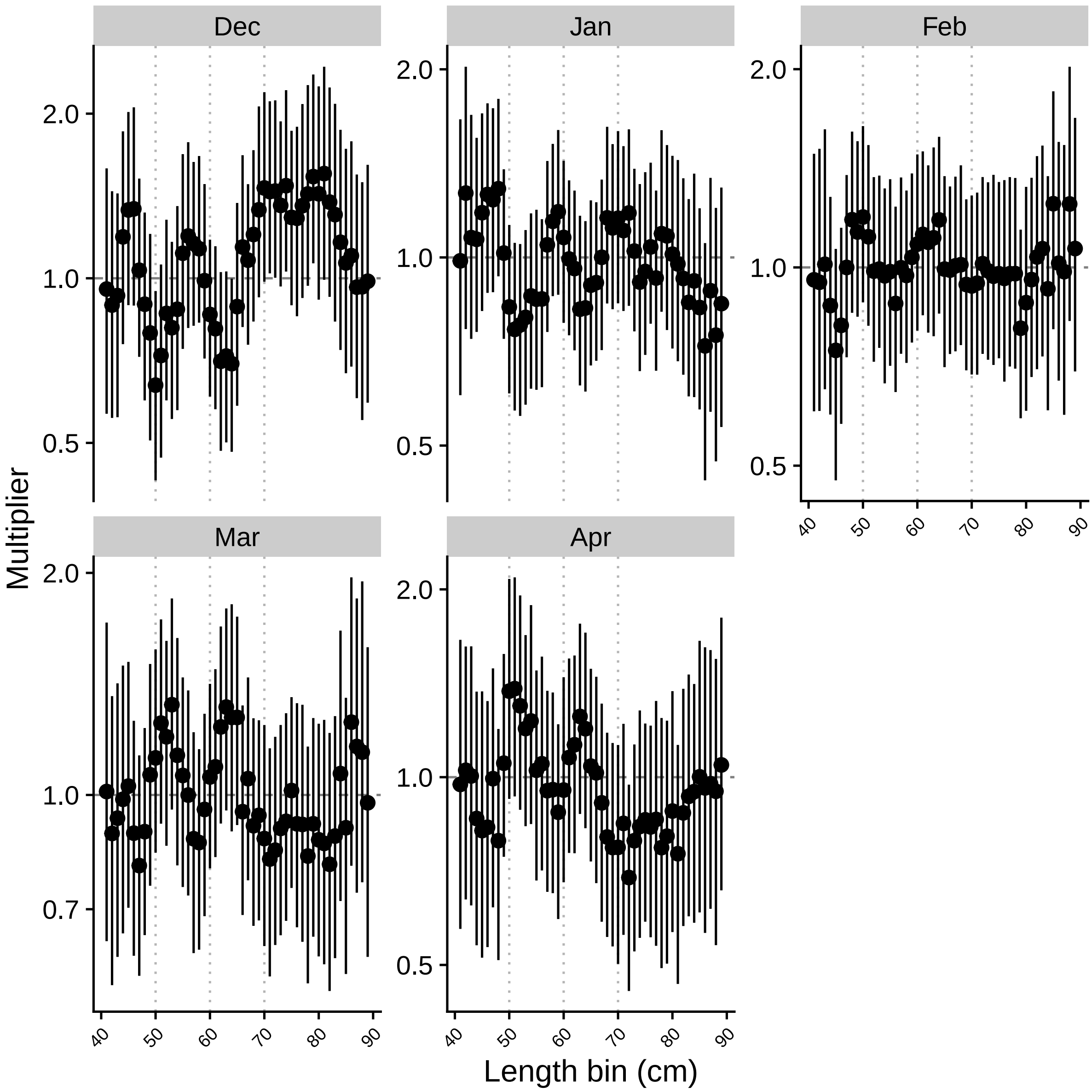

Figure 47: Month effect by length bin, relative to the over-all mean length composition for New Zealand troll-caught albacore, estimated by the length-composition standardisation model (black posterior median and 95 percent prediction interval).

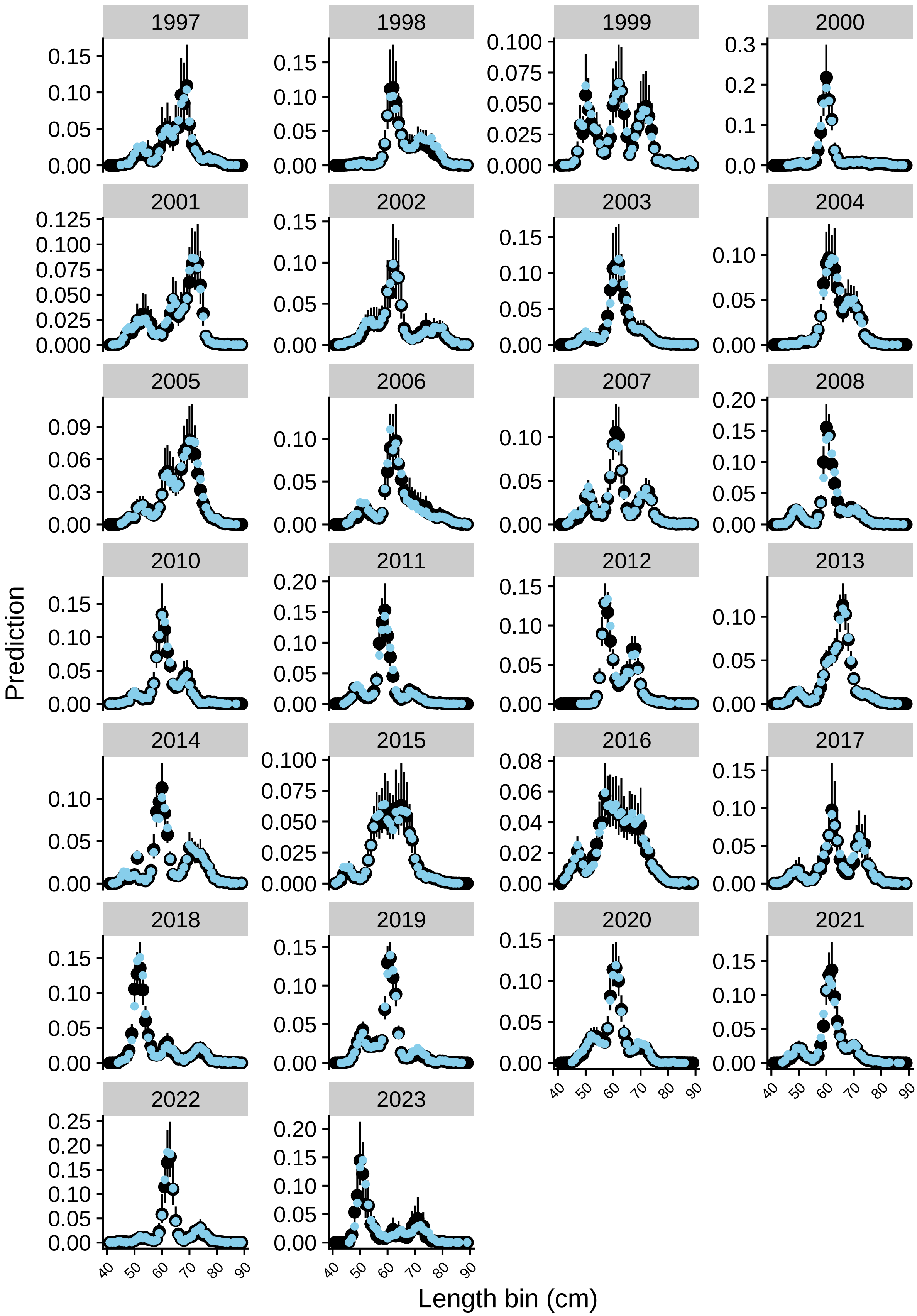

Figure 48: Predicted scaled catch length frequency by length bin and year, scaled by the number of troll-caught albacore in each fishing trip for the full catch-effort dataset, predicted from the length-composition standardisation model (black posterior median and 95 percent prediction interval). Unscaled proportions-at-length from the catch sampling programme are shown in blue.

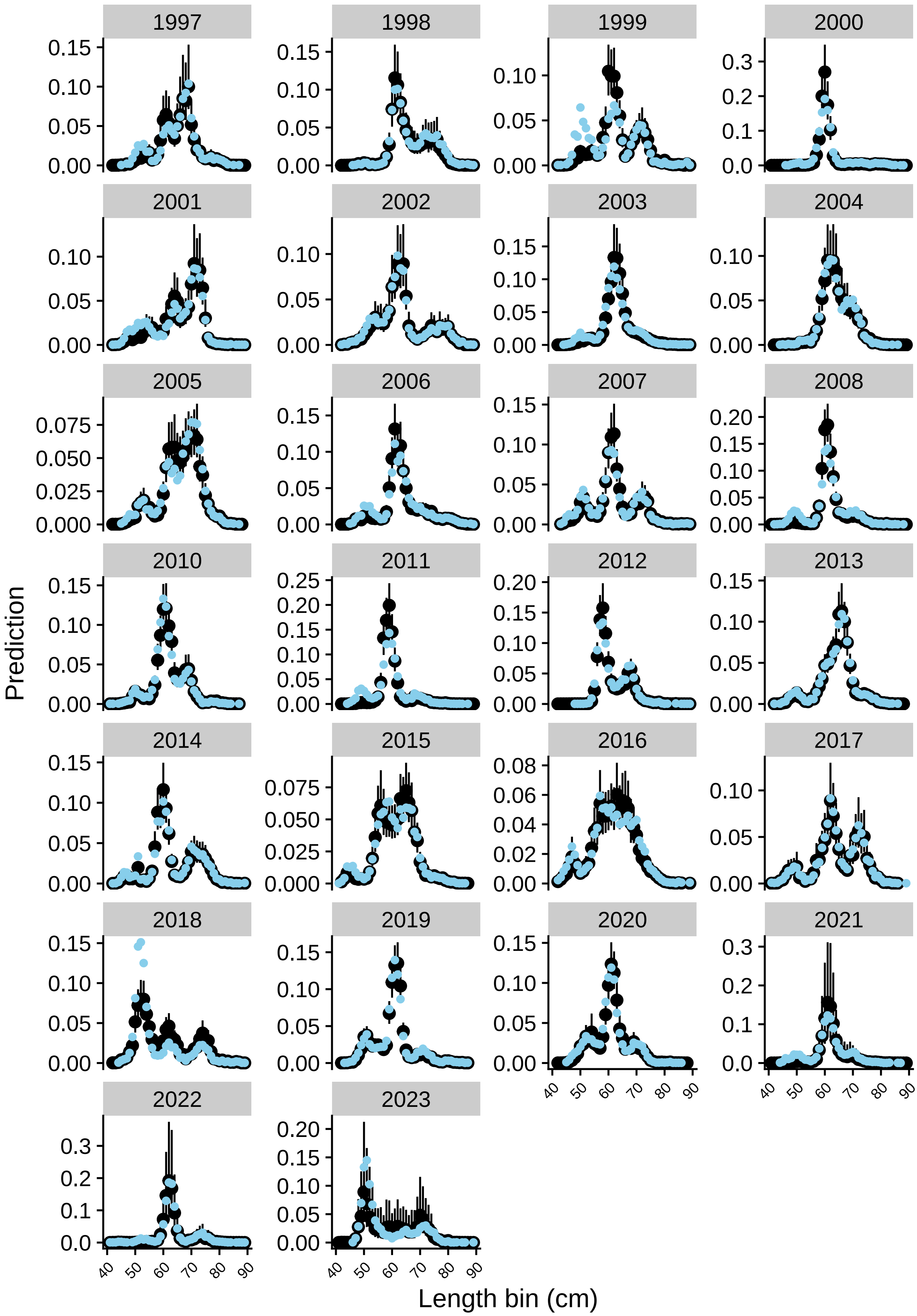

Figure 49: Predicted length frequency standardised for influence of ENSO (El Niño-Southern Oscillation) by length bin and year, scaled by the CPUE of troll-caught albacore in each fishing trip for the full catch-effort dataset, predicted from the length-composition standardisation model (black posterior median and 95 percent prediction interval). Unscaled proportions-at-length from the catch sampling programme are shown in blue.

Table 6: Parameter estimates for random effects standard deviations for the Poisson-factorised multinomial model for Albacore length compositions. rhat: convergence statistic; rhat close to 1 (< 1.05) suggests model is converged) based on standard deviation within chains to standard deviation between chains. ess: effective sample size in the bulk and tail of the posterior distribution.

Variable	Mean	Median	SD	5th Perc.	95th Perc.	Rhat	Ess bulk	Ess tail
fishing year	0.83	0.83	0.02	0.79	0.87	1.01	364.60	428.01
fishing year:month	0.45	0.45	0.02	0.42	0.48	1.00	176.52	302.05
fishing year:month:stat area	0.53	0.53	0.01	0.51	0.55	1.00	252.79	357.03
month	0.26	0.26	0.03	0.22	0.31	1.00	240.44	193.34
stat area	0.38	0.38	0.02	0.34	0.42	1.00	276.96	409.25
stat area:month	0.03	0.02	0.02	0.00	0.06	1.00	123.79	220.50
vessel id	0.29	0.29	0.01	0.28	0.30	1.00	254.33	352.92

5. CATCH-PER-UNIT-EFFORT

5.1 ALB 1 T pseudoCELR

The ALB 1 T pseudoCELR CPUE series was derived from daily troll records landing to the ALB 1 fishstock on CEL and ERS other lining reporting forms. The target species was albacore, and catch was recorded from 22 statistical areas between 1990 and 2022 (Table 7).

A large number of vessels ($\sim$1000) have participated in the albacore troll fishery. The effort in this fishery is often opportunistic where vessels participate when either the albacore catch is good or catch in their usual target fishery is poor. It is easy for fishers to use albacore opportunistically as it falls outside of the QMS and the requirement to obtain ACE is not a constraint. A set of core fleet selection rules were used to reduce the number of vessels in the dataset to those that had participated with some longevity, with fleet overlap and coverage extending throughout the time series, and while retaining a reasonable proportion of the catch. The final selection criteria required a vessel to have fished for a minimum of ten years and to have conducted at least five trips per year. This resulted in the removal of over 600 vessels and retained just over 300 vessels and >80% of the catch (Figure 50). This selection also resulted in retaining a number of vessels that had fished since the early to mid-1990s, with a number of them conducting 10 or more trips per year (Figure 51). Most vessels have fished since the early 2000s with only a few recent entrants that have participated since 2010. Alternative vessel selection criteria were tested by Brouwer et al. (2021), but were found to have minimal influence on resulting CPUE indices.

The data removed by the filtering are presented in Table 8. The main grooming rules that resulted in the reduction of records included in the analysis were for records that had no catch in numbers recorded (i.e., catch was erroneously recorded in weight, see Appendix B.3), and the core fleet selection. All other grooming steps tended to remove a very small number of records, with minimal effect on catch.

The number of records in the dataset that recorded a positive daily catch are shown by fishing year in Table 9. With the exception of 2023, all years had at least 150 trips and records from at least 40 vessels. Overall, the number of records in the dataset peaked in the mid-1990s and early 2000s, but remained relatively consistent from 2013 onwards (Figure 51), and has dropped substantially in 2023.

The reduced model without environmental predictors applied to the albacore troll catches in ALB 1 using the ALB 1 T pseudoCELR dataset is described in Table 10, and did not provide much of a standardising effect in comparison to the unstandardised series (Figure 54). Fishing year (forced into the model as the first variable) explained 5.1% of the deviance from the null model. Fishing duration and vessel key explained an additional 7% and 7.5% of deviance, respectively. The statistical area and month interaction term was also selected, explaining $<$1% additional variation. The final model explained 23.7% of the deviance.

Diagnostic residual plots for the negative binomial-model (Figure 52) indicated that the residuals followed the modeled distribution reasonably well except for extreme values. Note, the Poisson distribution failed to fit these data reasonably (Figure 53) and results using this model are not reported further.

The trends in the ALB 1 T pseudoCELR index did not change appreciably as terms were successively entered into the model (Figures 55–59). While the influence of fishing duration was seen to fluctuate, it does so over 0.1 influence points and its effect on the series overall is minimal (Figure 59). The influence (CDI) plots for vessel key (Figure 56) showed an increasing trend throughout the series which tended to elevate the beginning of the CPUE series and decrease the series in later years (Figure 55), third panel from the top), however, this effect was minimal. Due to only minor variation in CPUE between December and April, fishing month had little influence on CPUE (Figure 58).

The resulting CPUE index was largely driven by trends on the west coast of the South Island (areas 034 and 035; Figure 60) as these have the highest effort. Correspondingly, these areas showed high correlation with the over-all year trends, whereas areas on the west-coast North Island (041–046) showed poor correlation with over-all CPUE trends, with a noisy decline in catch rates since about 2008 contrasting with the main annual trends driven by more southern effort that showed little over-all trend over the length of the time series. Nevertheless, recent trends in the over-all time-series suggested an over-all decline in catch-rates since 2018 (Figure 61, Table 11). Although this decline is largely within levels of variation seen previously, the 2023 CPUE index point was estimated to be the lowest on record.

The full model, with environmental predictor variables included in the model (Table A.1), applied to the albacore troll catches using the ALB 1 T pseudoCELR dataset is described in Appendix Appendix A. Similarly to models excluding environmental effects, the full model did not provide much of a standardising effect (Table A.4, Figure A.6).

The daily resolution ALB 1T pseudoCELR full index did not change appreciably as terms were successively added to the model (Figure A.7). However, the MEI showed some positive influence for the 1992 and 1998 indices in particular and then a dampening trend later in the series (Figure A.7, bottom panel).

Table 7: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the ALB 1 T pseudoCELR CPUE series.

Series	ALB 1 T pseudoCELR
QMS stock	ALB1
Reporting forms	CEL, ERS - Other Lining
Fishing methods	T
Target species	ALB
Statistical Areas	002, 007, 008, 009, 013, 014, 030, 031, 032, 033, 034, 035, 036, 037, 038, 039, 040, 041, 042, 045, 046, 047
Period	1991-10-01, 2023-09-30
Resolution	Day
Core fleet years	4
Core fleet trips	3
Default model	nfish ~ fyear + vessel_key + stat_area*month + ns(log(fishing_duration), 3)
Stepwise selection	No
Positive catch distribution	Negative-Binomial

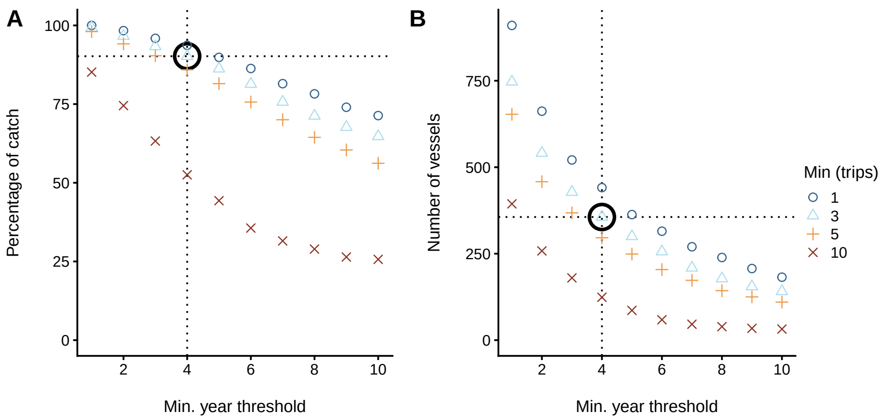

Figure 50: Percentage of catch and number of vessels for different core vessel selection criteria for the ALB 1 T pseudoCELR CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

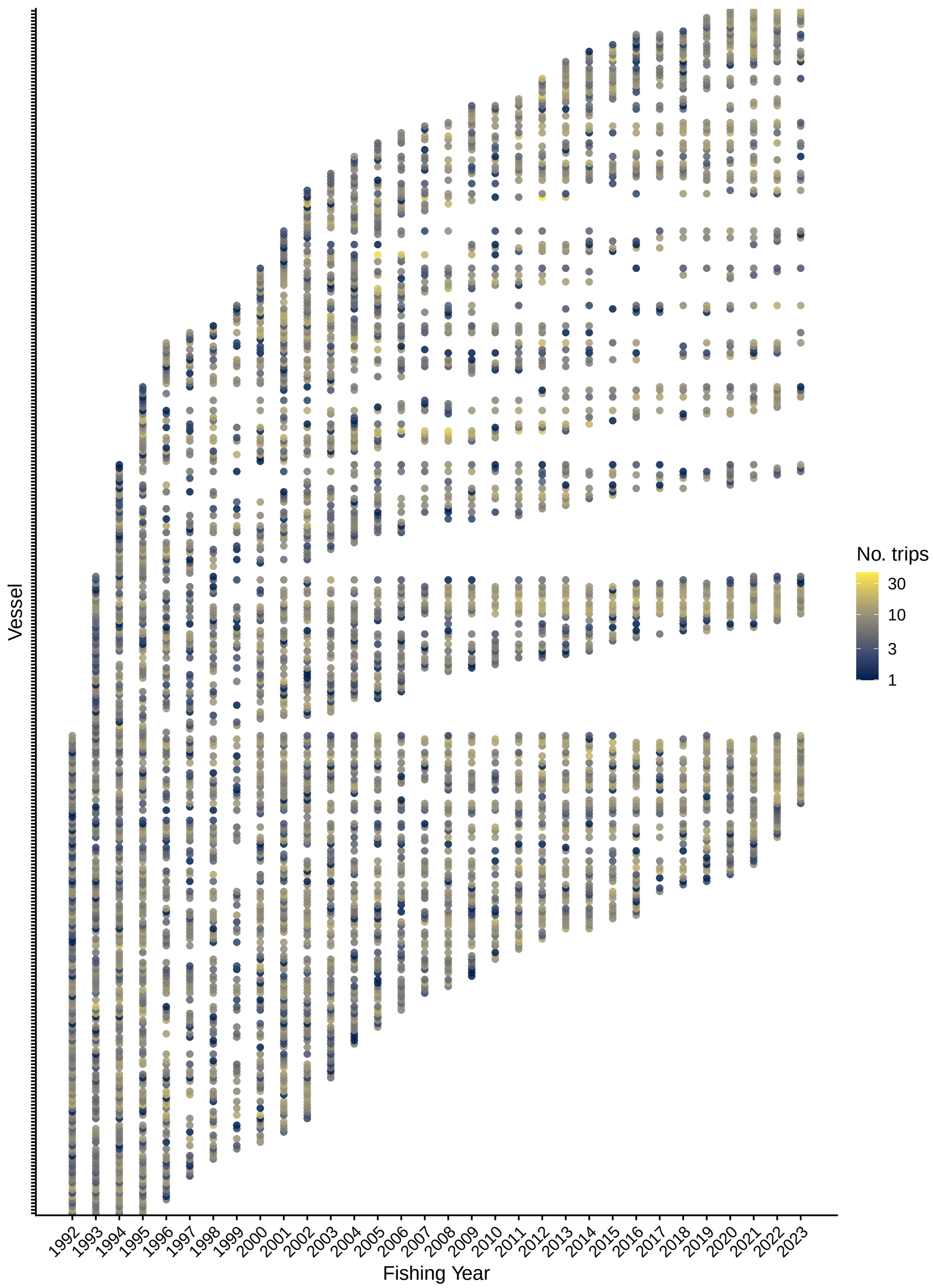

Figure 51: Number of trips by fishing year for core vessels in the ALB 1 T pseudoCELR series. The colour of the points is proportional to the number of trips undertaken by a vessel in a fishing year.

Table 8: Summary of the ALB 1 T pseudoCELR dataset total catch (tonnes) and number of records (n), by fishing year after the application of various filters. The first row gives the catch and number of records before filters were applied (ungroomed data). Subsequent rows display the remaining catch (and percent of catch), and the number of records, after the specified filter was applied. (Continued on next page)

Filter	1992	1993	1994	1995	1996	1997	1998	1999	2000
Ungroomed data	609 (100%) n: 4935	486 (100%) n: 5919	880 (100%) n: 8895	914 (100%) n: 7556	715 (100%) n: 6373	403 (100%) n: 5287	705 (100%) n: 6490	309 (100%) n: 2548	622 (100%) n: 6160
Fishing duration is not NA	606 (99.6%) n: 4909	481 (98.9%) n: 5844	869 (98.8%) n: 8766	881 (96.4%) n: 7371	685 (95.7%) n: 6083	375 (93.2%) n: 4897	682 (96.8%) n: 6234	302 (97.7%) n: 2452	571 (91.8%) n: 5620
Positive fishing duration	606 (99.5%) n: 4902	481 (98.9%) n: 5842	868 (98.6%) n: 8743	879 (96.1%) n: 7342	684 (95.7%) n: 6077	375 (93.1%) n: 4881	682 (96.8%) n: 6226	302 (97.7%) n: 2452	561 (90.2%) n: 5568
Fishing duration <20hrs	595 (97.7%) n: 4858	460 (94.5%) n: 5767	851 (96.7%) n: 8668	845 (92.5%) n: 7231	664 (92.8%) n: 5975	364 (90.5%) n: 4835	669 (94.9%) n: 6151	295 (95.3%) n: 2417	550 (88.4%) n: 5498
Season start day <212	594 (97.6%) n: 4847	459 (94.3%) n: 5741	845 (96.0%) n: 8587	841 (91.9%) n: 7128	663 (92.7%) n: 5945	364 (90.3%) n: 4809	659 (93.5%) n: 6009	294 (95.3%) n: 2408	544 (87.5%) n: 5376
Season start day >31	594 (97.6%) n: 4846	459 (94.3%) n: 5740	845 (96.0%) n: 8587	841 (91.9%) n: 7128	663 (92.6%) n: 5944	364 (90.3%) n: 4807	659 (93.5%) n: 6009	294 (95.3%) n: 2408	544 (87.5%) n: 5376
Positive catch	594 (97.6%) n: 4715	459 (94.3%) n: 5488	845 (96.0%) n: 8406	841 (91.9%) n: 6957	663 (92.6%) n: 5273	364 (90.3%) n: 4312	659 (93.5%) n: 5365	294 (95.3%) n: 2261	544 (87.5%) n: 5277
No inferred numbers	513 (84.3%) n: 3996	432 (88.8%) n: 5026	787 (89.5%) n: 7686	795 (86.9%) n: 6501	568 (79.5%) n: 4409	303 (75.2%) n: 3551	542 (76.8%) n: 4191	253 (82.0%) n: 1880	483 (77.6%) n: 4497
Core fleet selection	430 (70.6%) n: 3155	303 (62.3%) n: 3501	579 (65.7%) n: 5590	637 (69.7%) n: 4979	484 (67.7%) n: 3670	269 (66.8%) n: 3097	445 (63.1%) n: 3503	253 (81.7%) n: 1870	448 (72.1%) n: 4137

Filter	2001	2002	2003	2004	2005	2006	2007	2008	2009
Ungroomed data	549 (100%) n: 7211	585 (100%) n: 7134	779 (100%) n: 7485	733 (100%) n: 6178	503 (100%) n: 6571	429 (100%) n: 4175	377 (100%) n: 3234	669 (100%) n: 4320	412 (100%) n: 4230
Fishing duration is not NA	533 (97.1%) n: 6952	563 (96.1%) n: 6837	760 (97.6%) n: 7278	720 (98.2%) n: 6083	491 (97.7%) n: 6414	409 (95.2%) n: 3991	374 (99.1%) n: 3201	655 (98.0%) n: 4187	407 (98.9%) n: 4158
Positive fishing duration	533 (97.1%) n: 6944	562 (96.0%) n: 6827	760 (97.6%) n: 7277	720 (98.2%) n: 6083	491 (97.7%) n: 6413	409 (95.2%) n: 3991	374 (99.1%) n: 3201	655 (98.0%) n: 4186	407 (98.9%) n: 4154
Fishing duration <20hrs	526 (95.8%) n: 6890	555 (94.8%) n: 6753	751 (96.5%) n: 7238	717 (97.8%) n: 6057	489 (97.3%) n: 6398	407 (94.8%) n: 3975	372 (98.5%) n: 3188	650 (97.2%) n: 4169	405 (98.3%) n: 4139
Season start day <212	511 (93.1%) n: 6625	552 (94.4%) n: 6687	740 (95.1%) n: 7063	714 (97.4%) n: 5994	486 (96.8%) n: 6341	404 (94.2%) n: 3939	367 (97.3%) n: 3127	648 (97.0%) n: 4120	405 (98.3%) n: 4129
Season start day >31	511 (93.1%) n: 6625	552 (94.4%) n: 6687	740 (95.1%) n: 7063	714 (97.4%) n: 5994	486 (96.8%) n: 6339	404 (94.2%) n: 3939	367 (97.3%) n: 3127	648 (97.0%) n: 4120	405 (98.3%) n: 4128
Positive catch	511 (93.1%) n: 6477	552 (94.4%) n: 6588	740 (95.1%) n: 6973	714 (97.4%) n: 5780	486 (96.8%) n: 6207	404 (94.2%) n: 3886	367 (97.3%) n: 3085	648 (97.0%) n: 4088	405 (98.3%) n: 4082
No inferred numbers	499 (90.8%) n: 6126	537 (91.8%) n: 6189	709 (91.1%) n: 6492	692 (94.4%) n: 5449	451 (89.7%) n: 5509	391 (91.3%) n: 3647	361 (95.6%) n: 2982	635 (94.9%) n: 3930	388 (94.1%) n: 3812
Core fleet selection	462 (84.1%) n: 5525	482 (82.4%) n: 5556	612 (78.6%) n: 5591	613 (83.6%) n: 4830	411 (81.8%) n: 4956	370 (86.2%) n: 3434	357 (94.7%) n: 2953	611 (91.3%) n: 3778	375 (91.1%) n: 3673

Filter	2010	2011	2012	2013	2014	2015	2016	2017	2018
Ungroomed data	358 (100%) n: 3040	659 (100%) n: 4284	537 (100%) n: 4762	454 (100%) n: 4757	404 (100%) n: 4034	426 (100%) n: 3769	332 (100%) n: 3861	289 (100%) n: 3499	605 (100%) n: 4011
Fishing duration is not NA	354 (99.1%) n: 3010	653 (99.1%) n: 4215	517 (96.1%) n: 4545	446 (98.3%) n: 4647	392 (97.1%) n: 3870	419 (98.4%) n: 3682	325 (97.9%) n: 3766	284 (98.3%) n: 3423	597 (98.7%) n: 3940
Positive fishing duration	354 (99.1%) n: 3009	653 (99.1%) n: 4215	517 (96.1%) n: 4542	446 (98.3%) n: 4646	392 (97.1%) n: 3868	419 (98.4%) n: 3681	325 (97.9%) n: 3764	284 (98.3%) n: 3422	597 (98.7%) n: 3935
Fishing duration <20hrs	351 (98.2%) n: 2992	648 (98.4%) n: 4198	515 (95.8%) n: 4534	445 (98.1%) n: 4641	386 (95.4%) n: 3840	406 (95.5%) n: 3599	318 (95.8%) n: 3734	278 (96.2%) n: 3407	588 (97.1%) n: 3907
Season start day <212	347 (97.0%) n: 2925	648 (98.3%) n: 4191	511 (95.2%) n: 4462	439 (96.8%) n: 4563	379 (93.9%) n: 3745	405 (95.1%) n: 3536	308 (92.7%) n: 3580	272 (94.0%) n: 3316	587 (97.0%) n: 3872
Season start day >31	347 (97.0%) n: 2925	648 (98.3%) n: 4191	511 (95.2%) n: 4462	439 (96.8%) n: 4563	379 (93.9%) n: 3743	405 (95.1%) n: 3536	308 (92.7%) n: 3580	272 (94.0%) n: 3316	587 (97.0%) n: 3872
Positive catch	347 (97.0%) n: 2882	648 (98.3%) n: 4156	511 (95.2%) n: 4413	439 (96.8%) n: 4504	379 (93.9%) n: 3693	405 (95.1%) n: 3485	308 (92.7%) n: 3528	272 (94.0%) n: 3259	587 (97.0%) n: 3753
No inferred numbers	339 (94.8%) n: 2768	623 (94.6%) n: 3861	503 (93.5%) n: 4227	432 (95.2%) n: 4336	374 (92.5%) n: 3548	399 (93.7%) n: 3354	297 (89.4%) n: 3330	261 (90.2%) n: 3034	567 (93.7%) n: 3528
Core fleet selection	338 (94.5%) n: 2742	605 (91.9%) n: 3741	478 (89.0%) n: 4001	422 (93.0%) n: 4201	363 (89.8%) n: 3431	388 (91.1%) n: 3243	286 (86.2%) n: 3234	254 (87.7%) n: 2942	546 (90.1%) n: 3354

Filter	2019	2020	2021	2022	2023
Ungroomed data	519 (100%) n: 4599	578 (100%) n: 4936	658 (100%) n: 5746	410 (100%) n: 5085	189 (100%) n: 2853
Fishing duration is not NA	512 (98.7%) n: 4503	578 (100%) n: 4936	658 (100%) n: 5746	410 (100%) n: 5085	189 (100%) n: 2853
Positive fishing duration	512 (98.7%) n: 4503	573 (99.1%) n: 4871	644 (97.9%) n: 5652	401 (97.8%) n: 4987	186 (98.4%) n: 2810
Fishing duration <20hrs	485 (93.5%) n: 4426	568 (98.3%) n: 4851	640 (97.3%) n: 5612	397 (97.0%) n: 4961	185 (97.9%) n: 2797
Season start day <212	481 (92.6%) n: 4304	566 (97.9%) n: 4736	638 (97.1%) n: 5528	396 (96.5%) n: 4872	185 (97.9%) n: 2789
Season start day >31	481 (92.6%) n: 4304	566 (97.9%) n: 4736	638 (97.1%) n: 5528	396 (96.5%) n: 4872	185 (97.9%) n: 2789
Positive catch	481 (92.6%) n: 4159	566 (97.9%) n: 4479	638 (97.1%) n: 5244	396 (96.5%) n: 4638	185 (97.9%) n: 2631
No inferred numbers	454 (87.5%) n: 3831	566 (97.9%) n: 4479	638 (97.1%) n: 5244	396 (96.5%) n: 4638	185 (97.9%) n: 2631
Core fleet selection	433 (83.3%) n: 3587	528 (91.3%) n: 4063	558 (84.8%) n: 4448	354 (86.4%) n: 4096	175 (92.6%) n: 2419

Table 9: Summary of ALB 1 T pseudoCELR data subset by fishing year after the data was checked for missing values and outliers were removed. Records represent a row in the dataset daily catch.

Fishing year	Vessels	Trips	Records	Hrs	Catch (no. fish)
1992	142	894	3 155	42 083.20	429 852
1993	169	1 015	3 501	46 646.77	302 844
1994	200	1 443	5 590	73 147.92	578 613
1995	197	1 483	4 979	65 479.42	636 918
1996	161	1 127	3 670	47 877.38	484 383
1997	144	857	3 097	41 561.22	268 719
1998	141	990	3 503	46 260.43	444 963
1999	96	559	1 870	24 863.18	252 525
2000	163	1 209	4 137	55 598.48	448 439
2001	199	1 504	5 525	74 573.83	461 955
2002	201	1 525	5 556	75 362.10	482 058
2003	184	1 326	5 591	77 398.68	612 402
2004	176	1 137	4 830	66 831.77	612 915
2005	155	1 136	4 956	67 075.95	411 395
2006	139	842	3 434	47 506.52	369 754
2007	106	677	2 953	39 476.43	357 217
2008	123	1 014	3 778	49 370.23	610 815
2009	120	853	3 673	49 266.10	374 847
2010	97	677	2 742	36 853.90	337 986
2011	110	929	3 741	50 519.93	605 283
2012	117	1 047	4 001	54 009.40	477 999
2013	117	1 001	4 201	57 754.18	422 017
2014	114	832	3 431	47 023.10	362 771
2015	94	760	3 243	44 215.65	387 714
2016	99	731	3 234	43 509.82	286 382
2017	74	596	2 942	40 637.73	253 760
2018	97	762	3 354	45 763.95	545 623
2019	94	763	3 587	48 354.93	432 667
2020	103	793	4 063	53 259.82	527 866
2021	104	885	4 448	59 200.85	558 046
2022	94	825	4 096	52 803.77	353 863
2023	68	518	2 419	30 706.85	175 214

Table 10: Summary table for the negative-binomial model. Model terms are listed in the order offered to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
intercept	1	1 410 709	0.00	0.00	*
fyear	31	1 401 705	5.14	5.14	*
vessel_key	355	1 389 225	7.47	12.61	*
stat_area	21	1 387 009	1.28	13.89	*
month	5	1 383 807	1.82	15.71	*
ns(log(fishing_duration), 3)	3	1 371 449	7.01	22.71	*
stat_area:month	105	1 369 897	0.99	23.70	*

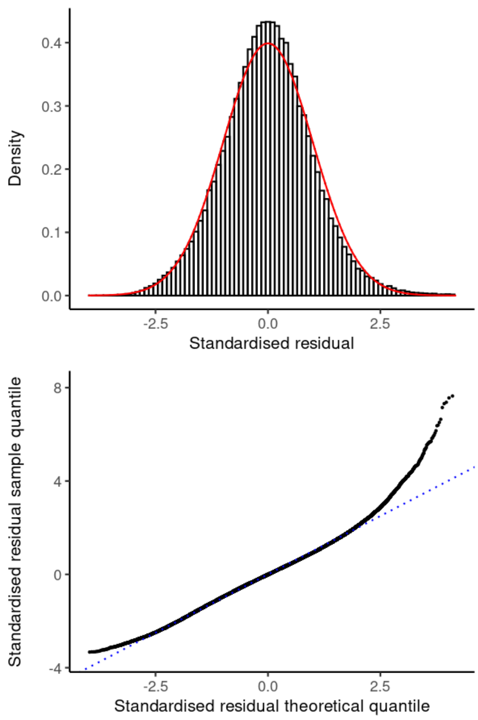

Figure 52: Diagnostic plots for the selected negative-binomial model for positive catches in the ALB 1 T pseudoCELR dataset.

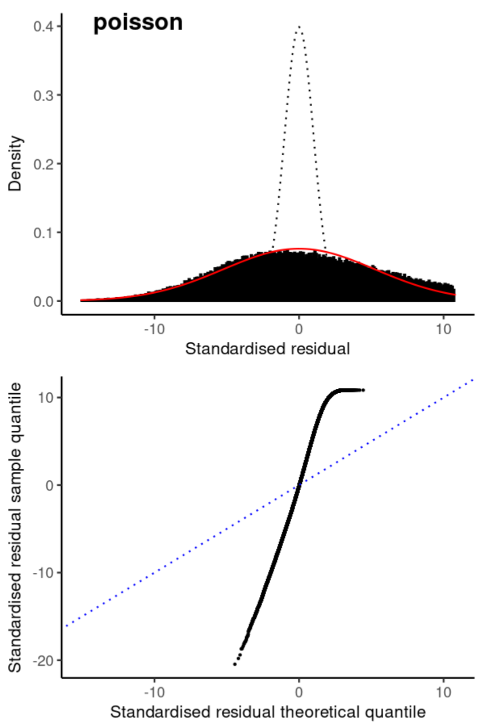

Figure 53: Diagnostic plots for the alternative poisson models considered for positive catches in the ALB 1 T pseudoCELR dataset.

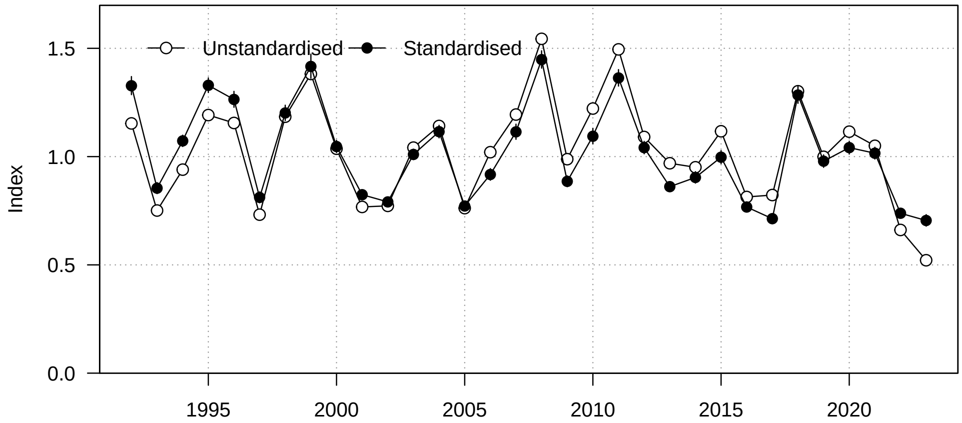

Figure 54: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch using the negative-binomial model for the ALB 1 T pseudoCELR dataset.

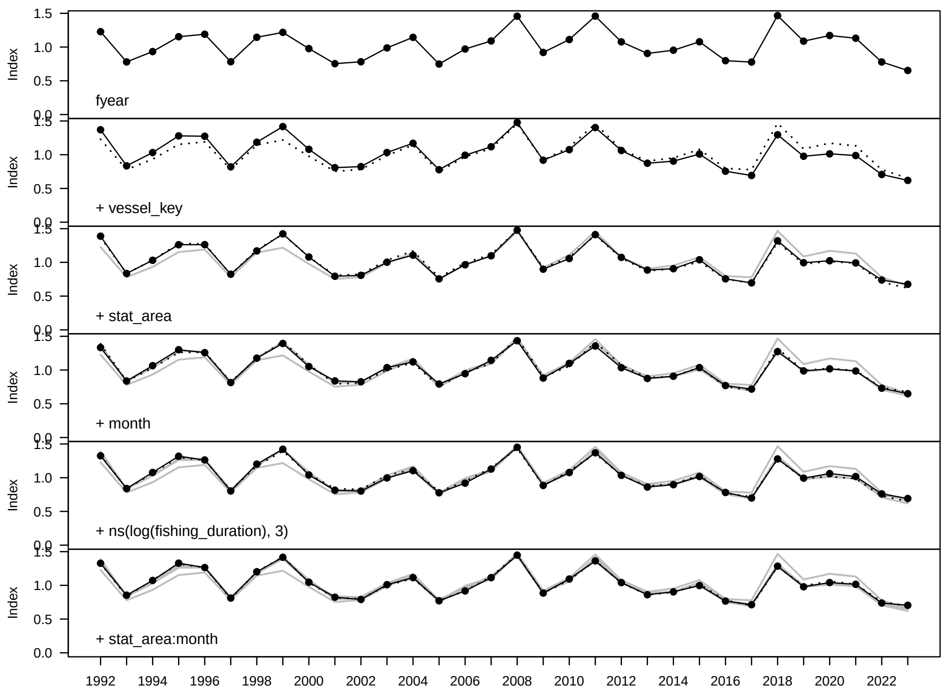

Figure 55: Changes to the ALB 1 T pseudoCELR positive catch index as terms are successively entered into the negative-binomial model.

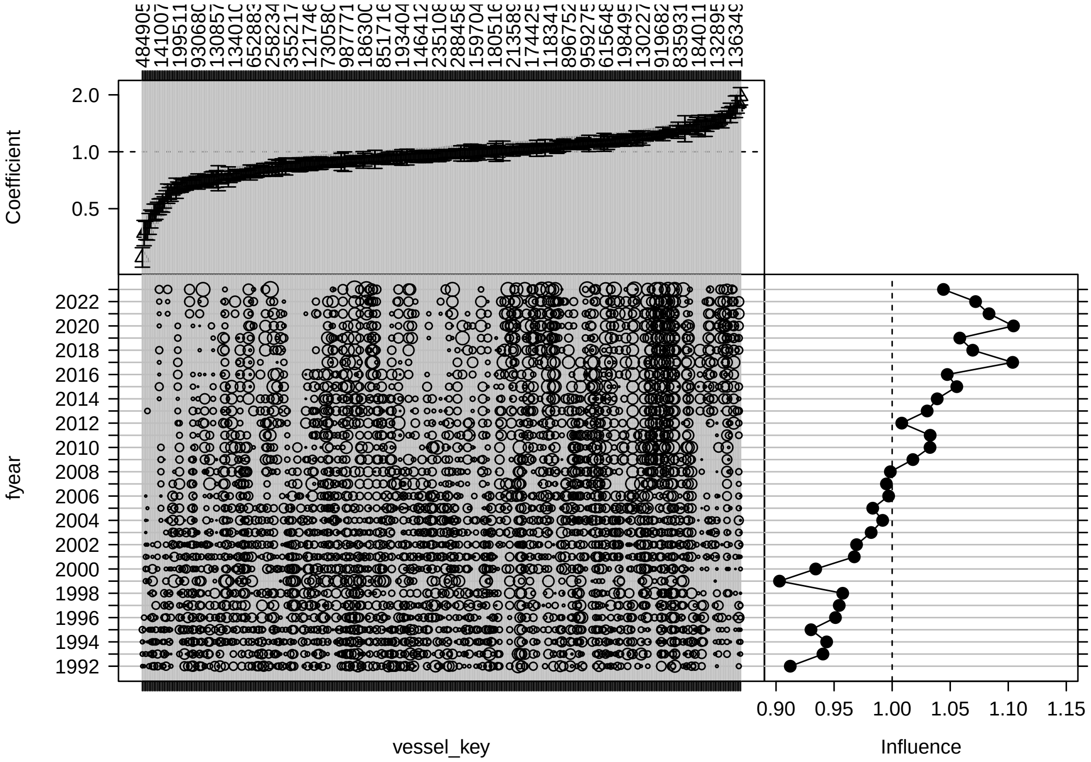

Figure 56: CDI plot for vessel key for the negative-binomial model of positive catches in the ALB 1 T pseudoCELR catch-per-unit-effort dataset.

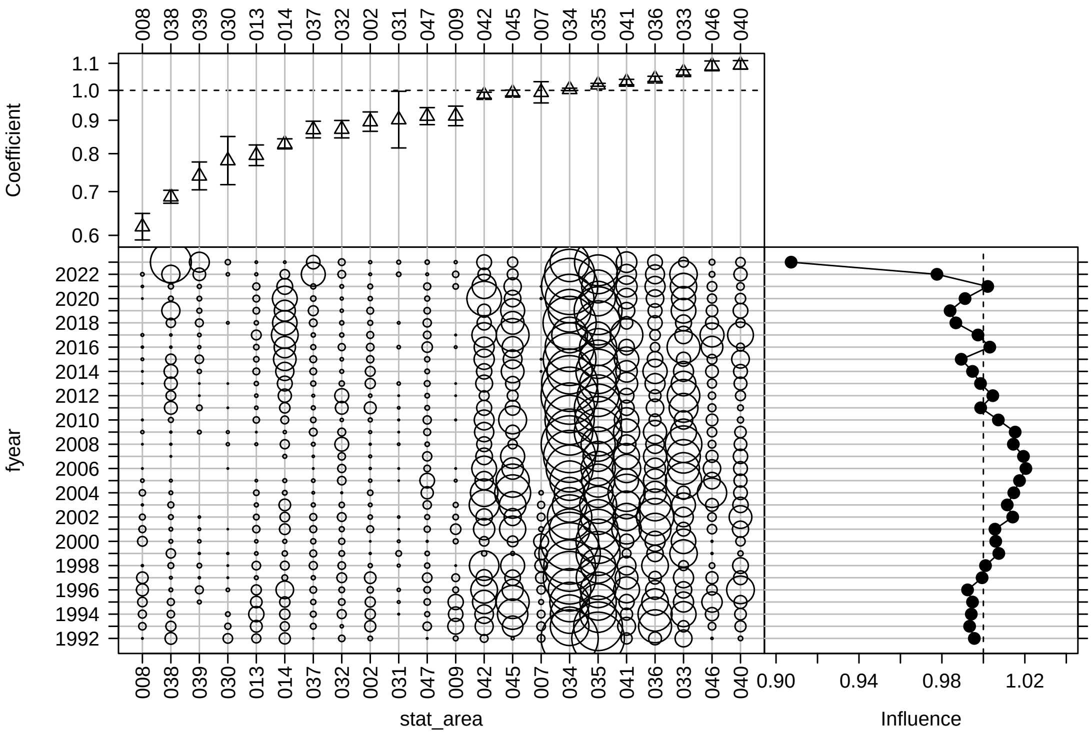

Figure 57: CDI plot for statistical area for the negative-binomial model of positive catches in the ALB 1 T pseudoCELR catch-per-unit-effort dataset.

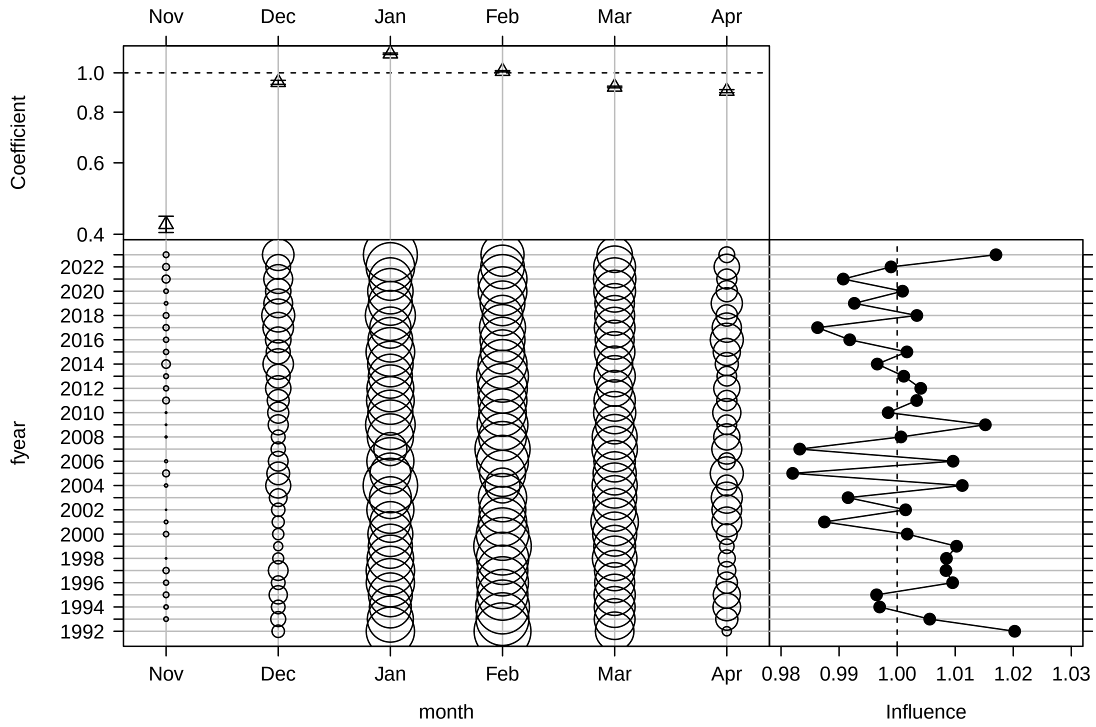

Figure 58: CDI plot for month for the negative-binomial model of positive catches in the ALB 1 T pseudoCELR catch-per-unit-effort dataset.

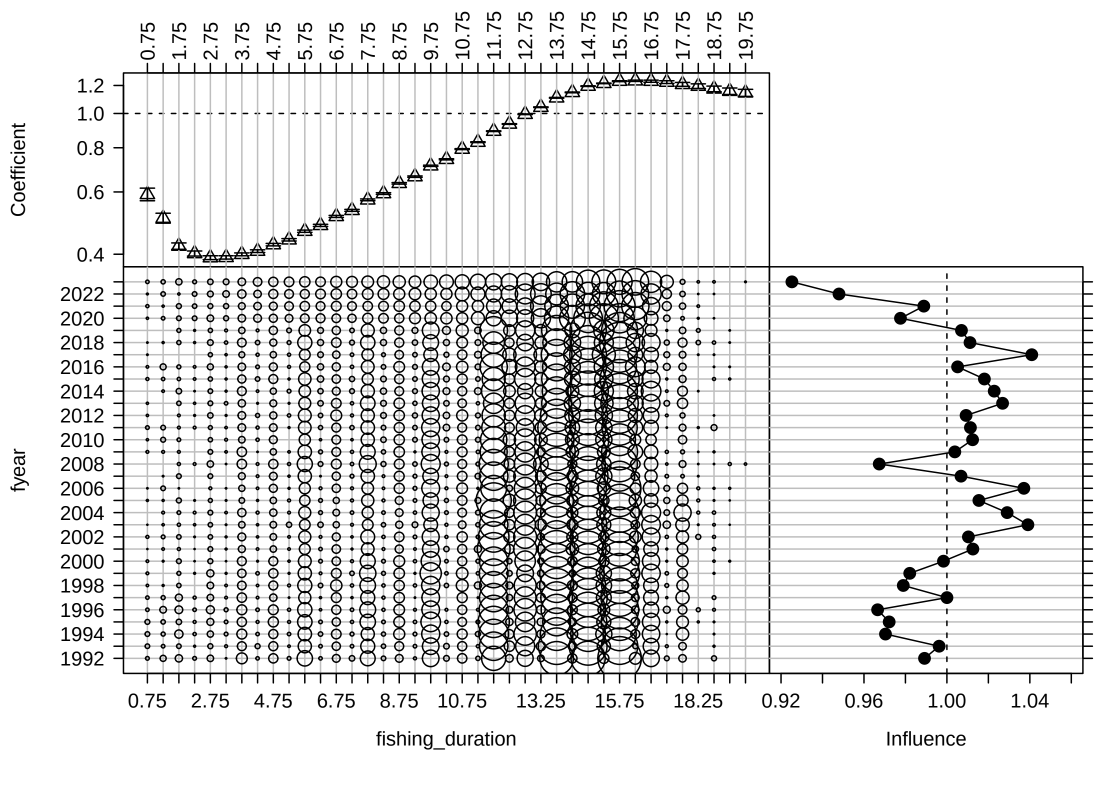

Figure 59: CDI plot for fishing duration (h) for the negative-binomial model of positive catches in the ALB 1 T pseudoCELR catch-per-unit-effort dataset.

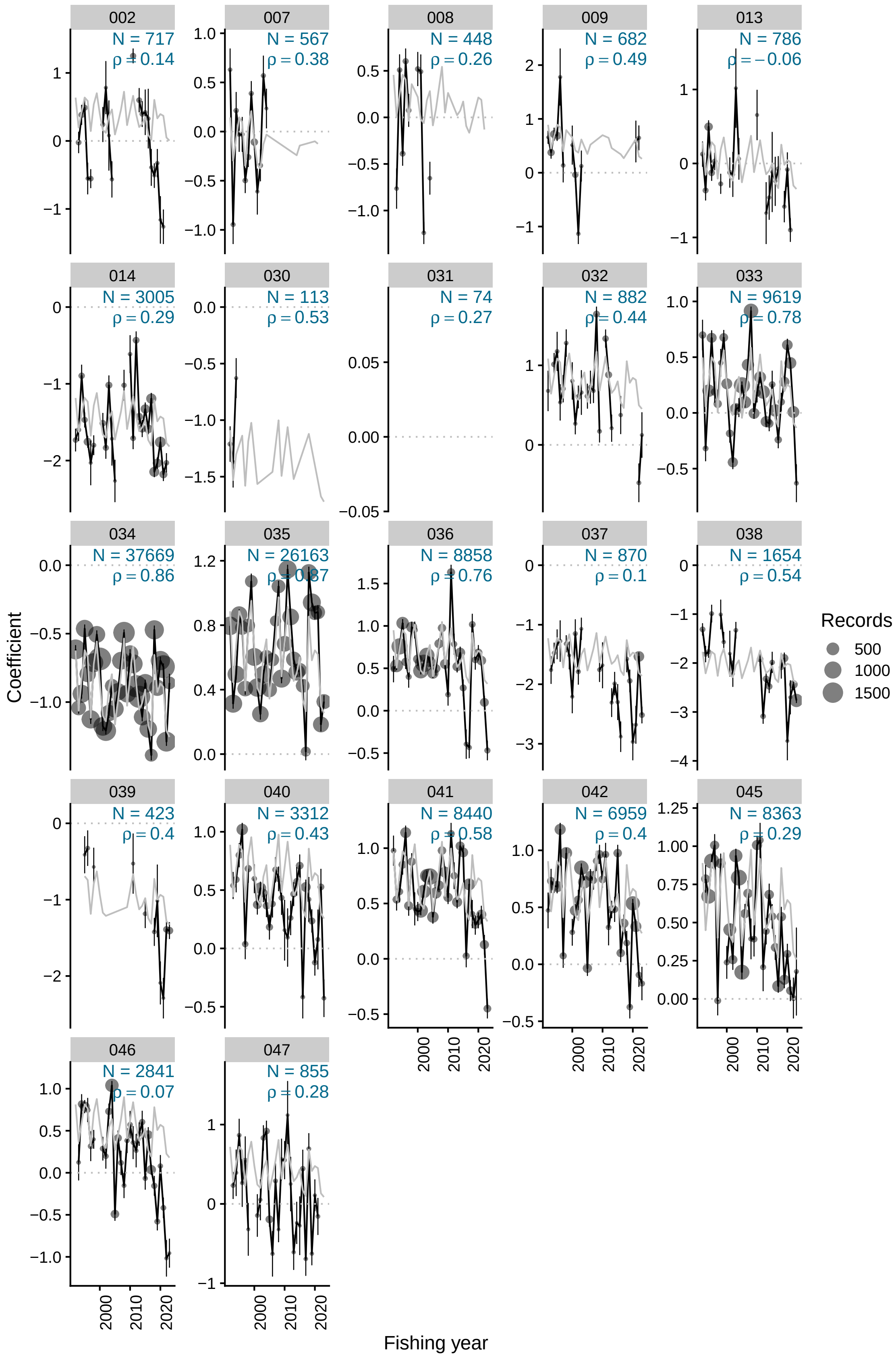

Figure 60: Residual implied coefficients for area-year in the negative-binomial positive catch model for the ALB 1 T pseudoCELR dataset.

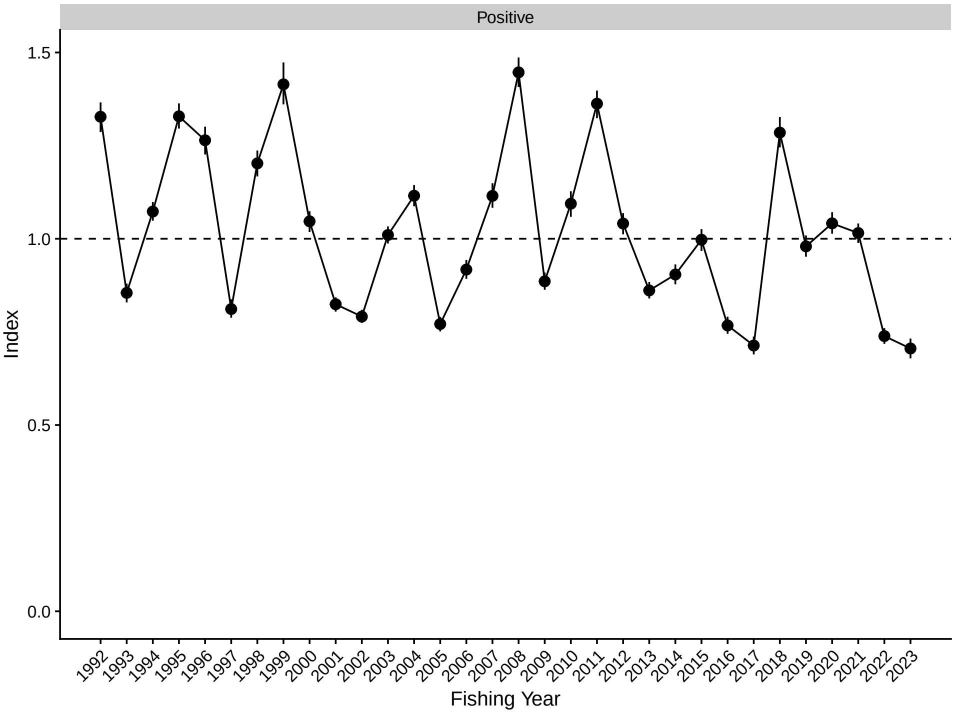

Figure 61: Standardised indices and 95% confidence intervals for the ALB 1 T pseudoCELR dataset.

Table 11: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in ALB 1 T pseudoCELR.

	Positive			
Fishing year	index	SE	LCI	UCI
1992	1.327	0.020	1.286	1.366
1993	0.855	0.013	0.829	0.879
1994	1.073	0.013	1.049	1.099
1995	1.329	0.017	1.296	1.363
1996	1.264	0.019	1.226	1.301
1997	0.811	0.013	0.788	0.838
1998	1.202	0.018	1.167	1.237
1999	1.415	0.029	1.361	1.473
2000	1.047	0.014	1.018	1.074
2001	0.824	0.010	0.804	0.843
2002	0.791	0.009	0.774	0.809
2003	1.010	0.012	0.987	1.033
2004	1.115	0.015	1.087	1.144
2005	0.771	0.010	0.751	0.790
2006	0.917	0.013	0.892	0.943
2007	1.115	0.017	1.083	1.149
2008	1.447	0.020	1.407	1.486
2009	0.886	0.012	0.863	0.909
2010	1.094	0.018	1.059	1.128
2011	1.363	0.019	1.324	1.398
2012	1.041	0.015	1.012	1.069
2013	0.861	0.011	0.840	0.884
2014	0.904	0.014	0.878	0.931
2015	0.997	0.015	0.967	1.026
2016	0.767	0.012	0.745	0.791
2017	0.713	0.012	0.690	0.738
2018	1.285	0.021	1.245	1.327
2019	0.980	0.015	0.952	1.009
2020	1.041	0.015	1.014	1.071
2021	1.015	0.013	0.989	1.041
2022	0.739	0.011	0.718	0.760
2023	0.705	0.014	0.679	0.732

5.2 ALB 1 T CELR trip

The ALB 1 T CPUE TRIP series was derived from troll records landing to the ALB 1 fishstock on CEL and ERS other lining reporting forms aggregated at the trip level. The target species was albacore, and catch was recorded from 18 statistical areas between 1990 and 2022 (Table 12).

A large number of vessels was available for the ALB 1 T CPUE TRIP series. As with the ALB 1 T pseudoCELR series the core fleet selection aimed to create rules that removed a large number of vessels but retained a reasonable proportion of the catch in order to provide an index that is informative for describing trends in the fishstock. The final selection criteria were the same as ALB 1 T CELR trip CPUE series and led to a similar composition of the fleet retained for CPUE analysis (Figure 62). This selection also resulted in retaining a number of vessels that had fished since the early to mid-1990s and a number of them conducting 10 or more trips per year (Figure 63).

The number of records in the dataset that recorded positive daily catch are shown by fishing year in Table 14. In most years more than 40 vessels are retained per year, with a high number of trips (>400) (also equivalent to the number of records for this dataset). Overall, the number of records in the dataset peaked in the mid-1990s and early 2000s, but remained relatively consistent from 2007 onwards. The number of vessels and trips in the data set declines slightly after 2014 (Table 14), with a big drop in 2023, which showed very little catch and participation in the fishery, due to a combination of low ex-vessel price and low CPUE.

The data removed by the filtering are presented in Table 13. The core vessel selection had the greatest effect on the data removing the highest number of records and catch throughout the time series, but still retained between 70% of catch in early years, and around 95% in recent years. All other grooming steps tended to remove a very small number of records, with minimal effect on catch.

The reduced model without environmental predictors for the ALB 1 T CELR trip dataset, applied to the albacore troll catches in ALB 1 is described in Table 15. Fishing year (forced into the model as the first variable) explained 3.5% variation in the logarithm of catch. As with the previous model, fishing duration and vessel key were also important, explaining an additional 19% and 30% respectively. The statistical area (modal stat area) and month terms explained nearly 2% additional variation, and their interaction explained less than 1%. The final model explained 56.9% of the variance in log(catch).

Diagnostic residual plots for the gamma model are presented in Figure 64. The residuals followed the modeled distribution well except for extreme values. Other distributions appeared to fit the data less well (Figure 65).

The resulting model provided more of a standardising effect (Figure 66) than did the same linear predictor applied to the daily dataset. The ALB 1 T CELR trip indices were mainly standardised by vessel, which had a similar influence as in the ALB 1 T pseudoCELR model (Figures 67–71). The influence of vessels on the resulting series increased consistently over the course of the series, leading to a strong pivot of the CPUE series in recent years, with a strong downward standardisation effect (Figure 68). The influence of fishing duration changed over the series (Figure 71), with two major steps: firstly, from 2003 more trips had longer total fishing duration; and, secondly, from 2016 fewer trips had a longer total fishing duration. Similar to the daily series, fishing month had a relatively small influence on CPUE (Figure 70).

Although the trip-based CPUE index was driven by trends on the west coast of the South Island (areas 034 and 035; Figure 72), the resulting main index showed an over-all decline since 2008, while recent CPUE has declined since 2020 to an all-time low (Figure 73, Table 16).

The full model including environmental covariates (SST and MEIV) applied to the albacore troll catches using the ALB 1 T CELR trip dataset is described in Table A.6 and Table A.9. As with the reduced model with no environmental predictors applied to the trip dataset, this model provided more of a standardising effect in comparison to the unstandardised series (Figure A.22) than did the same model applied to the daily dataset. Vessel key and total fishing duration explained most of the variation in the catch. Also, MEI had a similar influence on the resulting series as it did in the full model applied to the daily dataset.

Table 12: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the ALB 1 T CELR trip CPUE series.

Series	ALB 1 T CELR trip
QMS stock	ALB1
Reporting forms	CEL, ERS - Other Lining
Fishing methods	T
Target species	ALB
Statistical Areas	002, 007, 008, 009, 013, 014, 030, 031, 032, 033, 034, 035, 036, 037, 038, 039, 040, 041, 042, 045, 046, 047
Period	1991-10-01, 2023-09-30
Resolution	Trip
Core fleet years	4
Core fleet trips	3
Default model	landkg ~ fyear + vessel_key + modal_stat_area*modal_month + ns(log(total_fishing_duration), 3)
Stepwise selection	No
Positive catch distribution	Gamma

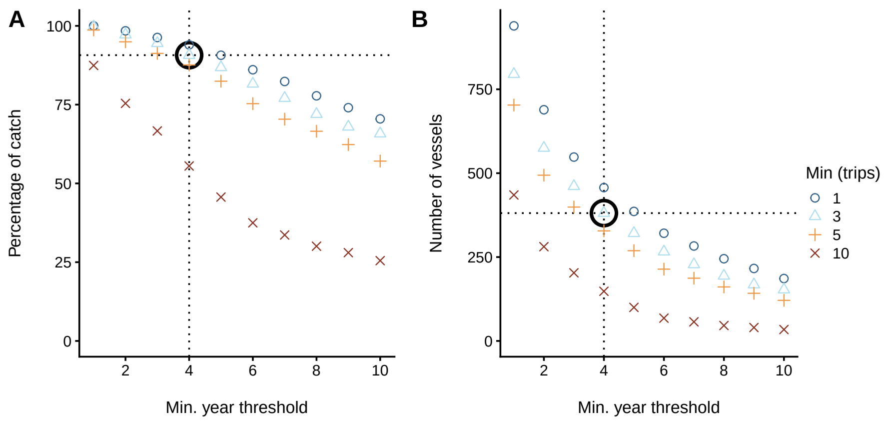

Figure 62: Percentage of catch and number of vessels for different core vessel selection criteria for the ALB 1 T CELR trip CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

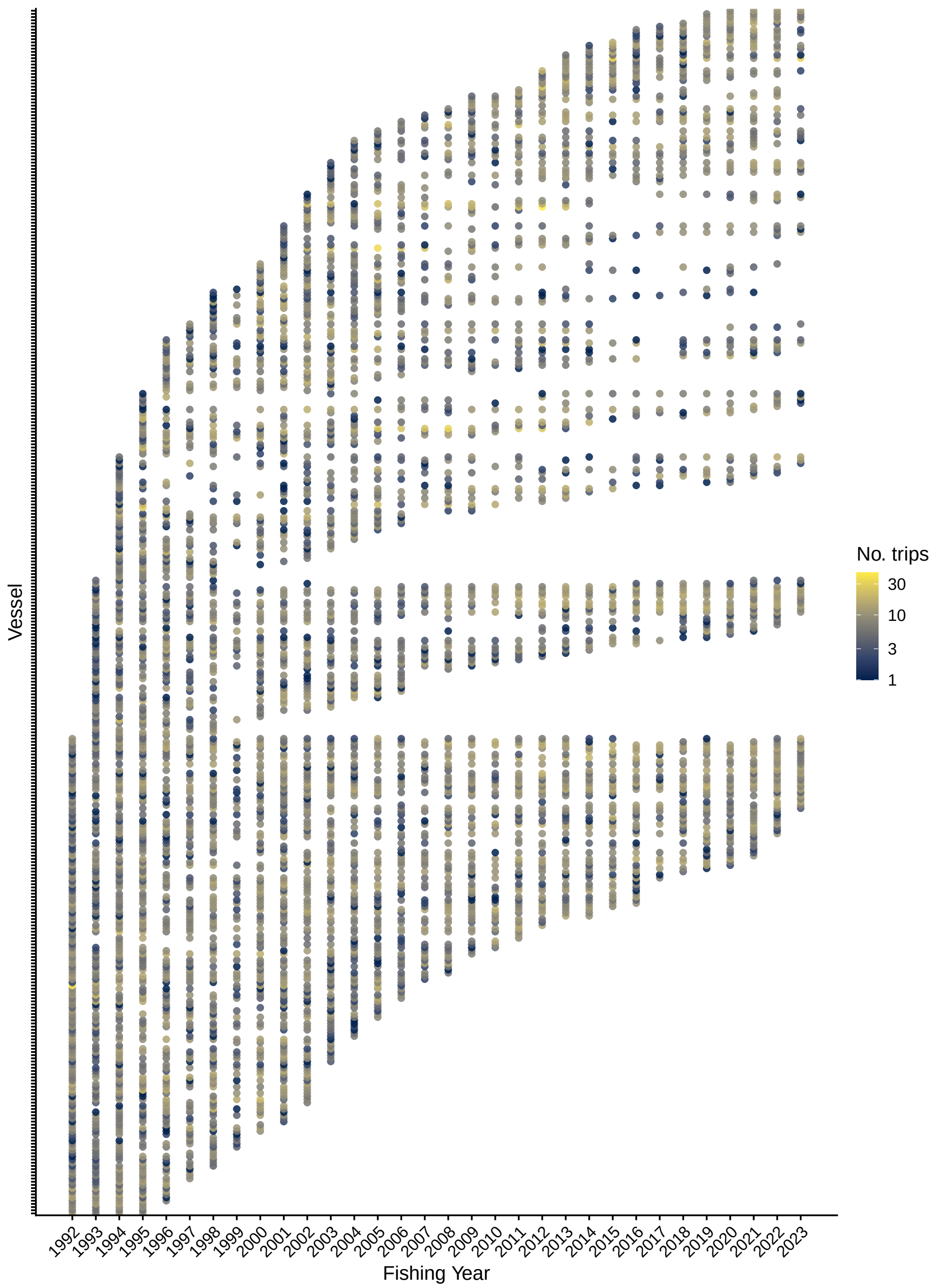

Figure 63: Number of trips by fishing year for core vessels in the ALB 1 T CELR trip series. The colour of the points is proportional to the number of trips undertaken by a vessel in a fishing year.

Table 13: Summary of the ALB 1 T CELR trip dataset total catch (tonnes) and number of records (n), by fishing year after the application of various filters. The first row gives the catch and number of records before filters were applied (ungroomed data). Subsequent rows display the remaining catch (and percent of catch), and the number of records, after the specified filter was applied. (Continued on next page)

Filter	1992	1993	1994	1995	1996	1997	1998	1999	2000
Ungroomed data	3057 (100%) n: 1496	2450 (100%) n: 1715	4277 (100%) n: 2462	4710 (100%) n: 2488	3887 (100%) n: 2003	2238 (100%) n: 1524	3986 (100%) n: 1805	1508 (100%) n: 726	2894 (100%) n: 1788
Fishing duration is not NA	3050 (99.8%) n: 1490	2434 (99.3%) n: 1697	4232 (98.9%) n: 2433	4596 (97.6%) n: 2417	3759 (96.7%) n: 1910	2083 (93.1%) n: 1424	3879 (97.3%) n: 1744	1474 (97.8%) n: 701	2685 (92.8%) n: 1626
Positive fishing duration	3050 (99.8%) n: 1490	2434 (99.3%) n: 1697	4232 (98.9%) n: 2433	4596 (97.6%) n: 2417	3759 (96.7%) n: 1910	2083 (93.1%) n: 1424	3879 (97.3%) n: 1744	1474 (97.8%) n: 701	2685 (92.8%) n: 1626
Total fishing duration <180hrs	2975 (97.3%) n: 1484	2235 (91.2%) n: 1682	3918 (91.6%) n: 2413	4535 (96.3%) n: 2411	3602 (92.7%) n: 1899	2037 (91.0%) n: 1419	3749 (94.0%) n: 1736	1474 (97.8%) n: 701	2673 (92.3%) n: 1624
Season Nov Apr	2974 (97.3%) n: 1482	2231 (91.0%) n: 1669	3908 (91.4%) n: 2392	4508 (95.7%) n: 2374	3600 (92.6%) n: 1889	2033 (90.8%) n: 1407	3701 (92.8%) n: 1701	1473 (97.7%) n: 697	2651 (91.6%) n: 1582
Positive catch	2974 (97.3%) n: 1458	2231 (91.0%) n: 1621	3908 (91.4%) n: 2346	4508 (95.7%) n: 2339	3600 (92.6%) n: 1854	2033 (90.8%) n: 1381	3701 (92.8%) n: 1661	1473 (97.7%) n: 690	2651 (91.6%) n: 1570
Core fleet selection	2435 (79.6%) n: 1051	1743 (71.1%) n: 1076	2990 (69.9%) n: 1551	3670 (77.9%) n: 1614	3160 (81.3%) n: 1492	1851 (82.7%) n: 1153	3187 (79.9%) n: 1402	1470 (97.5%) n: 681	2515 (86.9%) n: 1422

Filter	2001	2002	2003	2004	2005	2006	2007	2008	2009
Ungroomed data	2915 (100%) n: 2035	3061 (100%) n: 1993	3899 (100%) n: 1759	3928 (100%) n: 1469	2848 (100%) n: 1522	2210 (100%) n: 1031	1817 (100%) n: 751	3328 (100%) n: 1207	1776 (100%) n: 1024
Fishing duration is not NA	2830 (97.1%) n: 1954	2958 (96.6%) n: 1887	3820 (98.0%) n: 1697	3879 (98.7%) n: 1439	2788 (97.9%) n: 1465	2112 (95.5%) n: 966	1811 (99.6%) n: 737	3256 (97.8%) n: 1125	1761 (99.1%) n: 1006
Positive fishing duration	2830 (97.1%) n: 1954	2958 (96.6%) n: 1887	3820 (98.0%) n: 1697	3879 (98.7%) n: 1439	2788 (97.9%) n: 1465	2112 (95.5%) n: 966	1811 (99.6%) n: 737	3256 (97.8%) n: 1125	1761 (99.1%) n: 1006
Total fishing duration <180hrs	2814 (96.5%) n: 1951	2912 (95.1%) n: 1880	3772 (96.7%) n: 1690	3798 (96.7%) n: 1432	2777 (97.5%) n: 1463	2101 (95.0%) n: 964	1811 (99.6%) n: 737	3256 (97.8%) n: 1125	1757 (98.9%) n: 1005
Season Nov Apr	2761 (94.7%) n: 1851	2907 (95.0%) n: 1863	3737 (95.9%) n: 1658	3786 (96.4%) n: 1419	2766 (97.1%) n: 1449	2082 (94.2%) n: 957	1789 (98.5%) n: 721	3250 (97.7%) n: 1108	1756 (98.9%) n: 1002
Positive catch	2761 (94.7%) n: 1803	2907 (95.0%) n: 1825	3737 (95.9%) n: 1622	3786 (96.4%) n: 1379	2766 (97.1%) n: 1407	2082 (94.2%) n: 941	1789 (98.5%) n: 701	3250 (97.7%) n: 1098	1756 (98.9%) n: 996
Core fleet selection	2553 (87.6%) n: 1529	2607 (85.1%) n: 1598	3255 (83.5%) n: 1417	3310 (84.3%) n: 1210	2524 (88.6%) n: 1279	1987 (89.9%) n: 881	1769 (97.3%) n: 688	3132 (94.1%) n: 1031	1694 (95.3%) n: 922

Filter	2010	2011	2012	2013	2014	2015	2016	2017	2018
Ungroomed data	1720 (100%) n: 751	2970 (100%) n: 1097	2714 (100%) n: 1296	2574 (100%) n: 1169	2138 (100%) n: 968	2349 (100%) n: 882	1905 (100%) n: 851	1811 (100%) n: 702	2300 (100%) n: 888
Fishing duration is not NA	1713 (99.6%) n: 742	2948 (99.3%) n: 1059	2627 (96.8%) n: 1208	2541 (98.7%) n: 1127	2078 (97.2%) n: 924	2321 (98.8%) n: 863	1872 (98.2%) n: 828	1800 (99.4%) n: 690	2280 (99.1%) n: 872
Positive fishing duration	1713 (99.6%) n: 742	2948 (99.3%) n: 1059	2627 (96.8%) n: 1208	2541 (98.7%) n: 1127	2078 (97.2%) n: 924	2321 (98.8%) n: 863	1872 (98.2%) n: 828	1800 (99.4%) n: 690	2280 (99.1%) n: 872
Total fishing duration <180hrs	1702 (98.9%) n: 740	2917 (98.2%) n: 1056	2627 (96.8%) n: 1208	2541 (98.7%) n: 1127	2064 (96.5%) n: 920	2275 (96.9%) n: 858	1872 (98.2%) n: 828	1766 (97.5%) n: 687	2262 (98.3%) n: 869
Season Nov Apr	1675 (97.4%) n: 726	2916 (98.2%) n: 1054	2614 (96.3%) n: 1190	2522 (98.0%) n: 1103	2040 (95.4%) n: 895	2267 (96.5%) n: 836	1830 (96.0%) n: 803	1705 (94.2%) n: 660	2260 (98.2%) n: 860
Positive catch	1675 (97.4%) n: 712	2916 (98.2%) n: 1049	2614 (96.3%) n: 1179	2522 (98.0%) n: 1075	2040 (95.4%) n: 885	2267 (96.5%) n: 823	1830 (96.0%) n: 787	1705 (94.2%) n: 640	2260 (98.2%) n: 846
Core fleet selection	1623 (94.4%) n: 688	2818 (94.9%) n: 997	2481 (91.4%) n: 1080	2444 (94.9%) n: 1022	1985 (92.8%) n: 854	2224 (94.7%) n: 806	1753 (92.0%) n: 769	1641 (90.6%) n: 616	2181 (94.8%) n: 799

Filter	2019	2020	2021	2022	2023
Ungroomed data	2452 (100%) n: 985	2845 (100%) n: 1051	3268 (100%) n: 1182	2357 (100%) n: 1035	889 (100%) n: 613
Fishing duration is not NA	2430 (99.1%) n: 962	2845 (100%) n: 1051	3268 (100%) n: 1182	2357 (100%) n: 1035	889 (100%) n: 613
Positive fishing duration	2430 (99.1%) n: 962	2844 (100.0%) n: 1048	3244 (99.3%) n: 1171	2333 (99.0%) n: 1028	887 (99.7%) n: 610
Total fishing duration <180hrs	2414 (98.4%) n: 959	2822 (99.2%) n: 1034	3234 (99.0%) n: 1163	2328 (98.8%) n: 1025	884 (99.5%) n: 607
Season Nov Apr	2384 (97.3%) n: 931	2812 (98.8%) n: 1006	3226 (98.7%) n: 1139	2319 (98.4%) n: 1009	882 (99.2%) n: 604
Positive catch	2384 (97.3%) n: 916	2812 (98.8%) n: 950	3226 (98.7%) n: 1075	2319 (98.4%) n: 953	882 (99.2%) n: 579
Core fleet selection	2247 (91.6%) n: 861	2655 (93.3%) n: 833	2818 (86.2%) n: 888	2062 (87.5%) n: 825	824 (92.7%) n: 528

Table 14: Summary of ALB 1 T CELR trip data subset by fishing year after the data was checked for missing values and outliers were removed. Records represent a row in the dataset trip catch.

Fishing year	Vessels	Trips	Records	Hrs	Catch (t)
1992	151	1 051	1 051	48 902.10	2 434.71
1993	181	1 076	1 076	50 866.92	1 743.12
1994	213	1 551	1 551	81 540.15	2 989.86
1995	205	1 614	1 614	72 459.28	3 669.65
1996	196	1 492	1 492	65 579.18	3 159.84
1997	169	1 153	1 153	55 252.60	1 851.16
1998	184	1 402	1 402	66 151.65	3 187.18
1999	107	681	681	31 402.35	1 469.68
2000	176	1 422	1 422	67 633.97	2 514.70
2001	201	1 529	1 529	78 819.22	2 553.30
2002	203	1 598	1 598	81 169.77	2 606.59
2003	191	1 417	1 417	84 359.80	3 254.92
2004	180	1 210	1 210	70 987.13	3 309.84
2005	159	1 279	1 279	75 970.83	2 523.66
2006	142	881	881	50 725.27	1 986.72
2007	106	688	688	40 936.33	1 768.73
2008	121	1 031	1 031	51 290.17	3 131.65
2009	121	922	922	52 223.75	1 693.70
2010	89	688	688	37 485.32	1 623.49
2011	112	997	997	53 201.88	2 818.19
2012	115	1 080	1 080	56 096.82	2 480.51
2013	118	1 022	1 022	59 437.35	2 443.73
2014	113	854	854	48 954.02	1 984.76
2015	89	806	806	47 027.38	2 223.95
2016	99	769	769	47 458.18	1 752.86
2017	75	616	616	43 040.63	1 641.31
2018	100	799	799	49 757.08	2 180.63
2019	99	861	861	55 851.10	2 246.51
2020	105	833	833	60 288.14	2 655.07
2021	104	888	888	65 265.20	2 817.67
2022	95	825	825	56 825.88	2 061.55
2023	70	528	528	34 043.50	823.83

Table 15: Summary table for the gamma model. Model terms are listed in the order offered to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
intercept	1	585 695.1	0.00	0.00	*
fyear	31	584 348.6	3.54	3.54	*
vessel_key	380	570 787.6	30.15	33.68	*
modal_stat_area	21	569 894.1	1.64	35.32	*
modal_month	5	568 726.3	2.01	37.33	*
ns(log(total_fishing_duration), 3)	3	555 465.2	19.01	56.34	*
modal_stat_area:modal_month	105	555 148.5	0.60	56.94	*

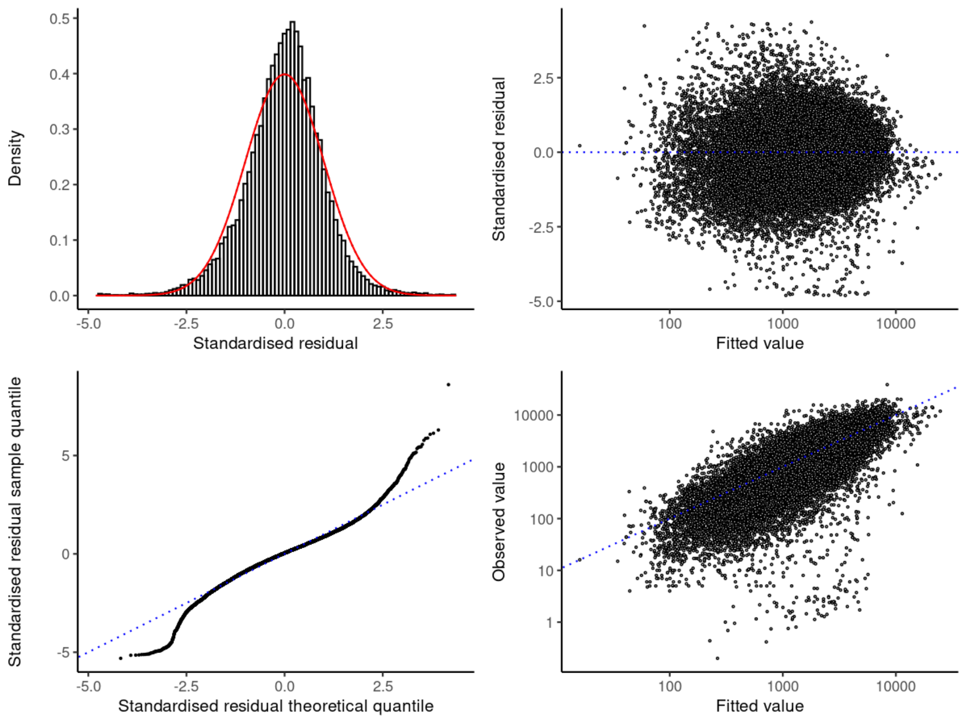

Figure 64: Diagnostic plots for the selected gamma model for positive catches in the ALB 1 T CELR trip dataset.

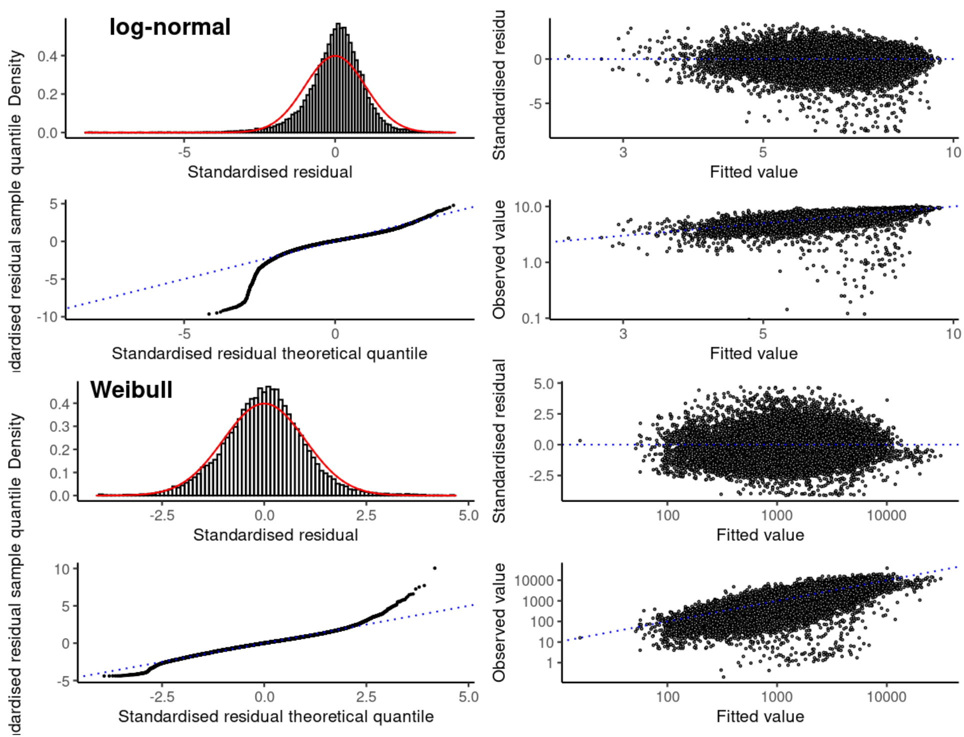

Figure 65: Diagnostic plots for the alternative log-normal and Weibull models considered for positive catches in the ALB 1 T CELR trip dataset.

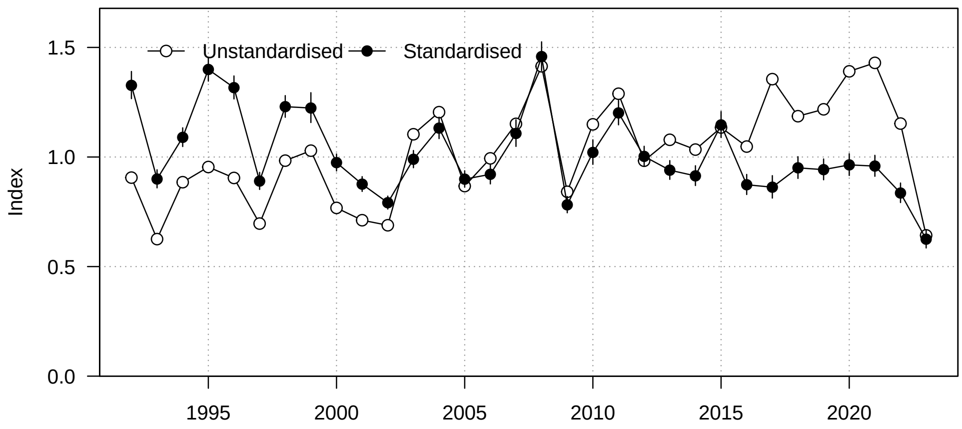

Figure 66: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch using the gamma model for the ALB 1 T CELR trip dataset.

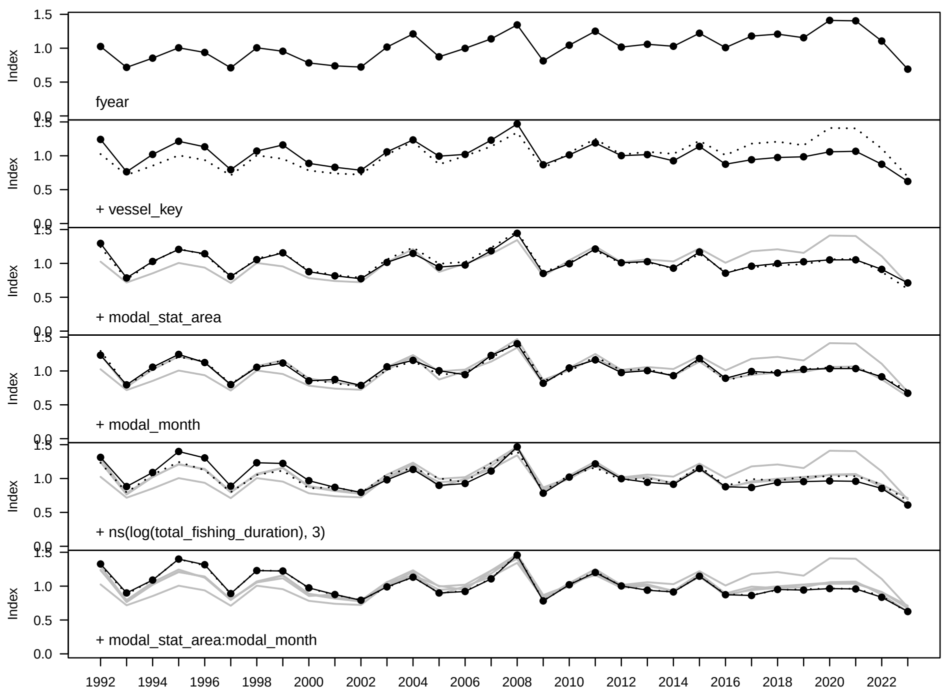

Figure 67: Changes to the ALB 1 T CELR trip positive catch index as terms are successively entered into the gamma model.

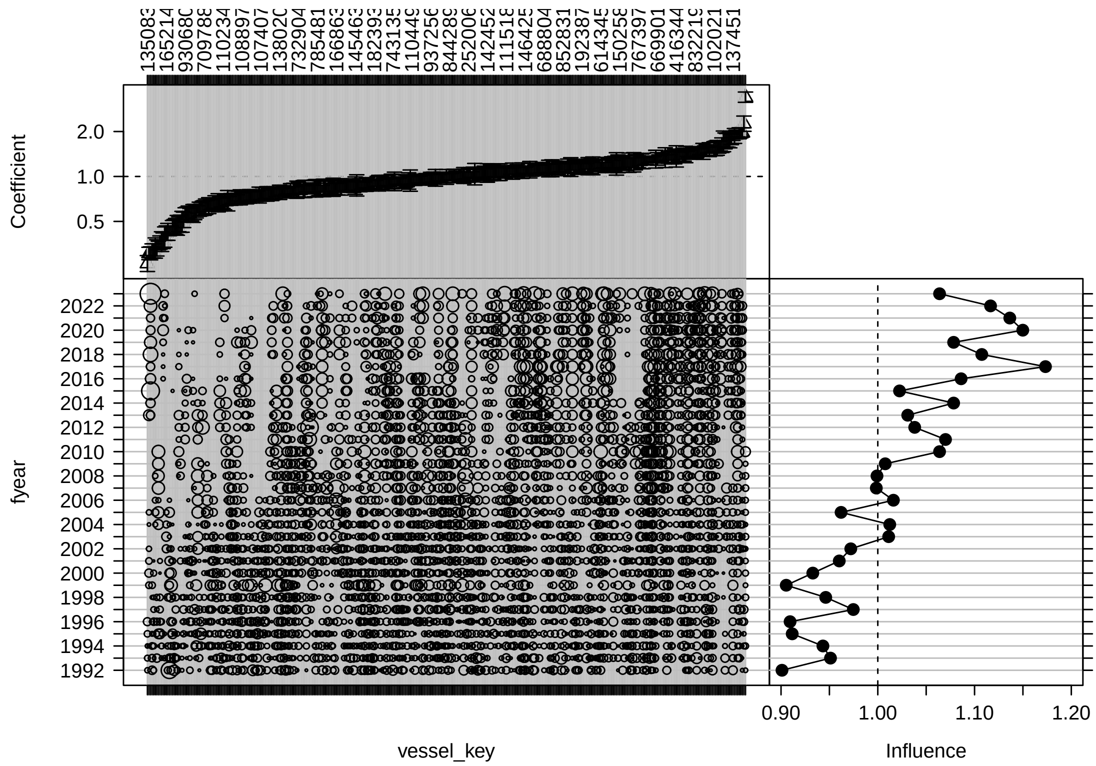

Figure 68: CDI plot for vessel key for the gamma model of positive catches in the ALB 1 T CELR trip catch-per-unit-effort dataset.

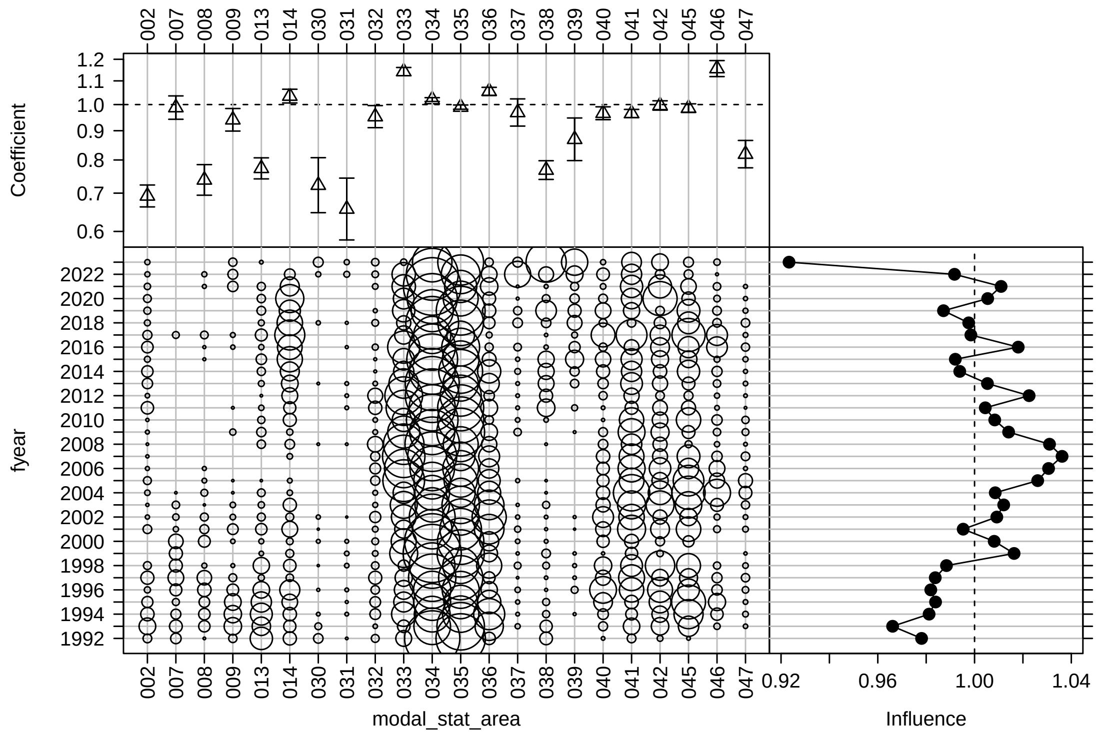

Figure 69: CDI plot for modal statistical area for the gamma model of positive catches in the ALB 1 T CELR trip catch-per-unit-effort dataset.

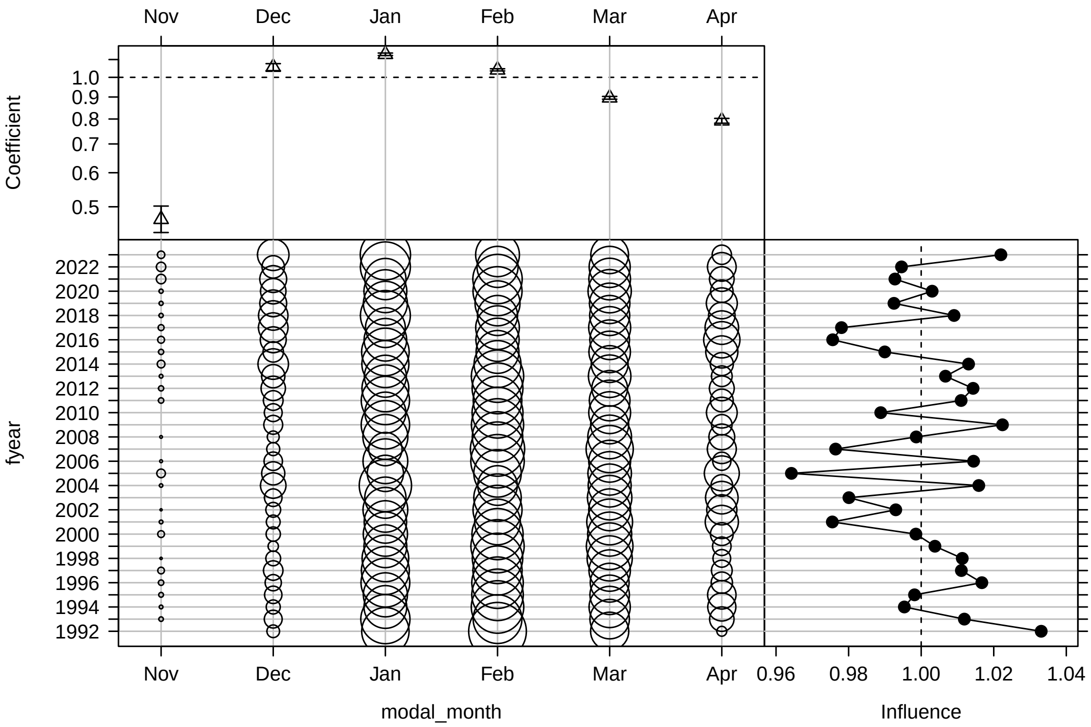

Figure 70: CDI plot for modal month for the gamma model of positive catches in the ALB 1 T CELR trip catch-per-unit-effort dataset.

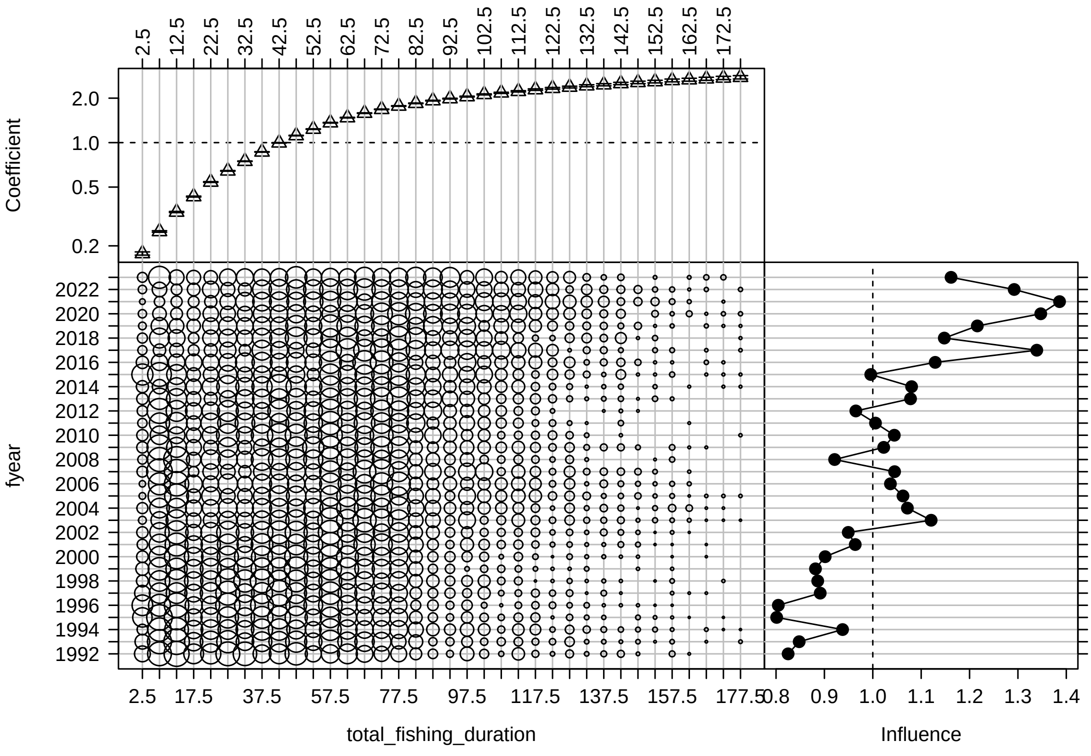

Figure 71: CDI plot for total fishing duration (h) for the gamma model of positive catches in the ALB 1 T CELR trip catch-per-unit-effort dataset.

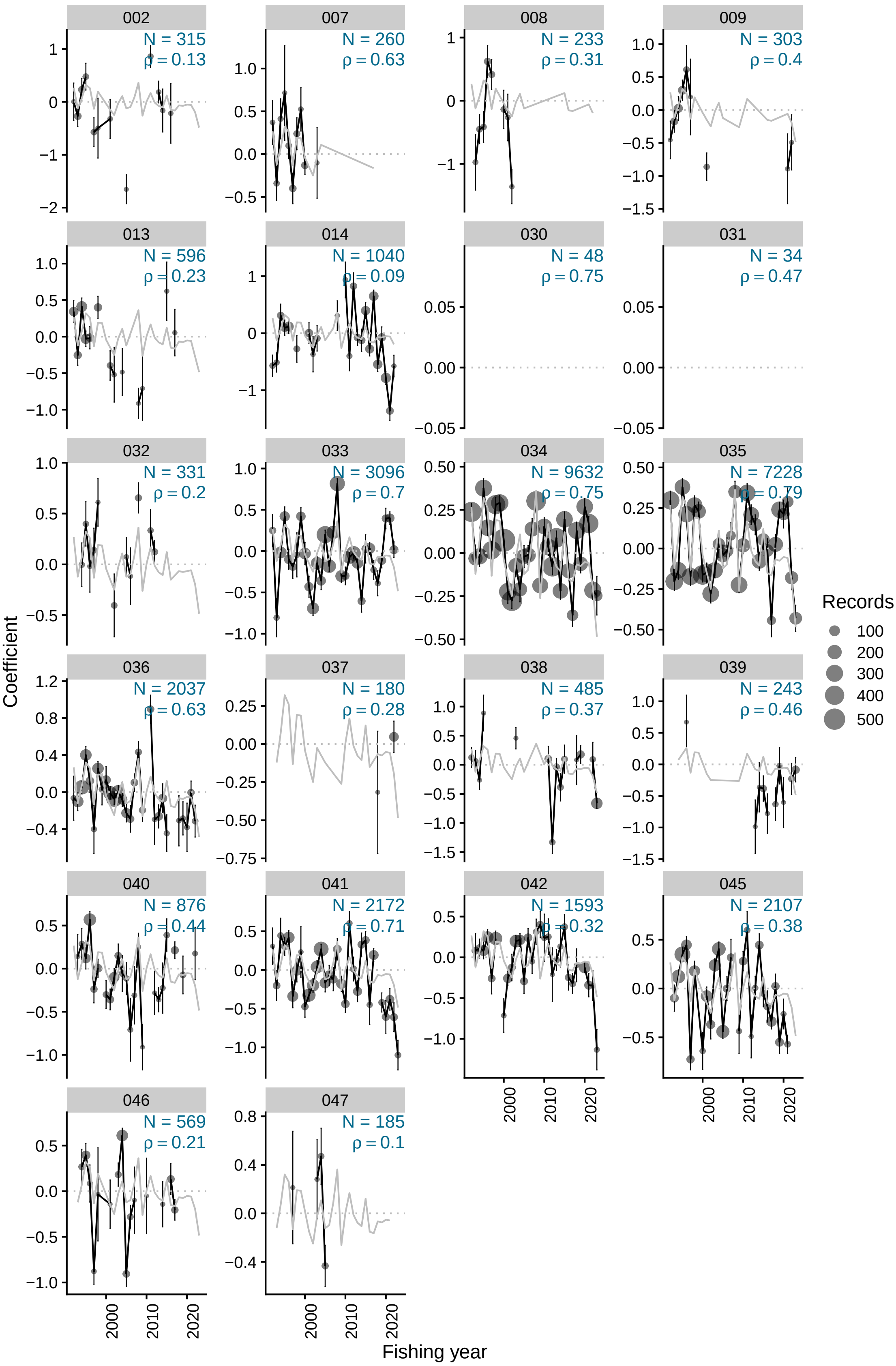

Figure 72: Residual implied coefficients for area-year in the gamma positive catch model for the ALB 1 T CELR trip dataset.

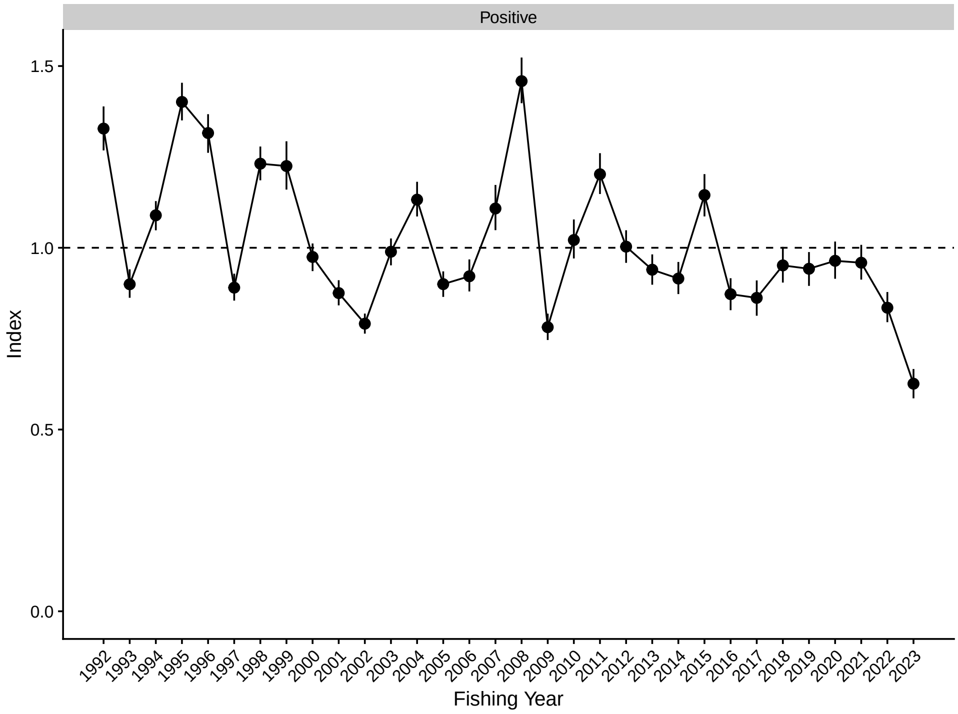

Figure 73: Standardised indices and 95% confidence intervals for the ALB 1 T CELR trip dataset.

Table 16: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in ALB 1 T CELR trip.

	Positive			
Fishing year	index	SE	LCI	UCI
1992	1.328	0.031	1.268	1.389
1993	0.900	0.020	0.862	0.941
1994	1.089	0.021	1.048	1.128
1995	1.401	0.026	1.350	1.454
1996	1.316	0.027	1.261	1.368
1997	0.890	0.019	0.855	0.929
1998	1.231	0.024	1.186	1.279
1999	1.225	0.034	1.160	1.293
2000	0.975	0.019	0.936	1.012
2001	0.875	0.018	0.842	0.911
2002	0.791	0.014	0.764	0.819
2003	0.989	0.019	0.952	1.026
2004	1.132	0.024	1.086	1.182
2005	0.900	0.018	0.865	0.935
2006	0.922	0.022	0.880	0.968
2007	1.108	0.032	1.049	1.173
2008	1.458	0.032	1.398	1.523
2009	0.782	0.018	0.746	0.819
2010	1.021	0.027	0.971	1.078
2011	1.202	0.029	1.148	1.260
2012	1.003	0.023	0.959	1.048
2013	0.940	0.021	0.898	0.982
2014	0.915	0.023	0.873	0.961
2015	1.145	0.030	1.086	1.203
2016	0.872	0.022	0.828	0.916
2017	0.862	0.025	0.813	0.910
2018	0.952	0.025	0.904	1.002
2019	0.942	0.024	0.895	0.988
2020	0.964	0.026	0.915	1.017
2021	0.959	0.024	0.912	1.008
2022	0.835	0.021	0.795	0.878
2023	0.626	0.021	0.586	0.667

6. COMPARING CPUE INDICES AND THE INFLUENCE OF ENVIRONMENTAL VARIABLES

The indices from each of the four models were plotted together, along with those from the Kendrick (2021) analysis, in Figure 74. The series showed little long-term trend, and the indices from this analysis closely followed those up to 2017 from Kendrick (2021) and those of 2020. SST did not appear to have an appreciable effect on CPUE in the NZ troll fishery (Figure 75). Comparing the four series from this analysis with the annual mean of the MEI (Figure 76) suggests that including the MEI may have a slightly intensifying effect in El Niño years (1992 and 1998), but a somewhat stronger dampening effect after 1998 (when El Niño has not been evident and the La Niña pattern has been more persistent), leading to less noisy but relatively flat series in recent years. However, all series end up at a similar low point in 2023 that mirrors the low point in CPUE seen in 2017.

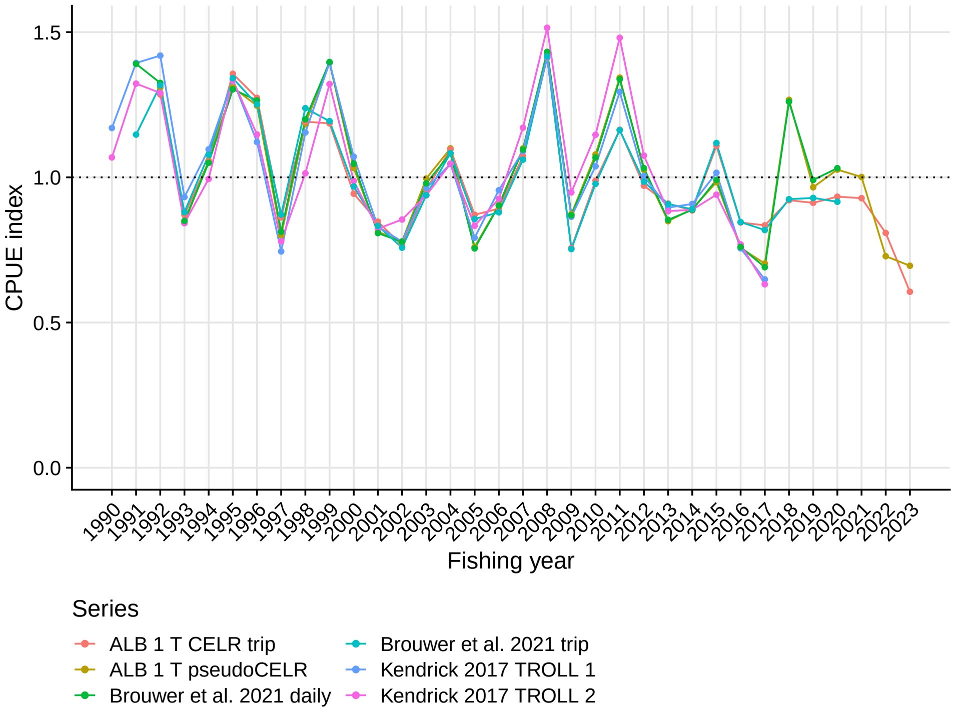

Figure 74: Comparing all ALB CPUE.

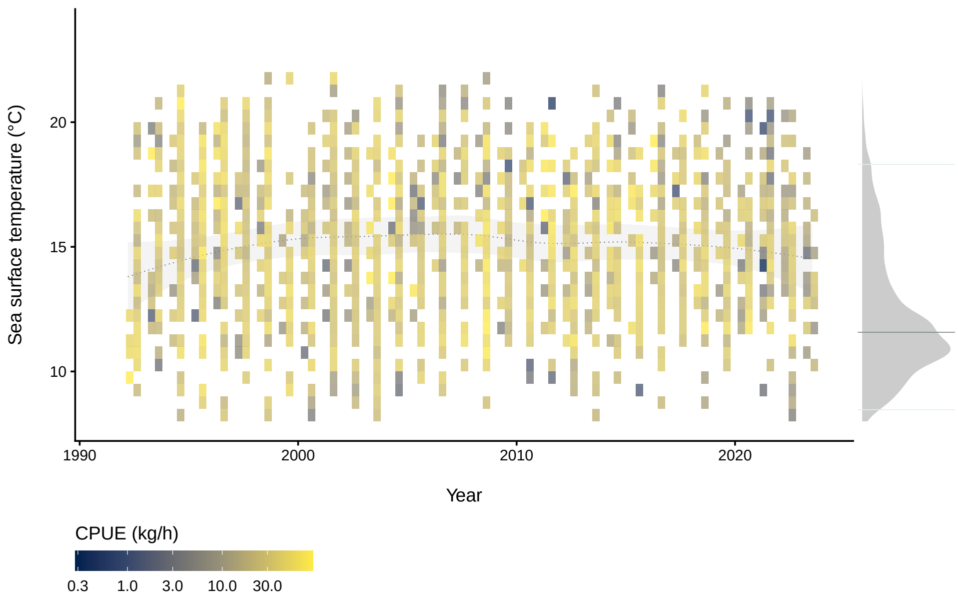

Figure 75: Albacore catch-per-unit-effort (CPUE; tonnes per hour (t/h)), aggregated by month and by sea surface temperature (SST) associated with a set, grouped by 0.5 C. Smoothed trend of overall SST distribution of effort for each target species is overlaid. Marginal density plots (right-hand side) show the overall distribution of Albacore by SST, with the median and 95% quantile range highlighted.

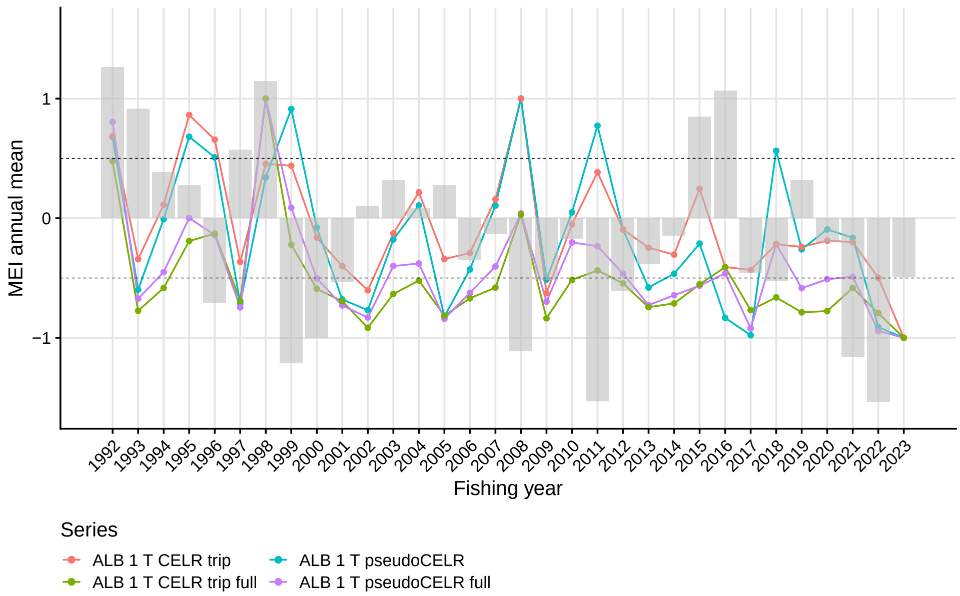

Figure 76: Comparing albacore CPUE indices (normalised to (-1,1)) with annual means (grey bars) of the Multivariate ENSO index (MEI). Dashed lines at +/- 0.5 threshold for El Nino and La Nina events.

7. DISCUSSION

The most recent assessment for south Pacific albacore used a range of information from New Zealand including tagging, length data and longline catch and effort data (Castillo Jordan et al. 2021). While New Zealand lands a small proportion of the WCPO catch, most of the troll catch (77%) comes from New Zealand and provides information on recruitment trends to the model. Although New Zealand troll CPUE was not used in the most recent assessment, the length composition from this fishery was an important source of information about recruitment. Therefore, in addition to updating the commercial troll fishery CPUE for albacore in NZ waters, we concentrated our analyses on factors influencing the size composition of albacore caught in New Zealand waters, with the aim to contribute to the upcoming stock assessment of albacore in the southwest Pacific Ocean.

CPUE standardisation at the event level had little effect on the ALB 1 indices, while the trip-based indices were standardised by the inclusion of vessel ID from increasing trends to a steady trend with a recent decline. Some spatial discrepancies in trends were evident in the daily index, with northern areas showing a steady decline since about 2008, whereas core areas off the west coast of the South Island remained stable. In recent years however, all indices declined to the lowest levels on record.

Composition analyses could not identify strong links between individual cohorts or between compositions in general and sea-surface temperature. Strong inter-annual variability in compositions was highlighted, driven by high variability between years in the presence of one-year-old to three-year-old fish in New Zealand waters. Although a considerable proportion of variability in compositions was also attributed to vessels, predicted compositions across total (including unsampled) effort were very similar to unscaled (sampled) compositions. The results between the mixture and composition model are therefore largely in agreement that the strong variability in annual compositions in the troll fishery is not due to sampling artefacts, but rather due to variability in the availability of fish from different cohorts.

Whether these patterns are due to abundance (i.e., a recruitment signal) or merely to environmentally driven availability, remains an open question. While availability is necessarily tied to abundance at some level, it remains unclear how important the abundance signal in New Zealand troll data is, or whether availability is largely driven by environmentally mediated migration or movement patterns.

Relationships between the presence of particular cohorts in New Zealand troll catch and environmental predictors could potentially shed light on the importance of environmentally driven availability. The monthly ENSO index did appear to substantially smooth CPUE indices, and standardised compositions reflected the estimated effects of ENSO driving availability of small 1-year-old fish during La-Niña years, and larger 3-year old fish during El Niño years, with a dominance of 2-year-olds in years without a strong ENSO signal. This pattern may be indicative of movement-mediated availability of different cohorts in the New Zealand troll fishery. ENSO-standardised compositions suggested that the very weak 2016 cohort identified in Scott et al. (2023) in New Zealand troll data may have been due to low presence of larger fish in New Zealand waters as opposed to low abundance of this cohort across the wider assessment region. In addition, there is little evidence for cohort progression in the NZ troll data, which would be expected if variability was largely due to recruitment strength. We attempted to repeat our composition modeling with a lagged ENSO index (to be indicative of conditions at birth year) to understand if such a model, with ENSO driving recruitment conditions, could be compared with the present model (using ENSO without a lag). However, the model results were difficult to interpret, and more research is needed to understand the relationship between birth-year conditions and compositions seen in the New Zealand fishery. However, to date the main hypothesis for variability in New Zealand troll-caught ALB length data remains that of environmentally-mediated availability, with the ENSO signal driving the availability of different cohorts in New Zealand waters.

ENSO, as a broad-scale pattern with ocean-wide impacts, may be driving both the abundance (i.e., recruitment trends) and migration of juvenile albacore. In addition, over the course of the present time-series, there were relatively few strong ENSO events, and the sample size at the extremes is therefore relatively small, so standardisation effects need to be considered with some caution.

The relationship with sea surface temperature, a more local signal, did not appear as a strong predictor of length compositions or CPUE in the present analysis (mixture and composition standardisation models). It is likely that currently available data, even that recorded at daily scales (catch-effort data and previously conducted observer sampling), do not have the necessary resolution to resolve albacore interaction with more localised features, such as ocean fronts. Length compositions from observer data appear multi-modal (Appendix E), even at the event level (results not shown for privacy reasons), suggesting that the daily resolution of troll data likely still integrates over too large an area to differentiate between cohort association with certain environmental features. In addition, the limited amount of years available from observer sampling means these data are of limited use to establish relationships with environmental drivers.

8. ACKNOWLEDGEMENTS

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APPENDIX A: ADDITIONAL CPUE SERIES

A.1 ALB 1 T pseudoCELR full

Table A.1: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the ALB 1 T pseudoCELR full CPUE series.

Series	ALB 1 T pseudoCELR full
QMS stock	ALB1
Reporting forms	CEL, ERS - Other Lining
Fishing methods	T
Target species	ALB
Statistical Areas	002, 007, 008, 009, 013, 014, 030, 031, 032, 033, 034, 035, 036, 037, 038, 039, 040, 041, 042, 045, 046, 047
Period	1991-10-01, 2023-09-30
Resolution	Day
Core fleet years	4
Core fleet trips	3
Default model	nfish ~ fyear + vessel_key + stat_area*month + ns(log(fishing_duration), 3) + ns(SST, 3) + ns(meiv2, 3)
Stepwise selection	No
Positive catch distribution	Negative-Binomial

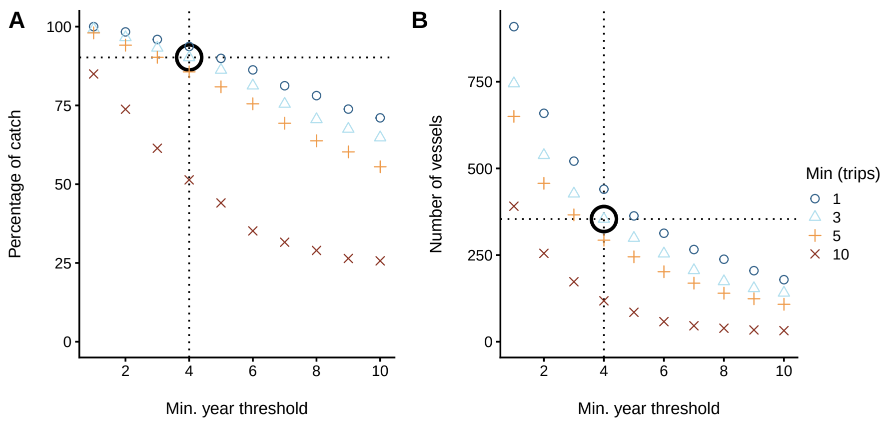

Figure A.1: Percentage of catch and number of vessels for different core vessel selection criteria for the ALB 1 T pseudoCELR full CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

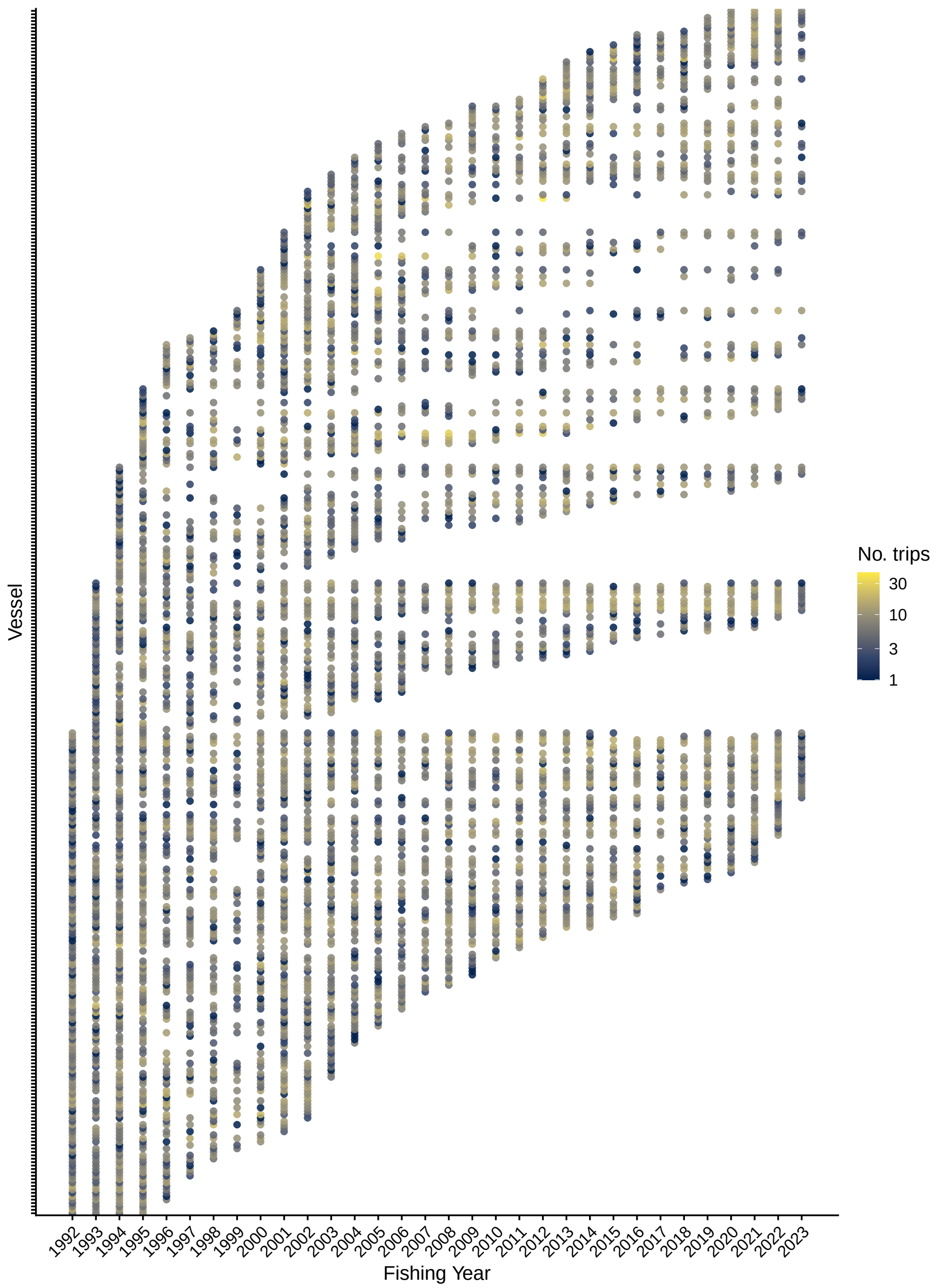

Figure A.2: Number of trips by fishing year for core vessels in the ALB 1 T pseudoCELR full series. The colour of the points is proportional to the number of trips undertaken by a vessel in a fishing year.

Table A.2: Summary of the ALB 1 T pseudoCELR full dataset total catch (tonnes) and number of records (n), by fishing year after the application of various filters. The first row gives the catch and number of records before filters were applied (ungroomed data). Subsequent rows display the remaining catch (and percent of catch), and the number of records, after the specified filter was applied. (Continued on next page)

Filter	1992	1993	1994	1995	1996	1997	1998	1999	2000
Ungroomed data	609 (100%) n: 4935	486 (100%) n: 5919	880 (100%) n: 8895	914 (100%) n: 7556	715 (100%) n: 6373	403 (100%) n: 5287	705 (100%) n: 6490	309 (100%) n: 2548	622 (100%) n: 6160
Fishing duration is not NA	606 (99.6%) n: 4909	481 (98.9%) n: 5844	869 (98.8%) n: 8766	881 (96.4%) n: 7371	685 (95.7%) n: 6083	375 (93.2%) n: 4897	682 (96.8%) n: 6234	302 (97.7%) n: 2452	571 (91.8%) n: 5620
Positive fishing duration	606 (99.5%) n: 4902	481 (98.9%) n: 5842	868 (98.6%) n: 8743	879 (96.1%) n: 7342	684 (95.7%) n: 6077	375 (93.1%) n: 4881	682 (96.8%) n: 6226	302 (97.7%) n: 2452	561 (90.2%) n: 5568
Fishing duration <20hrs	595 (97.7%) n: 4858	460 (94.5%) n: 5767	851 (96.7%) n: 8668	845 (92.5%) n: 7231	664 (92.8%) n: 5975	364 (90.5%) n: 4835	669 (94.9%) n: 6151	295 (95.3%) n: 2417	550 (88.4%) n: 5498
Season start day <212	594 (97.6%) n: 4847	459 (94.3%) n: 5741	845 (96.0%) n: 8587	841 (91.9%) n: 7128	663 (92.7%) n: 5945	364 (90.3%) n: 4809	659 (93.5%) n: 6009	294 (95.3%) n: 2408	544 (87.5%) n: 5376
Season start day >31	594 (97.6%) n: 4846	459 (94.3%) n: 5740	845 (96.0%) n: 8587	841 (91.9%) n: 7128	663 (92.6%) n: 5944	364 (90.3%) n: 4807	659 (93.5%) n: 6009	294 (95.3%) n: 2408	544 (87.5%) n: 5376
Positive catch	594 (97.6%) n: 4715	459 (94.3%) n: 5488	845 (96.0%) n: 8406	841 (91.9%) n: 6957	663 (92.6%) n: 5273	364 (90.3%) n: 4312	659 (93.5%) n: 5365	294 (95.3%) n: 2261	544 (87.5%) n: 5277
No inferred numbers	513 (84.3%) n: 3996	432 (88.8%) n: 5026	787 (89.5%) n: 7686	795 (86.9%) n: 6501	568 (79.5%) n: 4409	303 (75.2%) n: 3551	542 (76.8%) n: 4191	253 (82.0%) n: 1880	483 (77.6%) n: 4497
Core fleet selection	425 (69.8%) n: 3130	301 (61.9%) n: 3465	573 (65.1%) n: 5545	635 (69.4%) n: 4963	482 (67.4%) n: 3635	265 (65.8%) n: 3045	438 (62.1%) n: 3429	248 (80.3%) n: 1829	437 (70.2%) n: 4012

Filter	2001	2002	2003	2004	2005	2006	2007	2008	2009
Ungroomed data	549 (100%) n: 7211	585 (100%) n: 7134	779 (100%) n: 7485	733 (100%) n: 6178	503 (100%) n: 6571	429 (100%) n: 4175	377 (100%) n: 3234	669 (100%) n: 4320	412 (100%) n: 4230
Fishing duration is not NA	533 (97.1%) n: 6952	563 (96.1%) n: 6837	760 (97.6%) n: 7278	720 (98.2%) n: 6083	491 (97.7%) n: 6414	409 (95.2%) n: 3991	374 (99.1%) n: 3201	655 (98.0%) n: 4187	407 (98.9%) n: 4158
Positive fishing duration	533 (97.1%) n: 6944	562 (96.0%) n: 6827	760 (97.6%) n: 7277	720 (98.2%) n: 6083	491 (97.7%) n: 6413	409 (95.2%) n: 3991	374 (99.1%) n: 3201	655 (98.0%) n: 4186	407 (98.9%) n: 4154
Fishing duration <20hrs	526 (95.8%) n: 6890	555 (94.8%) n: 6753	751 (96.5%) n: 7238	717 (97.8%) n: 6057	489 (97.3%) n: 6398	407 (94.8%) n: 3975	372 (98.5%) n: 3188	650 (97.2%) n: 4169	405 (98.3%) n: 4139
Season start day <212	511 (93.1%) n: 6625	552 (94.4%) n: 6687	740 (95.1%) n: 7063	714 (97.4%) n: 5994	486 (96.8%) n: 6341	404 (94.2%) n: 3939	367 (97.3%) n: 3127	648 (97.0%) n: 4120	405 (98.3%) n: 4129
Season start day >31	511 (93.1%) n: 6625	552 (94.4%) n: 6687	740 (95.1%) n: 7063	714 (97.4%) n: 5994	486 (96.8%) n: 6339	404 (94.2%) n: 3939	367 (97.3%) n: 3127	648 (97.0%) n: 4120	405 (98.3%) n: 4128
Positive catch	511 (93.1%) n: 6477	552 (94.4%) n: 6588	740 (95.1%) n: 6973	714 (97.4%) n: 5780	486 (96.8%) n: 6207	404 (94.2%) n: 3886	367 (97.3%) n: 3085	648 (97.0%) n: 4088	405 (98.3%) n: 4082
No inferred numbers	499 (90.8%) n: 6126	537 (91.8%) n: 6189	709 (91.1%) n: 6492	692 (94.4%) n: 5449	451 (89.7%) n: 5509	391 (91.3%) n: 3647	361 (95.6%) n: 2982	635 (94.9%) n: 3930	388 (94.1%) n: 3812
Core fleet selection	461 (83.9%) n: 5508	479 (81.8%) n: 5510	607 (77.9%) n: 5553	611 (83.3%) n: 4818	411 (81.8%) n: 4956	370 (86.2%) n: 3434	357 (94.7%) n: 2953	611 (91.3%) n: 3778	375 (91.1%) n: 3673

Filter	2010	2011	2012	2013	2014	2015	2016	2017	2018
Ungroomed data	358 (100%) n: 3040	659 (100%) n: 4284	537 (100%) n: 4762	454 (100%) n: 4757	404 (100%) n: 4034	426 (100%) n: 3769	332 (100%) n: 3861	289 (100%) n: 3499	605 (100%) n: 4011
Fishing duration is not NA	354 (99.1%) n: 3010	653 (99.1%) n: 4215	517 (96.1%) n: 4545	446 (98.3%) n: 4647	392 (97.1%) n: 3870	419 (98.4%) n: 3682	325 (97.9%) n: 3766	284 (98.3%) n: 3423	597 (98.7%) n: 3940
Positive fishing duration	354 (99.1%) n: 3009	653 (99.1%) n: 4215	517 (96.1%) n: 4542	446 (98.3%) n: 4646	392 (97.1%) n: 3868	419 (98.4%) n: 3681	325 (97.9%) n: 3764	284 (98.3%) n: 3422	597 (98.7%) n: 3935
Fishing duration <20hrs	351 (98.2%) n: 2992	648 (98.4%) n: 4198	515 (95.8%) n: 4534	445 (98.1%) n: 4641	386 (95.4%) n: 3840	406 (95.5%) n: 3599	318 (95.8%) n: 3734	278 (96.2%) n: 3407	588 (97.1%) n: 3907
Season start day <212	347 (97.0%) n: 2925	648 (98.3%) n: 4191	511 (95.2%) n: 4462	439 (96.8%) n: 4563	379 (93.9%) n: 3745	405 (95.1%) n: 3536	308 (92.7%) n: 3580	272 (94.0%) n: 3316	587 (97.0%) n: 3872
Season start day >31	347 (97.0%) n: 2925	648 (98.3%) n: 4191	511 (95.2%) n: 4462	439 (96.8%) n: 4563	379 (93.9%) n: 3743	405 (95.1%) n: 3536	308 (92.7%) n: 3580	272 (94.0%) n: 3316	587 (97.0%) n: 3872
Positive catch	347 (97.0%) n: 2882	648 (98.3%) n: 4156	511 (95.2%) n: 4413	439 (96.8%) n: 4504	379 (93.9%) n: 3693	405 (95.1%) n: 3485	308 (92.7%) n: 3528	272 (94.0%) n: 3259	587 (97.0%) n: 3753
No inferred numbers	339 (94.8%) n: 2768	623 (94.6%) n: 3861	503 (93.5%) n: 4227	432 (95.2%) n: 4336	374 (92.5%) n: 3548	399 (93.7%) n: 3354	297 (89.4%) n: 3330	261 (90.2%) n: 3034	567 (93.7%) n: 3528
Core fleet selection	338 (94.5%) n: 2742	605 (91.9%) n: 3741	478 (89.0%) n: 4001	422 (93.0%) n: 4201	363 (89.8%) n: 3430	388 (91.1%) n: 3242	286 (86.2%) n: 3234	254 (87.7%) n: 2942	546 (90.1%) n: 3354

Filter	2019	2020	2021	2022	2023
Ungroomed data	519 (100%) n: 4599	578 (100%) n: 4936	658 (100%) n: 5746	410 (100%) n: 5085	189 (100%) n: 2853
Fishing duration is not NA	512 (98.7%) n: 4503	578 (100%) n: 4936	658 (100%) n: 5746	410 (100%) n: 5085	189 (100%) n: 2853
Positive fishing duration	512 (98.7%) n: 4503	573 (99.1%) n: 4871	644 (97.9%) n: 5652	401 (97.8%) n: 4987	186 (98.4%) n: 2810
Fishing duration <20hrs	485 (93.5%) n: 4426	568 (98.3%) n: 4851	640 (97.3%) n: 5612	397 (97.0%) n: 4961	185 (97.9%) n: 2797
Season start day <212	481 (92.6%) n: 4304	566 (97.9%) n: 4736	638 (97.1%) n: 5528	396 (96.5%) n: 4872	185 (97.9%) n: 2789
Season start day >31	481 (92.6%) n: 4304	566 (97.9%) n: 4736	638 (97.1%) n: 5528	396 (96.5%) n: 4872	185 (97.9%) n: 2789
Positive catch	481 (92.6%) n: 4159	566 (97.9%) n: 4479	638 (97.1%) n: 5244	396 (96.5%) n: 4638	185 (97.9%) n: 2631
No inferred numbers	454 (87.5%) n: 3831	566 (97.9%) n: 4479	638 (97.1%) n: 5244	396 (96.5%) n: 4638	185 (97.9%) n: 2631
Core fleet selection	433 (83.3%) n: 3587	528 (91.2%) n: 4061	558 (84.8%) n: 4447	354 (86.4%) n: 4096	102 (54.0%) n: 1305

Table A.3: Summary of ALB 1 T pseudoCELR full data subset by fishing year after the data was checked for missing values and outliers were removed. Records represent a row in the dataset daily catch.

Fishing year	Vessels	Trips	Records	Hrs	Catch (no. fish)
1992	142	882	3 130	41 754.20	425 097
1993	165	990	3 434	45 823.77	299 986
1994	198	1 429	5 536	72 500.92	571 961
1995	195	1 468	4 941	64 990.35	631 958
1996	161	1 114	3 635	47 482.38	481 835
1997	142	845	3 045	40 858.22	265 084
1998	136	966	3 428	45 253.93	437 480
1999	93	545	1 829	24 309.68	248 085
2000	160	1 172	3 996	53 617.07	435 654
2001	199	1 499	5 508	74 351.83	460 842
2002	201	1 517	5 510	74 737.60	478 789
2003	183	1 318	5 553	76 861.68	606 756
2004	176	1 136	4 818	66 657.77	610 740
2005	155	1 136	4 956	67 075.95	411 395
2006	139	842	3 434	47 506.52	369 754
2007	106	677	2 953	39 476.43	357 217
2008	123	1 014	3 778	49 370.23	610 815
2009	120	853	3 673	49 266.10	374 847
2010	97	677	2 742	36 853.90	337 986
2011	110	929	3 741	50 519.93	605 283
2012	117	1 047	4 001	54 009.40	477 999
2013	117	1 001	4 201	57 754.18	422 017
2014	114	831	3 430	47 016.10	362 761
2015	94	759	3 242	44 208.65	387 712
2016	99	731	3 234	43 509.82	286 382
2017	74	596	2 942	40 637.73	253 760
2018	97	762	3 354	45 763.95	545 623
2019	94	763	3 587	48 354.93	432 667
2020	103	793	4 061	53 228.29	527 541
2021	103	880	4 435	59 042.48	557 153
2022	93	823	4 087	52 707.73	353 646
2023	61	258	1 295	17 867.88	101 712

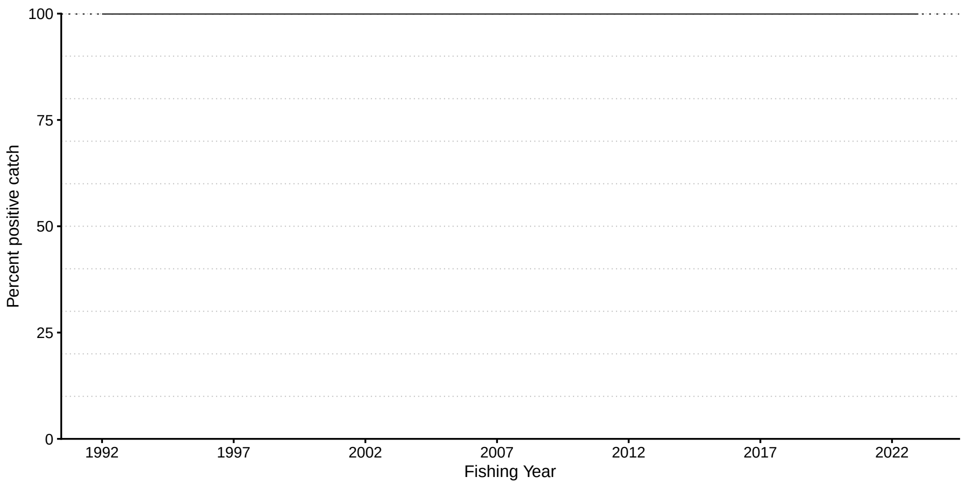

Figure A.3: Percentage of positive catch records in the ALB 1 T pseudoCELR full catch-per-unit-effort dataset.

Table A.4: Summary table for the negative-binomial model. Model terms are listed in the order offered to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
intercept	1	1 392 146	0.00	0.00	*
fyear	31	1 383 563	4.97	4.97	*
vessel_key	355	1 371 053	7.60	12.57	*
stat_area	20	1 369 130	1.13	13.70	*
month	5	1 365 857	1.89	15.59	*
ns(log(fishing_duration), 3)	3	1 353 762	6.96	22.55	*
ns(SST, 3)	3	1 353 584	0.11	22.65	*
ns(meiv2, 3)	3	1 353 511	0.05	22.70	*
stat_area:month	100	1 352 016	0.96	23.66	*

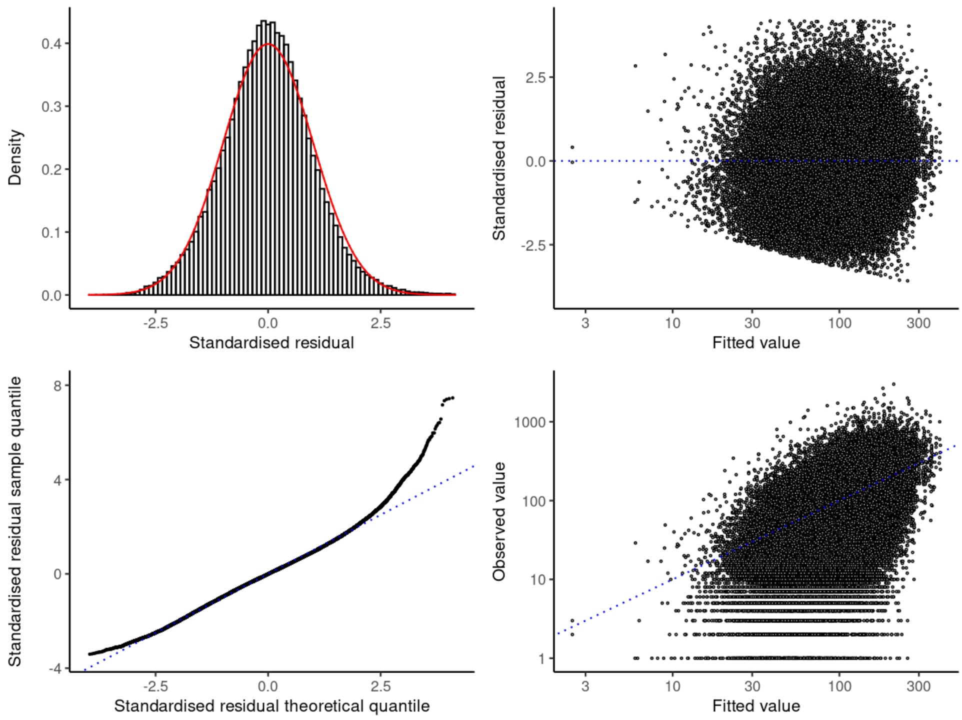

Figure A.4: Diagnostic plots for the selected negative-binomial model for positive catches in the ALB 1 T pseudoCELR full dataset.

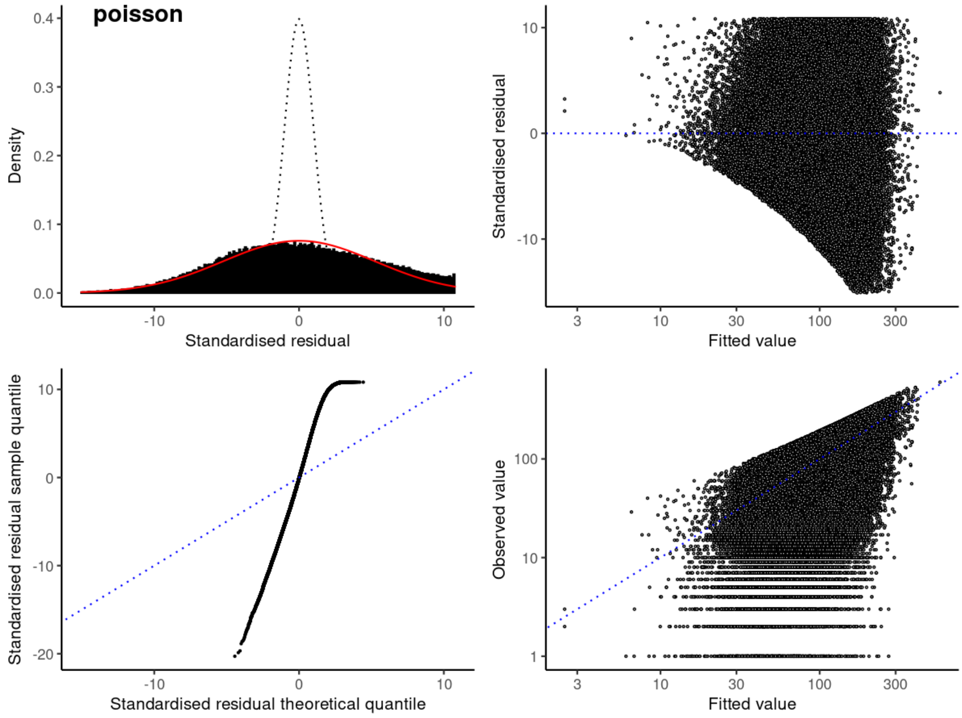

Figure A.5: Diagnostic plots for the alternative poisson models considered for positive catches in the ALB 1 T pseudoCELR full dataset.

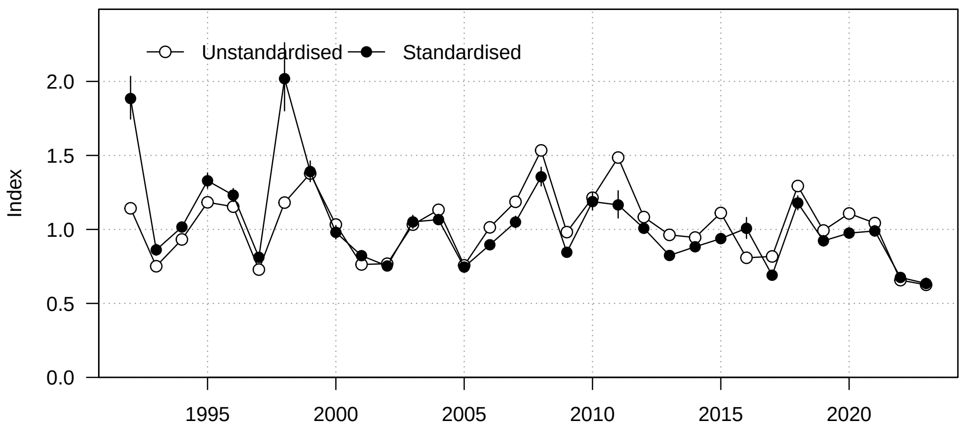

Figure A.6: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch using the negative-binomial model for the ALB 1 T pseudoCELR full dataset.

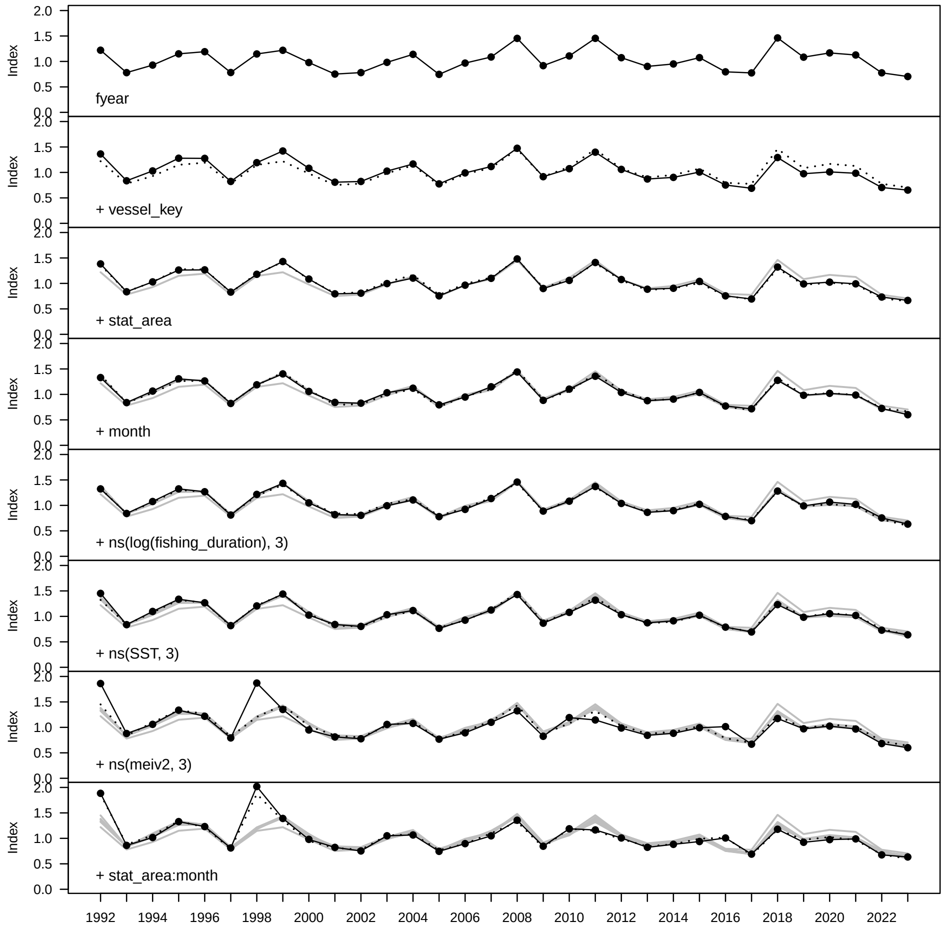

Figure A.7: Changes to the ALB 1 T pseudoCELR full positive catch index as terms are successively entered into the negative-binomial model.

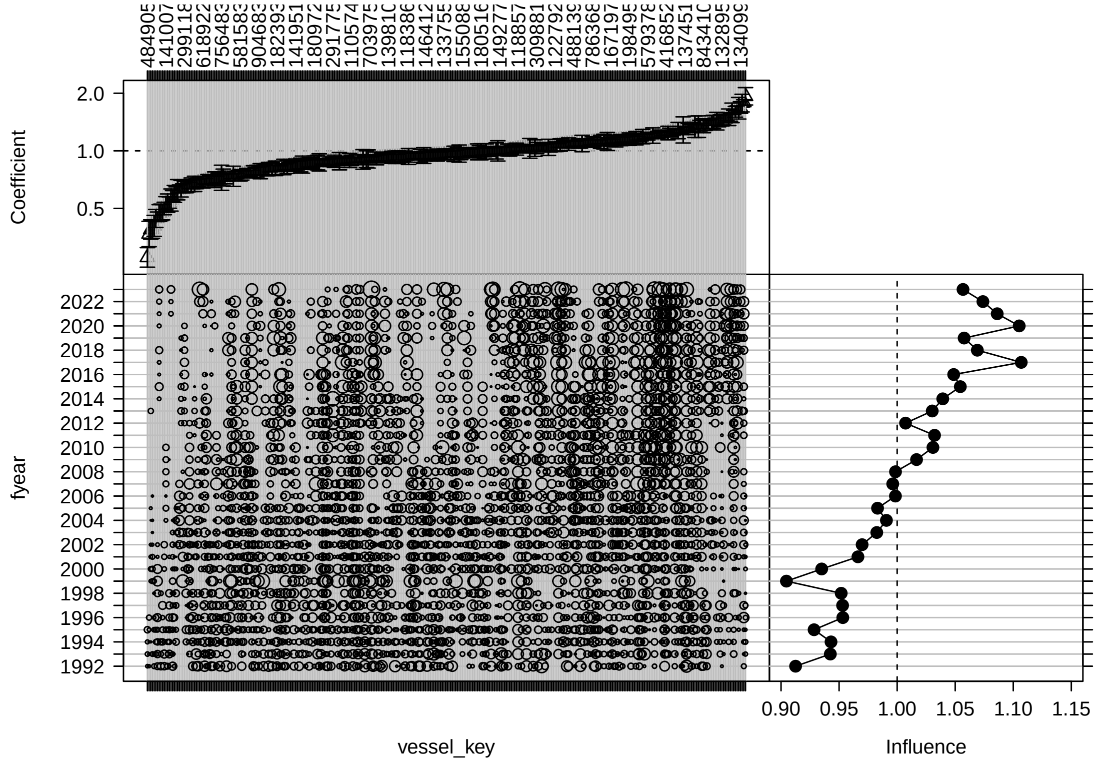

Figure A.8: CDI plot for vessel key for the negative-binomial model of positive catches in the ALB 1 T pseudoCELR full catch-per-unit-effort dataset.

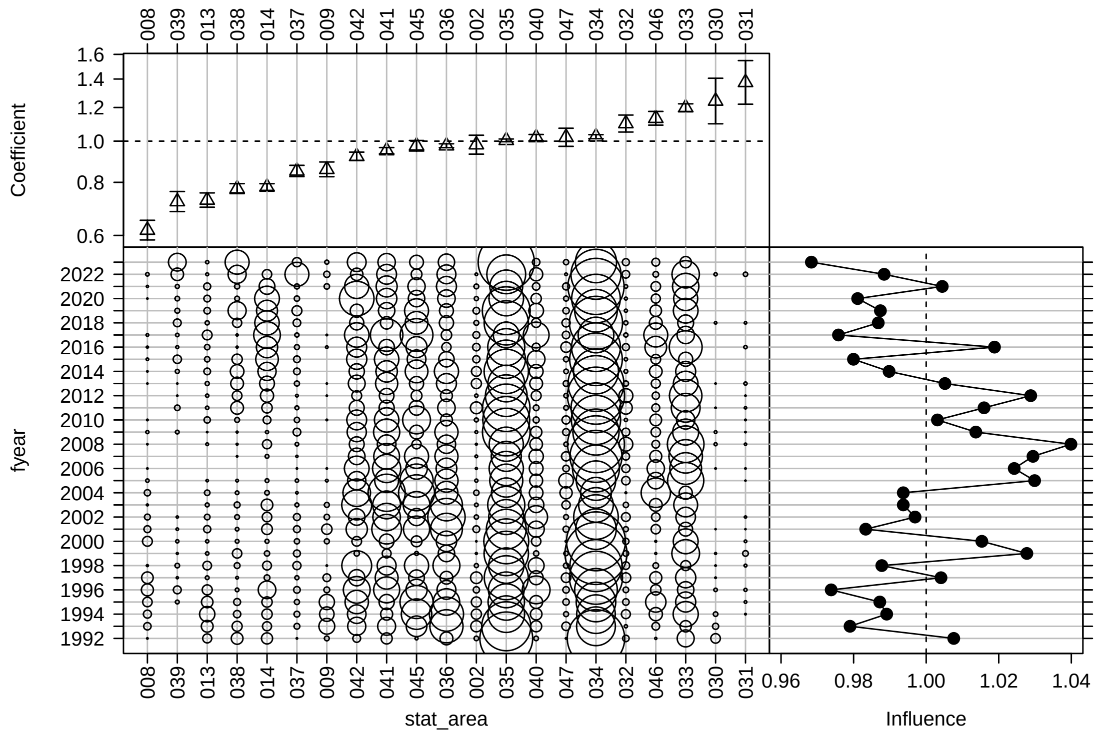

Figure A.9: CDI plot for statistical area for the negative-binomial model of positive catches in the ALB 1 T pseudoCELR full catch-per-unit-effort dataset.

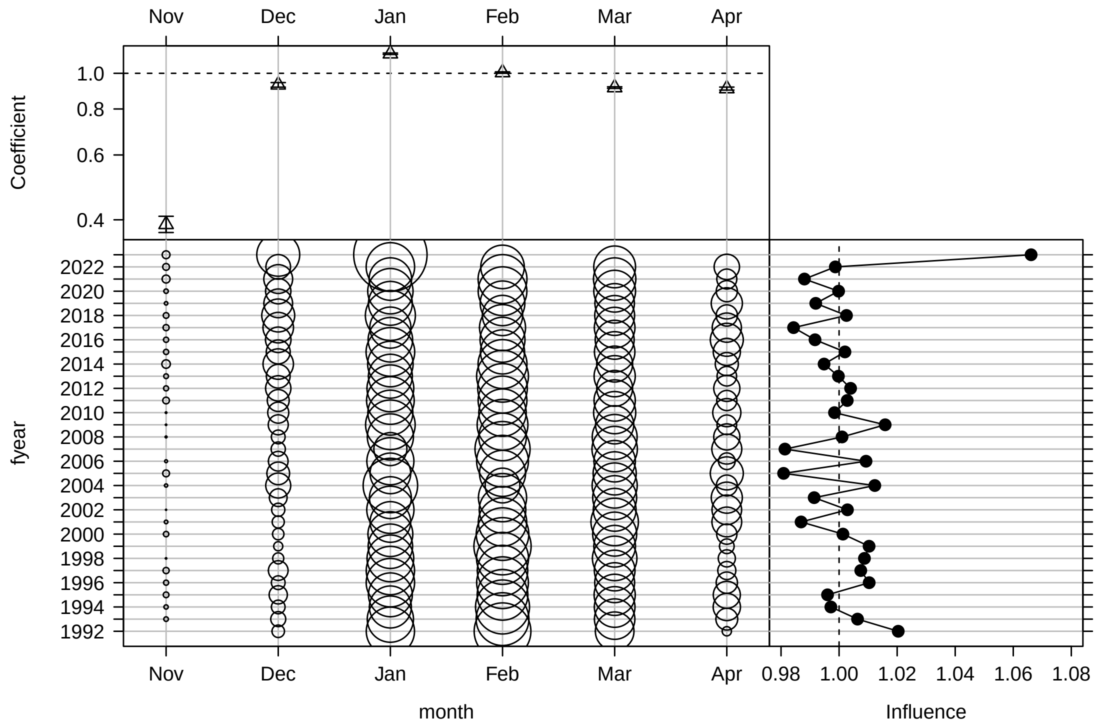

Figure A.10: CDI plot for month for the negative-binomial model of positive catches in the ALB 1 T pseudoCELR full catch-per-unit-effort dataset.

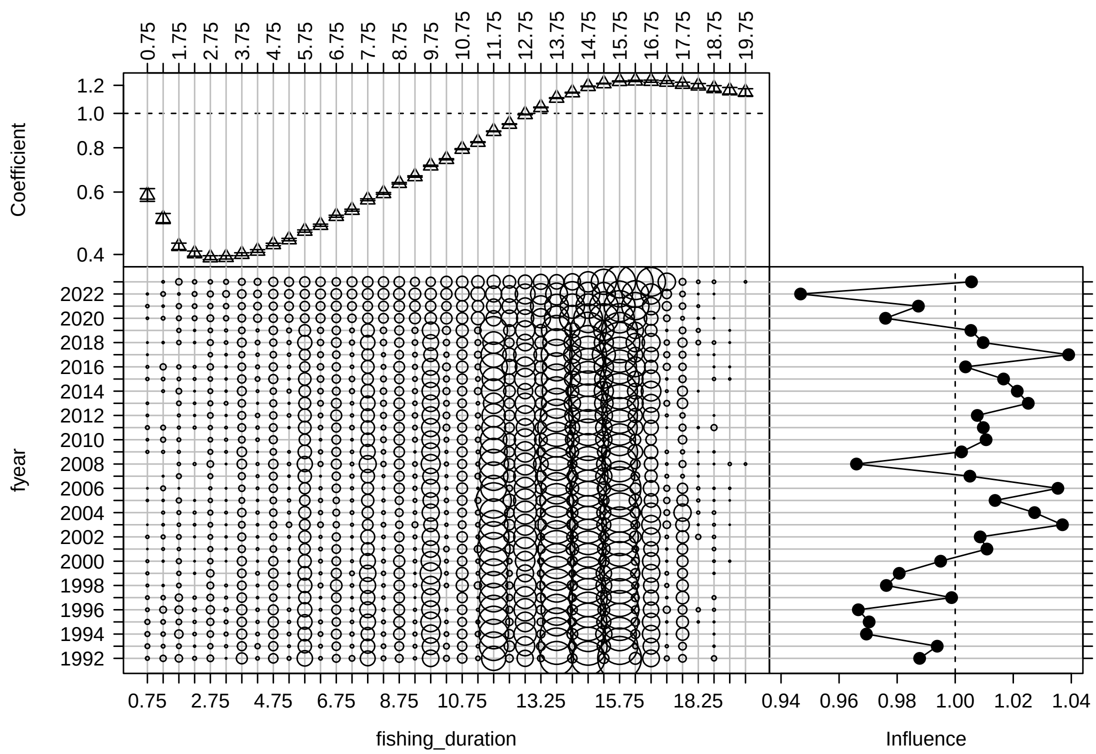

Figure A.11: CDI plot for fishing duration (h) for the negative-binomial model of positive catches in the ALB 1 T pseudoCELR full catch-per-unit-effort dataset.

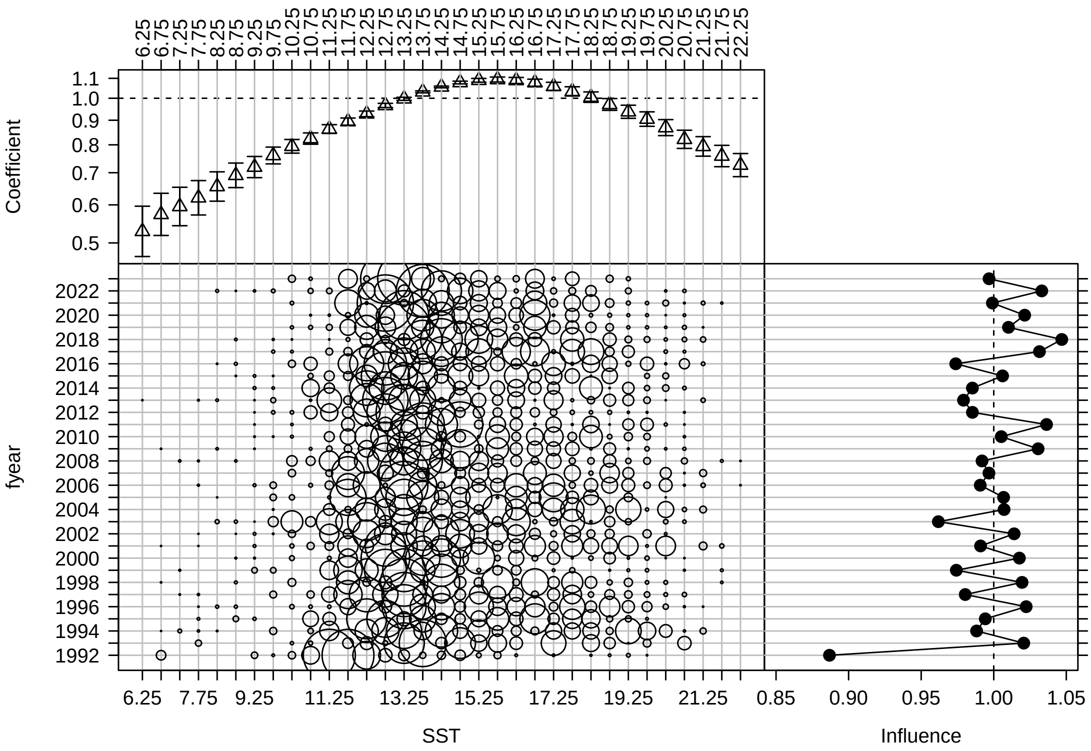

Figure A.12: CDI plot for SST for the negative-binomial model of positive catches in the ALB 1 T pseudoCELR full catch-per-unit-effort dataset.

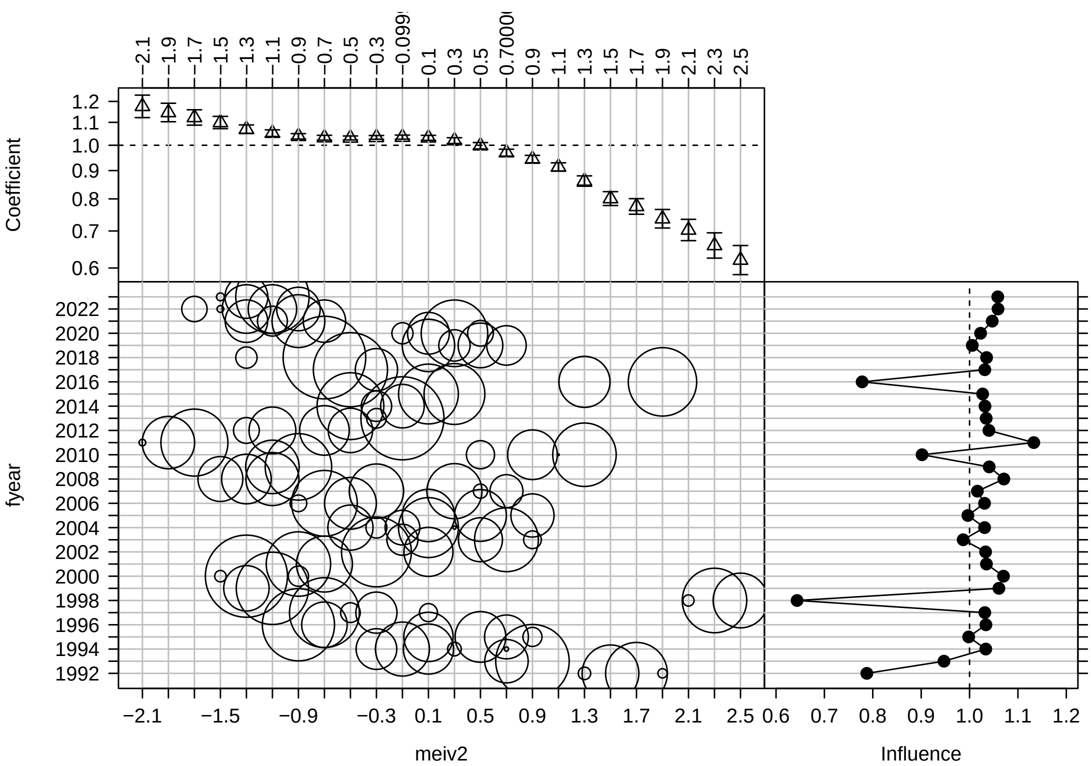

Figure A.13: CDI plot for meiv for the negative-binomial model of positive catches in the ALB 1 T pseudoCELR full catch-per-unit-effort dataset.

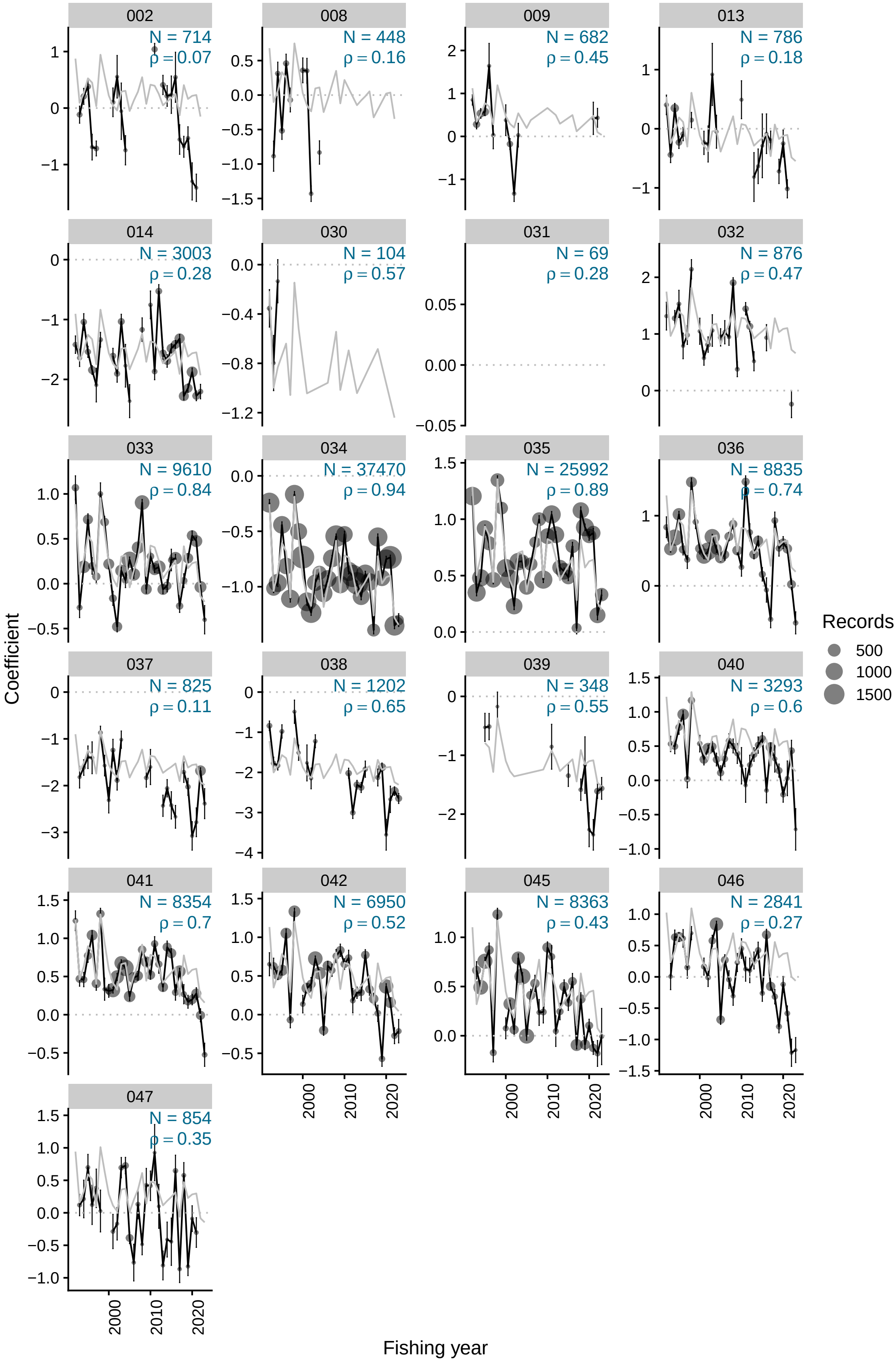

Figure A.14: Residual implied coefficients for area-year in the negative-binomial positive catch model for the ALB 1 T pseudoCELR full dataset.

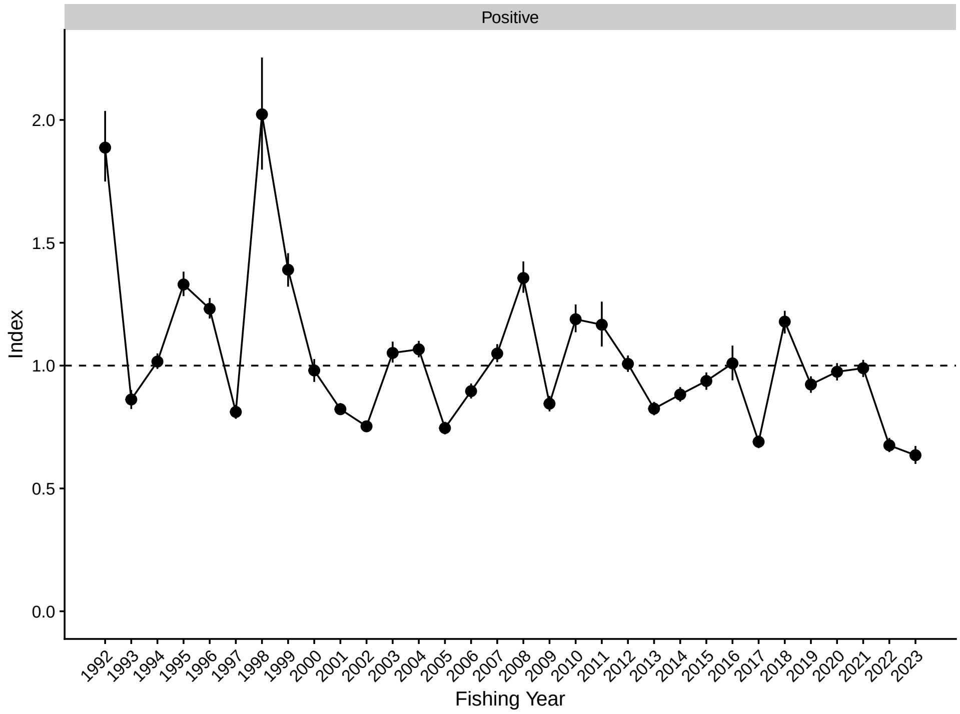

Figure A.15: Standardised indices and 95% confidence intervals for the ALB 1 T pseudoCELR full dataset.

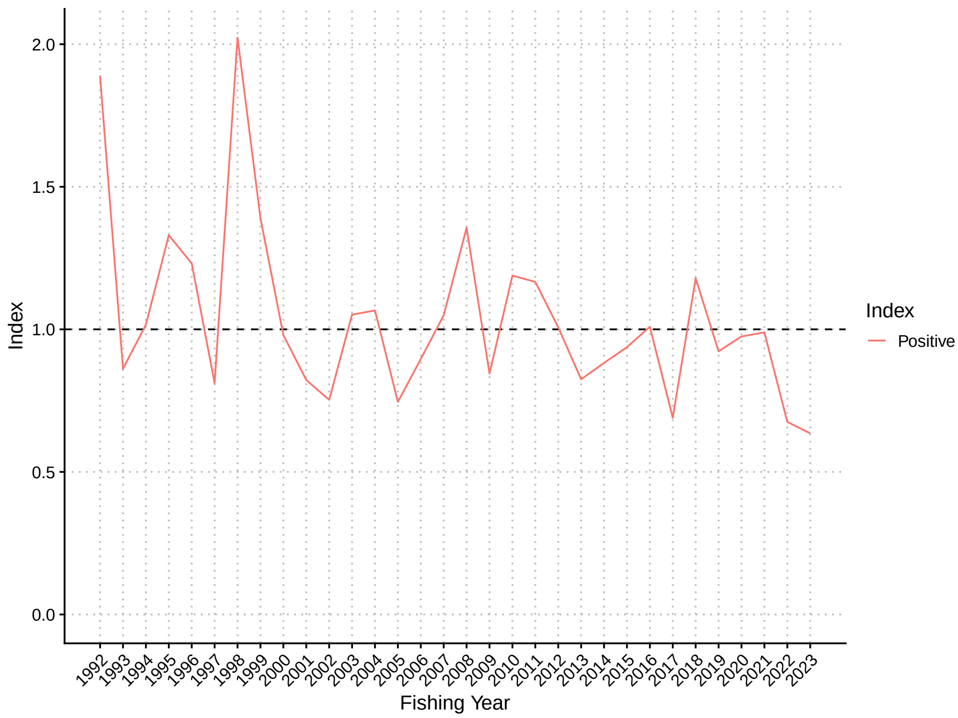

Figure A.16: Standardised indices for the ALB 1 T pseudoCELR full dataset.

Table A.5: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in ALB 1 T pseudoCELR full.

	Positive			
Fishing year	index	SE	LCI	UCI
1992	1.887	0.073	1.749	2.037
1993	0.862	0.020	0.823	0.901
1994	1.016	0.016	0.986	1.050
1995	1.330	0.025	1.283	1.382
1996	1.231	0.021	1.191	1.275
1997	0.811	0.014	0.783	0.840
1998	2.023	0.116	1.798	2.254
1999	1.390	0.035	1.321	1.458
2000	0.980	0.024	0.934	1.027
2001	0.823	0.012	0.799	0.847
2002	0.753	0.011	0.734	0.775
2003	1.052	0.022	1.012	1.098
2004	1.066	0.017	1.034	1.101
2005	0.746	0.013	0.720	0.771
2006	0.896	0.016	0.866	0.927
2007	1.049	0.019	1.014	1.087
2008	1.357	0.033	1.296	1.424
2009	0.845	0.016	0.814	0.877
2010	1.189	0.029	1.136	1.249
2011	1.166	0.047	1.078	1.261
2012	1.007	0.017	0.974	1.041
2013	0.825	0.014	0.798	0.852
2014	0.882	0.015	0.853	0.913
2015	0.937	0.018	0.902	0.972
2016	1.009	0.036	0.940	1.081
2017	0.690	0.013	0.664	0.715
2018	1.179	0.024	1.131	1.223
2019	0.923	0.017	0.889	0.957
2020	0.975	0.018	0.939	1.010
2021	0.989	0.018	0.953	1.023
2022	0.675	0.015	0.648	0.706
2023	0.635	0.019	0.600	0.673

A.2 ALB 1 T CELR trip full

Table A.6: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the ALB 1 T CELR trip full CPUE series.

Series	ALB 1 T CELR trip full
QMS stock	ALB1
Reporting forms	CEL, ERS - Other Lining
Fishing methods	T
Target species	ALB
Statistical Areas	002, 007, 008, 009, 013, 014, 030, 031, 032, 033, 034, 035, 036, 037, 038, 039, 040, 041, 042, 045, 046, 047
Period	1991-10-01, 2023-09-30
Resolution	Trip
Core fleet years	4
Core fleet trips	3
Default model	landkg ~ fyear + vessel_key + modal_stat_area*modal_month + ns(log(total_fishing_duration), 3) + ns(SST, 3) + ns(meiv2, 3)
Stepwise selection	No
Positive catch distribution	Gamma

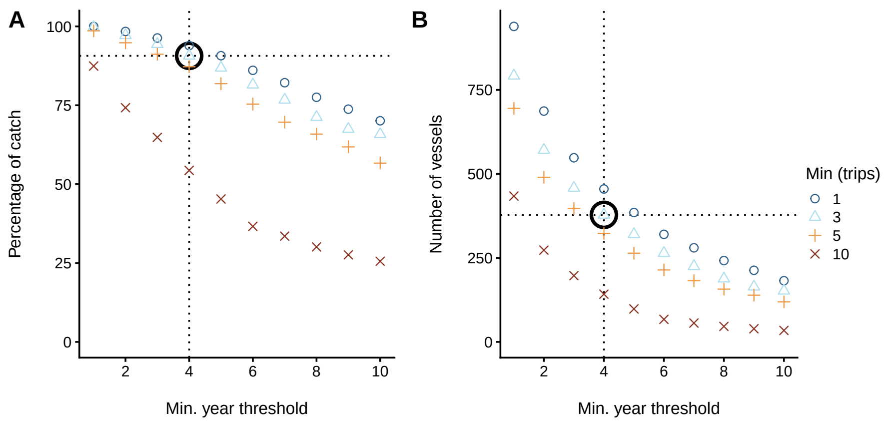

Figure A.17: Percentage of catch and number of vessels for different core vessel selection criteria for the ALB 1 T CELR trip full CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

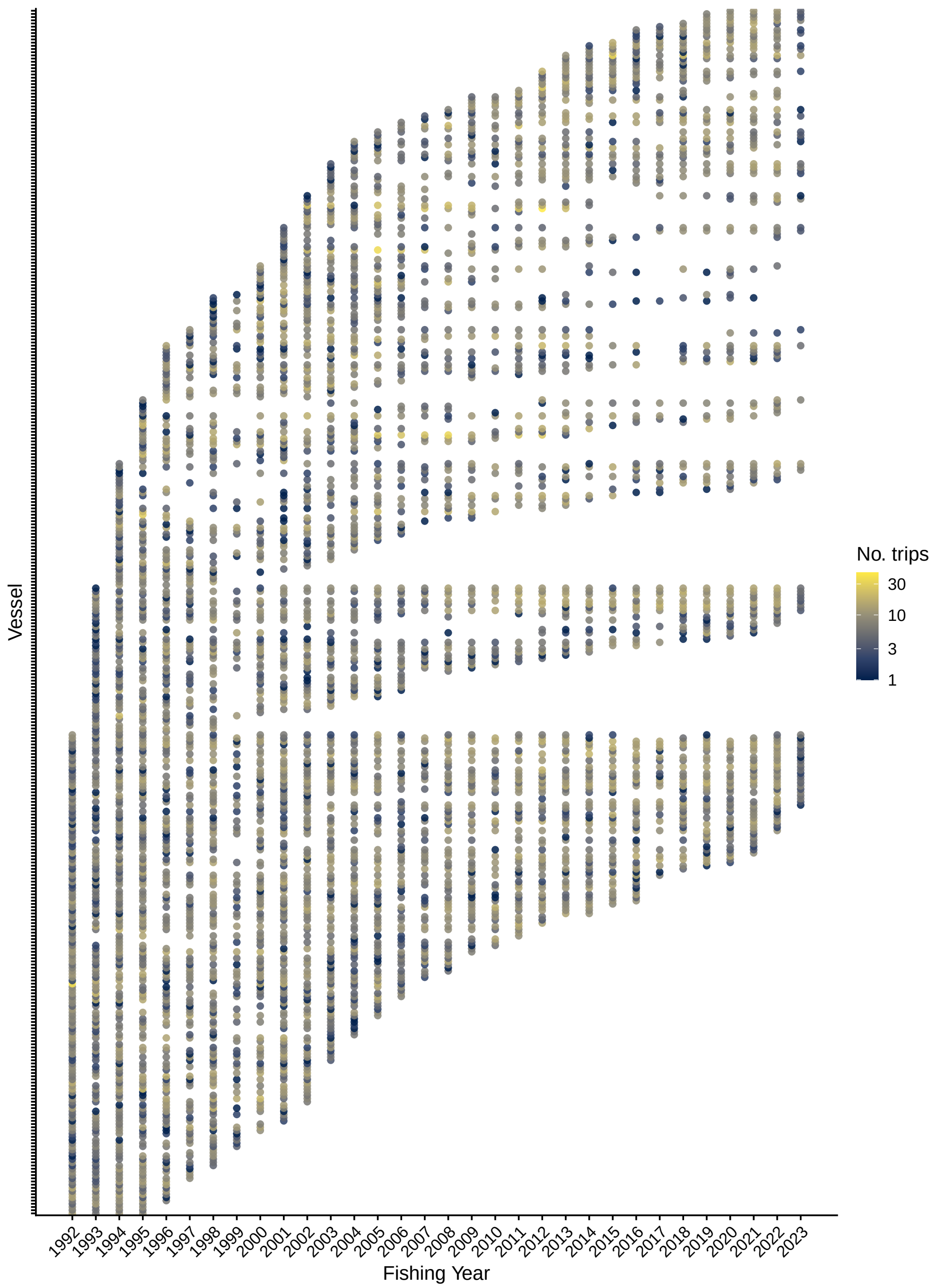

Figure A.18: Number of trips by fishing year for core vessels in the ALB 1 T CELR trip full series. The colour of the points is proportional to the number of trips undertaken by a vessel in a fishing year.

Table A.7: Summary of the ALB 1 T CELR trip full dataset total catch (tonnes) and number of records (n), by fishing year after the application of various filters. The first row gives the catch and number of records before filters were applied (ungroomed data). Subsequent rows display the remaining catch (and percent of catch), and the number of records, after the specified filter was applied. (Continued on next page)

Filter	1992	1993	1994	1995	1996	1997	1998	1999	2000
Ungroomed data	3057 (100%) n: 1496	2450 (100%) n: 1715	4277 (100%) n: 2462	4710 (100%) n: 2488	3887 (100%) n: 2003	2238 (100%) n: 1524	3986 (100%) n: 1805	1508 (100%) n: 726	2894 (100%) n: 1788
Fishing duration is not NA	3050 (99.8%) n: 1490	2434 (99.3%) n: 1697	4232 (98.9%) n: 2433	4596 (97.6%) n: 2417	3759 (96.7%) n: 1910	2083 (93.1%) n: 1424	3879 (97.3%) n: 1744	1474 (97.8%) n: 701	2685 (92.8%) n: 1626
Positive fishing duration	3050 (99.8%) n: 1490	2434 (99.3%) n: 1697	4232 (98.9%) n: 2433	4596 (97.6%) n: 2417	3759 (96.7%) n: 1910	2083 (93.1%) n: 1424	3879 (97.3%) n: 1744	1474 (97.8%) n: 701	2685 (92.8%) n: 1626
Total fishing duration <180hrs	2975 (97.3%) n: 1484	2235 (91.2%) n: 1682	3918 (91.6%) n: 2413	4535 (96.3%) n: 2411	3602 (92.7%) n: 1899	2037 (91.0%) n: 1419	3749 (94.0%) n: 1736	1474 (97.8%) n: 701	2673 (92.3%) n: 1624
Season Nov Apr	2974 (97.3%) n: 1482	2231 (91.0%) n: 1669	3908 (91.4%) n: 2392	4508 (95.7%) n: 2374	3600 (92.6%) n: 1889	2033 (90.8%) n: 1407	3701 (92.8%) n: 1701	1473 (97.7%) n: 697	2651 (91.6%) n: 1582
Positive catch	2974 (97.3%) n: 1458	2231 (91.0%) n: 1621	3908 (91.4%) n: 2346	4508 (95.7%) n: 2339	3600 (92.6%) n: 1854	2033 (90.8%) n: 1381	3701 (92.8%) n: 1661	1473 (97.7%) n: 690	2651 (91.6%) n: 1570
Core fleet selection	2408 (78.8%) n: 1035	1721 (70.2%) n: 1052	2947 (68.9%) n: 1530	3642 (77.3%) n: 1603	3118 (80.2%) n: 1463	1794 (80.1%) n: 1114	3121 (78.3%) n: 1370	1444 (95.8%) n: 665	2451 (84.7%) n: 1381

Filter	2001	2002	2003	2004	2005	2006	2007	2008	2009
Ungroomed data	2915 (100%) n: 2035	3061 (100%) n: 1993	3899 (100%) n: 1759	3928 (100%) n: 1469	2848 (100%) n: 1522	2210 (100%) n: 1031	1817 (100%) n: 751	3328 (100%) n: 1207	1776 (100%) n: 1024
Fishing duration is not NA	2830 (97.1%) n: 1954	2958 (96.6%) n: 1887	3820 (98.0%) n: 1697	3879 (98.7%) n: 1439	2788 (97.9%) n: 1465	2112 (95.5%) n: 966	1811 (99.6%) n: 737	3256 (97.8%) n: 1125	1761 (99.1%) n: 1006
Positive fishing duration	2830 (97.1%) n: 1954	2958 (96.6%) n: 1887	3820 (98.0%) n: 1697	3879 (98.7%) n: 1439	2788 (97.9%) n: 1465	2112 (95.5%) n: 966	1811 (99.6%) n: 737	3256 (97.8%) n: 1125	1761 (99.1%) n: 1006
Total fishing duration <180hrs	2814 (96.5%) n: 1951	2912 (95.1%) n: 1880	3772 (96.7%) n: 1690	3798 (96.7%) n: 1432	2777 (97.5%) n: 1463	2101 (95.0%) n: 964	1811 (99.6%) n: 737	3256 (97.8%) n: 1125	1757 (98.9%) n: 1005
Season Nov Apr	2761 (94.7%) n: 1851	2907 (95.0%) n: 1863	3737 (95.9%) n: 1658	3786 (96.4%) n: 1419	2766 (97.1%) n: 1449	2082 (94.2%) n: 957	1789 (98.5%) n: 721	3250 (97.7%) n: 1108	1756 (98.9%) n: 1002
Positive catch	2761 (94.7%) n: 1803	2907 (95.0%) n: 1825	3737 (95.9%) n: 1622	3786 (96.4%) n: 1379	2766 (97.1%) n: 1407	2082 (94.2%) n: 941	1789 (98.5%) n: 701	3250 (97.7%) n: 1098	1756 (98.9%) n: 996
Core fleet selection	2546 (87.3%) n: 1523	2583 (84.4%) n: 1589	3239 (83.1%) n: 1406	3298 (83.9%) n: 1209	2524 (88.6%) n: 1279	1987 (89.9%) n: 881	1769 (97.3%) n: 688	3132 (94.1%) n: 1031	1694 (95.3%) n: 922

Filter	2010	2011	2012	2013	2014	2015	2016	2017	2018
Ungroomed data	1720 (100%) n: 751	2970 (100%) n: 1097	2714 (100%) n: 1296	2574 (100%) n: 1169	2138 (100%) n: 968	2349 (100%) n: 882	1905 (100%) n: 851	1811 (100%) n: 702	2300 (100%) n: 888
Fishing duration is not NA	1713 (99.6%) n: 742	2948 (99.3%) n: 1059	2627 (96.8%) n: 1208	2541 (98.7%) n: 1127	2078 (97.2%) n: 924	2321 (98.8%) n: 863	1872 (98.2%) n: 828	1800 (99.4%) n: 690	2280 (99.1%) n: 872
Positive fishing duration	1713 (99.6%) n: 742	2948 (99.3%) n: 1059	2627 (96.8%) n: 1208	2541 (98.7%) n: 1127	2078 (97.2%) n: 924	2321 (98.8%) n: 863	1872 (98.2%) n: 828	1800 (99.4%) n: 690	2280 (99.1%) n: 872
Total fishing duration <180hrs	1702 (98.9%) n: 740	2917 (98.2%) n: 1056	2627 (96.8%) n: 1208	2541 (98.7%) n: 1127	2064 (96.5%) n: 920	2275 (96.9%) n: 858	1872 (98.2%) n: 828	1766 (97.5%) n: 687	2262 (98.3%) n: 869
Season Nov Apr	1675 (97.4%) n: 726	2916 (98.2%) n: 1054	2614 (96.3%) n: 1190	2522 (98.0%) n: 1103	2040 (95.4%) n: 895	2267 (96.5%) n: 836	1830 (96.0%) n: 803	1705 (94.2%) n: 660	2260 (98.2%) n: 860
Positive catch	1675 (97.4%) n: 712	2916 (98.2%) n: 1049	2614 (96.3%) n: 1179	2522 (98.0%) n: 1075	2040 (95.4%) n: 885	2267 (96.5%) n: 823	1830 (96.0%) n: 787	1705 (94.2%) n: 640	2260 (98.2%) n: 846
Core fleet selection	1623 (94.4%) n: 688	2818 (94.9%) n: 997	2481 (91.4%) n: 1080	2444 (94.9%) n: 1022	1985 (92.8%) n: 854	2224 (94.7%) n: 806	1753 (92.0%) n: 769	1640 (90.6%) n: 612	2181 (94.8%) n: 799

Filter	**2019**	**2020**	**2021**	**2022**	**2023**
Ungroomed data	2452 (100%) n: 985	2845 (100%) n: 1051	3268 (100%) n: 1182	2357 (100%) n: 1035	889 (100%) n: 613
Fishing duration is not NA	2430 (99.1%) n: 962	2845 (100%) n: 1051	3268 (100%) n: 1182	2357 (100%) n: 1035	889 (100%) n: 613
Positive fishing duration	2430 (99.1%) n: 962	2844 (100.0%) n: 1048	3244 (99.3%) n: 1171	2333 (99.0%) n: 1028	887 (99.7%) n: 610
Total fishing duration <180hrs	2414 (98.4%) n: 959	2822 (99.2%) n: 1034	3234 (99.0%) n: 1163	2328 (98.8%) n: 1025	884 (99.5%) n: 607
Season Nov Apr	2384 (97.3%) n: 931	2812 (98.8%) n: 1006	3226 (98.7%) n: 1139	2319 (98.4%) n: 1009	882 (99.2%) n: 604
Positive catch	2384 (97.3%) n: 916	2812 (98.8%) n: 950	3226 (98.7%) n: 1075	2319 (98.4%) n: 953	882 (99.2%) n: 579
Core fleet selection	2247 (91.6%) n: 861	2655 (93.3%) n: 833	2818 (86.2%) n: 888	2062 (87.5%) n: 825	515 (57.9%) n: 259

Table A.8: Summary of ALB 1 T CELR trip full data subset by fishing year after the data was checked for missing values and outliers were removed. Records represent a row in the dataset trip catch.

Fishing year	Vessels	Trips	Records	Hrs	Catch (t)
1992	151	1 035	1 035	48 486.10	2 407.80
1993	176	1 038	1 038	49 672.83	1 717.40
1994	210	1 517	1 517	79 903.38	2 925.55
1995	202	1 589	1 589	71 291.22	3 618.14
1996	194	1 463	1 463	64 164.68	3 118.07
1997	165	1 114	1 114	53 278.85	1 793.94
1998	178	1 368	1 368	64 735.98	3 119.14
1999	104	665	665	30 726.85	1 444.00
2000	172	1 372	1 372	65 018.22	2 442.93
2001	201	1 523	1 523	78 555.22	2 545.97
2002	202	1 584	1 584	80 288.27	2 578.87
2003	190	1 406	1 406	83 732.80	3 239.09
2004	180	1 209	1 209	70 828.13	3 297.86
2005	159	1 279	1 279	75 970.83	2 523.66
2006	142	881	881	50 725.27	1 986.72
2007	106	688	688	40 936.33	1 768.73
2008	121	1 031	1 031	51 290.17	3 131.65
2009	121	922	922	52 223.75	1 693.70
2010	89	688	688	37 485.32	1 623.49
2011	112	997	997	53 201.88	2 818.19
2012	115	1 080	1 080	56 096.82	2 480.51
2013	118	1 022	1 022	59 437.35	2 443.73
2014	113	854	854	48 954.02	1 984.76
2015	89	806	806	47 027.38	2 223.95
2016	99	769	769	47 458.18	1 752.86
2017	75	612	612	42 913.30	1 639.89
2018	100	799	799	49 757.08	2 180.63
2019	99	861	861	55 851.10	2 246.51
2020	105	833	833	60 288.14	2 655.07
2021	103	883	883	65 122.35	2 815.55
2022	94	823	823	56 729.85	2 060.93
2023	61	257	257	19 635.27	513.54

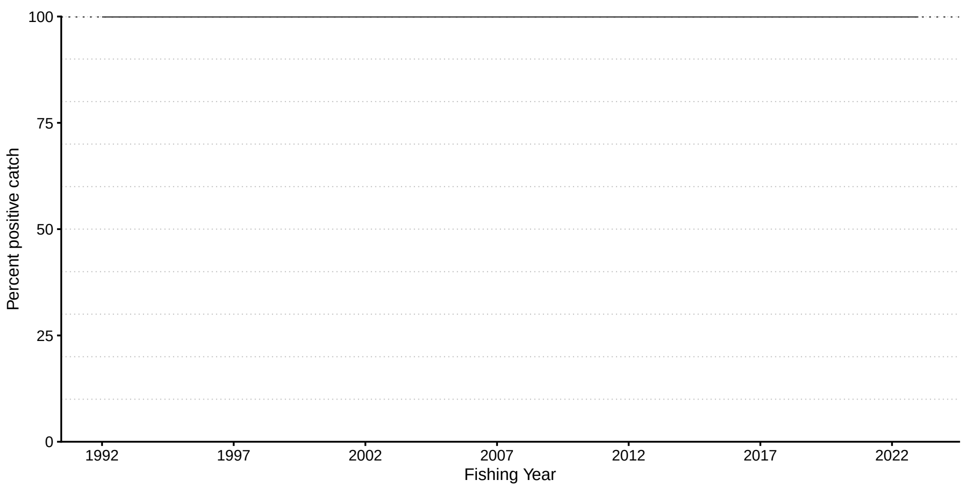

Figure A.19: Percentage of positive catch records in the ALB 1 T CELR trip full catch-per-unit-effort dataset.

Table A.9: Summary table for the gamma model. Model terms are listed in the order offered to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
intercept	1	576 852.4	0.00	0.00	*
fyear	31	575 588.3	3.39	3.39	*
vessel_key	380	562 114.9	30.45	33.83	*
modal_stat_area	20	561 250.3	1.61	35.44	*
modal_month	5	560 121.7	1.97	37.41	*
ns(log(total_fishing_duration), 3)	3	547 058.3	19.00	56.41	*
ns(SST, 3)	3	547 027.3	0.05	56.46	*
ns(meiv2, 3)	3	546 970.2	0.08	56.54	*
modal_stat_area:modal_month	100	546 674.6	0.57	57.11	*

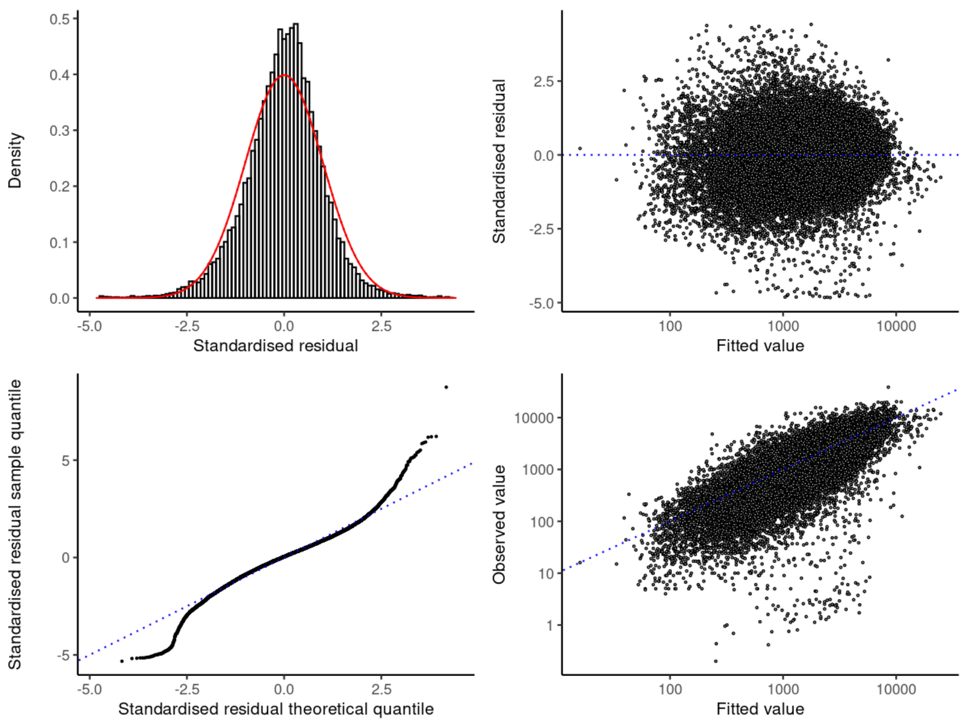

Figure A.20: Diagnostic plots for the selected gamma model for positive catches in the ALB 1 T CELR trip full dataset.

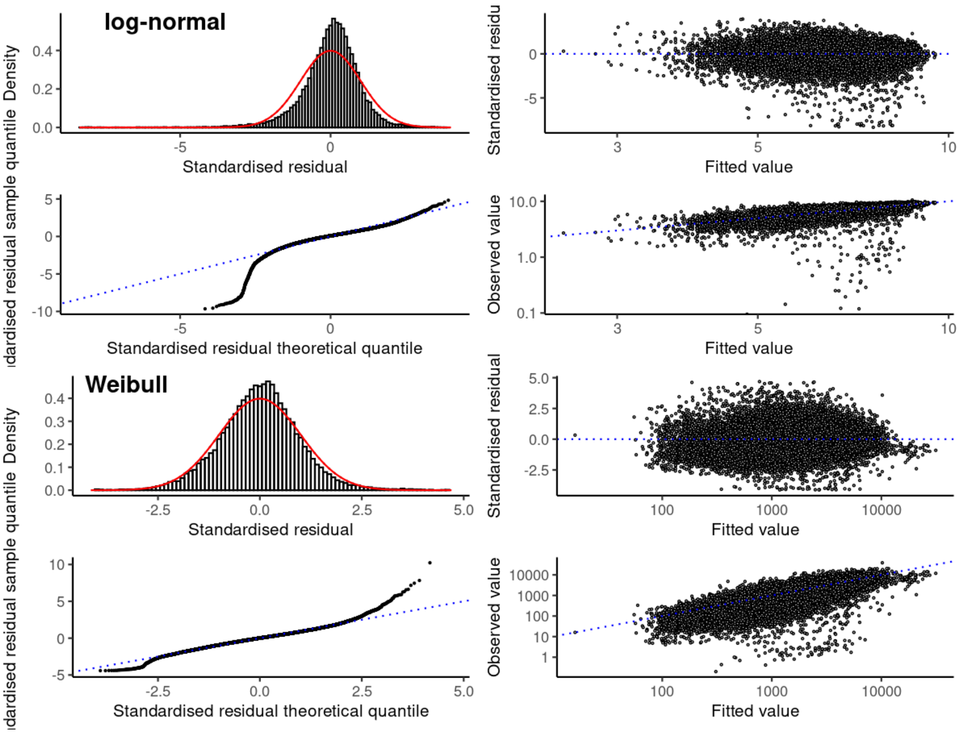

Figure A.21: Diagnostic plots for the alternative log-normal and Weibull models considered for positive catches in the ALB 1 T CELR trip full dataset.

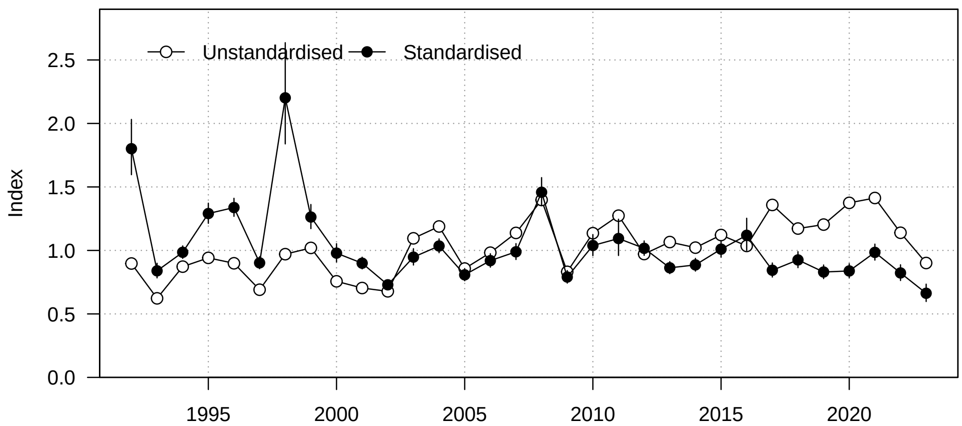

Figure A.22: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch using the gamma model for the ALB 1 T CELR trip full dataset.

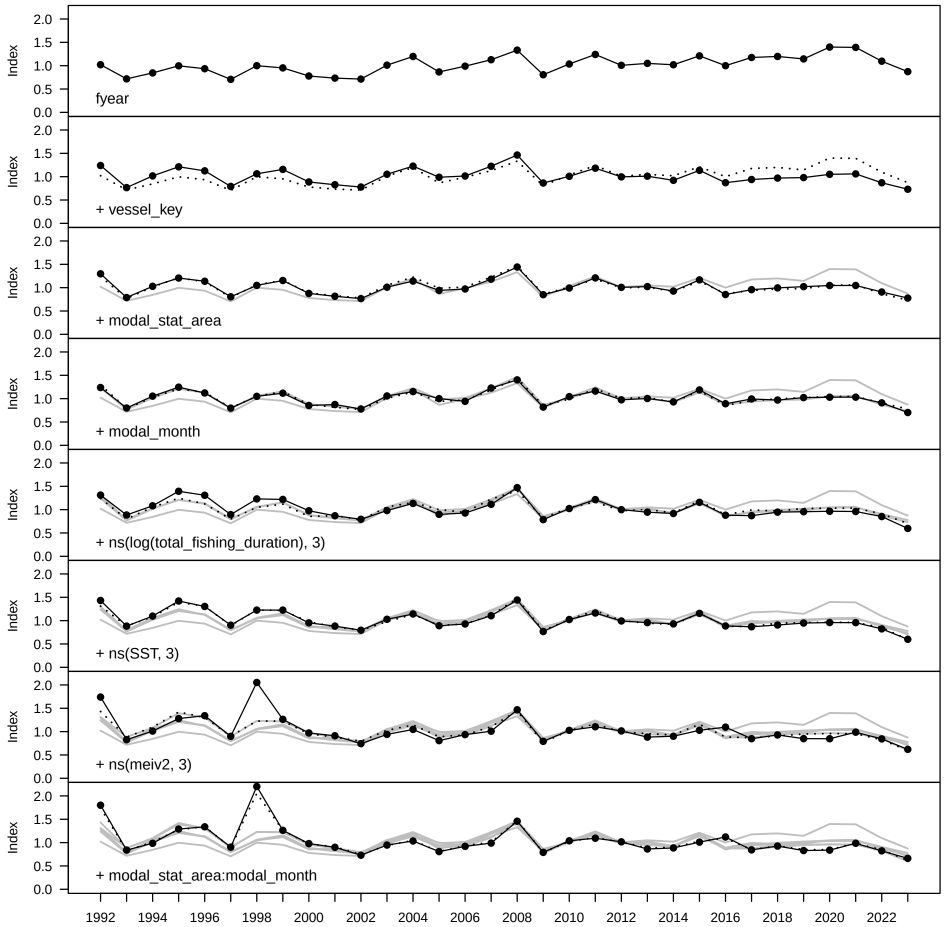

Figure A.23: Changes to the ALB 1 T CELR trip full positive catch index as terms are successively entered into the gamma model.

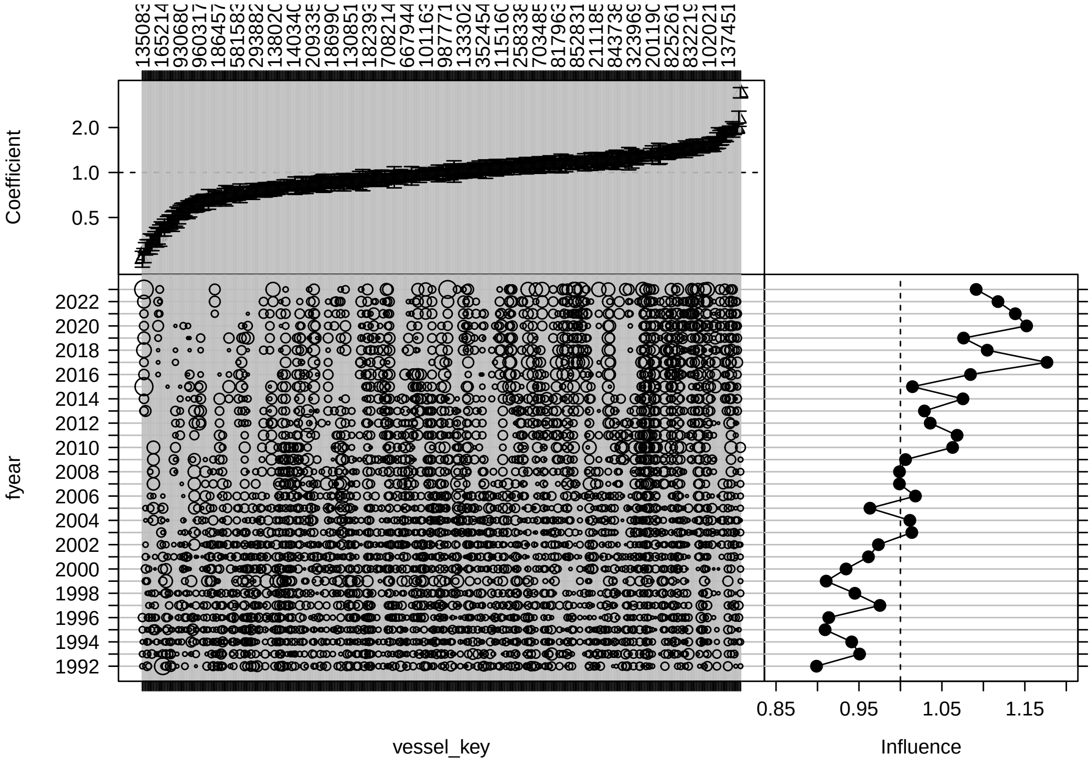

Figure A.24: CDI plot for vessel key for the gamma model of positive catches in the ALB 1 T CELR trip full catch-per-unit-effort dataset.

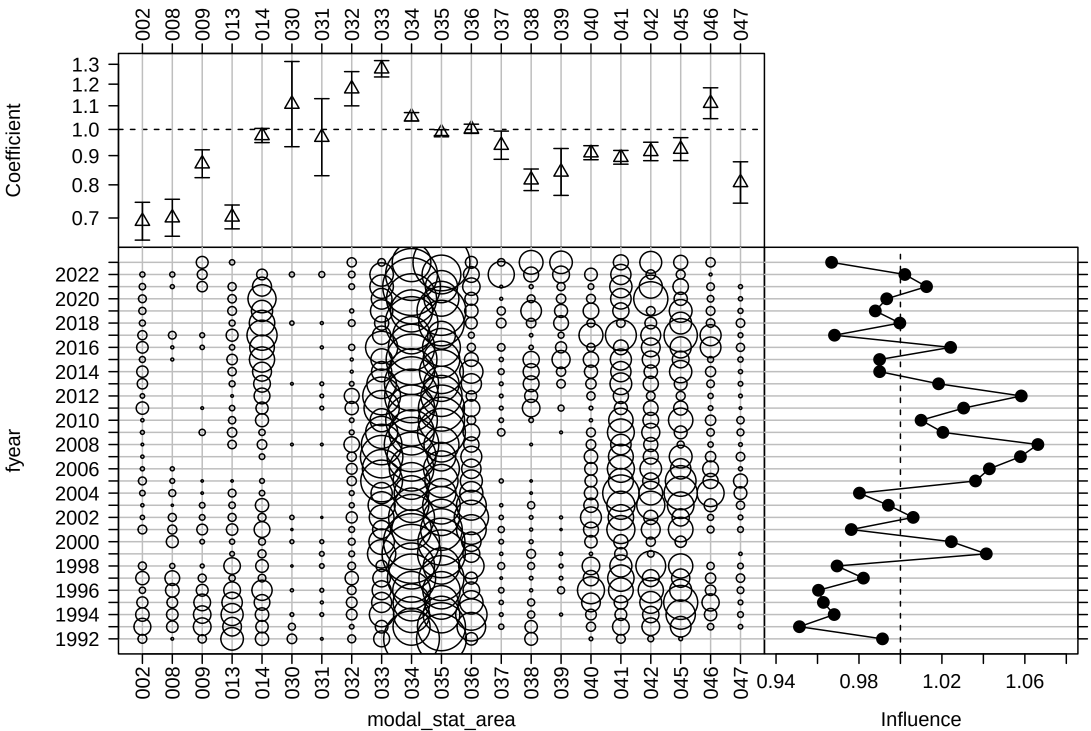

Figure A.25: CDI plot for modal statistical area for the gamma model of positive catches in the ALB 1 T CELR trip full catch-per-unit-effort dataset.

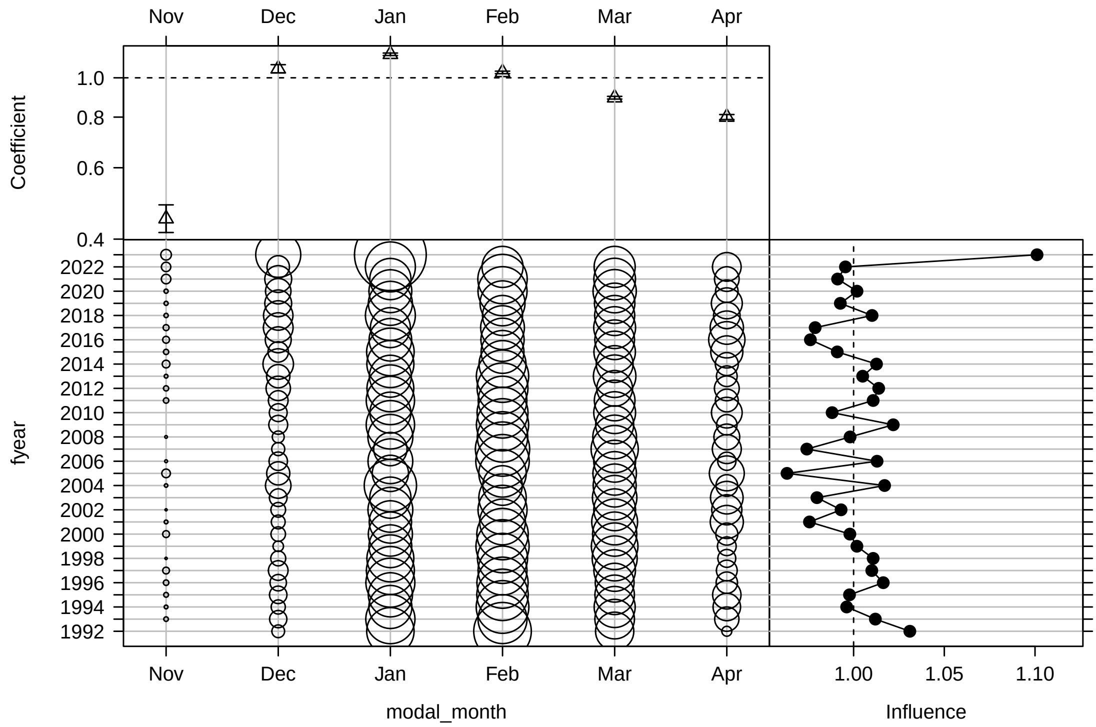

Figure A.26: CDI plot for modal month for the gamma model of positive catches in the ALB 1 T CELR trip full catch-per-unit-effort dataset.

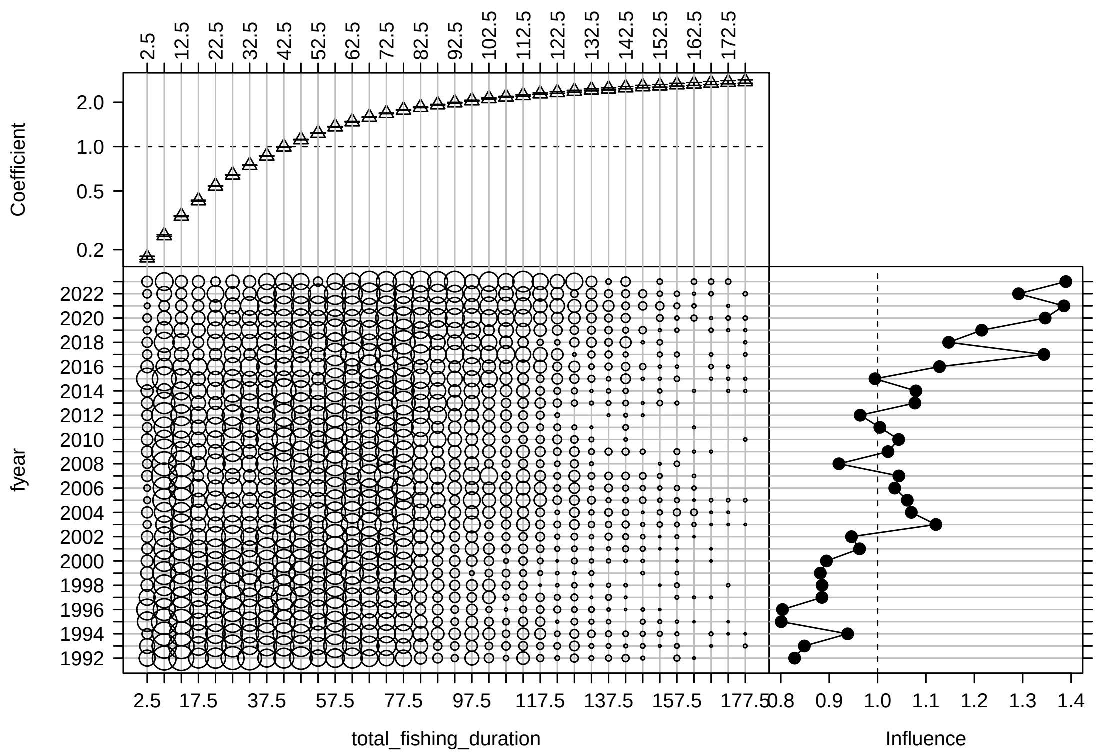

Figure A.27: CDI plot for total fishing duration (h) for the gamma model of positive catches in the ALB 1 T CELR trip full catch-per-unit-effort dataset.

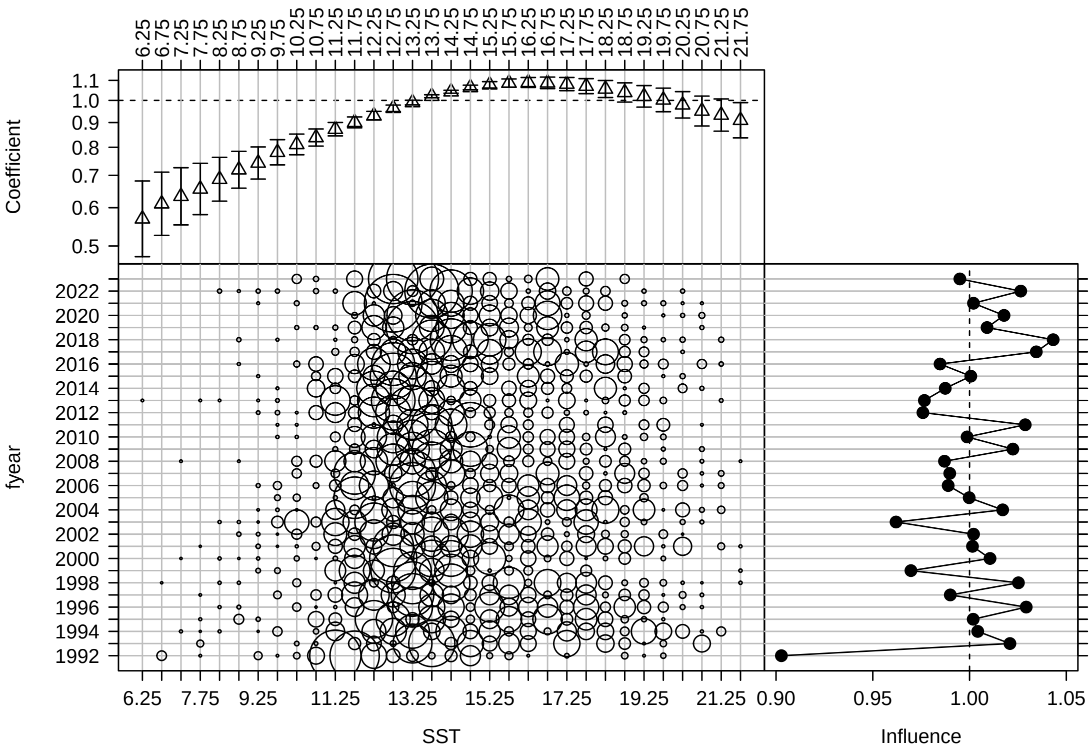

Figure A.28: CDI plot for SST for the gamma model of positive catches in the ALB 1 T CELR trip full catch-per-unit-effort dataset.

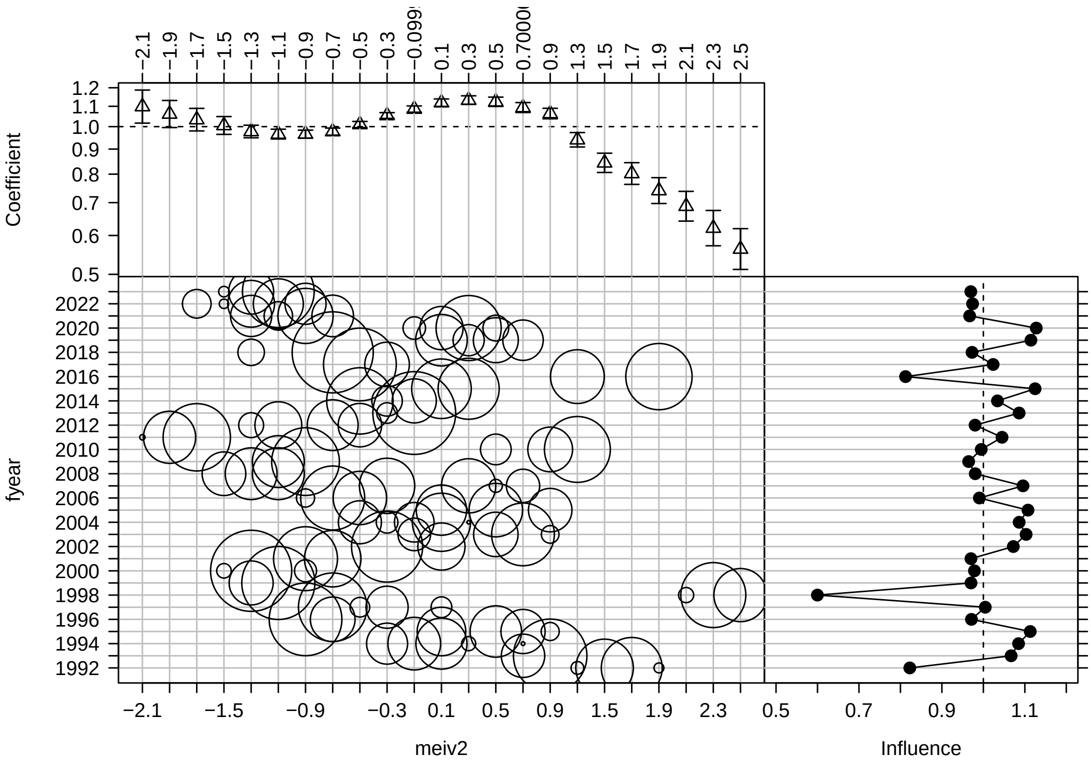

Figure A.29: CDI plot for meiv for the gamma model of positive catches in the ALB 1 T CELR trip full catch-per-unit-effort dataset.

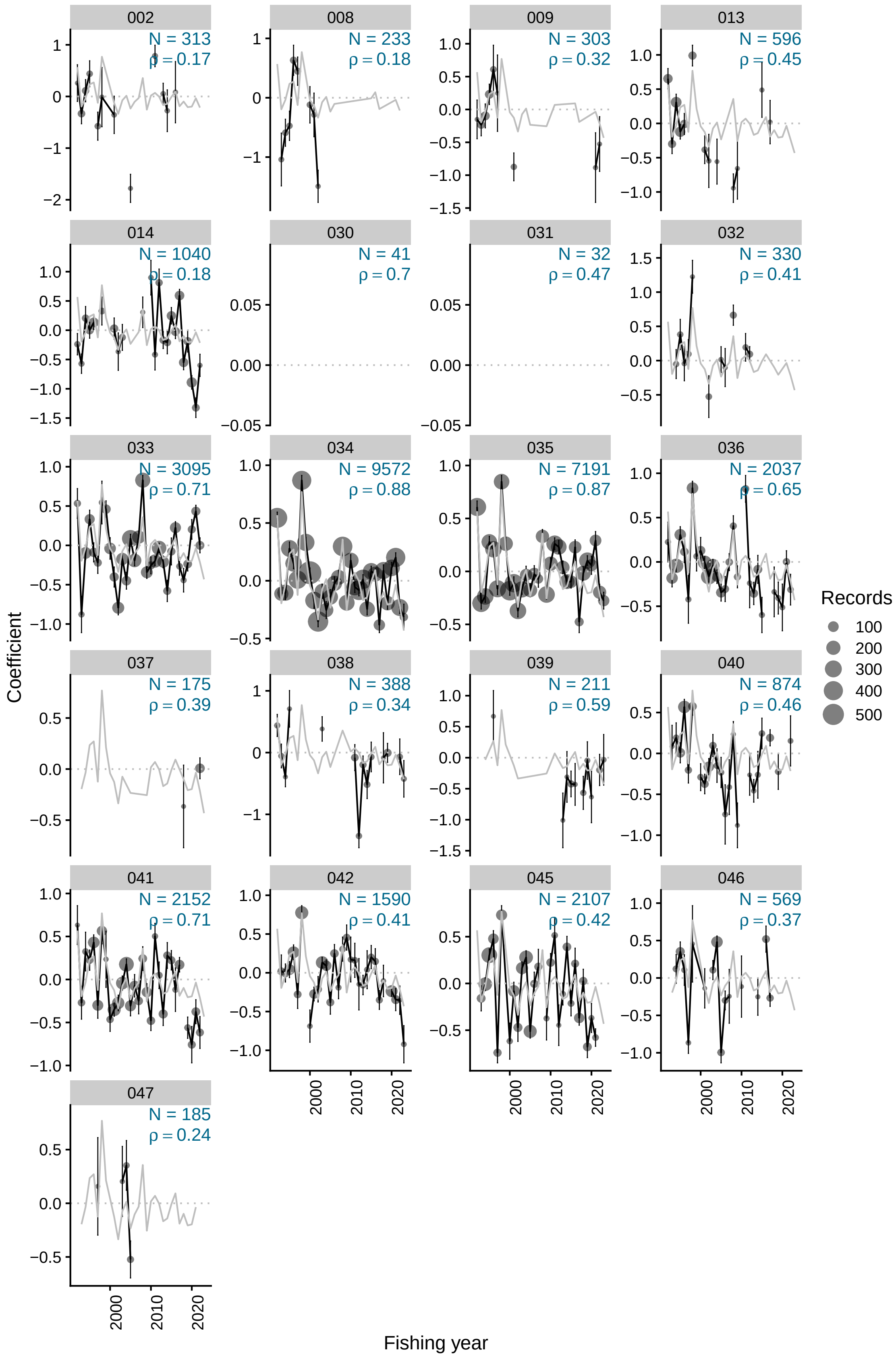

Figure A.30: Residual implied coefficients for area-year in the gamma positive catch model for the ALB 1 T CELR trip full dataset.

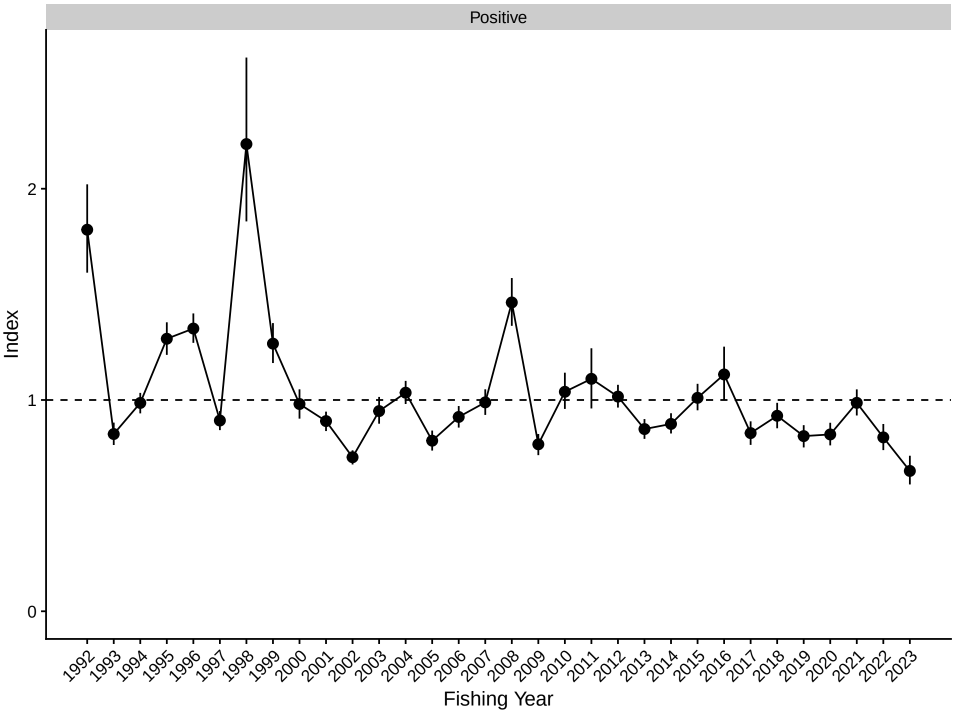

Figure A.31: Standardised indices and 95% confidence intervals for the ALB 1 T CELR trip full dataset.

Figure A.32: Standardised indices for the ALB 1 T CELR trip full dataset.

Table A.10: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in ALB 1 T CELR trip full.

	Positive			
Fishing year	index	SE	LCI	UCI
1992	1.806	0.107	1.603	2.021
1993	0.839	0.027	0.787	0.893
1994	0.986	0.025	0.937	1.034
1995	1.290	0.039	1.214	1.368
1996	1.338	0.036	1.270	1.410
1997	0.903	0.023	0.857	0.948
1998	2.211	0.198	1.845	2.621
1999	1.267	0.048	1.175	1.364
2000	0.981	0.035	0.912	1.051
2001	0.900	0.023	0.853	0.945
2002	0.729	0.017	0.695	0.762
2003	0.948	0.032	0.888	1.015
2004	1.034	0.028	0.981	1.091
2005	0.807	0.024	0.761	0.855
2006	0.920	0.026	0.869	0.971
2007	0.989	0.031	0.929	1.051
2008	1.462	0.058	1.351	1.577
2009	0.790	0.026	0.739	0.839
2010	1.039	0.044	0.958	1.129
2011	1.100	0.073	0.960	1.245
2012	1.016	0.027	0.964	1.072
2013	0.862	0.024	0.816	0.910
2014	0.887	0.024	0.842	0.937
2015	1.010	0.032	0.951	1.077
2016	1.121	0.064	1.003	1.252
2017	0.843	0.028	0.788	0.899
2018	0.925	0.031	0.866	0.987
2019	0.829	0.027	0.775	0.881
2020	0.837	0.027	0.785	0.892
2021	0.986	0.032	0.927	1.050
2022	0.823	0.032	0.763	0.886
2023	0.664	0.035	0.600	0.736

APPENDIX B: DATA GROOMING

Grooming of the statutory commercial catch, effort and landings data followed the approach of Starr (2007), with a set of rules defined for each of the different types of data (Bentley 2012).

B.1 Landings

Table B.1: Grooming rules applied to landings data.

Rule	Effect	Description
FLKIN	Fix	Update landed species to SUR when KIN is landed from trips with diving events and no MHR support
LADAM	Flag	Landings where the landing date is missing
LADAF	Flag	Landings where the landing date is in the future
LADTI	Flag	Invalid landing destination
LAFLA	Fix	Correct landings using a flatfish species code to FLA
LAHPB	Fix	Correct landings using a groper species code to HPB
LASQU	Fix	Recode SQU1J and SQU1T landings to SQU1
LATUN	Fix	Correct stock code for non-QMS tunas
LASEC	Fix	Landings to Crown or experimental stock codes
LAQMS	Fix	Replace pre-QMS pseudo-stock with the post-QMS stock code
LADMR	Drop	Mandatory returns (e.g. sub-MLS)
LADTH	Drop	Retained (non-final) landings
LADTT	Flag	Vessel received transhipments
LASCF	Fix	Correct some state codes
LASCI	Flag	Landings to invalid state code
LASCD	Drop	Drop landings of secondary product states
LADUP	Drop	Duplicate landings
LACFM	Fix	Replace missing conversion factors with the median over all years
LAGWI	Fix	Estimate missing greenweights
LAGWM	Drop	Missing greenweights that cannot be estimated
LAGWO	Fix	Identify and fix order of magnitude errors in landings

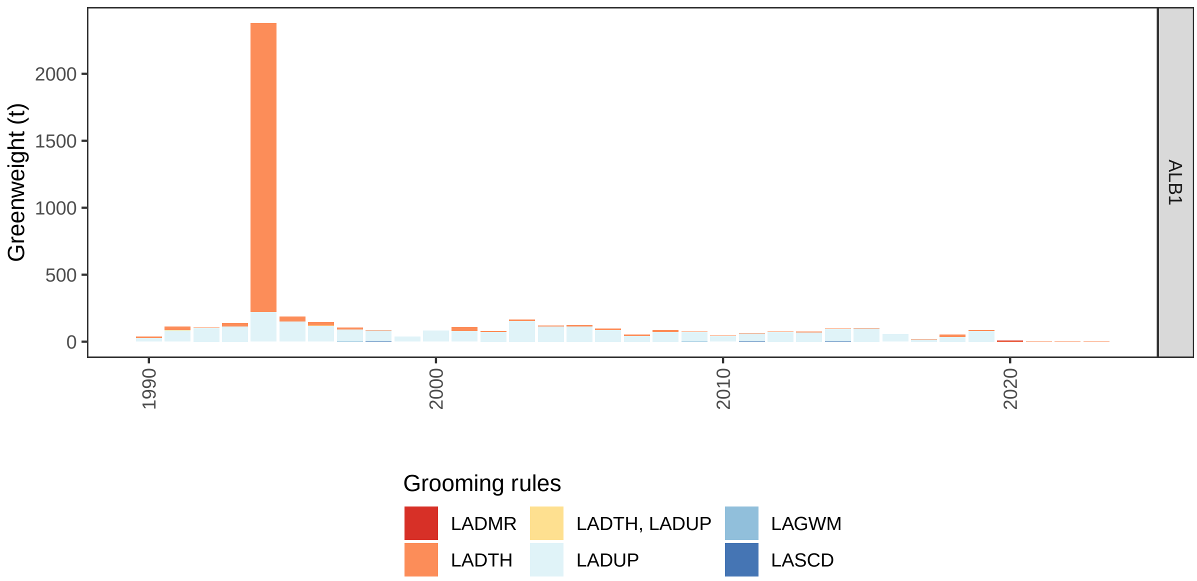

Figure B.1: The quantity of landings dropped, with the relevant grooming rules indicated, by stock and fishing year.

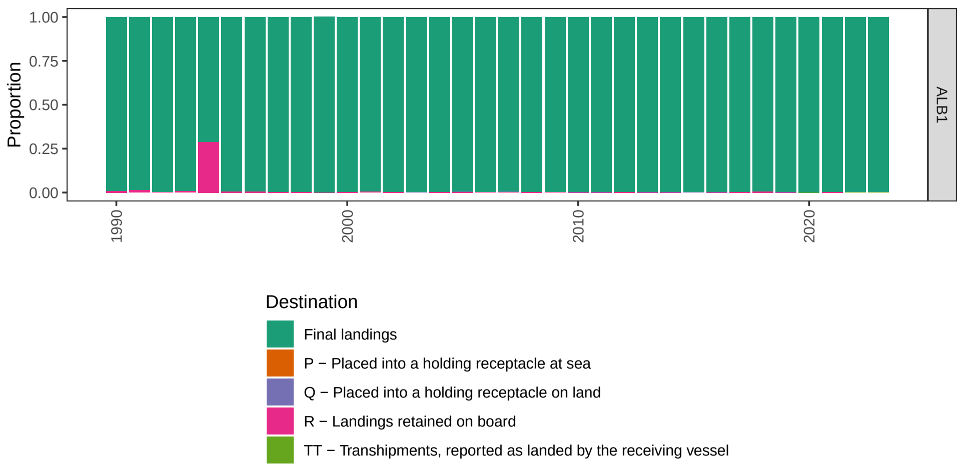

Figure B.2: The proportion of total (final and non-final) landings that are initially to non-final destinations, by stock and fishing year.

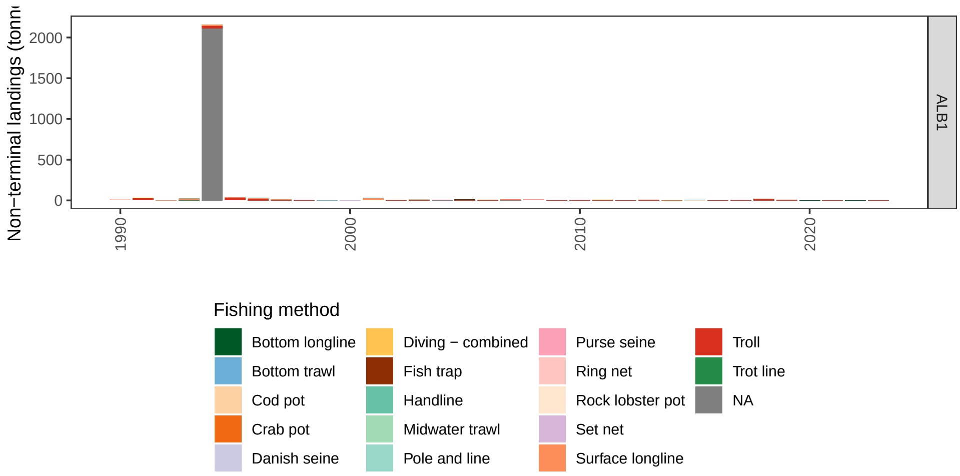

Figure B.3: The quantity of non-final landings, by stock, fishing year, and the modal fishing method used on the trip.

Table B.2: Annual number of trips, and affected greenweight quantity, where the LAGWO rule indicated an order of magnitude error in the landing weight and this was adjusted.

			Greenweight (kg)	
QMA	Fishing year	Trips	Original	Adjusted
ALB1	1990	9	23 612.0	210.6320
ALB1	1991	8	25 660.0	197.6050
ALB1	1992	13	231 712.0	2 317.1200
ALB1	1993	8	136 636.0	1 334.1040
ALB1	1994	12	747 397.0	1 491.4000
ALB1	1995	14	322 977.0	3 229.7700
ALB1	1996	26	282 647.4	2 764.6800
ALB1	1997	12	524 143.0	3 259.0900
ALB1	1998	15	415 564.0	2 082.7960
ALB1	1999	12	207 075.1	2 038.4590
ALB1	2000	7	84 354.0	843.5400
ALB1	2001	25	145 032.8	851.8280
ALB1	2002	7	17 182.0	171.8200
ALB1	2003	3	18 965.0	189.6500
ALB1	2004	4	146 421.7	1 464.2170
ALB1	2005	2	5 128.4	51.2840
ALB1	2007	2	18 309.0	183.0900
ALB1	2008	7	116 818.0	1 168.1800
ALB1	2009	3	1 595.0	15.9500
ALB1	2010	1	1 152.0	11.5200
ALB1	2011	1	553.0	5.5300
ALB1	2012	1	369.0	3.6900
ALB1	2014	2	24 624.0	246.2400
ALB1	2015	1	2 949.0	29.4900
ALB1	2016	2	10 012.0	100.1200
ALB1	2017	1	936.0	9.3600
ALB1	2018	4	9 497.5	94.9750
ALB1	2019	1	24 931.5	249.3150
ALB1	2020	1	6 121.5	6.1215
ALB1	2021	1	1 701.0	17.0100
ALB1	2022	3	1 144.0	11.4400

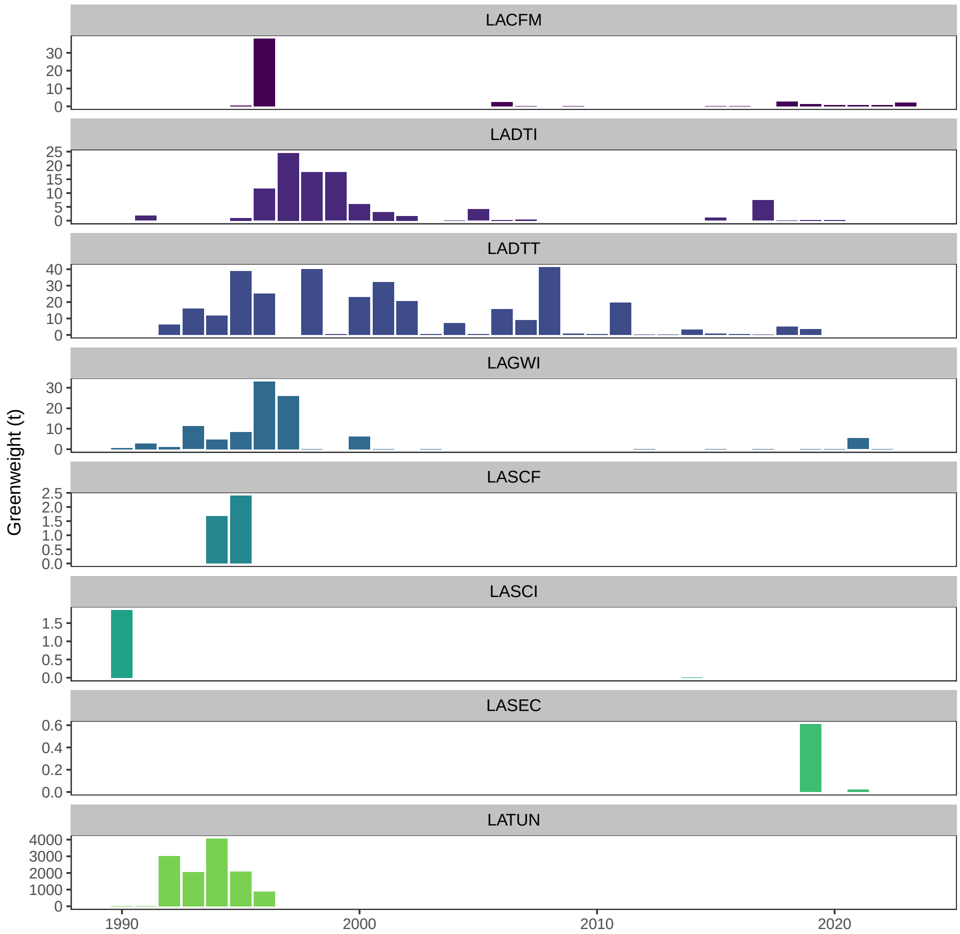

Figure B.4: The quantity of landings flagged by the grooming rules, or where fixes were applied to fields other than the landed greenweight. Note that some landing events may be affected by multiple rules.

B.2 Effort

Table B.3: Grooming rules applied to effort data.

Rule	Effect	Description
FLKIN	Fix	Update target species to SUR when KIN is reported from diving events with no MHR support
FEMDV	Fix	Update historical diving method codes to DV
FEPMN	Fix	Add PSH as a method code for certain vessels if method is null
FEPMI	Fix	Replace missing methods if there is only one method used on the trip (by form type)
FEPMM	Flag	Flag trips if any events have a missing method
FESAI	Fix	Substitute the modal statistical area from a trip for missing areas
FESAM	Flag	Flag events with missing statistical areas
FESAS	Fix	For BCO4 only correct RL statistical areas to general areas
FESAF	Flag	Flag non RLP events using RL statistical area codes
FESDF	Flag	Flag events in the future
FESDM	Flag	Flag events with missing start date/time
FETSE	Fix	Set target species to group code for HPB and FLA species
FETSW	Fix	Flag and set target species to null if target species is not a valid species code
FETSI	Fix	Replace missing target species with the modal value for a trip
FEETN	Fix	Flag and fix some CP effort errors
FEEHN	Fix	Fix transposed effort numbers for lining methods on CELR forms
FEEMU	Fix	Fix SN mesh sizes recorded in inches
FEFMA	Flag	Mark trips which landed to more than one fishstock for straddling statistical areas
FEMEM	Flag	Flag events where the primary effort measure is missing
FEHDE	Flag	Flag records where the maximum daily effort is out of range
FEDBE	Fix	Transpose bottom and effort depths if reported effort depth > bottom depth

Table B.4: Grooming rules applied to estimated catch data.

Rule	Effect	Description
FLKIN	Fix	Update estimated catch species to SUR when KIN is reported from diving events with no MHR support
ESTGT	Fix	Create estimated catch records for events with a total catch weight only
ESCWN	Fix	Correct cases where estimated catch is recorded in weight but number of fish is expected

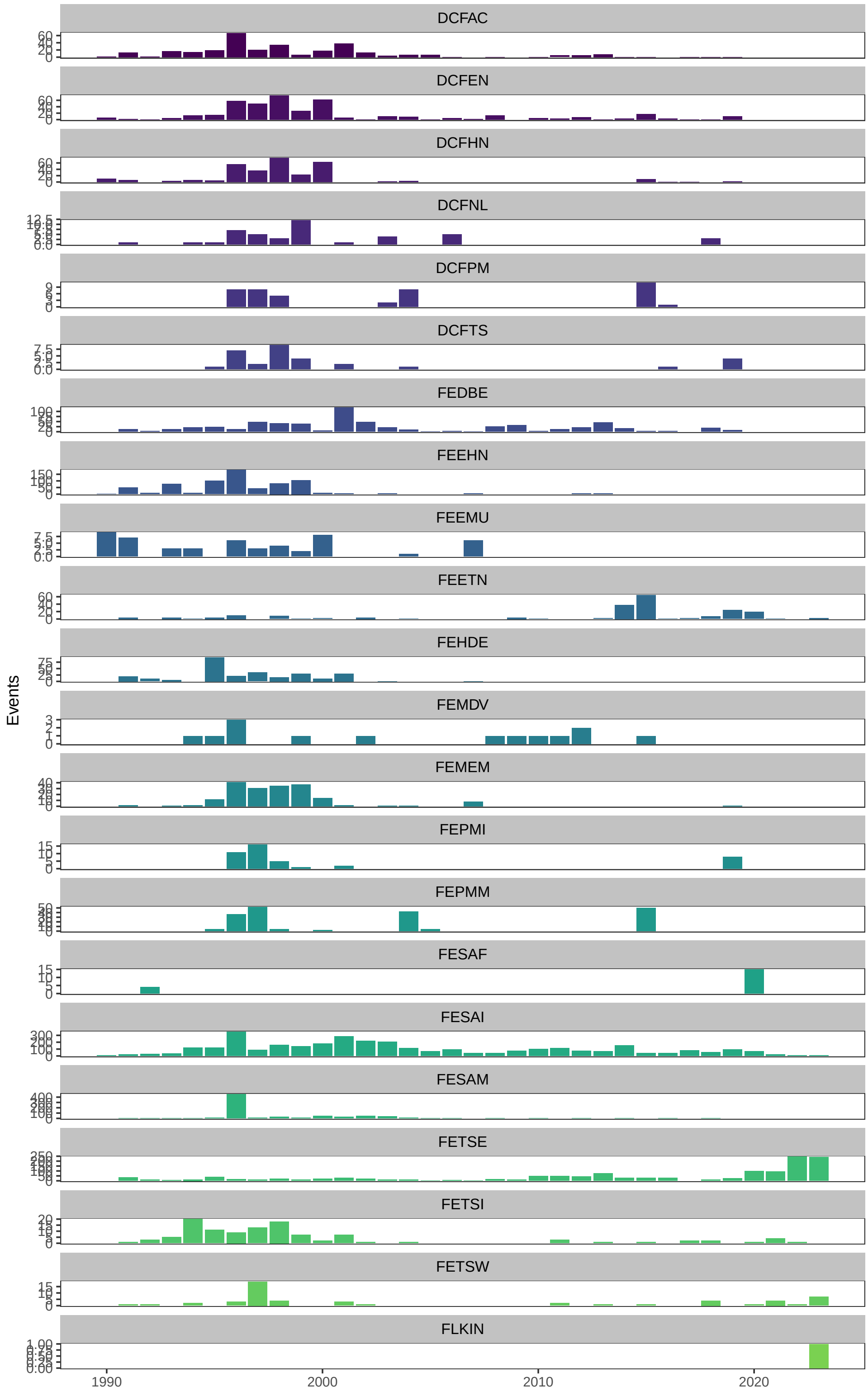

Figure B.5: The number of fishing events flagged or fixed by the grooming rules. Note that some events may be affected by multiple rules.

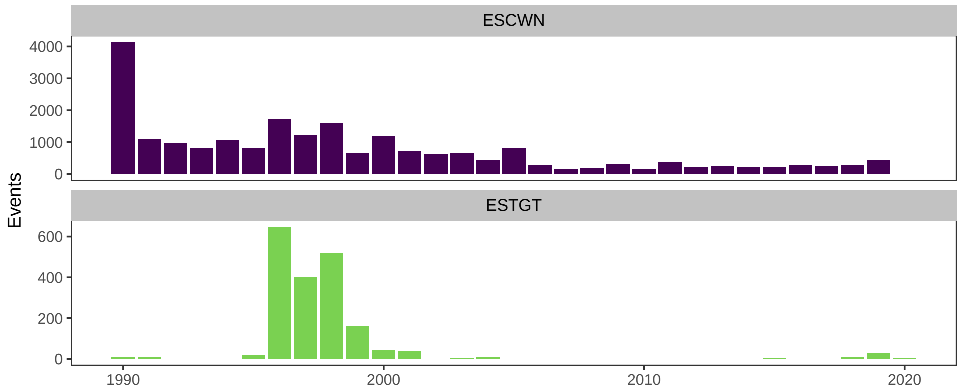

Figure B.6: The number of fishing events where the estimated catch of albacore was flagged or fixed by the grooming rules. Note that some events may be affected by multiple rules.

B.3 Grooming of catch numbers

For some species, and certain fishing methods and reporting forms, fishers have been instructed to report the estimated catch from a fishing event in numbers of fish instead of, or in addition to, the estimated catch weight. However, landings data for these species are usually reported in kilograms. The requirement to use different quantities for reporting the same fish in different parts of the reporting system has the potential to cause confusion. This is particularily relevant in cases where the Catch, Effort and Landing Return (CELR) form was in use, because the multi-purpose use of this form meant that the same fields had differing interpretations in different circumstances (i.e. depending on the species caught and method used).

In the case of albacore, calculation of the mean weight of fish from a trip (i.e. landed weight divided by estimated catch numbers) provides evidence that reporting errors have occured (Figure B.7): there is a mode of trips with a mean fish weight around 1 kg, in addition to a mode around 5 kg, whereas the lowest recorded weight of albacore in catch sampling data is around 1.5 kg (see, for example, Griggs 2008, Fig. 7). There are a smaller number of trips with unrealistically high mean weights (i.e. > 20 kg).

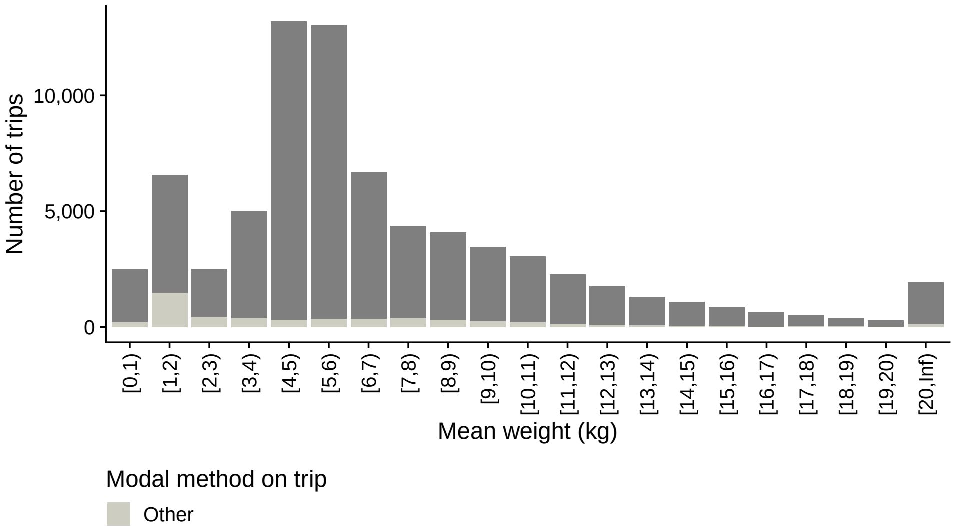

Figure B.7: Trip level mean weight of albacore by method, prior to the application of the ESCWN grooming rule.

Small mean weights from a trip are likely to arise from estimates being recorded in weight rather than numbers. In such cases, the calculated mean weight need not be exactly one because the fishers' estimated weights may differ somewhat from the weighed landed weight. A closer examination of the lower end of the distribution of mean weights (Figure B.8) suggests that a cut-off of 1.5 kg, based on the lowest weight recorded in catch sampling, will separate most of the trips with unreasonably low weights, although a somewhat higher threshold could be considered.

Trips with mean fish weights above and below the 1.5 kg threshold unsurprisingly have quite different relationships between estimated catch numbers and landed weights (Figure B.9). Although trips with a low mean fish weight have a wider distribution of estimated catch numbers, the distributions of landed weights and estimated numbers for the two classes of trip show considerable overlap (Figure B.10). As a result, the possibility that landed weights have been erroneously recorded in numbers, rather than estimated catches in weight, must also be considered.

Examining the relationship between catch (in numbers and weight) and catch rate (catch per day) demonstrates that trips with a mean fish weight below 1.5 kg tend to have higher catch rates in numbers than trips with larger mean fish weights, whilst that there is no clear grouping of catch rates when considered in terms of landed weight (Figure B.11). This provides strong evidence that low mean

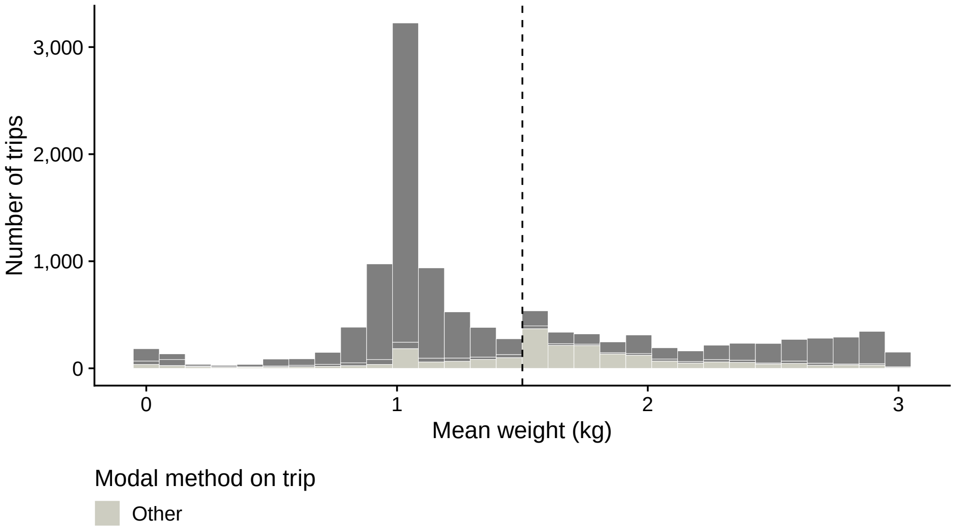

Figure B.8: Trip level mean weight of albacore by method, prior to the application of the ESCWN grooming rule, restricted to trips with a mean weight of less than 3kg.

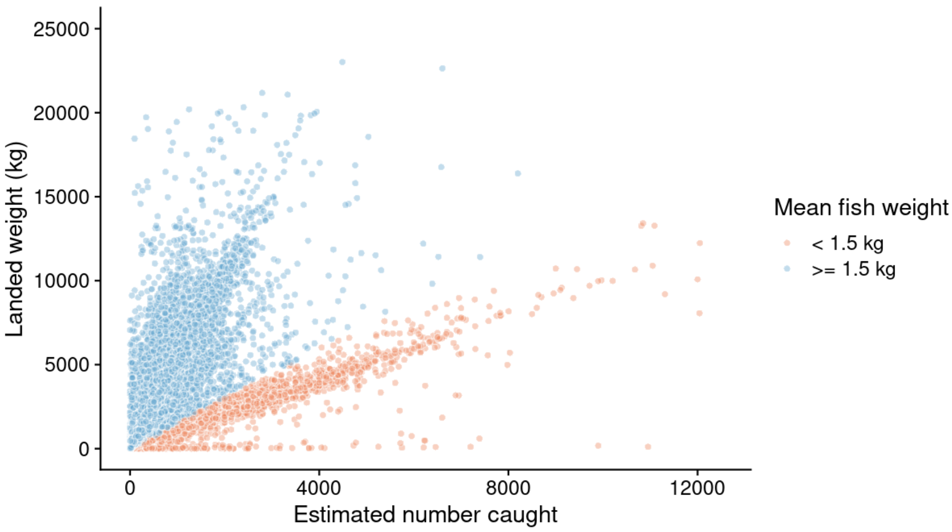

Figure B.9: The relationship between trip estimated catch numbers and landed weight of albacore, prior to the application of the ESCWN grooming rule.

weights arise when estimated catches are recorded in weight (when numbers are expected) rather than landed weights erroneously recorded in numbers. This is consistent with the fact that landed weights are reported by both the fisher and Licensed Fish Receiver so should be less prone to error.

As a result, the grooming rule ESCWN corrects the estimated numbers for fishing events on trips with an implied mean fish weight less than 1.5 kg, where the estimated catch should be reported in numbers and where an estimated weight was not separately reported for the event. The recorded catch in numbers is divided by the mean fish weight for trips in the same fishing year and with the same modal fishing method, after excluding trips with a mean fish weight below the 1.5 kg threshold or exceeding 20 kg (Table B.5). This approach removes the mode of low mean fish weight trips in the groomed data (Figure B.12).

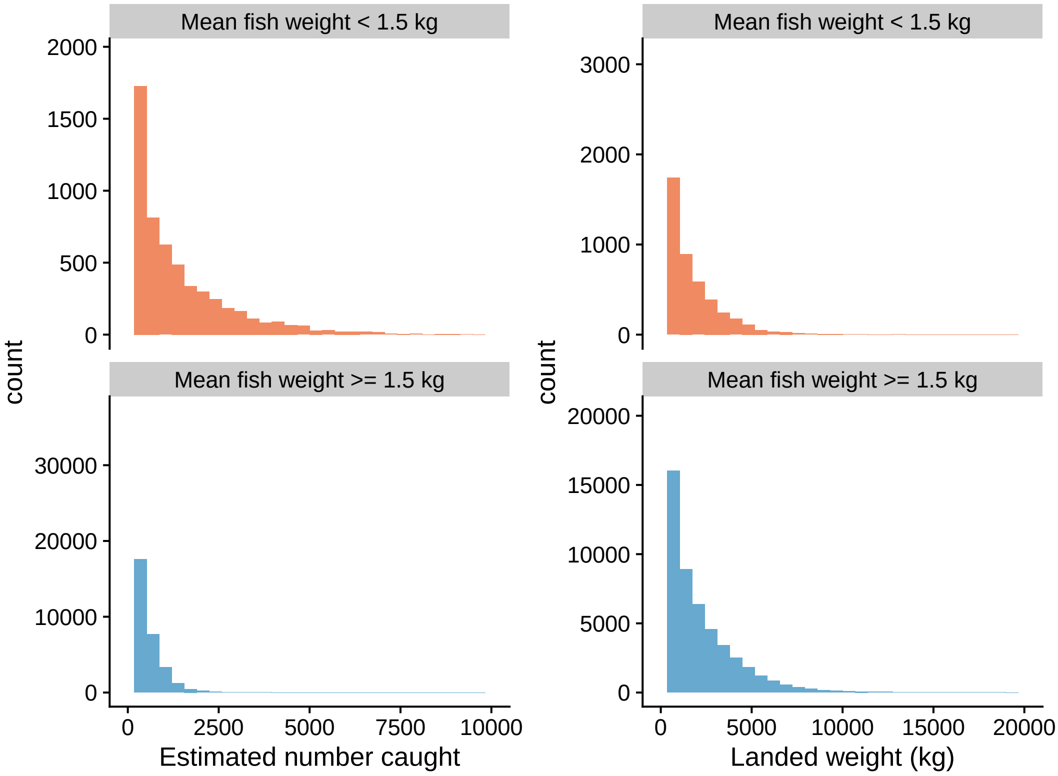

Figure B.10: The distributions of trip estimated catch numbers and landed weight of albacore, for trips with mean fish weights above and below 1.5 kg, prior to the application of the ESCWN grooming rule.

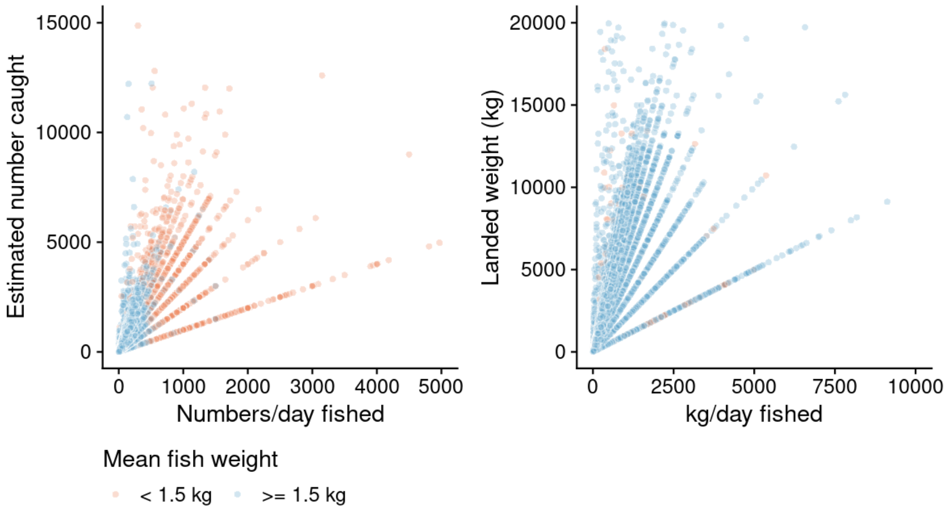

Figure B.11: The relationship between catch rate and catch in numbers and weight, for trips with mean fish weights above and below 1.5 kg, prior to the application of the ESCWN grooming rule.

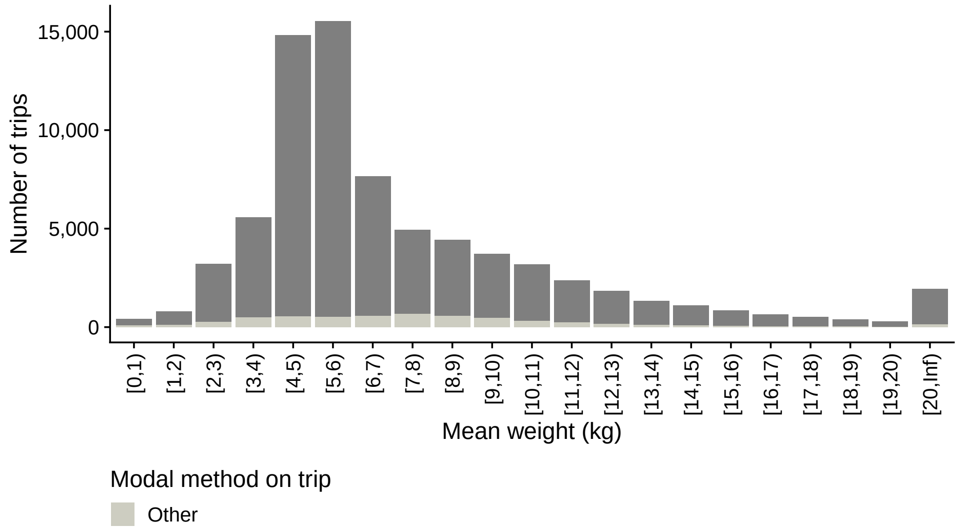

Figure B.12: Trip level mean weight of albacore by method, after application of the ESCWN grooming rule.

Table B.5: Mean fish weight (kg; total weight landed divided by estimated numbers landed) by fishing year and modal fishing method used on a trip, for the key methods catching albacore. Number of trips are indicated in parenthesis.

	Modal method on trip		
Fishing year	SLL	T	BLL
1990	1.86 (11)	2.81 (60)	-
1991	5.07 (37)	4.60 (843)	3.90 (23)
1992	8.53 (92)	5.12 (1289)	5.09 (30)
1993	9.61 (177)	5.23 (1719)	4.63 (66)
1994	9.48 (366)	4.90 (2487)	4.18 (94)
1995	8.25 (616)	5.16 (2690)	3.95 (103)
1996	7.66 (604)	5.21 (1854)	5.35 (58)
1997	9.54 (518)	5.35 (1342)	5.68 (42)
1998	9.41 (894)	5.32 (1451)	2.54 (36)
1999	8.85 (1341)	4.73 (731)	4.62 (24)
2000	9.33 (1697)	4.75 (1609)	7.06 (23)
2001	8.97 (1983)	5.43 (1947)	4.18 (55)
2002	9.78 (2212)	5.25 (1893)	4.53 (27)
2003	9.08 (1624)	5.17 (1588)	4.42 (77)
2004	8.17 (1097)	5.39 (1338)	5.35 (35)
2005	9.88 (580)	5.87 (1307)	5.00 (60)
2006	10.76 (624)	5.36 (964)	5.44 (28)
2007	10.17 (434)	4.91 (706)	5.52 (41)
2008	10.53 (354)	5.12 (1142)	4.69 (41)
2009	9.27 (471)	4.49 (924)	4.15 (41)
2010	10.39 (486)	4.91 (698)	5.92 (30)
2011	9.02 (512)	4.57 (973)	4.81 (23)
2012	9.40 (484)	5.19 (1222)	4.78 (29)
2013	9.31 (440)	5.81 (1061)	6.07 (56)
2014	9.38 (364)	5.50 (919)	5.18 (36)
2015	9.08 (364)	5.69 (812)	4.22 (25)
2016	9.51 (462)	5.90 (789)	4.37 (21)
2017	9.79 (402)	6.26 (649)	6.28 (31)
2018	11.39 (437)	3.83 (833)	3.98 (22)
2019	10.89 (298)	4.79 (863)	4.27 (41)
2020	9.56 (321)	4.85 (1006)	4.71 (11)
2021	11.22 (258)	4.93 (1170)	6.26 (18)
2022	12.12 (238)	5.68 (1006)	6.78 (16)
2023	10.72 (224)	4.64 (612)	5.71 (9)
2024	11.27 (141)	5.27 (443)	7.68 (7)

APPENDIX C: TABULATED FISHERIES CHARACTERISATION DATA

Table C.1: Monthly Harvest Return totals for ALB 1 from 2002 to 2023.

Fishing year	ALB1	
	TACC	MHR/QMR
1990	-	-
1991	-	-
1992	-	-
1993	-	-
1994	-	-
1995	-	-
1996	-	-
1997	-	-
1998	-	-
1999	-	-
2000	-	-
2001	-	-
2002	-	5 532.63
2003	-	6 317.26
2004	-	4 968.66
2005	-	3 500.50
2006	-	2 627.14
2007	-	2 068.52
2008	-	3 631.07
2009	-	2 246.38
2010	-	2 186.47
2011	-	3 266.43
2012	-	3 039.25
2013	-	2 927.30
2014	-	2 466.70
2015	-	2 536.81
2016	-	2 218.60
2017	-	2 035.42
2018	-	2 641.78
2019	-	2 691.76
2020	-	3 083.04
2021	-	3 480.61
2022	-	2 519.41
2023	-	1 005.14

Table C.2: Annual ALB 1 catches (t) from the different sources of data used in the fishery characterisation. QMR = Quota Management Reports; MHR = Monthly Harvest Returns. Catches represent groomed (Appendix B) landings/discards data summed by stock (see Table 1 for destination codes included). Allocated catch represents catches allocated to fishing events in the characterisation dataset, with the percentage taken by key fishing methods indicated. Target catch is the allocated catch taken on fishing events where albacore was targeted. – : no observations.

Fishing year	QMR/MHR (t)	Catches (t)	Allocated catches			Target catches	
			Total (t)	T (%)	SLL (%)	tonnes	%
1990	-	1 988.49	2 015.23	95.13	2.05	1 924.91	95.52
1991	-	2 189.80	2 187.41	95.46	1.43	2 125.55	97.17
1992	-	3 319.68	3 358.69	95.45	2.70	3 229.60	96.16
1993	-	3 233.41	3 263.20	88.71	8.86	2 928.35	89.74
1994	-	5 341.78	5 336.18	88.81	9.43	4 815.02	90.23
1995	-	6 501.18	5 969.64	89.40	8.79	5 483.73	91.86
1996	-	5 824.64	5 687.20	86.81	10.94	5 081.88	89.36
1997	-	3 524.50	3 478.82	79.78	17.80	2 866.22	82.39
1998	-	6 206.78	6 118.81	75.05	23.83	4 886.75	79.86
1999	-	3 613.38	3 578.32	55.06	44.03	2 176.27	60.82
2000	-	4 709.94	4 730.66	69.31	29.43	3 493.05	73.84
2001	-	5 247.52	5 303.30	61.47	37.55	3 459.60	65.23
2002	5 532.63	5 724.33	5 750.70	57.80	41.74	3 725.81	64.79
2003	6 317.26	6 404.95	6 408.71	63.41	35.66	4 751.33	74.14
2004	4 968.66	4 974.99	4 988.92	81.35	17.85	4 177.05	83.73
2005	3 500.50	3 494.44	3 516.17	84.59	14.20	3 022.99	85.97
2006	2 627.14	2 703.15	2 733.90	82.35	16.39	2 267.70	82.95
2007	2 068.52	2 156.26	2 161.66	85.48	13.13	1 851.01	85.63
2008	3 631.07	3 660.48	3 650.25	92.74	5.77	3 385.35	92.74
2009	2 246.38	2 245.17	2 260.20	80.52	18.25	1 821.13	80.57
2010	2 186.47	2 218.46	2 224.55	78.78	19.61	1 761.73	79.20
2011	3 266.43	3 365.83	3 362.89	89.50	9.41	3 012.83	89.59
2012	3 039.25	3 054.51	3 039.97	91.05	7.55	2 766.15	90.99
2013	2 927.30	2 958.25	2 993.09	87.91	9.89	2 637.17	88.11
2014	2 466.70	2 473.47	2 493.17	88.97	8.27	2 223.31	89.18
2015	2 536.81	2 583.85	2 636.72	91.42	5.71	2 417.35	91.68
2016	2 218.60	2 249.03	2 277.70	86.86	11.57	1 985.44	87.17
2017	2 035.42	2 066.83	2 082.95	88.87	10.09	1 851.50	88.89
2018	2 641.78	2 664.36	2 698.32	87.70	9.88	2 362.17	87.54
2019	2 691.76	2 740.93	2 748.33	92.38	6.46	2 538.49	92.36
2020	3 083.04	3 114.61	3 069.89	93.15	6.05	2 877.75	93.74
2021	3 480.61	3 438.29	3 379.11	96.64	3.21	3 267.19	96.69
2022	2 519.41	2 490.68	2 486.95	95.75	3.95	2 395.99	96.34
2023	1 005.13	1 028.12	1 008.08	88.43	9.74	888.36	88.12

Table C.3: Annual albacore catches (t) by destination code for the ALB 1 Fisheries Management Area. L = Landings to an LFR. A complete list of destination codes is provided in Table 1. – : no observations.

Fishing year	L	Other	Total
1990	1 985.63	2.86	1 988.49
1991	2 158.00	31.79	2 189.80
1992	3 295.12	24.55	3 319.68
1993	3 205.86	27.55	3 233.41
1994	5 278.47	63.31	5 341.78
1995	6 478.51	22.67	6 501.18
1996	5 757.27	67.38	5 824.64
1997	3 474.19	50.31	3 524.50
1998	6 100.69	106.09	6 206.78
1999	3 572.14	41.24	3 613.38
2000	4 682.13	27.81	4 709.94
2001	5 212.39	35.14	5 247.52
2002	5 701.16	23.16	5 724.33
2003	6 035.50	369.45	6 404.95
2004	4 938.95	36.05	4 974.99
2005	3 461.56	32.87	3 494.44
2006	2 679.54	23.61	2 703.15
2007	2 146.10	10.16	2 156.26
2008	3 657.94	2.53	3 660.48
2009	2 230.54	14.63	2 245.17
2010	2 214.32	4.14	2 218.46
2011	3 362.58	3.25	3 365.83
2012	3 050.05	4.46	3 054.51
2013	2 954.23	4.01	2 958.25
2014	2 466.24	7.23	2 473.47
2015	2 578.63	5.22	2 583.85
2016	2 243.96	5.07	2 249.03
2017	2 057.14	9.69	2 066.83
2018	2 658.87	5.49	2 664.36
2019	2 734.97	5.96	2 740.93
2020	3 050.69	63.92	3 114.61
2021	3 404.62	33.67	3 438.29
2022	2 463.95	26.73	2 490.68
2023	1 021.78	6.34	1 028.12

Table C.4: Annual catches by landed state of albacore from the ALB 1 Fisheries Management Area. DRE = Dressed, GGO = Gilled and gutted tail on, GGU = Gilled and gutted, GRE = Green (or whole), GUT = Gutted, HGF = Headed, gutted, and finned, HGU = Headed and gutted, MEA = Fish meal. A complete list of state codes is provided in Table I.1. – : no observations. Records where the landed state was missing were excluded.

Fishing year	GRE	MEA	GUT	HGU	DRE	GGU	GGO	HGF	Other	Total
1990	1980.67	-	4.79	0.55	-	0.62	-	-	-	1986.62
1991	2187.65	0.00	0.92	0.20	0.44	0.16	-	-	0.04	2189.40
1992	3307.97	-	10.97	0.65	0.08	-	-	-	-	3319.68
1993	3220.41	0.03	10.73	2.15	0.08	-	-	-	-	3233.41
1994	5332.66	0.01	0.06	7.68	1.07	-	-	-	0.31	5341.78
1995	6483.51	-	3.18	9.92	4.55	-	-	-	-	6501.16
1996	5819.80	-	2.22	0.42	1.04	0.10	-	-	-	5823.58
1997	3498.00	-	5.53	1.29	6.44	0.26	-	-	-	3511.52
1998	6187.81	-	0.01	0.12	6.77	5.07	-	-	1.17	6200.93
1999	3601.45	0.12	0.18	0.89	0.74	5.77	-	0.55	0.72	3610.41
2000	4682.20	0.04	4.42	8.26	1.81	6.85	-	0.04	4.20	4707.81
2001	5232.19	-	5.40	2.77	1.40	5.75	-	-	-	5247.52
2002	5714.62	0.01	0.07	-	0.55	7.65	-	0.67	0.75	5724.33
2003	6395.63	0.03	0.97	0.24	-	-	7.63	-	0.46	6404.95
2004	4973.24	0.32	-	0.90	0.26	-	0.09	0.04	0.15	4974.99
2005	3485.75	0.06	5.89	0.01	0.01	-	0.93	-	0.19	3492.84
2006	2699.20	0.11	0.01	0.10	1.30	-	-	-	0.49	2701.21
2007	2155.37	0.31	0.01	0.48	-	-	-	-	0.10	2156.26
2008	3655.20	0.87	-	0.11	3.03	-	1.19	-	0.08	3660.48
2009	2240.43	0.80	0.01	0.80	1.61	-	-	-	1.53	2245.17
2010	2208.56	0.12	-	0.03	0.00	-	3.08	5.41	1.26	2218.46
2011	3361.43	2.11	-	0.04	0.49	-	-	-	1.76	3365.83
2012	3049.61	3.03	0.01	0.89	0.01	-	-	0.62	0.34	3054.51
2013	2945.99	10.90	0.01	-	-	-	-	-	1.35	2958.25
2014	2450.47	18.63	0.01	0.15	-	-	0.52	3.27	0.41	2473.47
2015	2558.99	20.84	2.22	0.01	0.76	-	0.04	0.29	0.70	2583.85
2016	2239.93	3.80	0.04	0.18	-	-	0.94	3.95	0.20	2249.03
2017	2062.19	2.58	0.20	0.37	-	-	-	1.35	0.15	2066.83
2018	2631.41	29.35	0.01	-	-	-	1.88	-	0.31	2662.95
2019	2730.18	6.88	0.04	-	-	-	3.43	-	0.40	2740.93
2020	3105.77	6.70	-	-	-	-	1.76	-	0.12	3114.34
2021	3434.21	2.98	0.00	0.02	-	-	0.34	-	0.74	3438.29
2022	2482.94	3.57	-	0.01	-	-	2.05	-	2.11	2490.68
2023	1006.33	17.32	0.02	0.02	-	-	4.16	-	0.27	1028.12

Table C.5: Annual modal conversion factor reported for product state codes of albacore from the ALB 1 Fisheries Management Areas. DRE = Dressed, FIL = Fillets: skin-on, GGO = Gilled and gutted tail on, GGT = Gilled and gutted tail off, GGU = Gilled and gutted, GRE = Green (or whole), GUT = Gutted, HGU = Headed and gutted, MEA = Fish meal, SKF = Fillets: skin-off. – : no observations.

Fishing year	GGU	GRE	GUT	HGU	DRE	FIL	MEA	SKF	GGO	GGT
1990	1.20	1.00	1.10	1.50	-	-	-	-	-	-
1991	1.20	1.00	1.10	1.50	1.80	2.50	5.60	-	-	-
1992	-	1.00	1.10	1.50	1.80	-	-	-	-	-
1993	-	1.00	1.10	1.50	1.80	-	5.60	-	-	-
1994	-	1.00	1.10	1.50	1.80	2.50	5.60	-	-	-
1995	-	1.00	1.10	1.50	1.80	-	-	-	-	-
1996	-	1.00	1.10	1.50	1.80	-	-	-	-	-
1997	-	1.00	1.10	1.50	1.80	-	-	-	-	-
1998	-	1.00	1.10	1.50	1.80	-	-	-	-	-
1999	-	1.00	1.10	1.50	1.80	-	5.60	-	-	-
2000	-	1.00	1.10	1.50	1.80	-	5.60	3.10	-	-
2001	-	1.00	1.10	1.50	1.80	-	-	-	-	-
2002	-	1.00	1.10	-	1.80	-	5.60	3.10	-	-
2003	-	1.00	1.10	1.50	-	2.50	5.60	-	1.10	1.15
2004	-	1.00	-	1.50	1.80	2.50	5.60	3.10	1.10	-
2005	-	1.00	1.10	1.50	1.80	-	5.60	3.10	1.10	1.15
2006	-	1.00	1.10	1.50	1.80	-	5.60	3.10	-	1.15
2007	-	1.00	1.10	1.50	-	2.50	5.60	3.10	-	-
2008	-	1.00	-	1.50	1.80	2.50	5.60	3.10	1.10	1.15
2009	-	1.00	1.10	1.50	1.80	2.50	5.60	3.10	-	1.15
2010	-	1.00	-	1.50	1.80	2.50	5.60	3.10	1.10	1.15
2011	-	1.00	-	1.50	1.80	2.50	5.60	3.10	-	1.15
2012	-	1.00	1.10	1.50	1.80	2.50	5.60	3.10	-	-
2013	-	1.00	1.10	-	-	2.50	5.60	3.10	-	1.15
2014	-	1.00	1.10	1.50	-	2.50	5.60	3.10	1.10	1.15
2015	-	1.00	1.10	1.50	1.80	2.50	5.60	3.10	1.10	1.15
2016	-	1.00	1.10	1.50	-	2.50	5.60	3.10	1.10	1.15
2017	-	1.00	1.10	1.50	-	2.50	5.60	3.10	-	1.15
2018	-	1.00	1.10	-	-	2.50	-	3.10	1.10	1.15
2019	-	1.00	1.10	-	-	2.50	-	3.10	1.10	1.15
2020	-	1.00	-	-	-	-	-	3.10	1.10	-
2021	-	1.00	1.10	1.50	-	2.50	-	3.10	1.10	1.15
2022	-	1.00	-	1.50	-	2.50	-	3.10	1.10	1.15
2023	-	1.00	1.10	1.50	-	-	-	3.10	1.10	1.15

Table C.6: Reporting forms used for effort on trips landing albacore from the ALB 1 Fisheries Management Area in terms of data records and their allocated catches. A complete list of form type codes is provided in Table I.2. – : no observations.

	Records (N)								Allocated catches (t)							
Fishing year	CEL	TCP	TUN	Other	ERS - Trawl	ERS - Tuna Lining	ERS - Other Lining	Total	CEL	TCP	TUN	Other	ERS - Trawl	ERS - Tuna Lining	ERS - Other Lining	Total
1990	5 255	41	-	-	-	-	-	5 296	2 014.76	0.47	-	-	-	-	-	2 015.23
1991	5 746	45	64	3	-	-	-	5 858	2 179.94	0.06	7.40	0.01	-	-	-	2 187.41
1992	6 205	156	791	-	-	-	-	7 152	3 282.28	0.34	76.08	-	-	-	-	3 358.69
1993	8 421	867	1 097	8	-	-	-	10 393	2 973.80	0.81	282.47	6.13	-	-	-	3 263.20
1994	11 636	562	1 544	-	-	-	-	13 742	4 851.69	0.67	483.81	-	-	-	-	5 336.18
1995	10 830	502	2 316	-	-	-	-	13 648	5 510.47	0.84	458.33	-	-	-	-	5 969.64
1996	9 843	939	1 791	5	-	-	-	12 578	5 144.33	1.65	538.56	2.65	-	-	-	5 687.20
1997	7 689	450	2 180	-	-	-	-	10 319	2 888.25	0.50	590.07	-	-	-	-	3 478.82
1998	8 669	425	3 077	-	-	-	-	12 171	4 691.42	0.29	1 427.09	-	-	-	-	6 118.81
1999	4 441	1 002	5 133	-	-	-	-	10 576	2 033.97	0.57	1 543.78	-	-	-	-	3 578.32
2000	7 918	665	6 270	-	-	-	-	14 853	3 366.45	0.40	1 363.81	-	-	-	-	4 730.66
2001	9 284	1 108	7 527	11	-	-	-	17 930	3 327.99	1.20	1 973.28	0.83	-	-	-	5 303.30
2002	8 512	498	8 525	-	-	-	-	17 535	3 354.23	0.99	2 395.48	-	-	-	-	5 750.70
2003	9 026	572	7 603	-	-	-	-	17 201	4 127.87	0.18	2 280.66	-	-	-	-	6 408.71
2004	7 274	410	5 376	134	-	-	-	13 194	4 098.38	0.42	890.02	0.10	-	-	-	4 988.92
2005	7 771	399	2 815	13	-	-	-	10 998	3 016.57	0.26	499.26	0.08	-	-	-	3 516.17
2006	4 925	404	2 962	226	-	-	-	8 517	2 285.62	0.28	447.92	0.08	-	-	-	2 733.90
2007	4 026	202	2 390	180	-	-	-	6 798	1 875.51	0.35	283.50	2.31	-	-	-	2 161.66
2008	4 629	657	1 870	1 368	-	-	-	8 524	3 389.33	0.94	207.64	52.35	-	-	-	3 650.25
2009	4 799	1 053	2 579	1 477	-	-	-	9 908	1 828.89	0.89	412.53	17.89	-	-	-	2 260.20
2010	3 500	917	2 727	1 311	-	-	-	8 455	1 762.60	0.26	434.89	26.79	-	-	-	2 224.55
2011	4 743	1 221	2 838	1 561	-	-	-	10 363	3 013.25	2.24	316.35	31.06	-	-	-	3 362.89
2012	5 284	1 876	2 663	1 141	-	-	-	10 964	2 774.17	2.45	229.47	33.89	-	-	-	3 039.97
2013	5 381	2 263	2 566	1 324	-	-	-	11 534	2 643.97	10.94	296.03	42.15	-	-	-	2 993.09
2014	4 768	3 184	2 218	1 268	-	-	-	11 438	2 234.90	34.61	203.10	20.56	-	-	-	2 493.17
2015	4 422	3 156	2 163	1 183	-	-	-	10 924	2 406.48	22.29	150.31	57.64	-	-	-	2 636.72
2016	4 426	1 146	2 556	790	-	-	-	8 918	1 981.85	3.89	263.58	28.38	-	-	-	2 277.70
2017	3 966	994	2 349	580	-	-	-	7 889	1 856.21	2.70	210.24	13.80	-	-	-	2 082.95
2018	4 410	39	2 386	671	1 912	-	-	9 418	2 374.52	0.01	260.22	33.98	29.59	-	-	2 698.32
2019	5 198	-	1 508	884	1 156	415	-	9 161	2 544.75	-	138.84	21.91	6.93	35.89	-	2 748.33
2020	1	-	10	924	2 200	1 829	5 245	10 209	0.37	-	0.04	2.16	7.98	185.68	2 873.68	3 069.89
2021	-	-	-	1 307	1 869	1 528	5 952	10 656	-	-	-	1.18	3.07	108.50	3 266.36	3 379.11
2022	-	-	-	928	2 361	1 295	5 246	9 830	-	-	-	1.89	4.24	98.18	2 382.64	2 486.95
2023	-	-	-	634	1 448	1 457	3 064	6 603	-	-	-	1.12	17.40	98.15	891.41	1 008.08

Table C.7: Allocated catches (t) of albacore in ALB 1 by method of capture and fishing year. A complete list of fishing method codes is provided in Table I.3. – : no observations.

Fishing year	MW	SLL	T	TL	Other	Total
1990	0.79	41.31	1 917.16	4.02	51.95	2 015.23
1991	0.07	31.33	2 088.18	29.81	38.01	2 187.41
1992	0.08	90.74	3 205.94	17.06	44.88	3 358.69
1993	0.41	289.24	2 894.87	6.83	71.86	3 263.20
1994	0.23	503.25	4 739.06	9.60	84.04	5 336.18
1995	0.31	524.49	5 336.67	11.24	96.93	5 969.64
1996	1.00	622.12	4 937.16	37.21	89.71	5 687.20
1997	0.20	619.15	2 775.40	3.74	80.32	3 478.82
1998	0.05	1 458.32	4 592.34	8.60	59.50	6 118.81
1999	0.21	1 575.40	1 970.33	0.28	32.11	3 578.32
2000	0.18	1 392.10	3 278.87	0.50	59.01	4 730.66
2001	0.17	1 991.64	3 259.76	0.53	51.20	5 303.30
2002	0.09	2 400.31	3 323.77	0.01	26.50	5 750.70
2003	0.07	2 285.08	4 063.98	-	59.58	6 408.71
2004	0.39	890.42	4 058.58	0.02	39.50	4 988.92
2005	0.09	499.38	2 974.30	0.00	42.40	3 516.17
2006	0.12	448.22	2 251.27	0.24	34.04	2 733.90
2007	0.33	283.76	1 847.79	0.05	29.73	2 161.66
2008	0.95	210.50	3 385.10	-	53.71	3 650.25
2009	0.81	412.53	1 819.96	0.05	26.85	2 260.20
2010	0.19	436.34	1 752.48	0.07	35.46	2 224.55
2011	2.21	316.53	3 009.91	-	34.24	3 362.89
2012	2.42	229.50	2 767.83	-	40.22	3 039.97
2013	10.92	296.03	2 631.22	0.01	54.91	2 993.09
2014	34.55	206.20	2 218.27	0.14	34.01	2 493.17
2015	22.27	150.60	2 410.48	7.77	45.61	2 636.72
2016	3.88	263.58	1 978.45	0.80	30.98	2 277.70
2017	2.66	210.24	1 851.04	0.05	18.95	2 082.95
2018	29.54	266.61	2 366.43	0.01	35.74	2 698.32
2019	6.83	177.45	2 538.94	0.00	25.11	2 748.33
2020	6.69	185.72	2 859.56	-	17.93	3 069.89
2021	3.02	108.50	3 265.68	-	1.91	3 379.11
2022	3.58	98.18	2 381.26	-	3.92	2 486.95
2023	17.39	98.15	891.41	-	1.14	1 008.08

APPENDIX D: MARKET SAMPLING DATA

D.1 Market length-frequency data

Table D.1: Market length frequency samples of albacore . For fishing years 1998-2008 and 2010-2022.

Area	Method	Sampled landings	Number of fish
FMA1	T	16	2 449
FMA2	T	1	100
FMA5	T	1	100
FMA7	BLL	1	100
FMA7	BT	1	58
FMA7	PL	1	100
FMA7	SLL	2	260
FMA7	SN	1	200
FMA7	T	592	7.155e+04
FMA7	TL	1	85
FMA8	T	2	385
FMA9	T	162	2.754e+04

D.2 Length composition by area and method

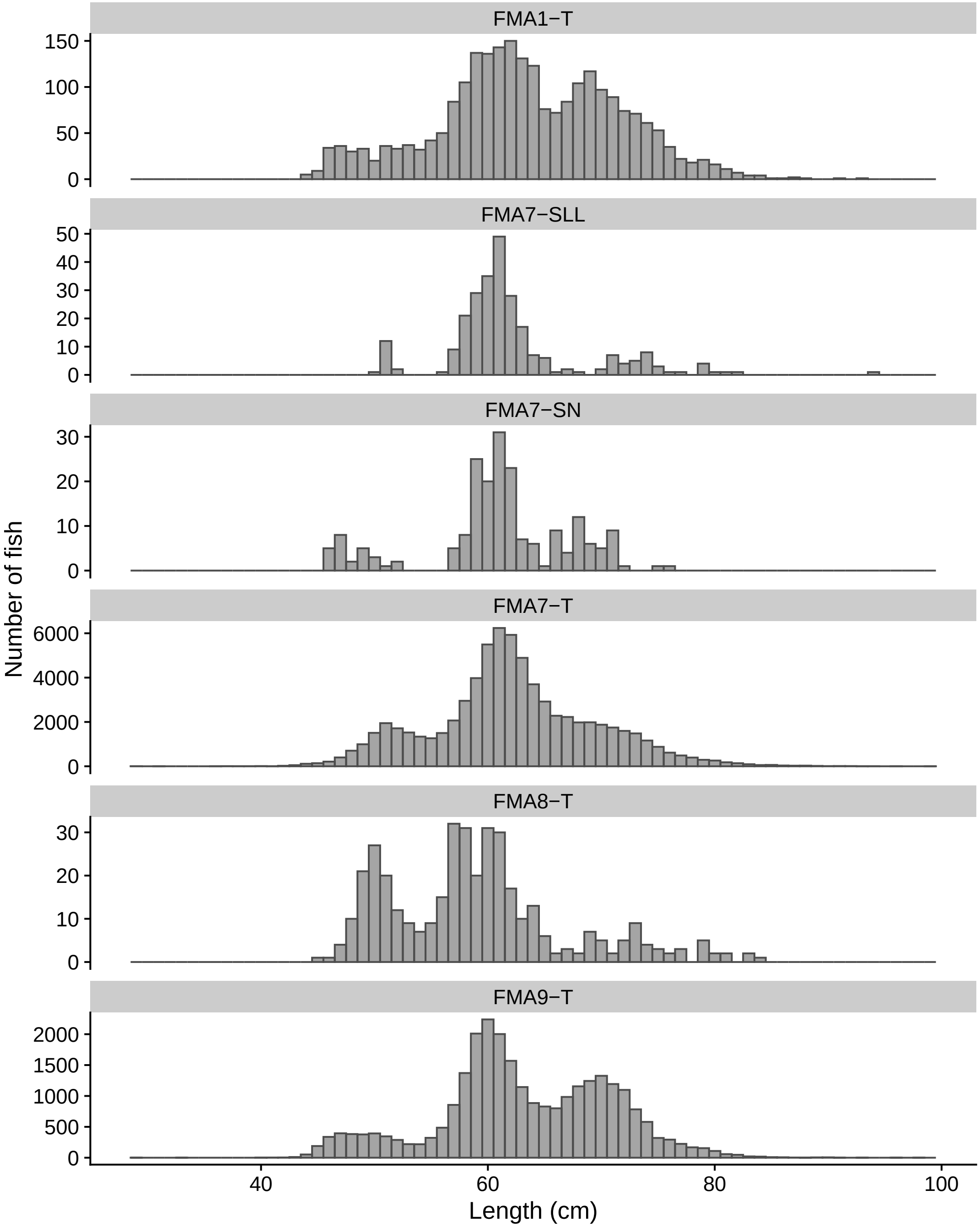

Figure D.1: Raw aggregate market sampling length-frequency distributions by area and method for albacore . For fishing years 1998-2008 and 2010-2022.

D.3 The troll fishery

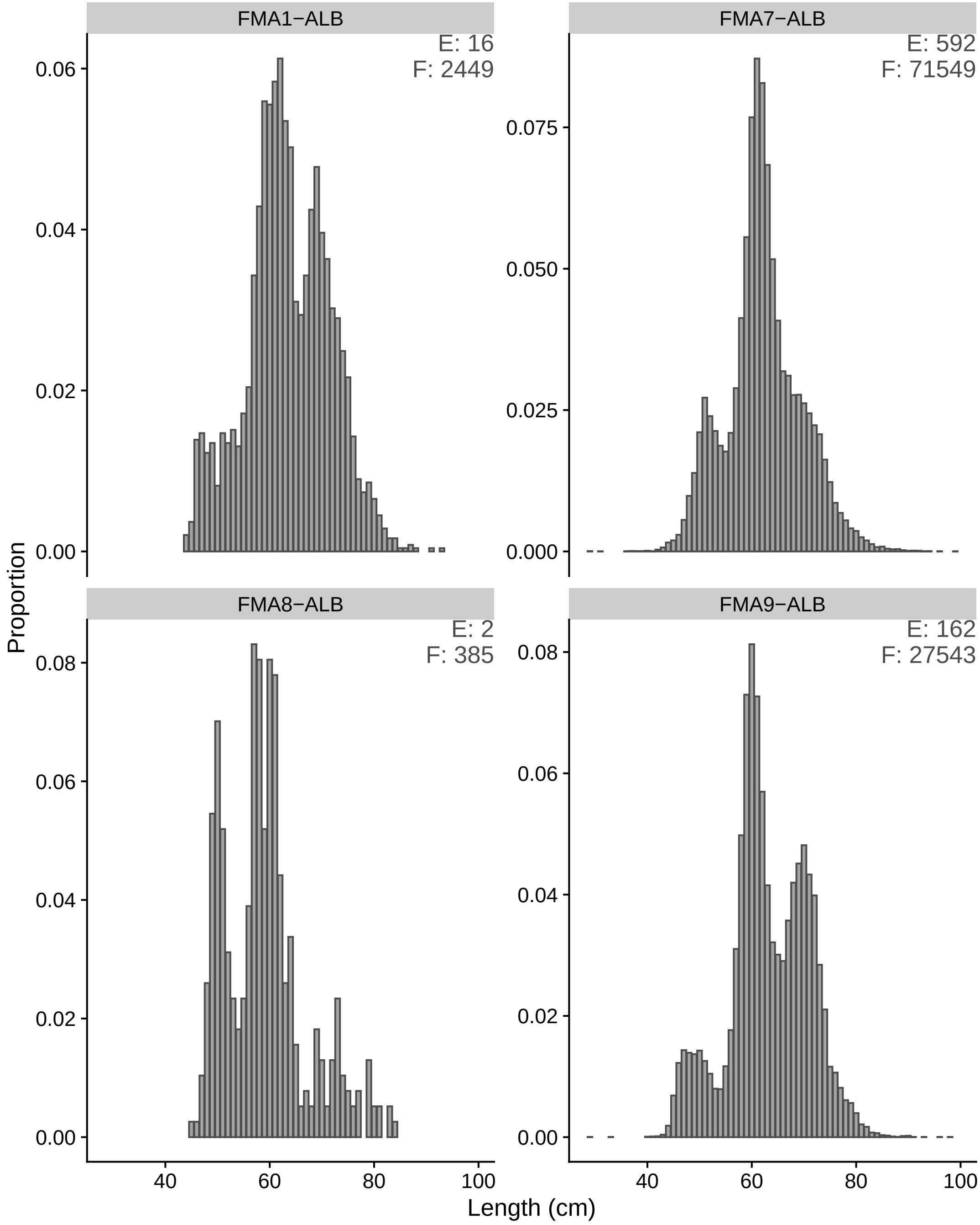

Figure D.2: Raw aggregate market sampling length-frequency distributions for albacore caught in the troll fishery, by area and target species. For fishing years 1998-2008 and 2010-2022.

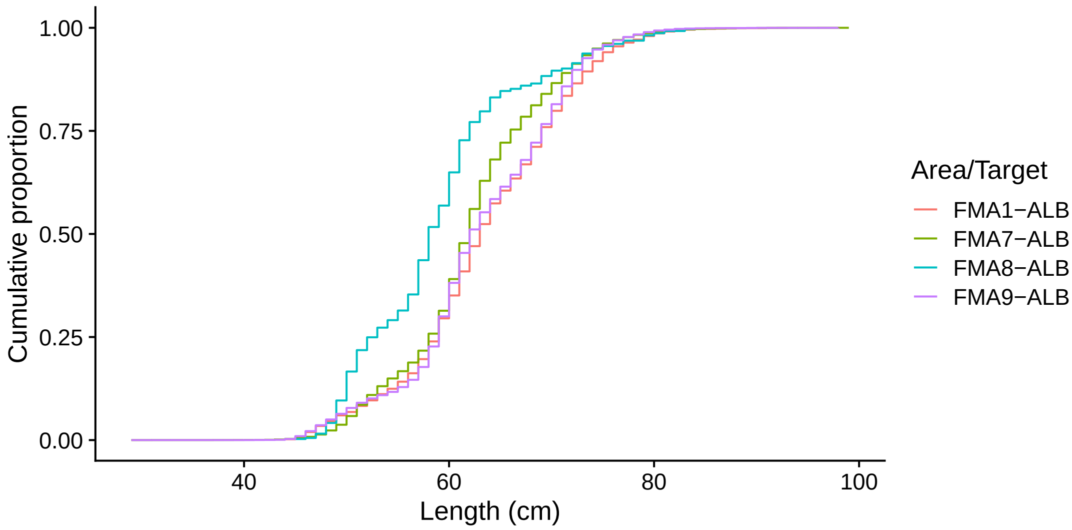

Figure D.3: Cumulative market sampling length-frequency distributions for albacore caught in the troll fishery, by area and target species. For fishing years 1998-2008 and 2010-2022.

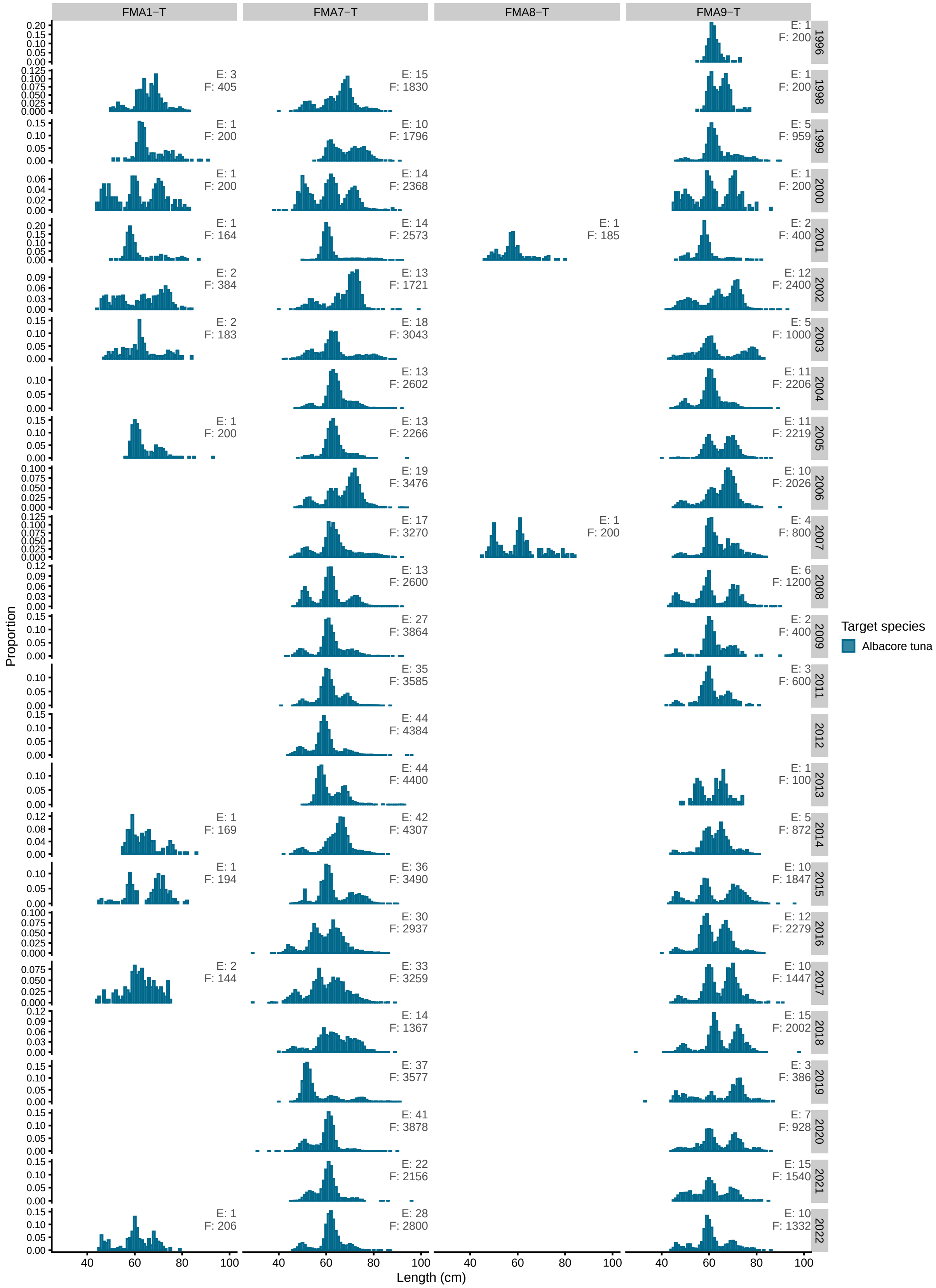

Figure D.4: Raw aggregate market sampling length-frequency distributions for albacore caught in the troll fishery, by area, year, and target species.

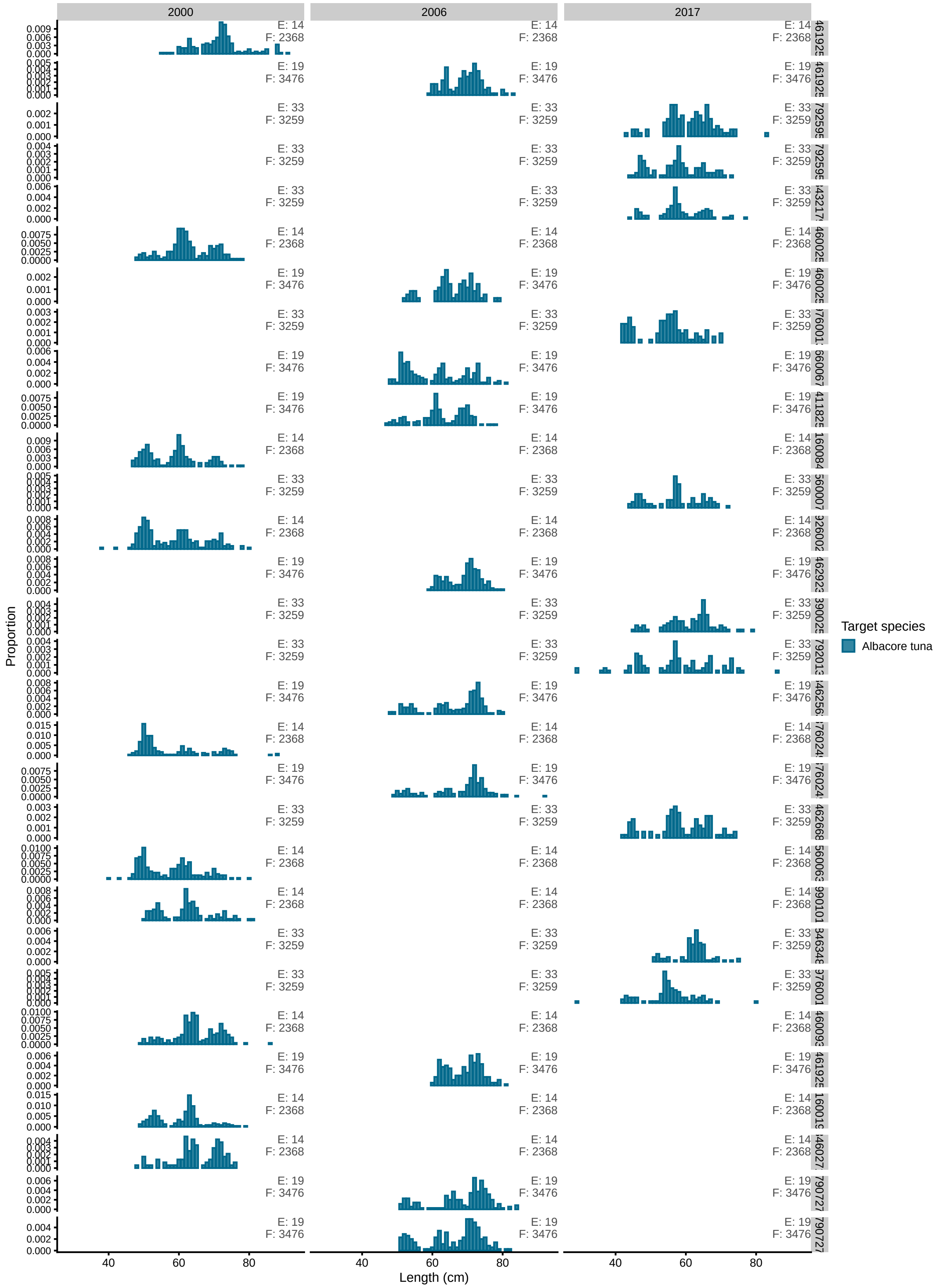

Figure D.5: Raw aggregate market sampling length-frequency distributions for albacore caught in the troll fishery, by trip, and target species. For years 2000, 2006, and 2017 from FMA7 troll fishery.

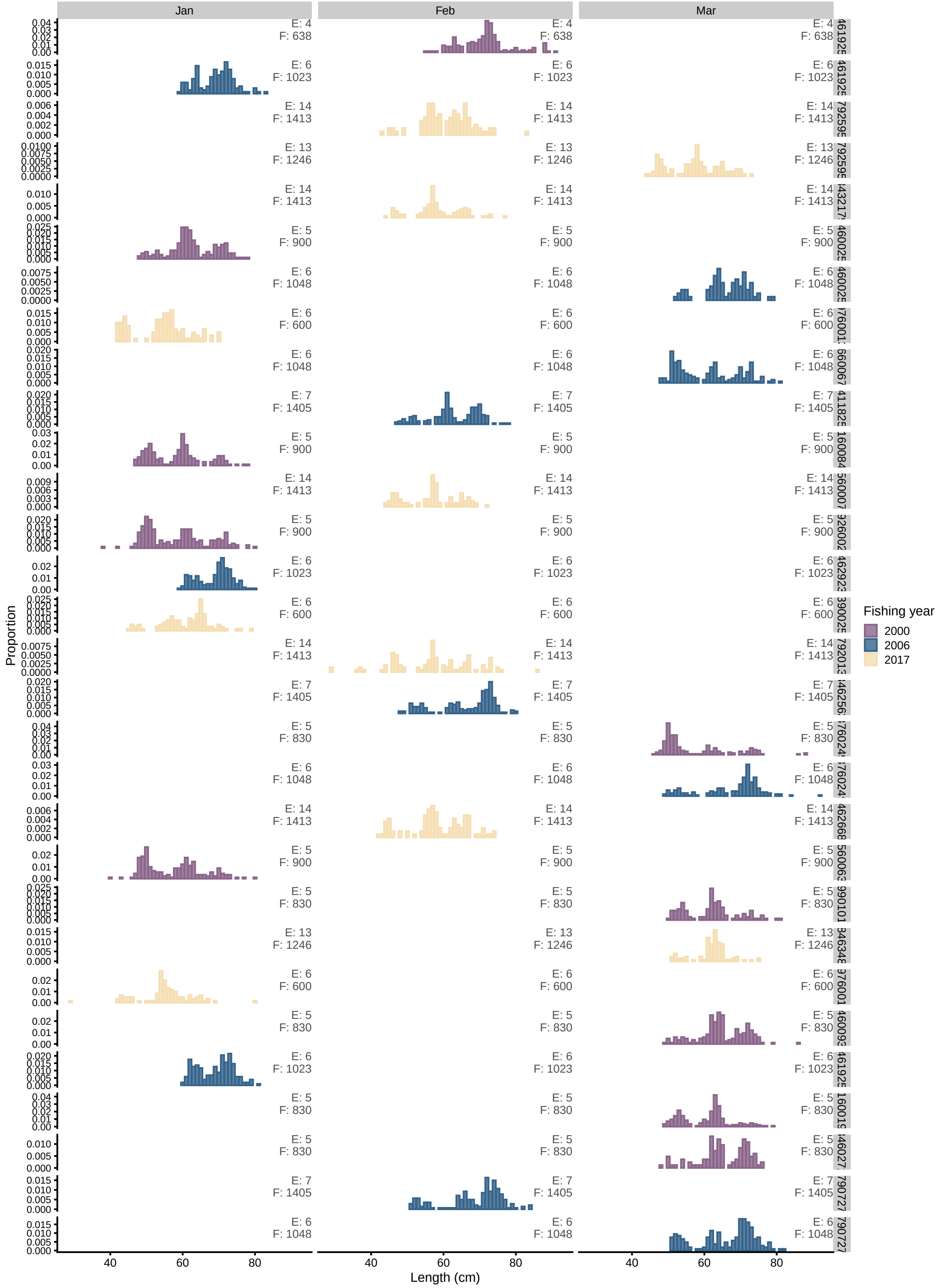

Figure D.6: Raw aggregate market sampling length-frequency distributions for albacore caught in the troll fishery, by trip, and modal month fished. For years 2000, 2006, and 2017 from FMA7 troll fishery.

APPENDIX E: OBSERVER SAMPLING DATA

E.1 Observer length-frequency data

Table E.1: Observer length frequency samples, from fishing years 1988 to 2021.

Area	Method	Sampled events	Number of fish
AKE	SLL	1009	20251
AKE	TRO	7	0
AKW	SLL	304	7432
AKW	TRO	183	130
CEE	SLL	1660	41204
CEE	TRO	166	520
CET	SLL	2	5
CET	TRO	1	0
CEW	SLL	6	203
CEW	TRO	370	1311
CHA	SLL	1697	6327
CHA	TRO	1947	10531
ET	TRO	3	0
HOWE	TRO	2	0
KER	SLL	202	7728
LOUR	TRO	4	38
SEC	SLL	24	18
SEC	TRO	2	0
SOE	SLL	4	60
SOE	TRO	2	0
SOU	SLL	1015	2332
WANB	SLL	1	1
WANB	TRO	13	0
-	SLL	13	655
-	TRO	6	0

E.2 Length composition by area and method

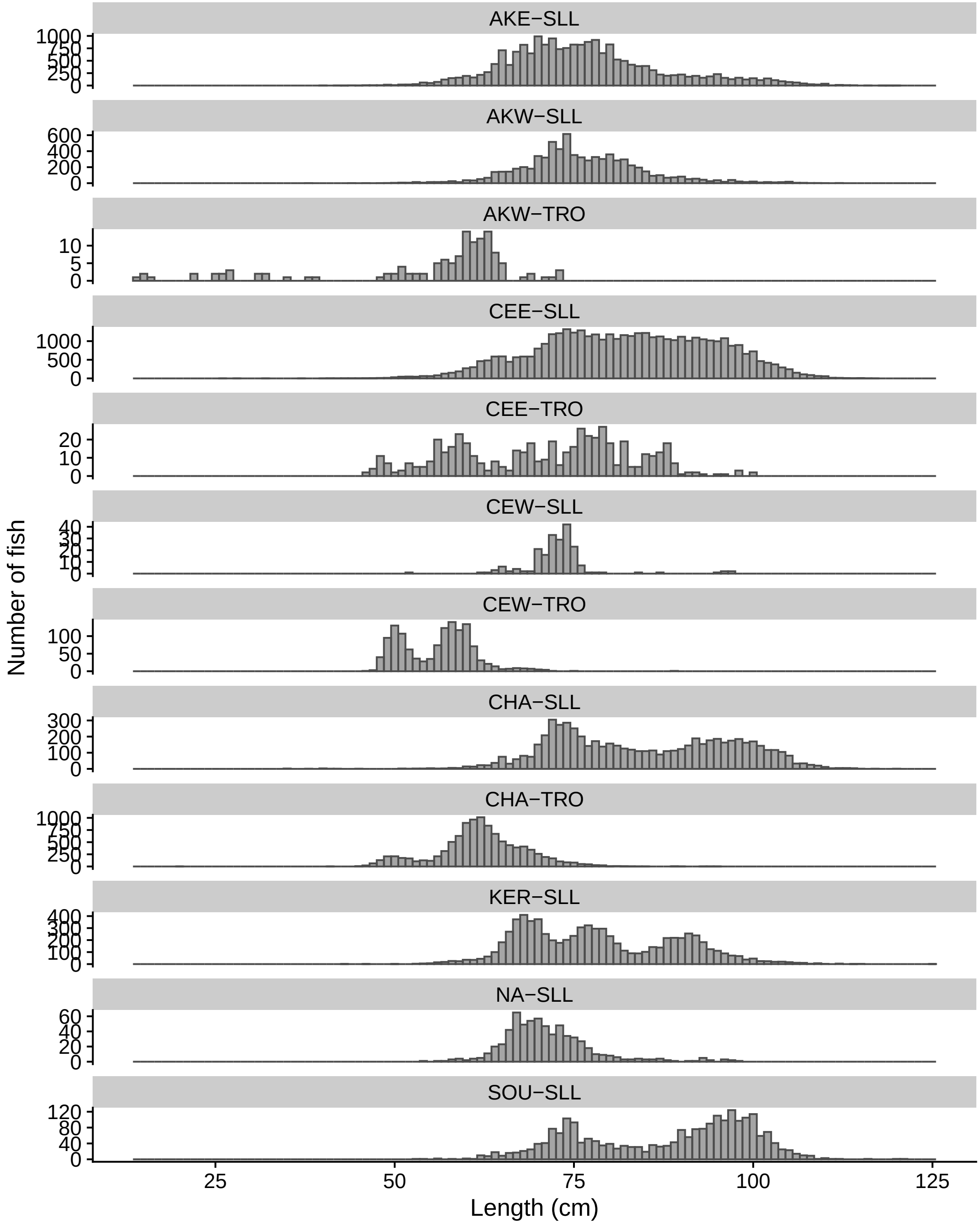

Figure E.1: Raw aggregate length-frequency distributions by area and method for albacore , from fishing years 1988 to 2021.

E.3 The surface longline fishery

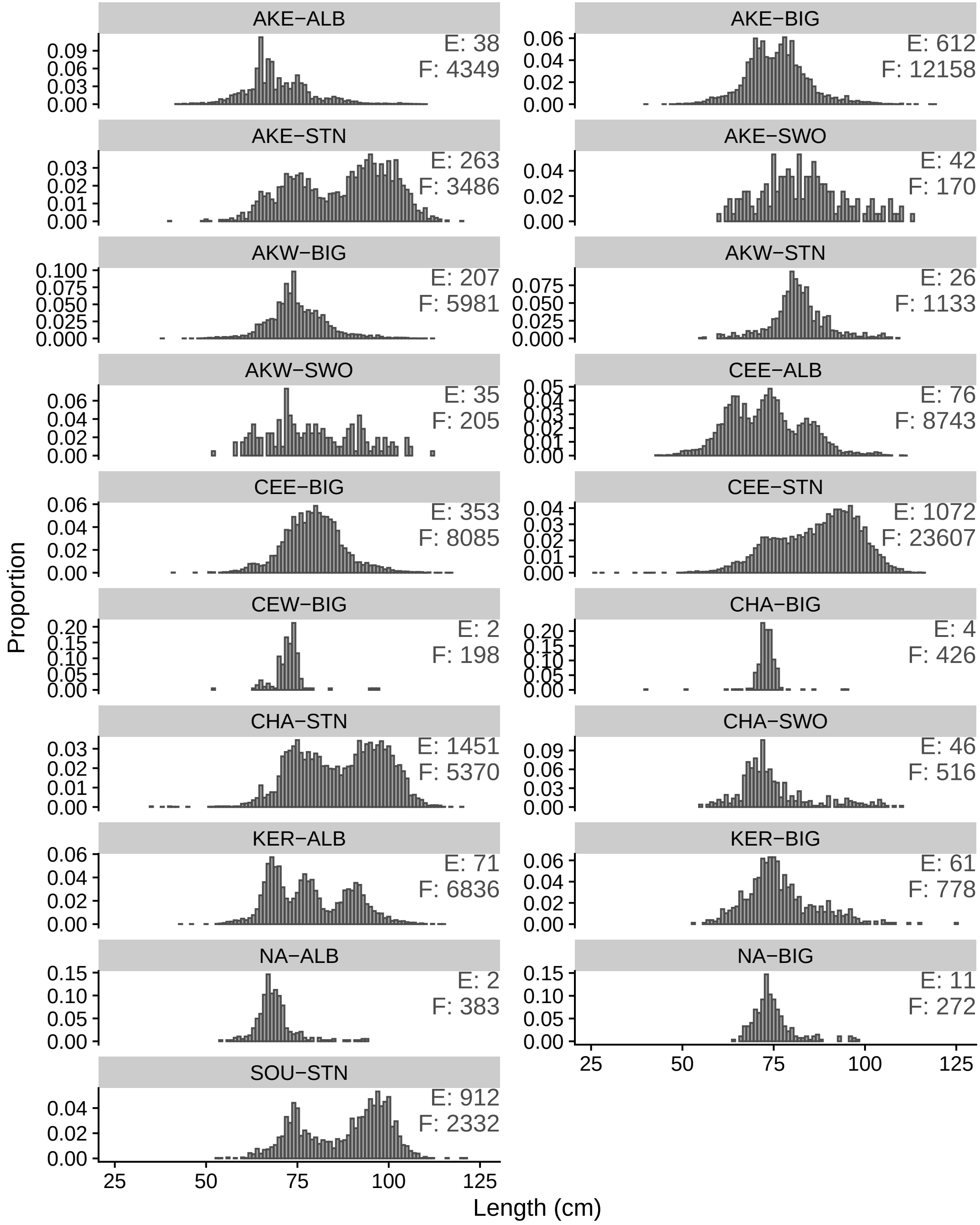

Figure E.2: Raw aggregate length-frequency distributions for albacore caught in the surface longline fishery, by area and target species, from fishing years 1988 to 2021.

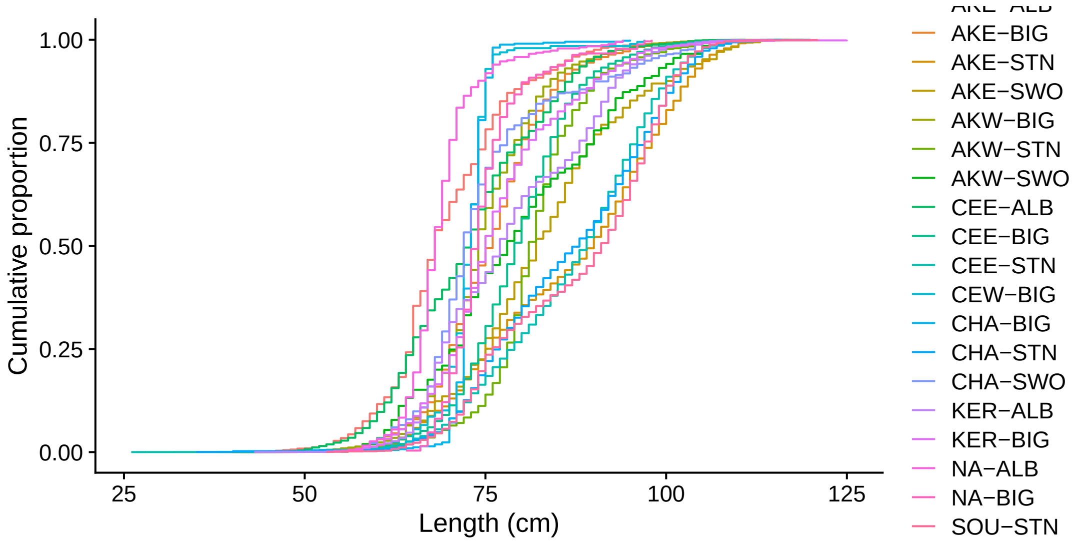

Figure E.3: Cumulative length-frequency distributions for albacore caught in the surface longline fishery, by area and target species, from fishing years 1988 to 2021.

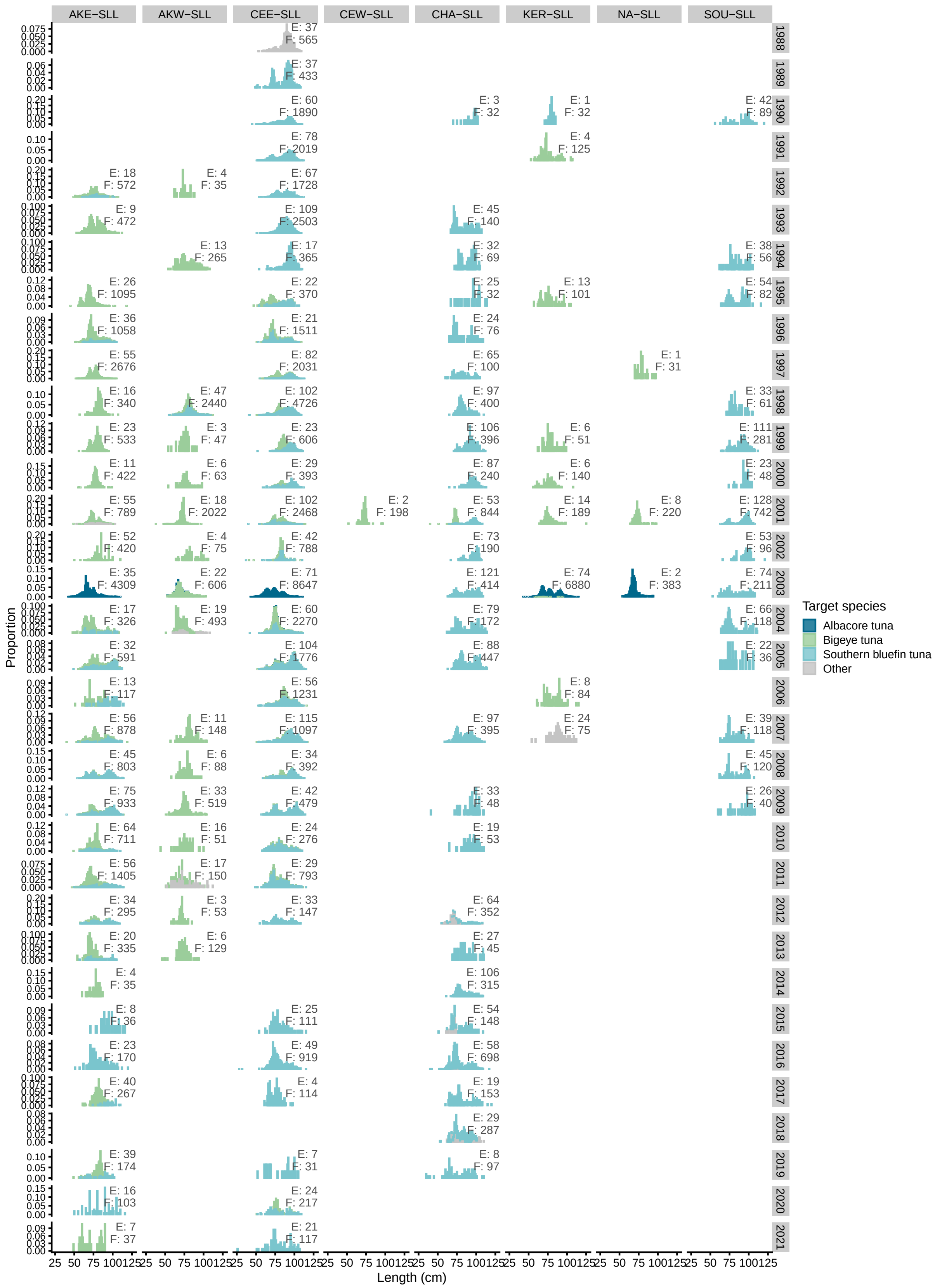

Figure E.4: Raw aggregate length-frequency distributions for albacore caught in the surface longline fishery, by area, year, and target species.

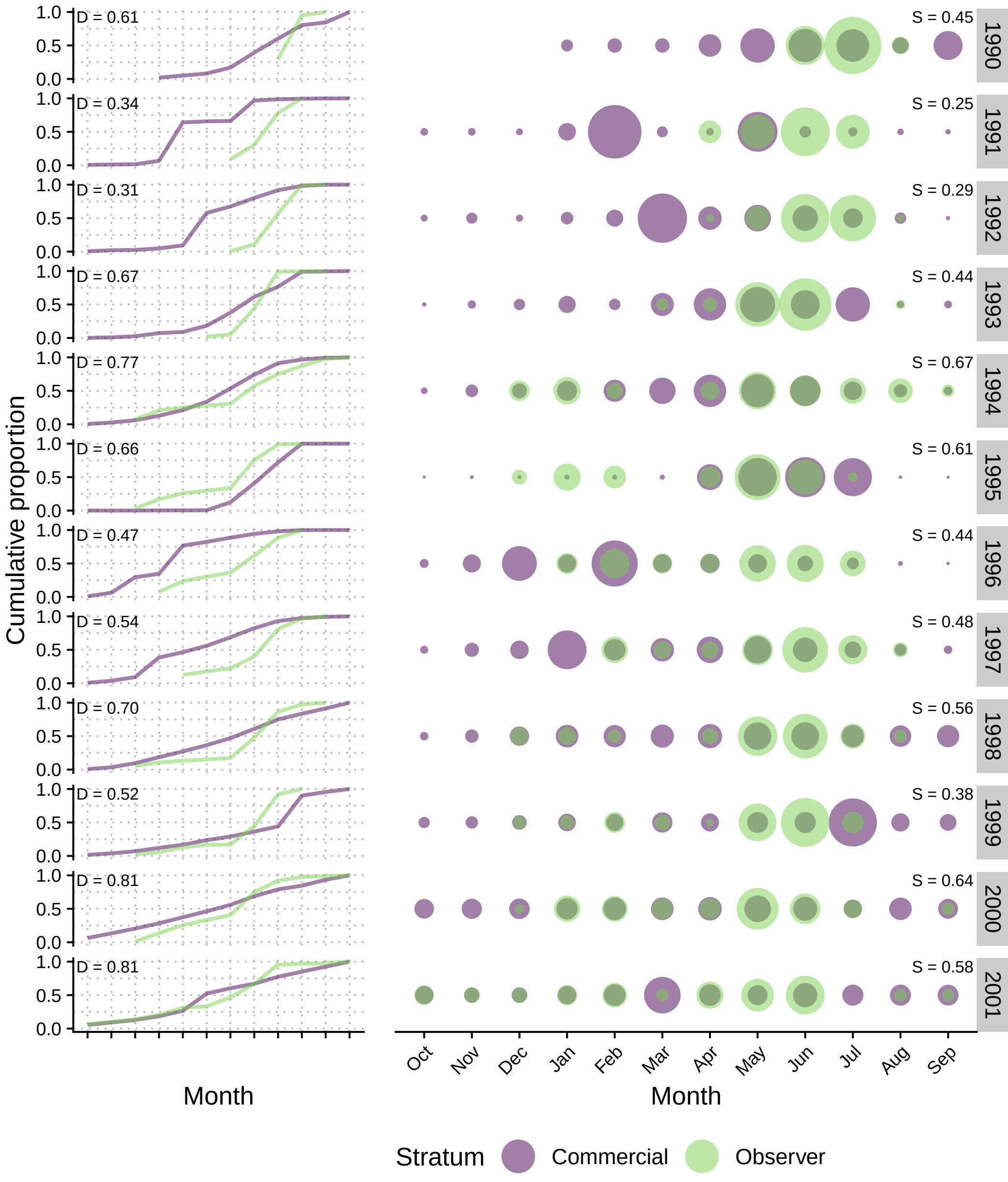

Figure E.5: Representativeness of observer sampling coverage of surface longline fishing events that caught albacore in 1990 to 2001 by fishing year and month. Observer data is for observed events with length sampling. Circle area is proportional to the proportion of events in a month, with proportions summing to one within each fishing year.

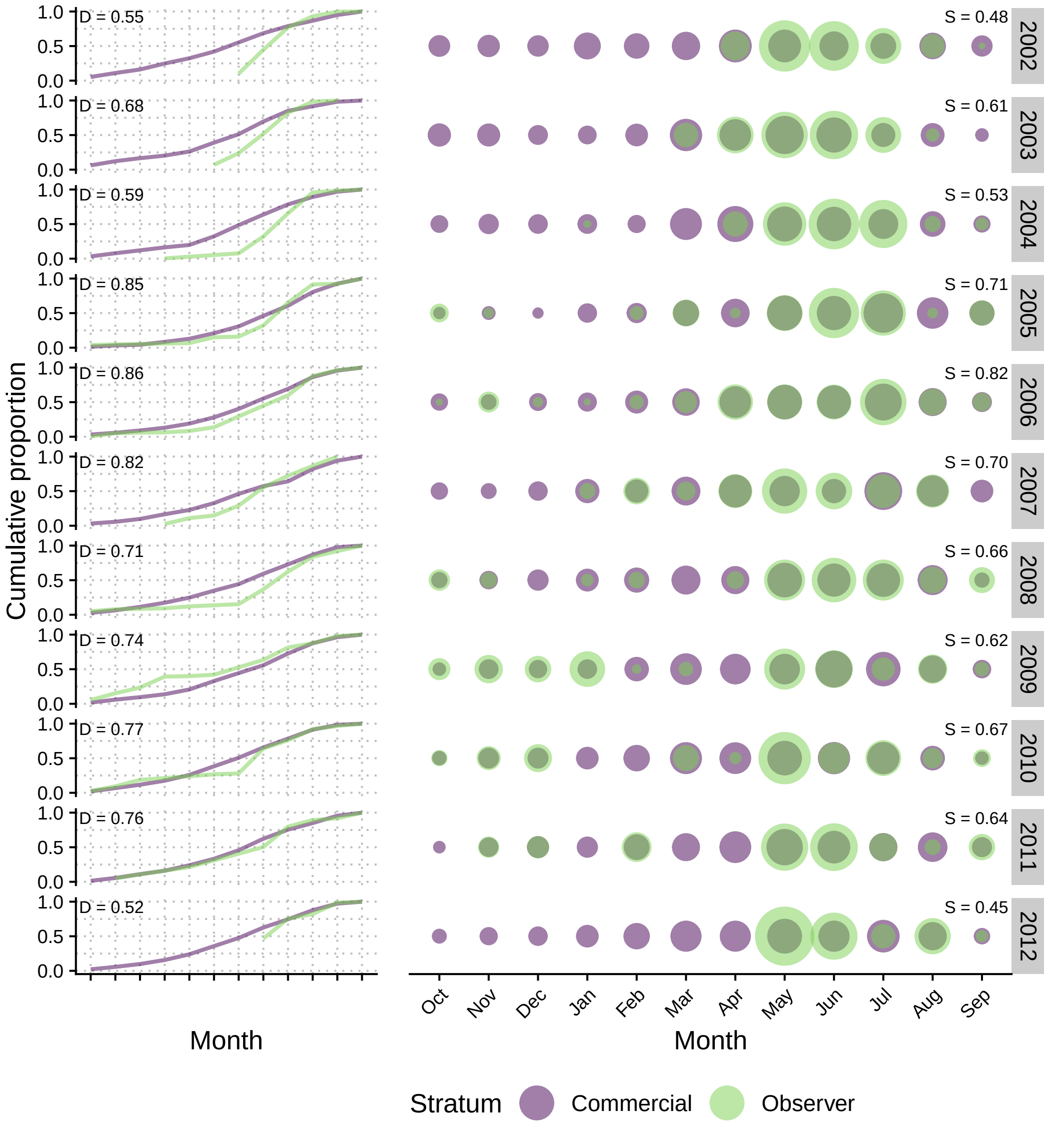

Figure E.6: Representativeness of observer sampling coverage of surface longline fishing events that caught albacore in 2002 to 2012 by fishing year and month. Observer data is for observed events with length sampling. Circle area is proportional to the proportion of events in a month, with proportions summing to one within each fishing year.

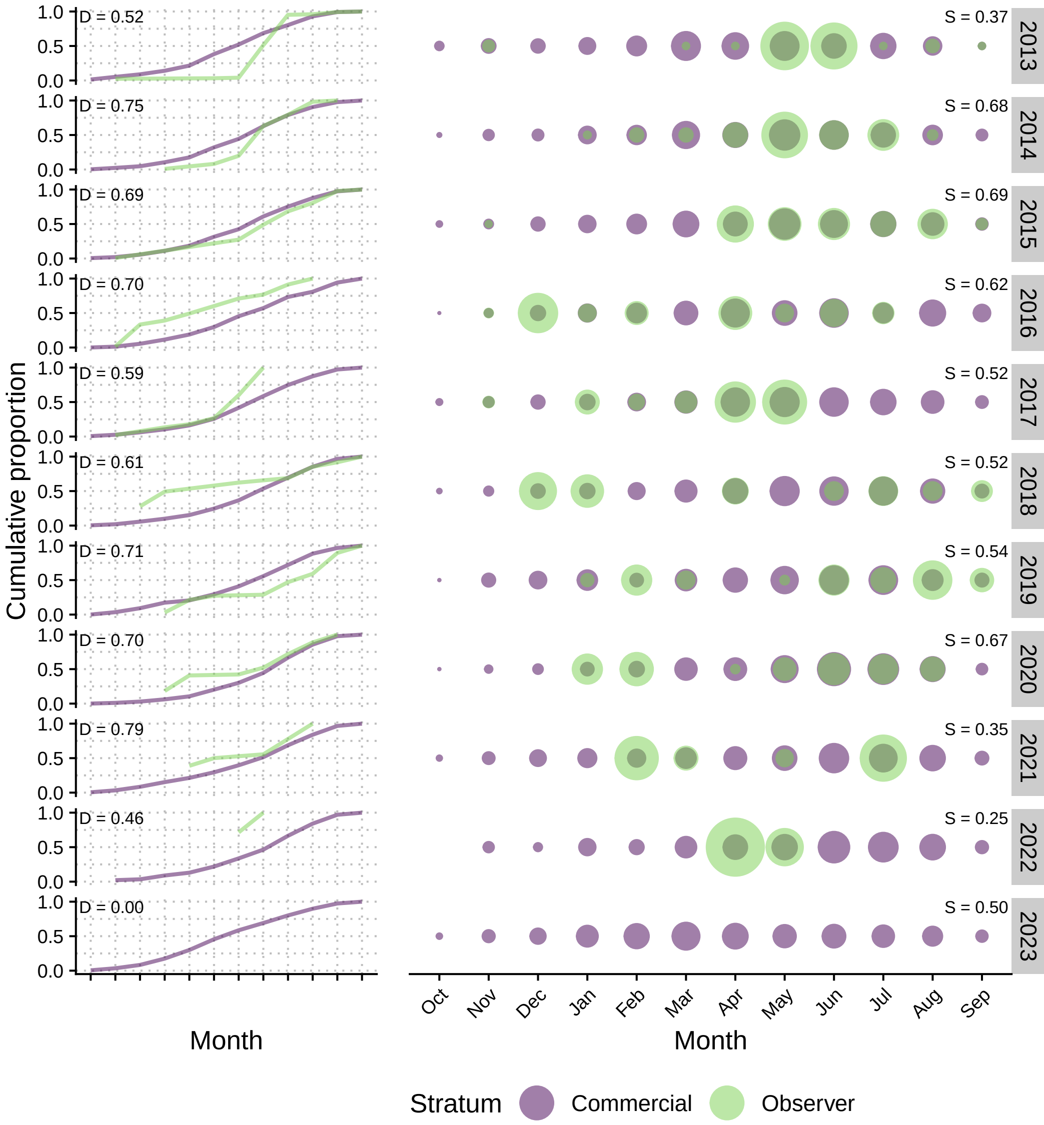

Figure E.7: Representativeness of observer sampling coverage of surface longline fishing events that caught albacore in 2013 to 2023 by fishing year and month. Observer data is for observed events with length sampling. Circle area is proportional to the proportion of events in a month, with proportions summing to one within each fishing year.

E.4 The troll fishery

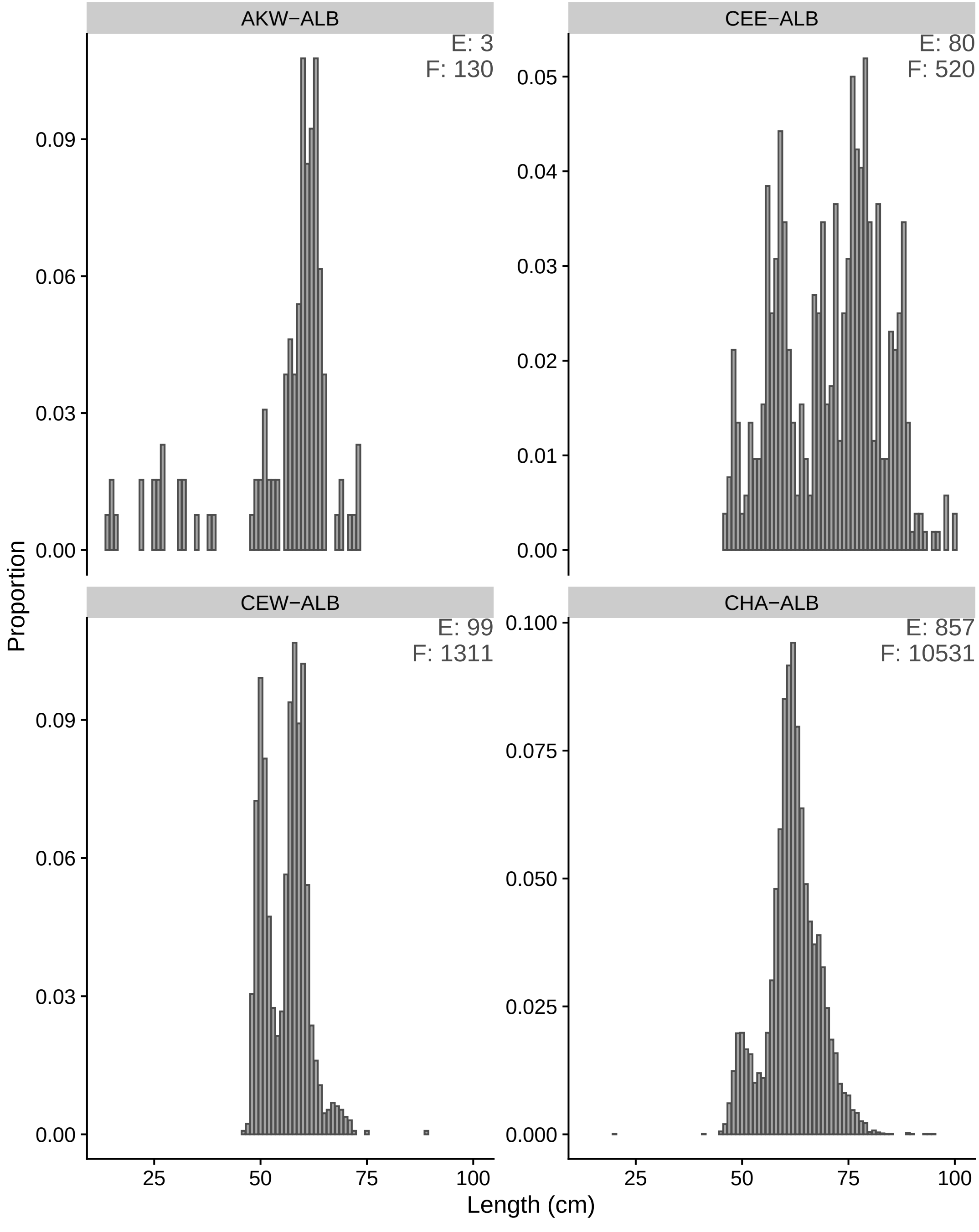

Figure E.8: Raw aggregate length-frequency distributions for albacore caught in the troll fishery, by area and target species, from fishing years 1988 to 2021.

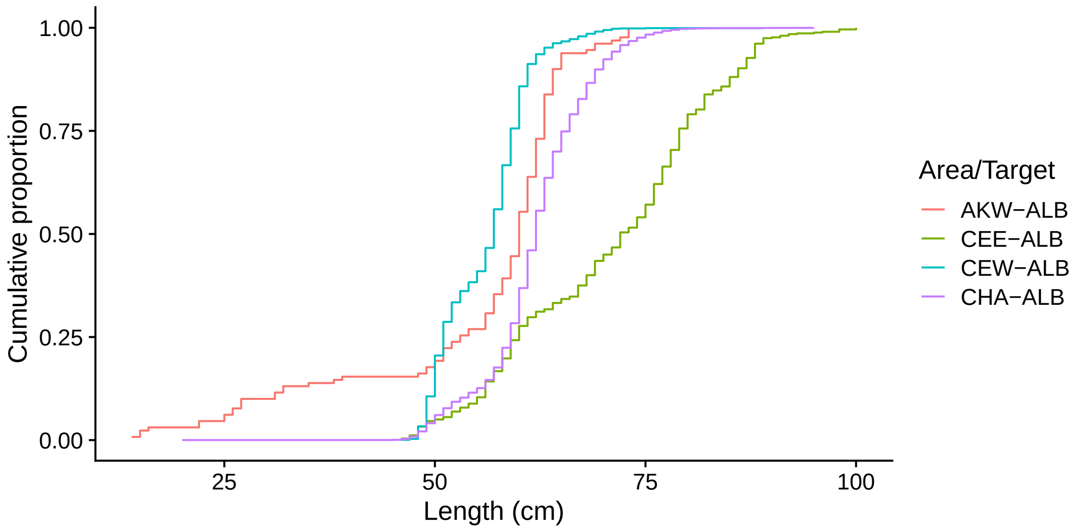

Figure E.9: Cumulative length-frequency distributions for albacore caught in the troll fishery, by area and target species, from fishing years 1988 to 2021.

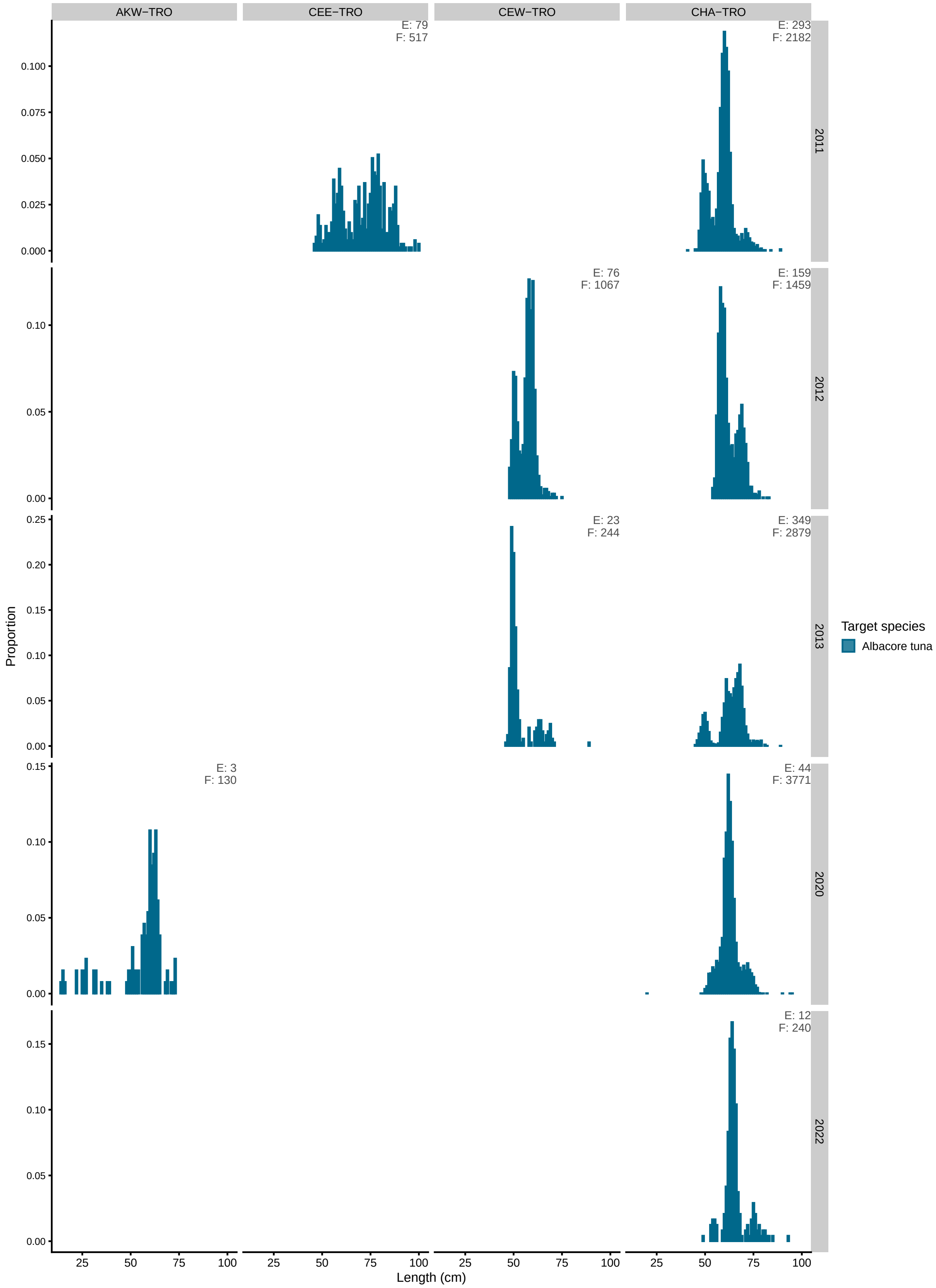

Figure E.10: Raw aggregate length-frequency distributions for albacore caught in the troll fishery, by area, year, and target species.

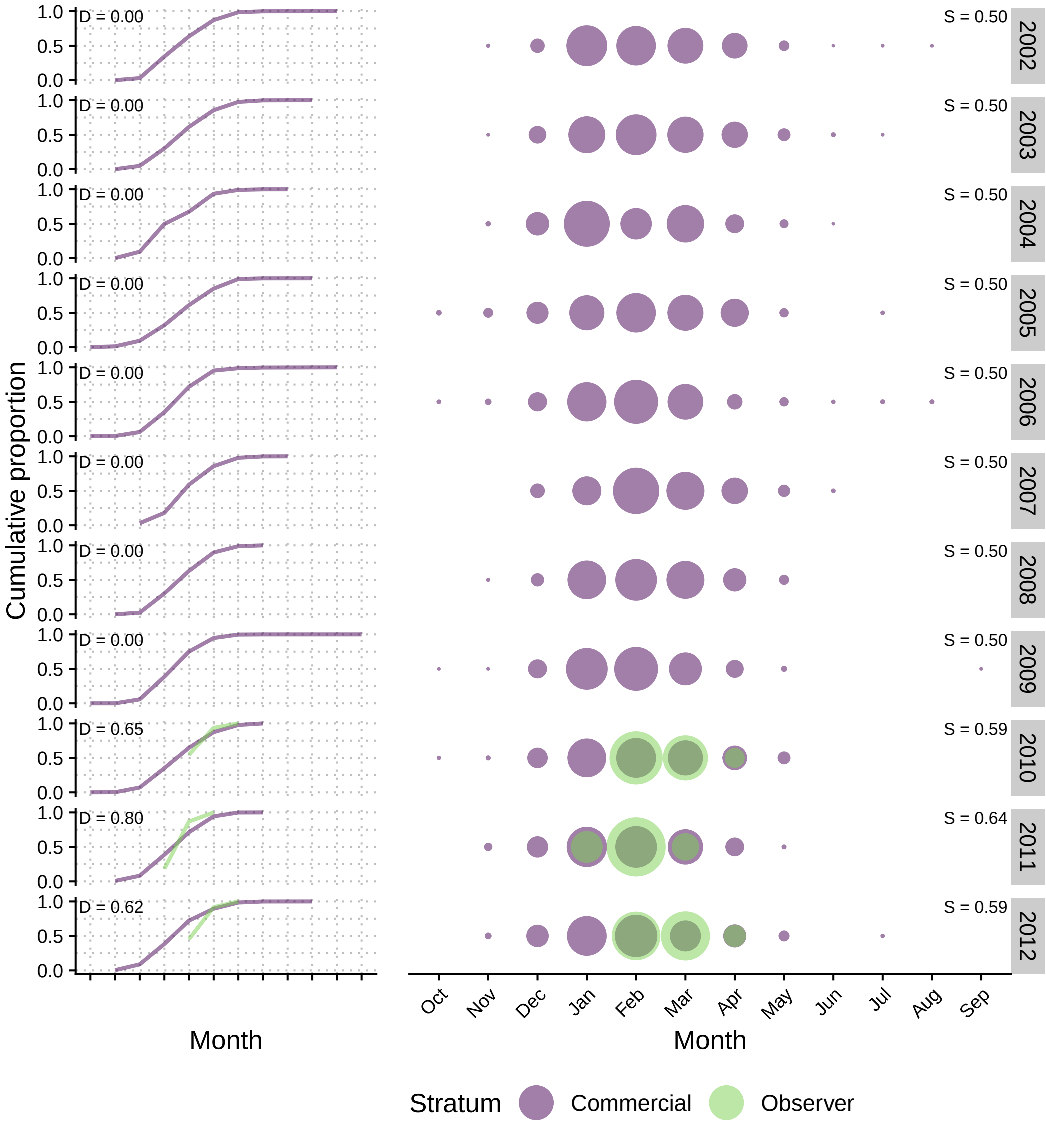

Figure E.11: Representativeness of observer sampling coverage of troll fishing events that caught albacore in 2002 to 2012 by fishing year and month. Observer data is for observed events with length sampling. Circle area is proportional to the proportion of events in a month, with proportions summing to one within each fishing year.

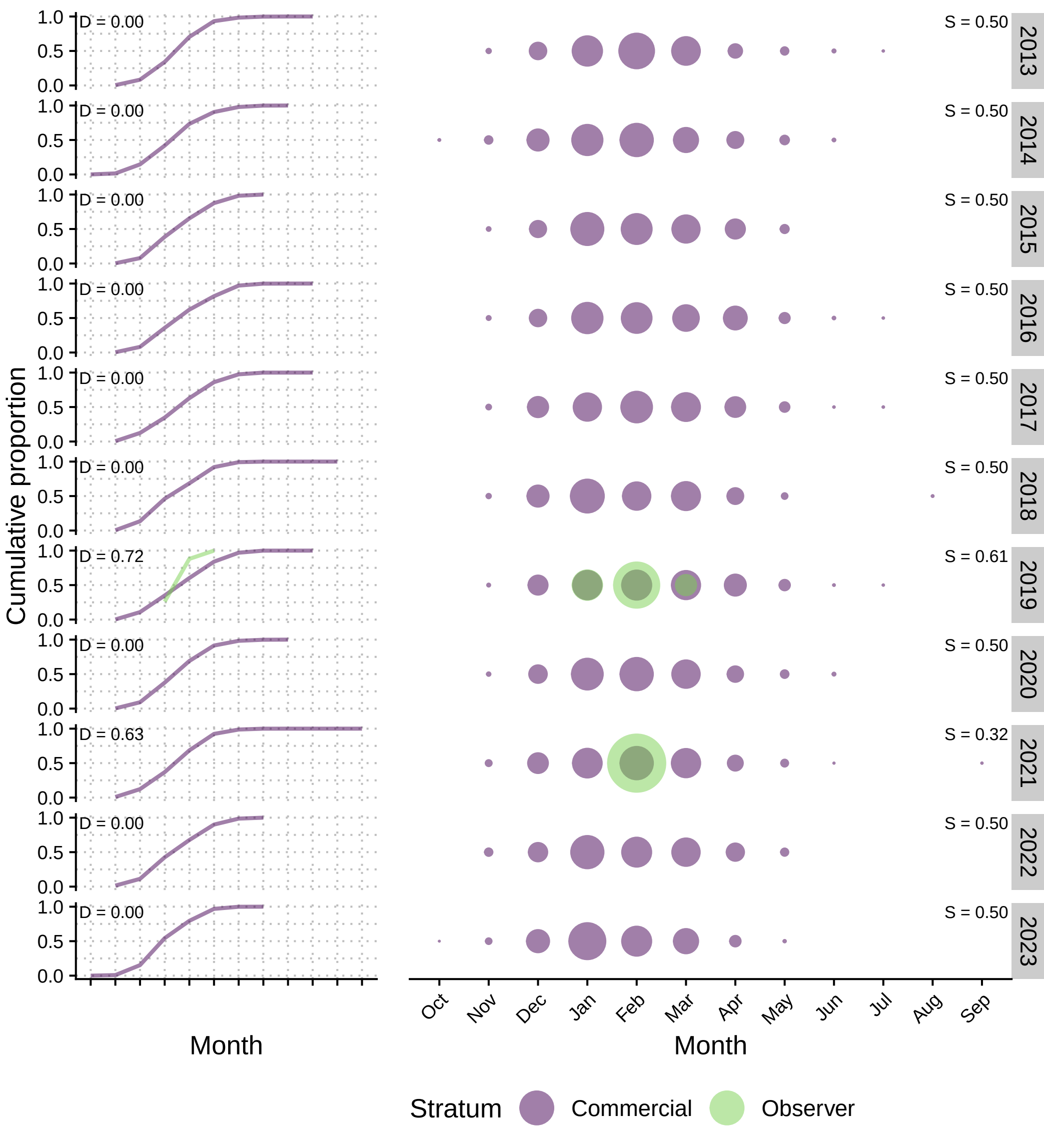

Figure E.12: Representativeness of observer sampling coverage of troll fishing events that caught albacore in 2013 to 2023 by fishing year and month. Observer data is for observed events with length sampling. Circle area is proportional to the proportion of events in a month, with proportions summing to one within each fishing year.

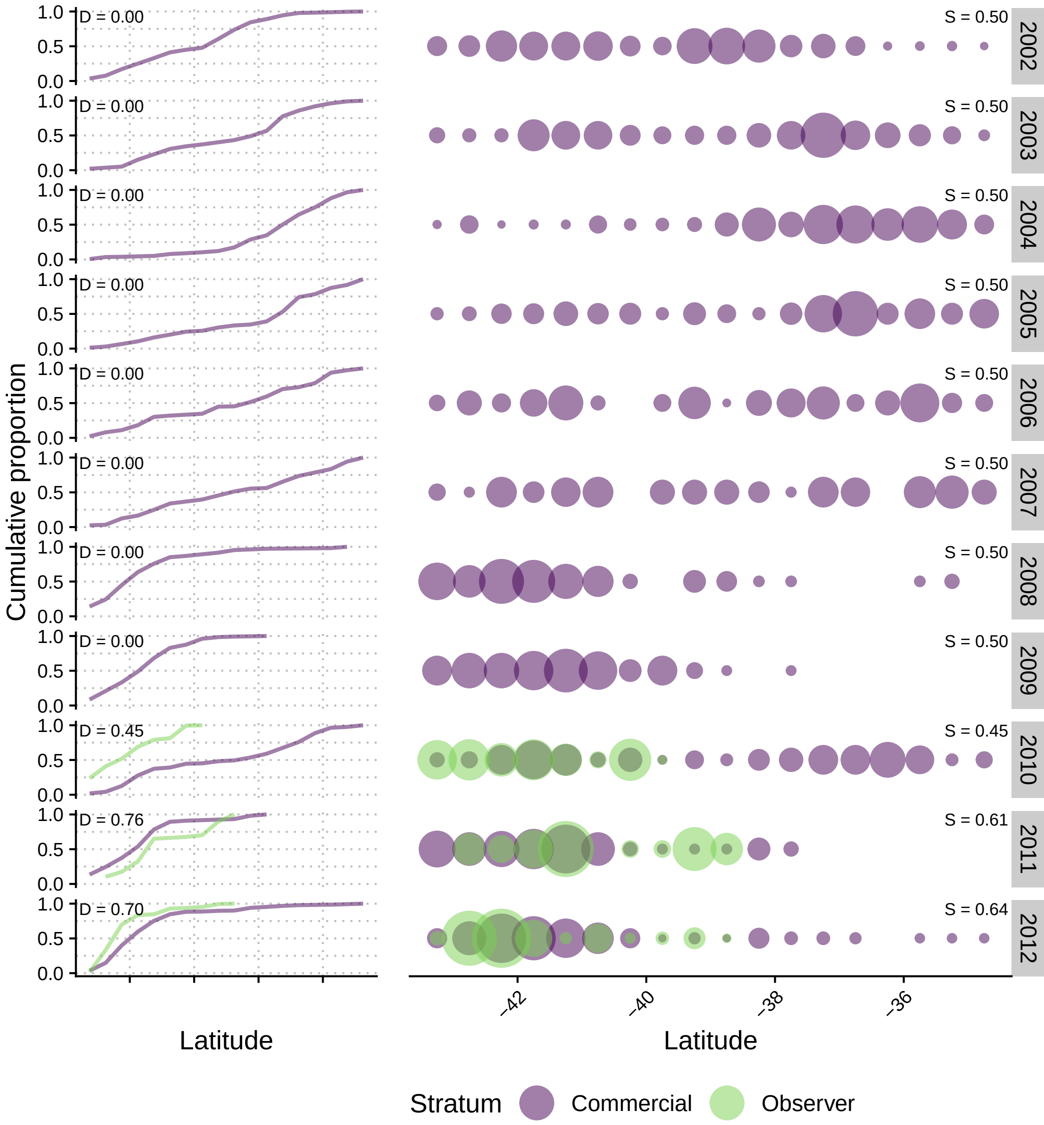

Figure E.13: Representativeness of observer sampling coverage of troll fishing events that caught albacore in 2002 to 2012 by fishing year and latitude. Observer data is for observed events with length sampling. Circle area is proportional to the proportion of events in a latitude bin, with proportions summing to one within each fishing year.

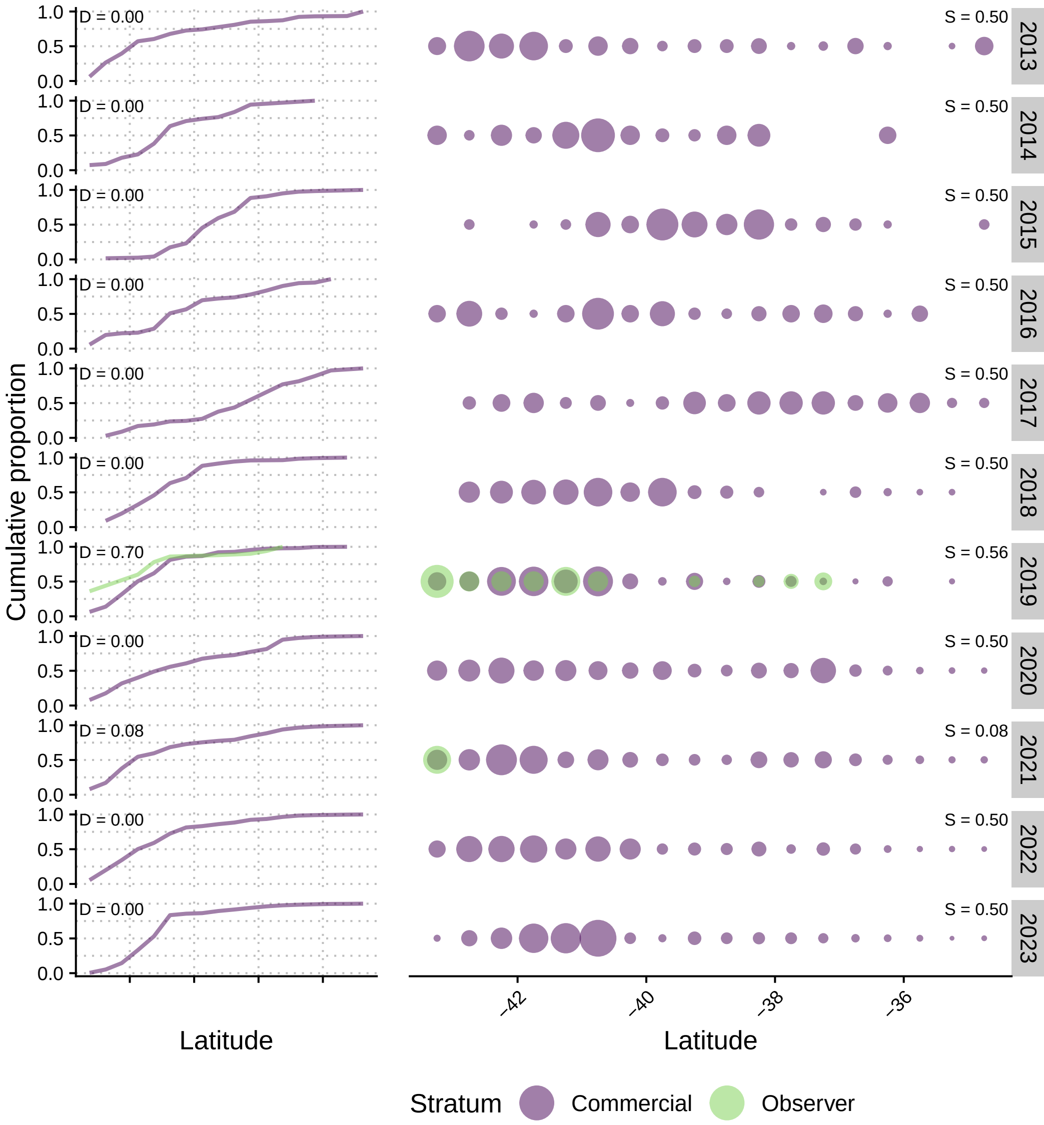

Figure E.14: Representativeness of observer sampling coverage of troll fishing events that caught albacore in 2013 to 2023 by fishing year and latitude. Observer data is for observed events with length sampling. Circle area is proportional to the proportion of events in a latitude bin, with proportions summing to one within each fishing year.

APPENDIX F: OBSERVER TROLL LENGTH FREQUENCY MODEL RESULTS

Table F.1: Expected log posterior density (elpd) and standard error (se) estimated from pseudo leave-one-out (loo) cross-validation, alongside estimated parameters (p), loo information criterion (ic) and elpd difference between models. Models are ordered from best to worst in terms of predictive performance (measured by highest elpd or lowest looic) for compositions. Models were fitted witout spatio-temporal terms (no ST), with statistical-area (SA) month effects, and with sea surface temperature (SST) to explain spatio-temporal patterns in compositions.

	elpd loo	se elpd loo	p loo	se p loo	looic	se looic	elpd diff	se diff
SA month	-12283	147	775	21	24566	293	0	0
w SST	-12536	152	627	19	25073	305	-253	32
no ST	-12582	153	623	20	25165	306	-299	31

Table F.2: Parameter estimates for random effects standard deviations for the Poisson-factorised multinomial model for Albacore length compositions. rhat: convergence statistic; rhat close to 1 ($<$ 1.05) suggests model is converged) based on standard deviation within chains to standard deviation between chains. ess: effective sample size in the bulk and tail of the posterior distribution.

Variable	Mean	Median	SD	5th Perc.	95th Perc.	Rhat	Ess bulk	Ess tail
fish year	1.03	1.02	0.08	0.91	1.18	1.00	350.39	439.07
fish year:month	0.33	0.33	0.07	0.19	0.44	1.01	159.88	284.97
fish year:month:stat area	0.38	0.37	0.06	0.28	0.48	1.00	153.96	174.87
month	0.06	0.05	0.04	0.00	0.13	1.01	298.86	317.23
stat area	1.18	1.18	0.07	1.07	1.31	1.00	400.17	500.66
stat area:month	0.37	0.37	0.07	0.24	0.47	1.00	160.51	237.13

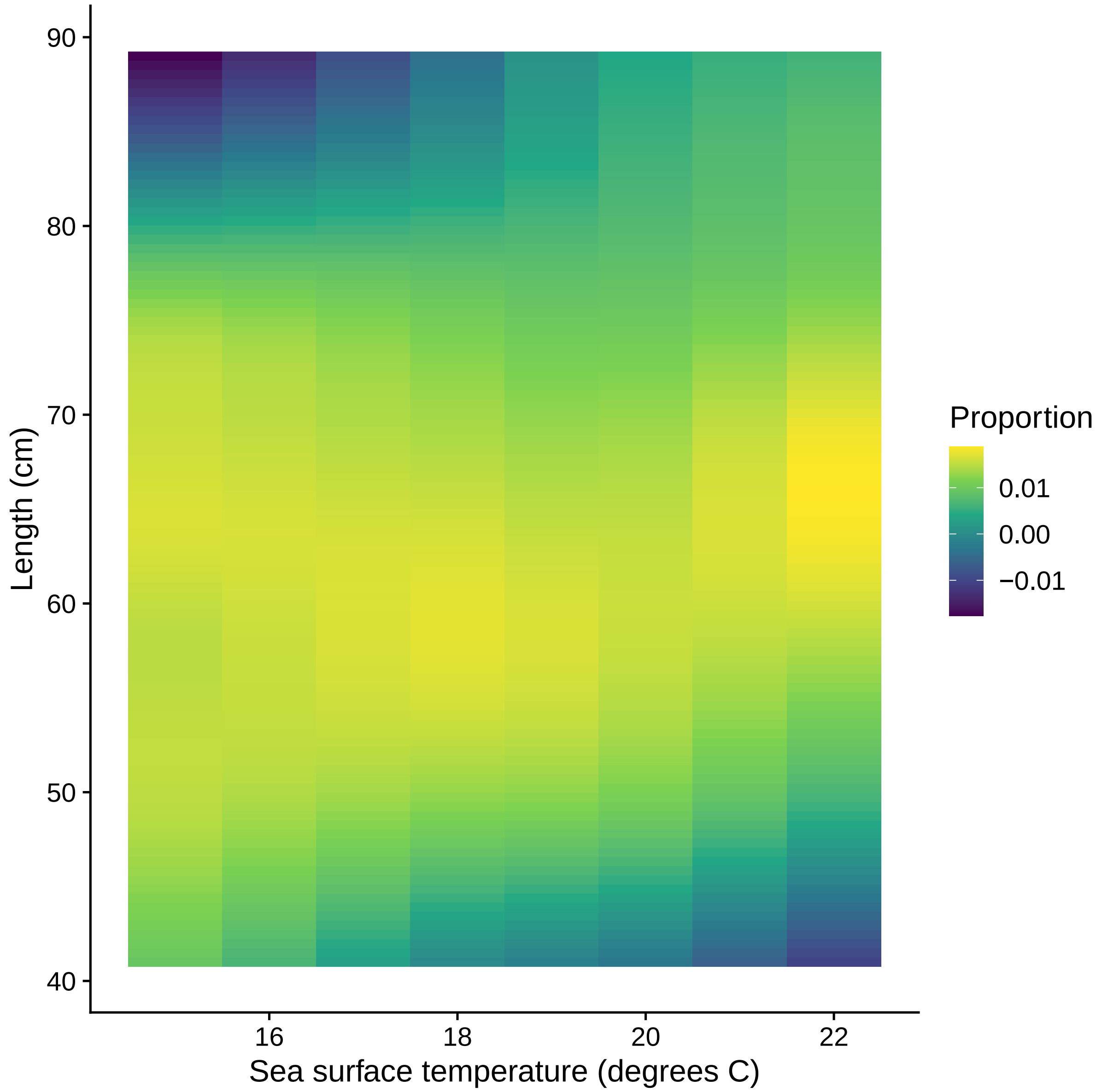

Figure F.1: Effect of sea-surface temperature on the expected proportions at length in New Zealand troll-caught albacore.

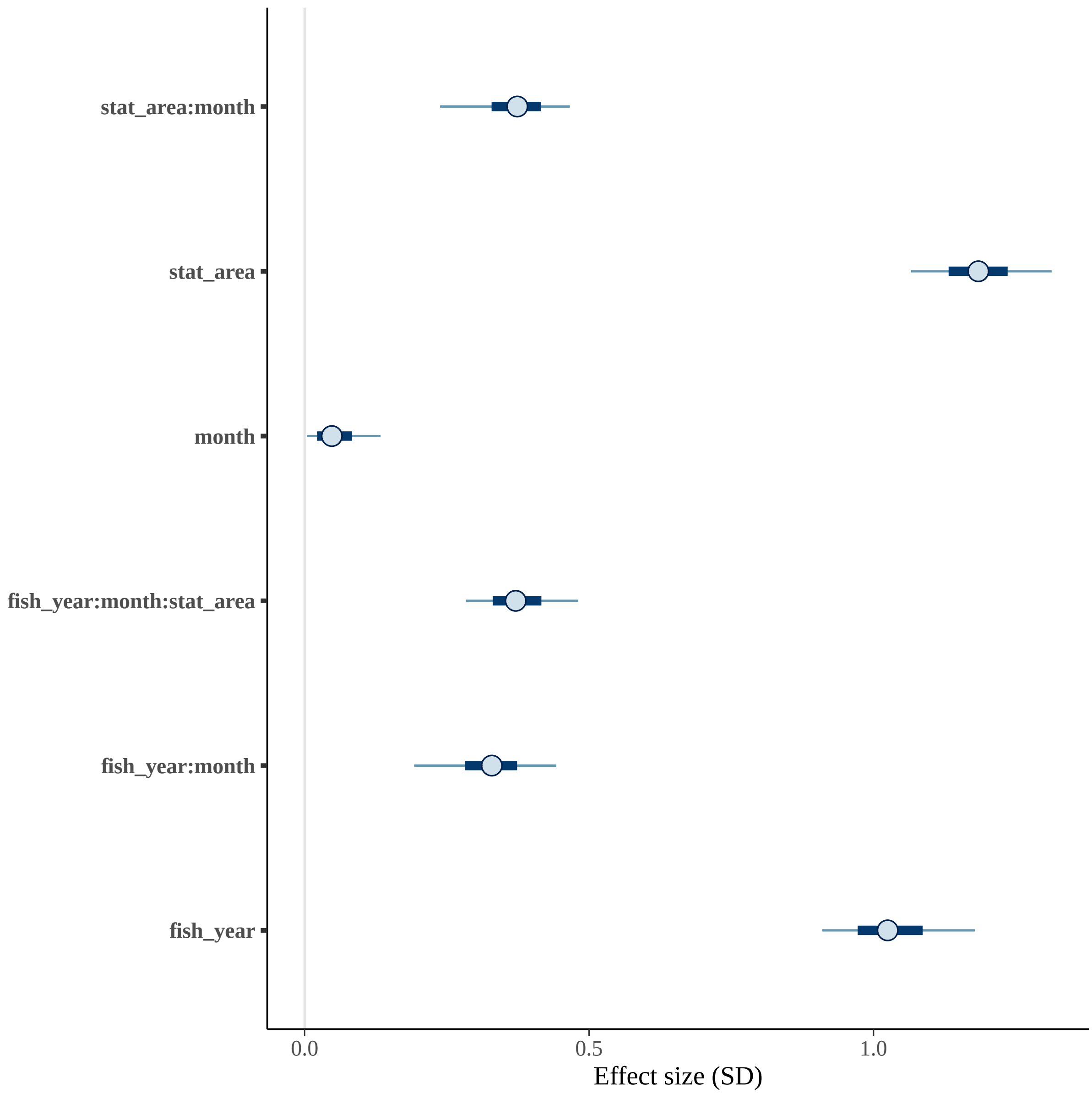

Figure F.2: Effect size in terms of random effect standard deviations affecting proportions at length in New Zealand troll-caught albacore

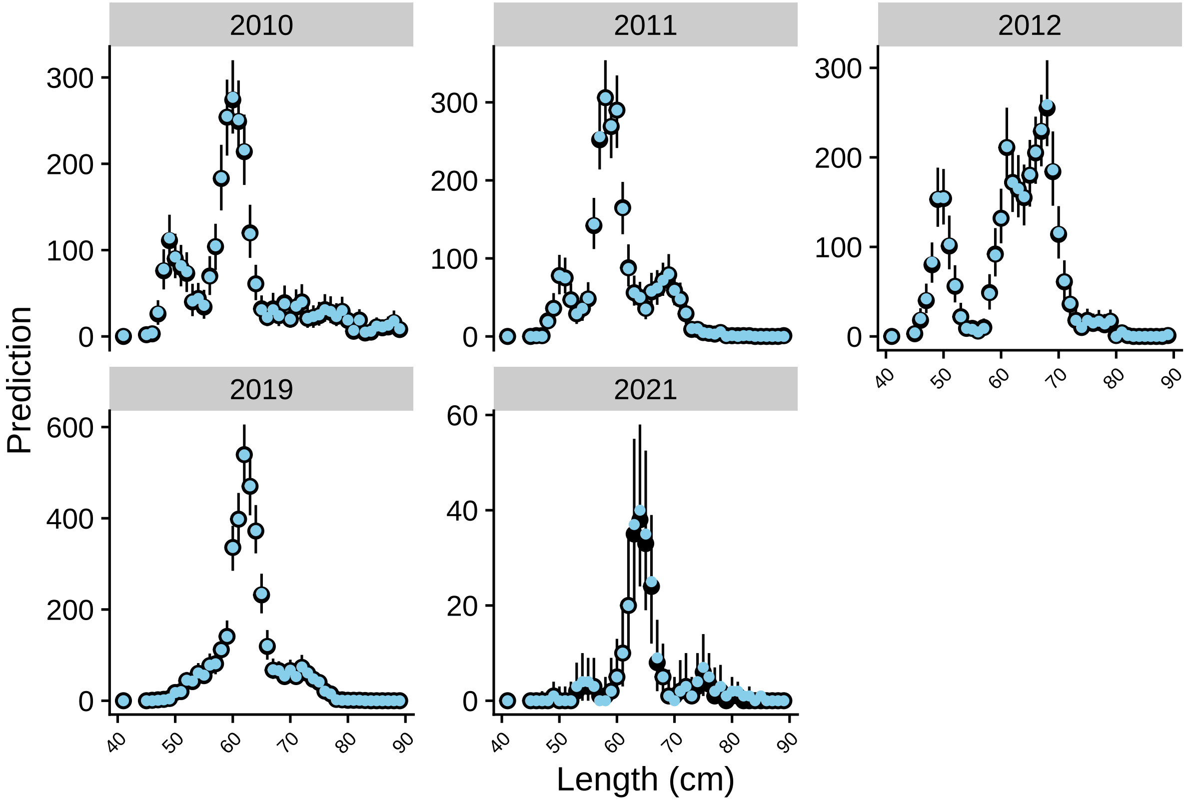

Figure F.3: Length-composition standardisation model fit (black posterior median and 95 percent prediction interval) to the sampled numbers in each length bin (blue) by year for New Zealand troll-caught albacore.

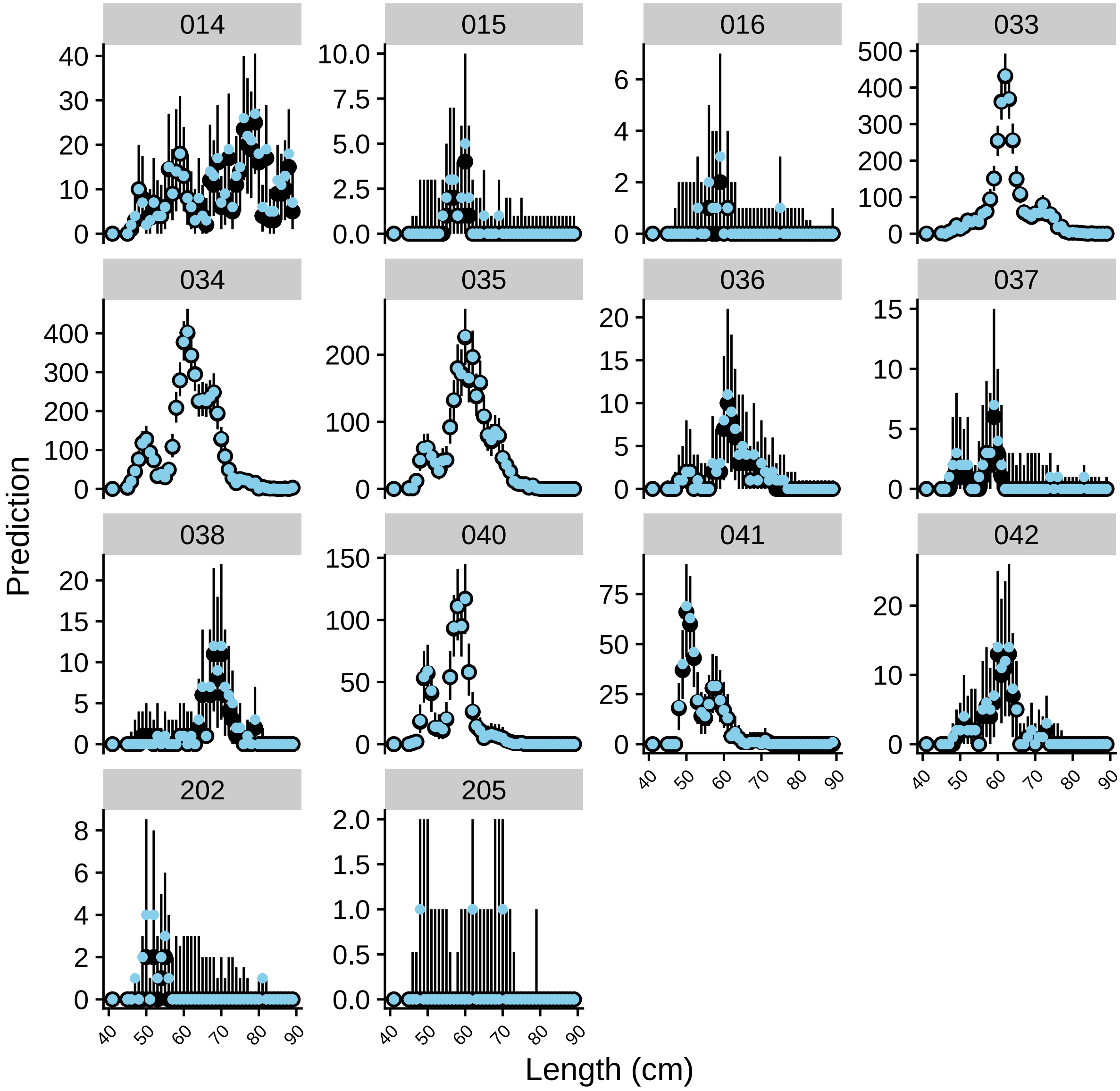

Figure F.4: Length-composition standardisation model fit (black posterior median and 95 percent prediction interval) to the sampled numbers in each length bin (blue) by statistical area for New Zealand troll-caught albacore.

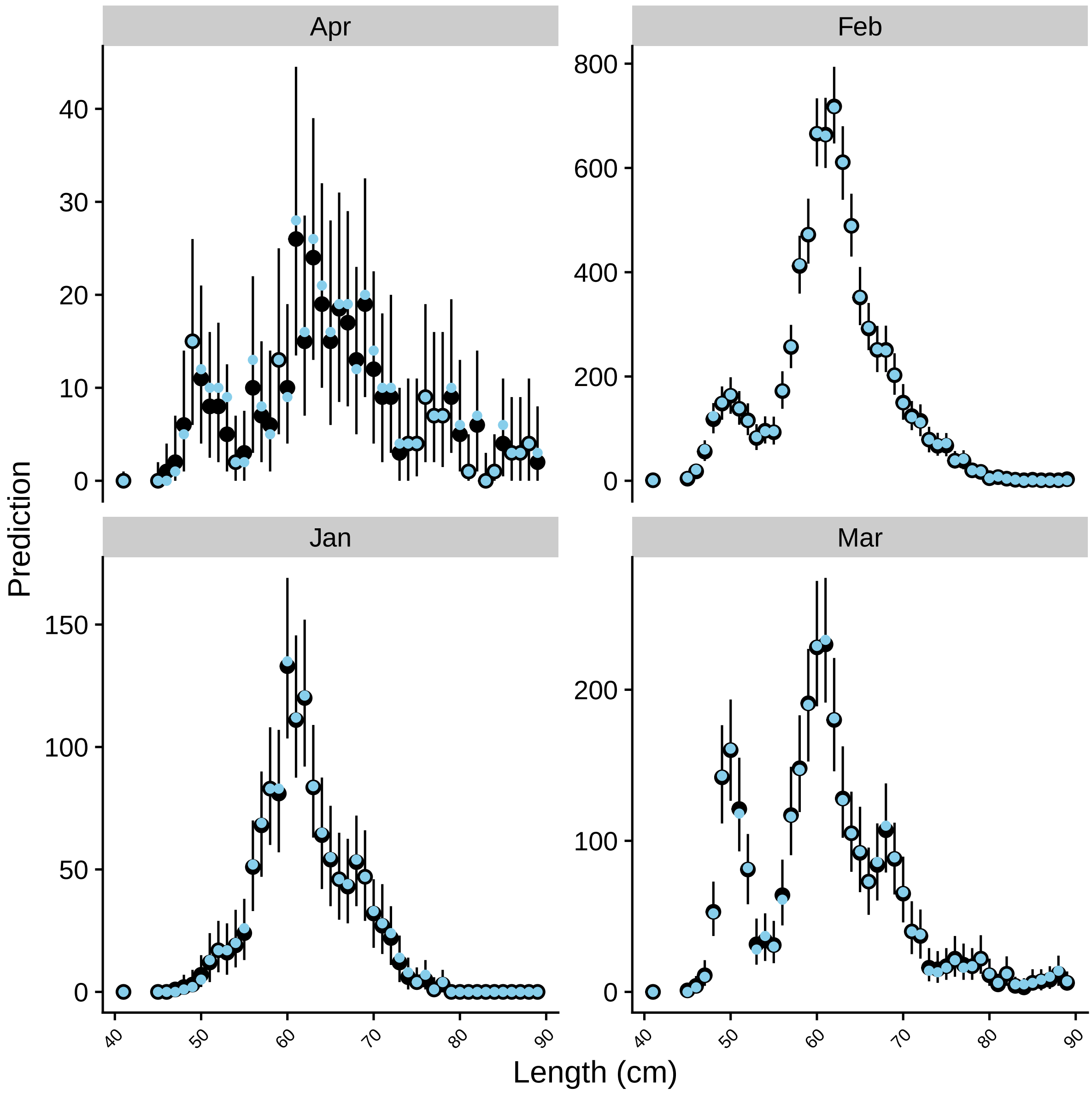

Figure F.5: Length-composition standardisation model fit (black posterior median and 95 percent prediction interval) to the sampled numbers in each length bin (blue) by month for New Zealand troll-caught albacore.

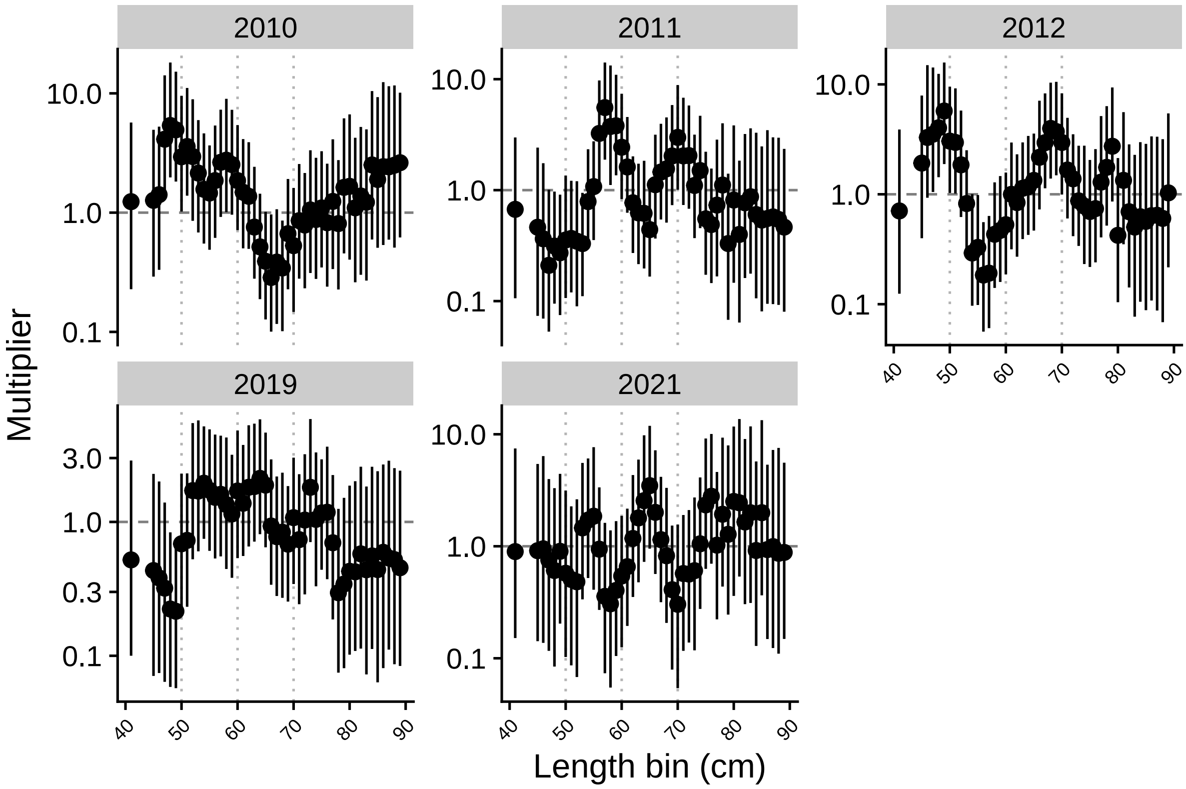

Figure F.6: Year effect by length bin, relative to the over-all mean length composition for New Zealand troll-caught albacore, estimated by the length-composition standardisation model (black posterior median and 95 percent prediction interval).

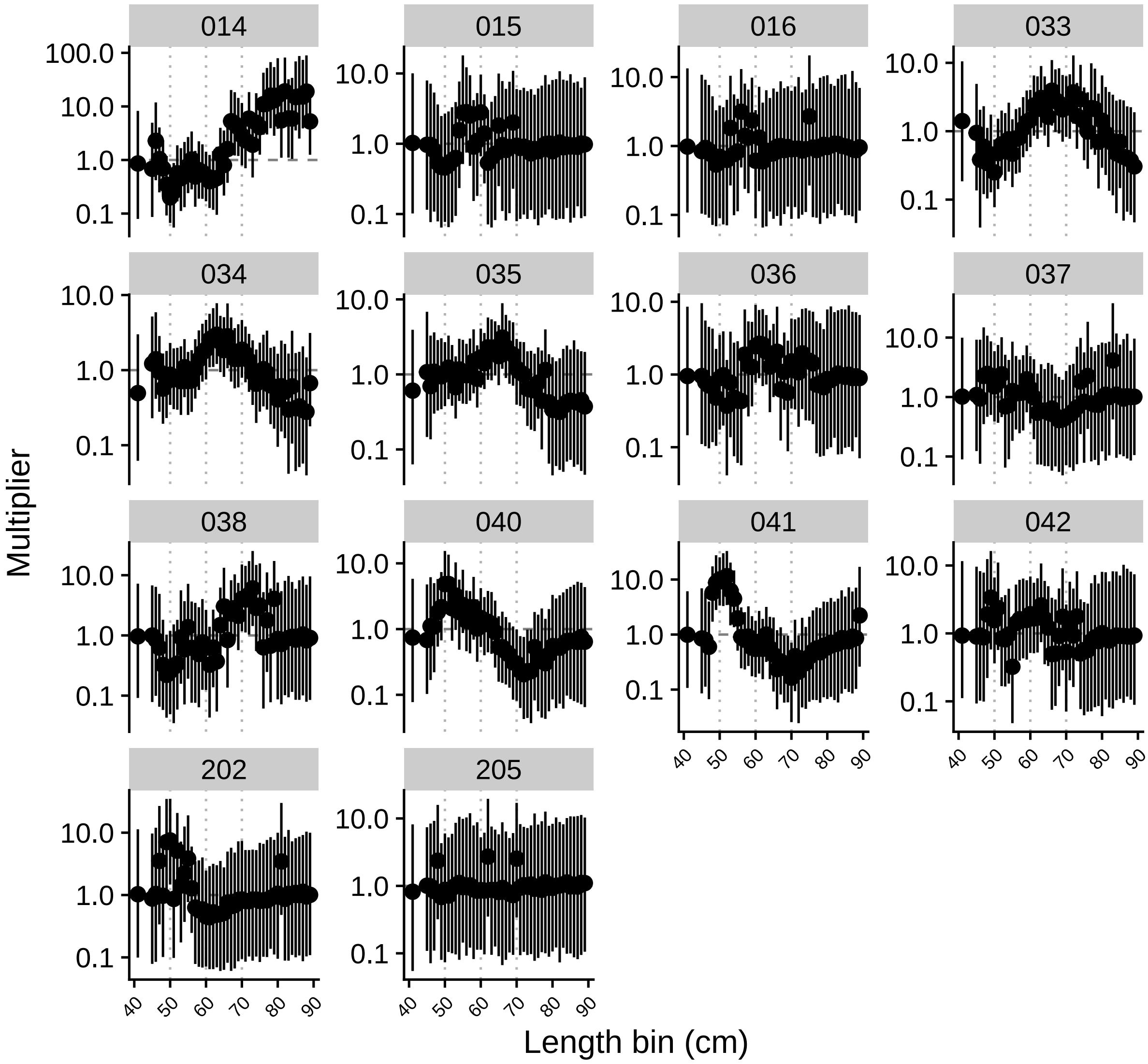

Figure F.7: Statistical area effect by length bin, relative to the over-all mean length composition for New Zealand troll-caught albacore, estimated by the length-composition standardisation model (black posterior median and 95 percent prediction interval).

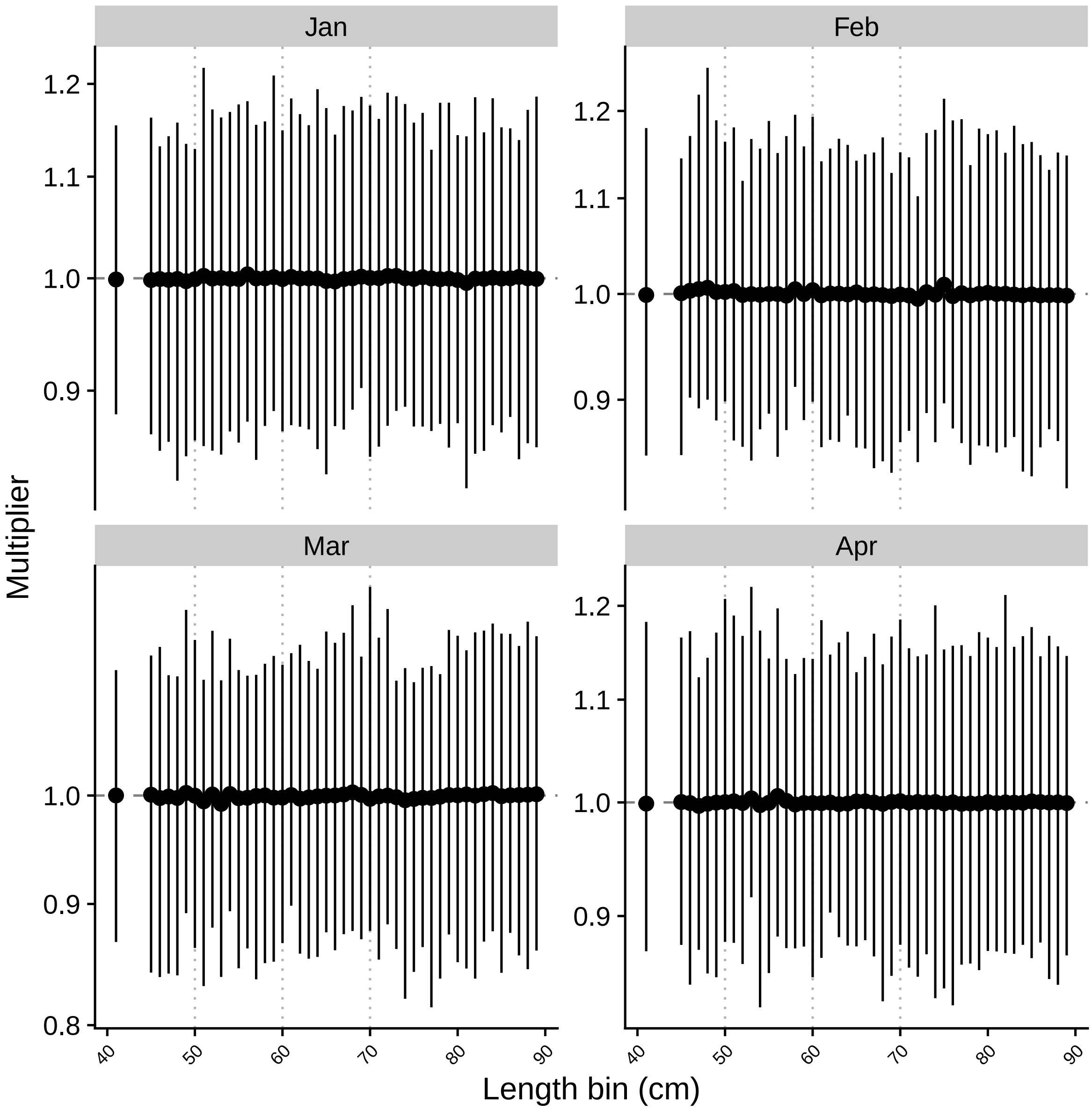

Figure F.8: Month effect by length bin, relative to the over-all mean length composition for New Zealand troll-caught albacore, estimated by the length-composition standardisation model (black posterior median and 95 percent prediction interval).

APPENDIX G: ADDITIONAL CHARACTERISATION PLOTS

G.1 Catch distributions by method

G.1.1 The Troll fishery

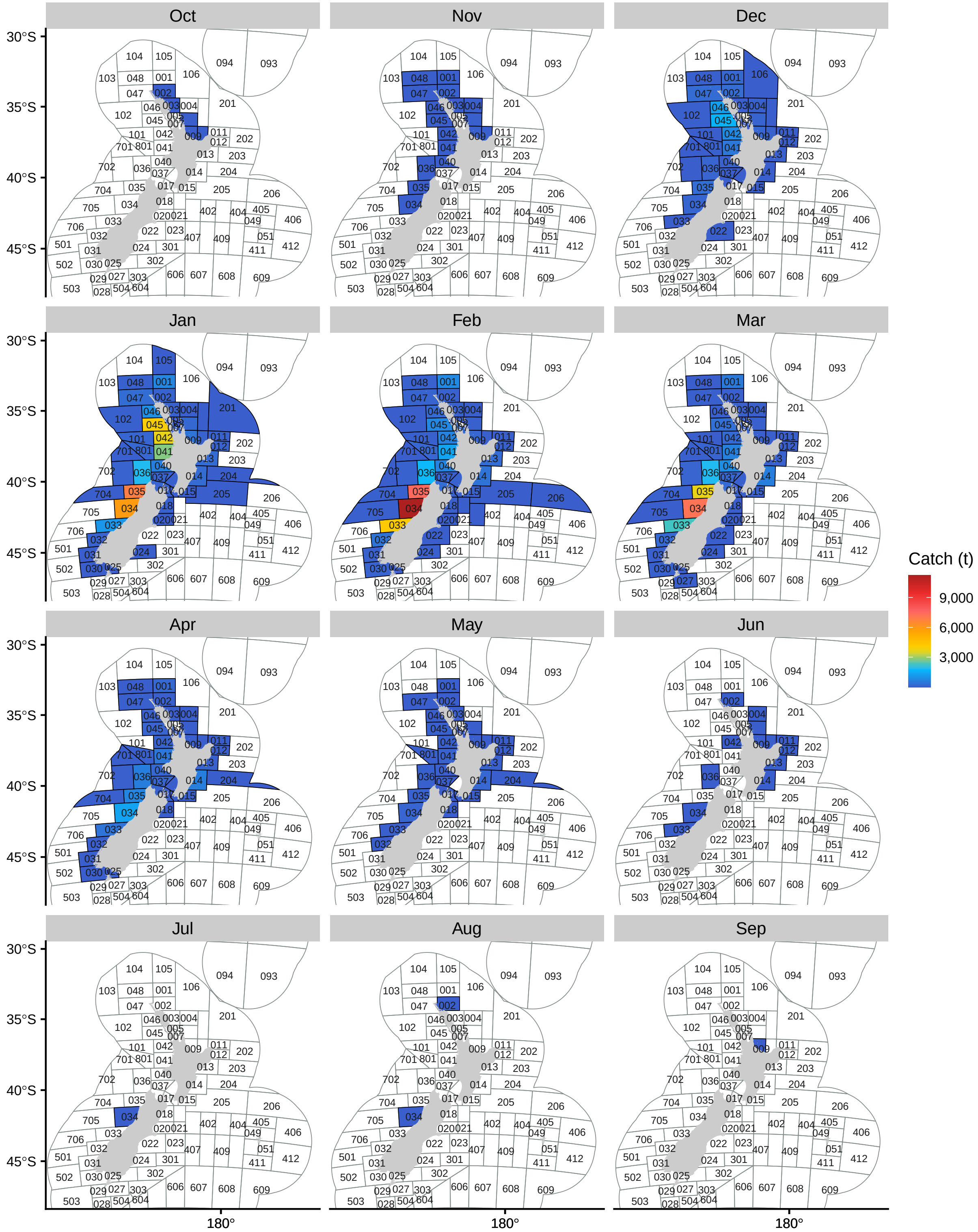

Figure G.1: Allocated landings (t) for the ALB 1 troll fishery, aggregated by month and by statistical area. Statistical areas with data from less than three vessels or permit holders are omitted. From 1990 to 2023 .

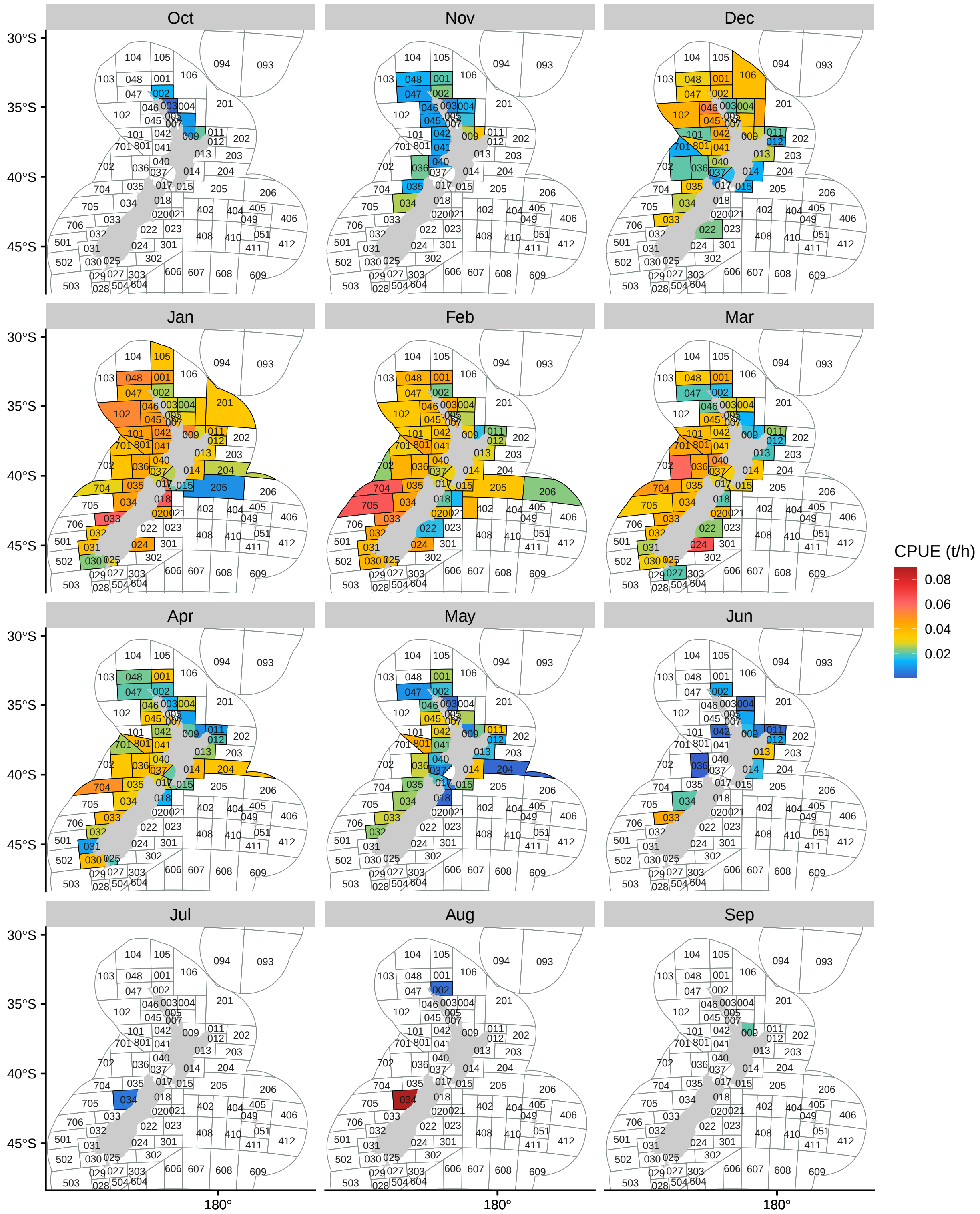

Figure G.2: Raw aggregate CPUE (t/h) for the ALB 1 troll fishery, aggregated by month and by statistical area. Statistical areas with data from less than three vessels or permit holders are omitted. From 1990 to 2023 .

G.1.2 The Surface longline fishery

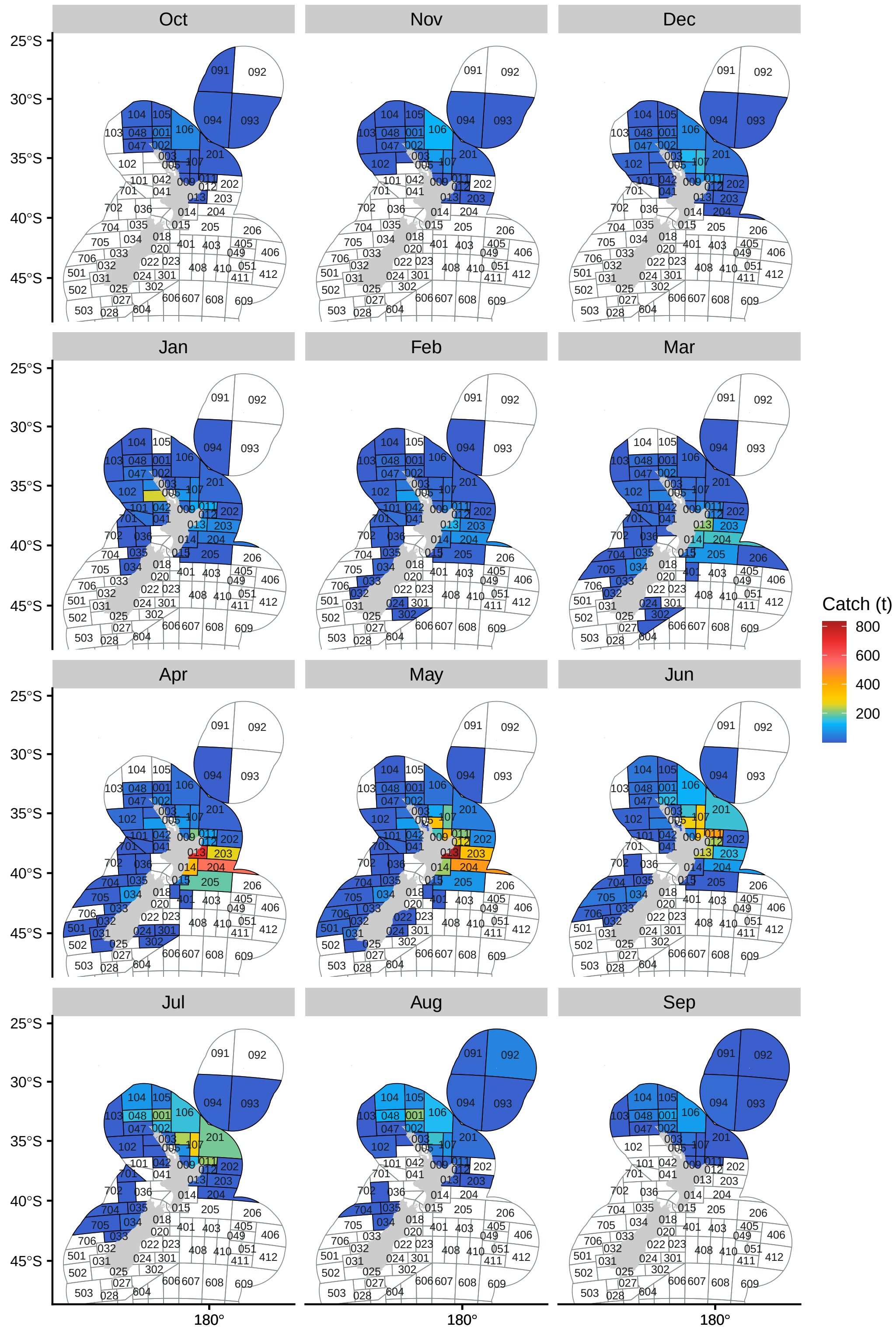

Figure G.3: Allocated landings (t) for the ALB 1 surface longline fishery, aggregated by month and by statistical area. Statistical areas with data from less than three vessels or permit holders are omitted. From 1990 to 2023 .

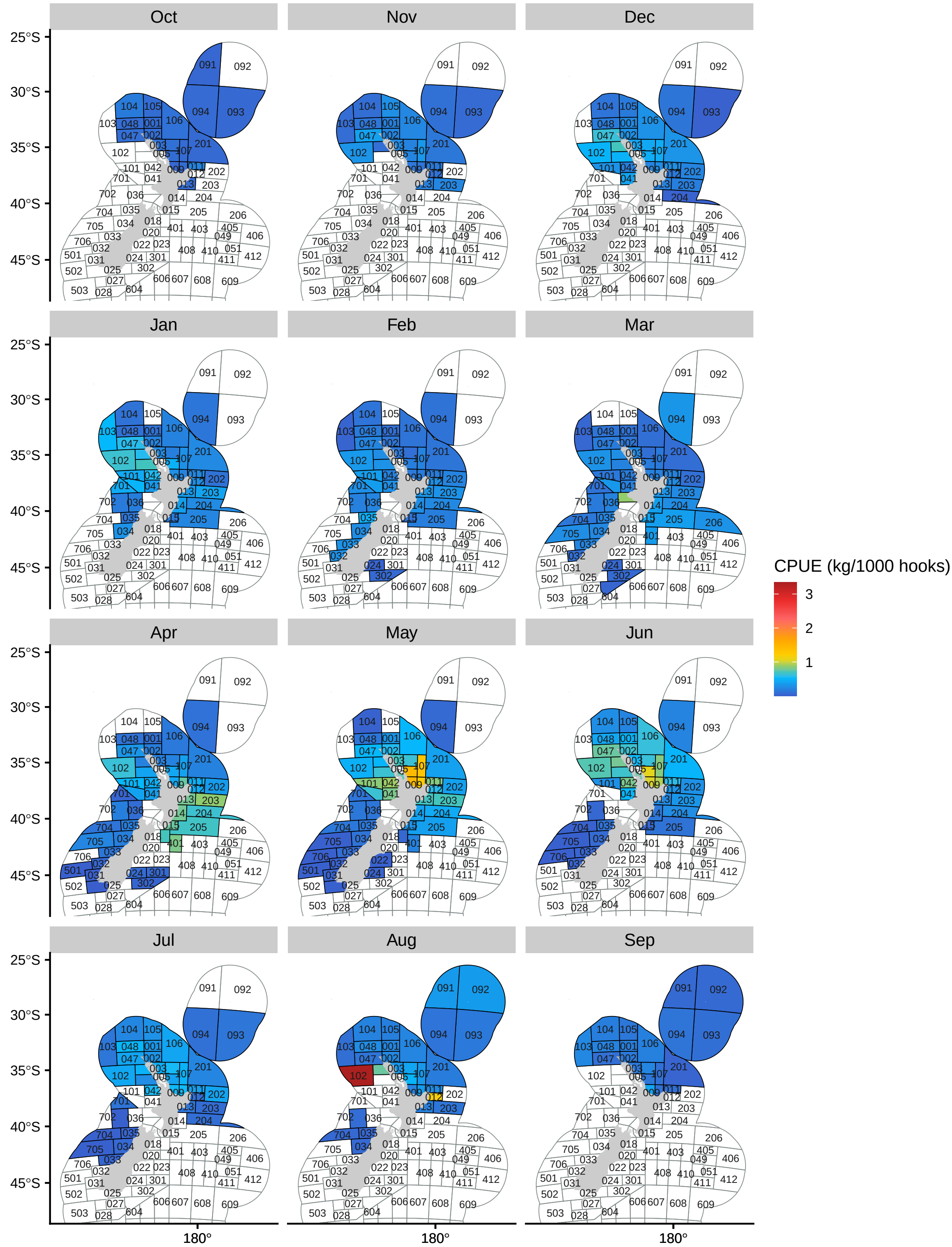

Figure G.4: Raw aggregate CPUE (kg/1000 hooks) for the ALB 1 surface longline fishery, aggregated by month and by statistical area. Statistical areas with data from less than three vessels or permit holders are omitted. From 1990 to 2023 .

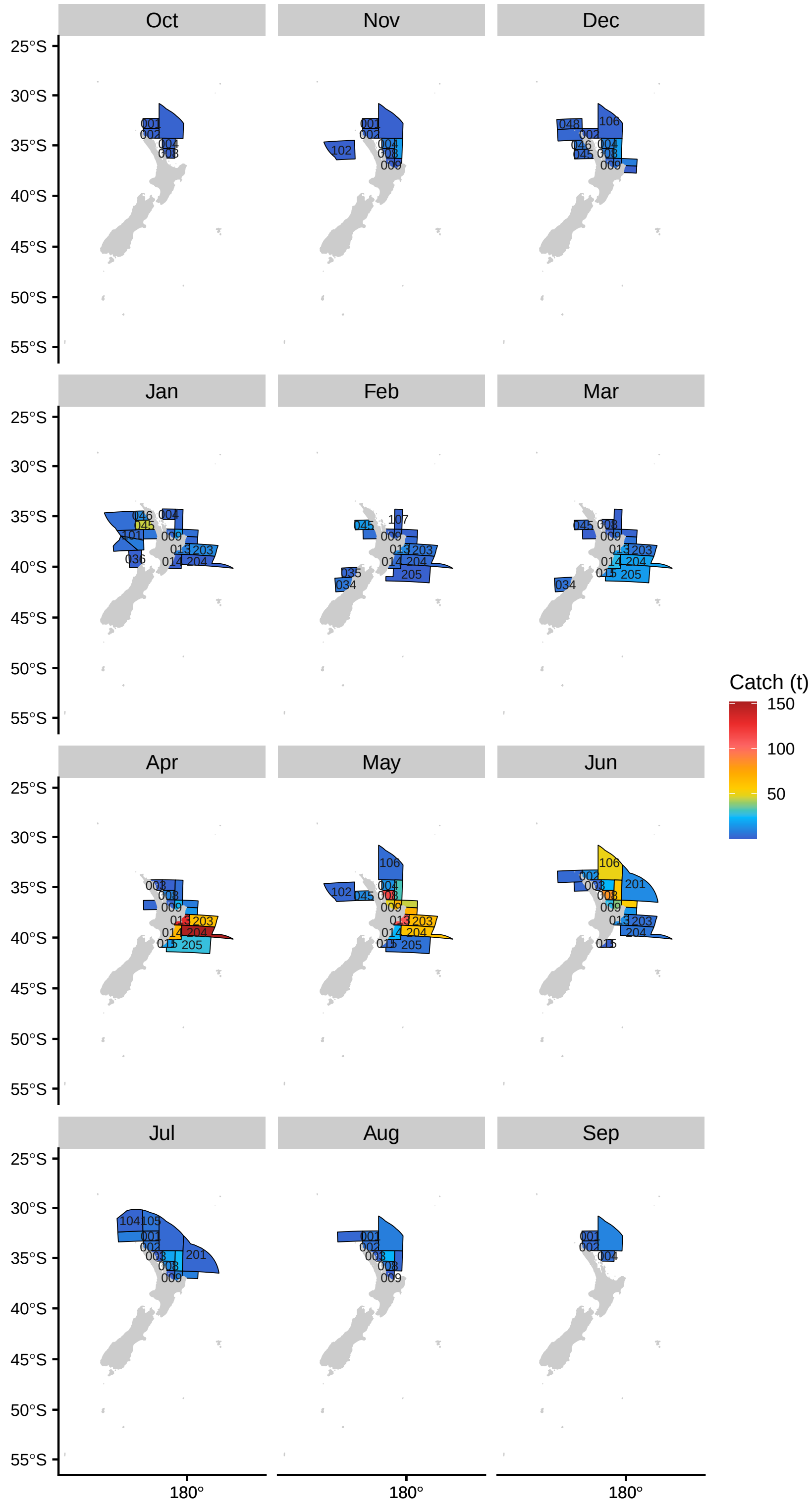

Figure G.5: Allocated ALB 1 landings (t) for the surface longline fishery by key target species ALB aggregated by month and by statistical area. Statistical areas with data from less than three vessels or permit holders are omitted. From 1990 to 2023 .

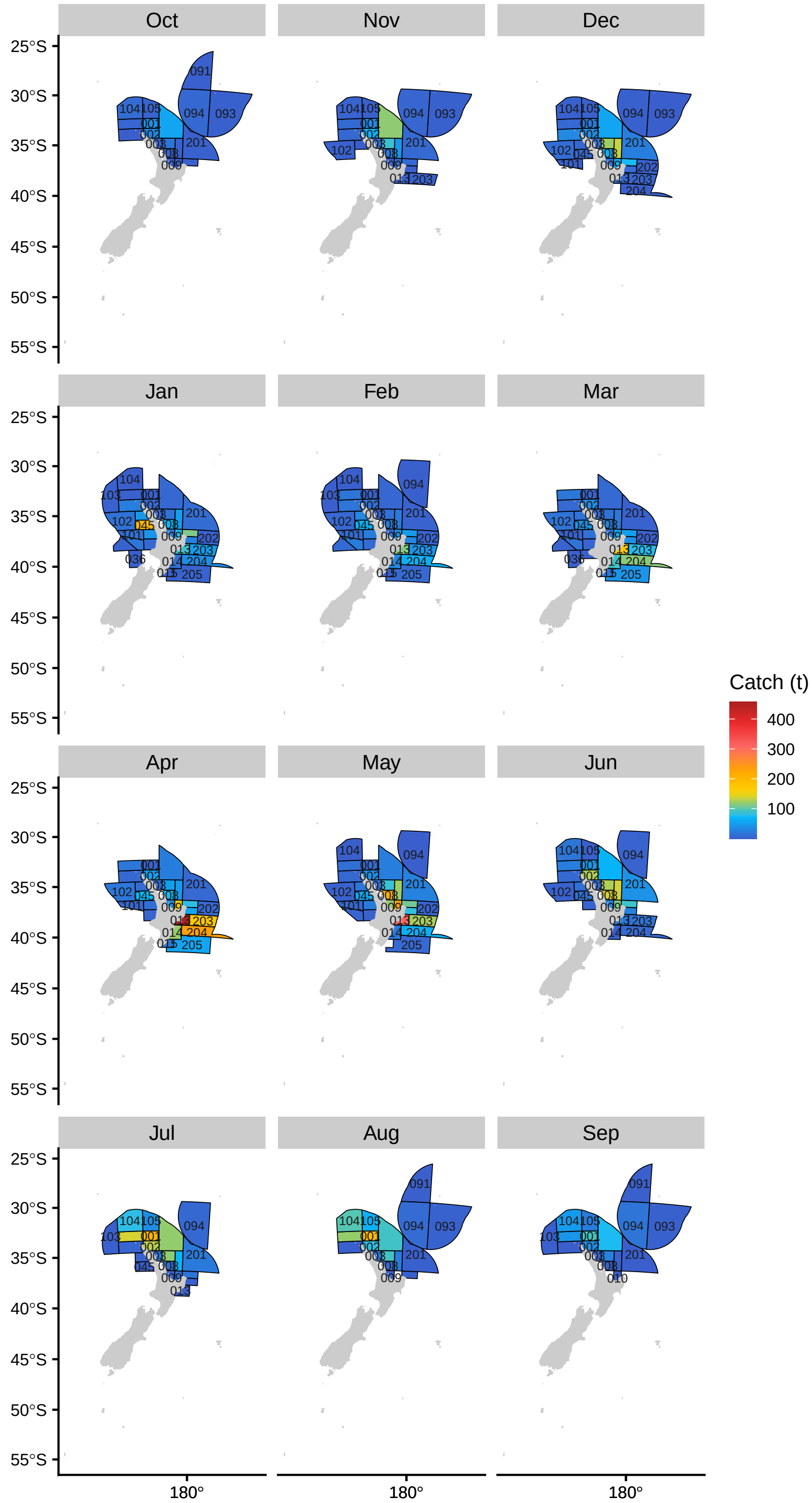

Figure G.6: Allocated ALB 1 landings (t) for the surface longline fishery by key target species BIG aggregated by month and by statistical area. Statistical areas with data from less than three vessels or permit holders are omitted. From 1990 to 2023 .

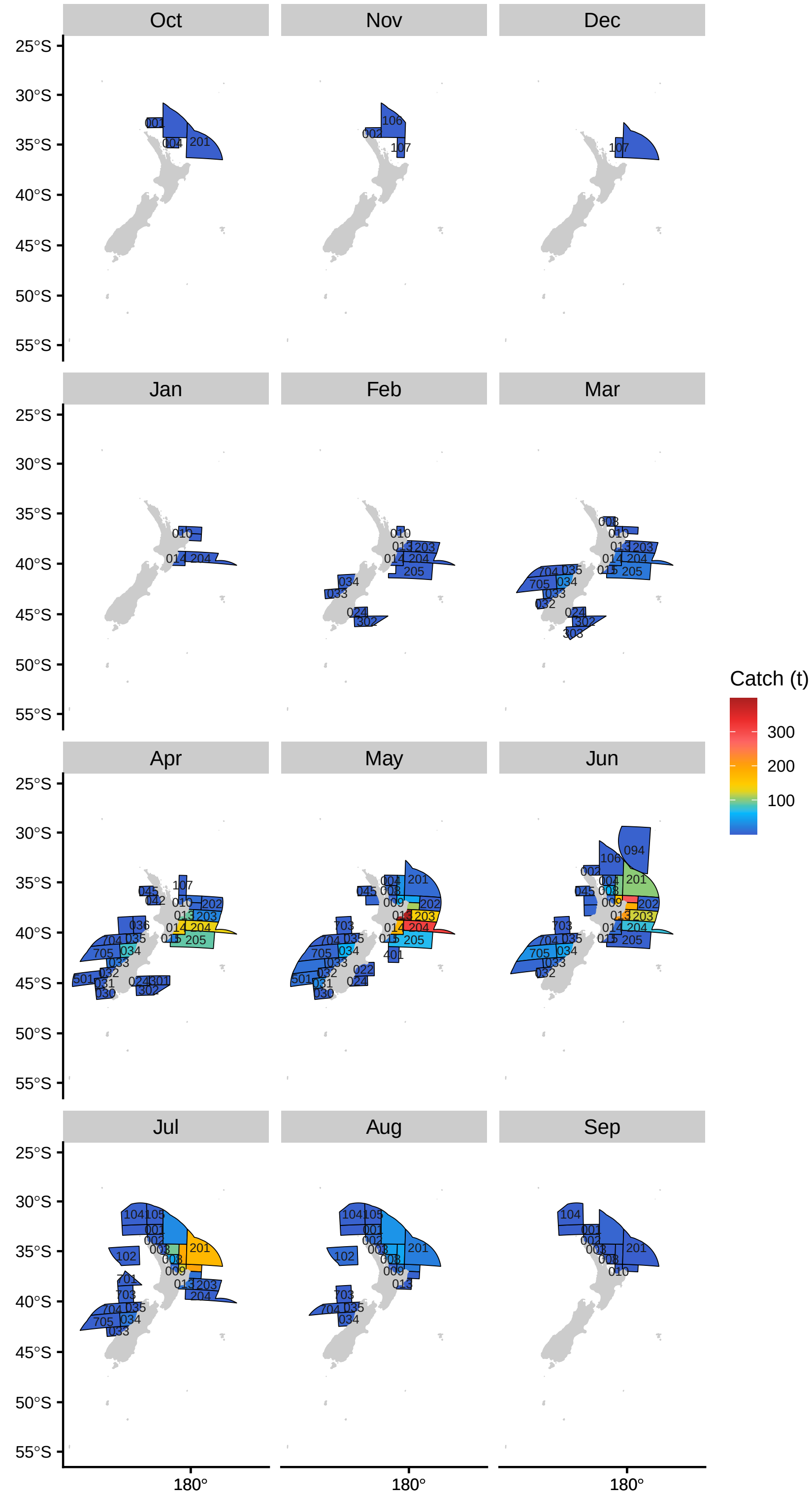

Figure G.7: Allocated ALB 1 landings (t) for the surface longline fishery by key target species STN aggregated by month and by statistical area. Statistical areas with data from less than three vessels or permit holders are omitted. From 1990 to 2023 .

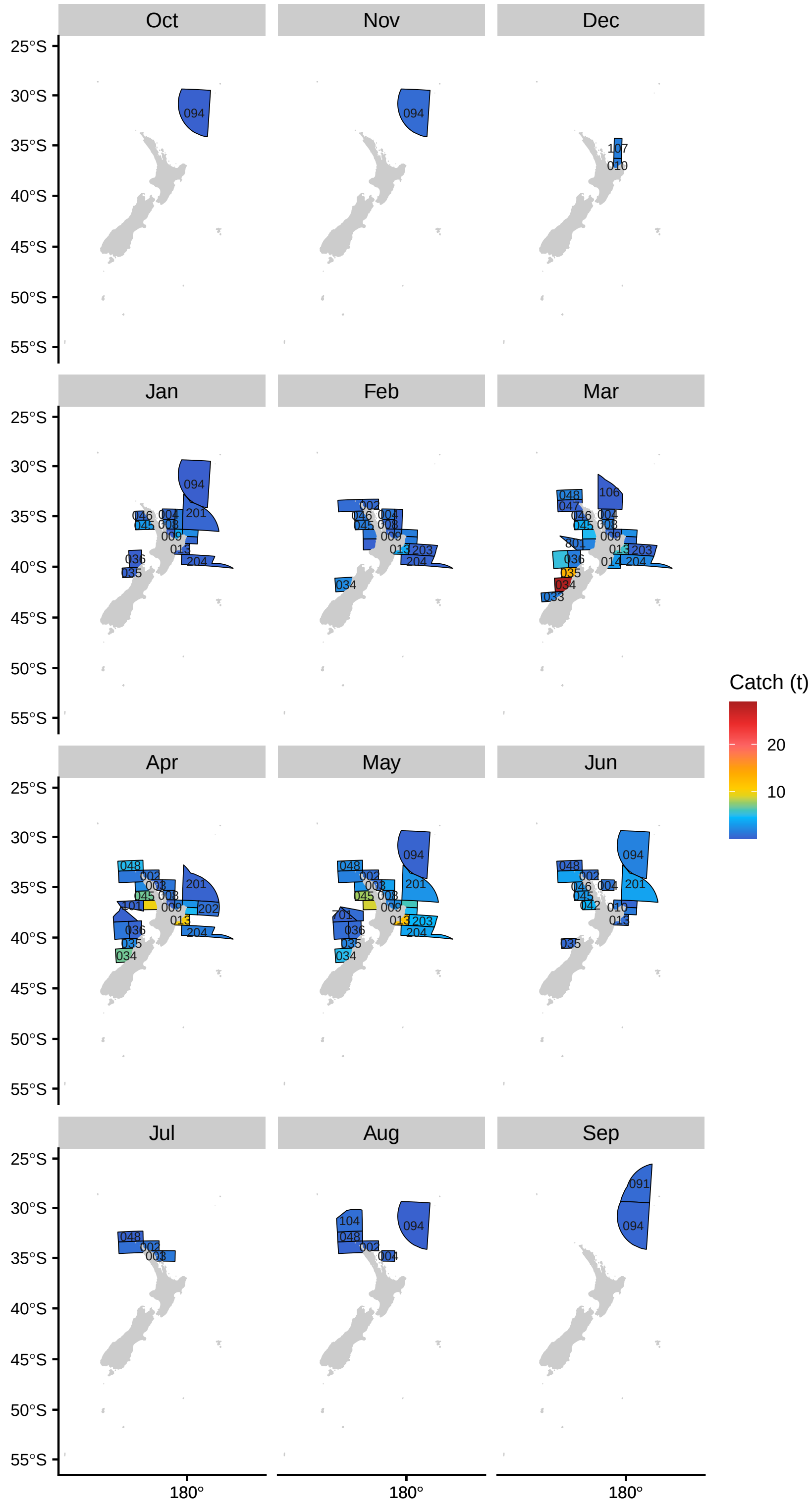

Figure G.8: Allocated ALB 1 landings (t) for the surface longline fishery by key target species SWO aggregated by month and by statistical area. Statistical areas with data from less than three vessels or permit holders are omitted. From 1990 to 2023 .

APPENDIX H: ADDITIONAL CHARACTERISATION TABLES

Table H.1: Landings by target species and fishing year, from 1990 to 2023, for the New Zealand surface longline fishery, for trips where the modal fishing method was surface longlining.

Fishing year	Albacore tuna	Bigeye tuna	Blue shark	Swordfish	Moonfish	Southern bluefin tuna	Yellowfin tuna	Other
1990	41.45	8.19	-	5.34	2.26	4.38	2.28	6.95
1991	28.62	17.08	0.16	13.61	5.59	34.43	4.44	38.19
1992	73.75	45.15	17.02	23.25	24.26	221.94	2.67	51.98
1993	267.30	39.35	30.06	53.20	42.01	179.82	2.33	76.12
1994	500.19	71.72	70.35	94.30	75.55	267.94	31.39	84.97
1995	512.08	46.69	228.41	89.59	108.47	417.35	80.53	249.65
1996	652.41	76.78	112.25	155.80	106.40	124.95	128.74	216.55
1997	604.37	97.13	140.86	225.06	114.71	312.26	110.31	485.77
1998	1434.23	312.73	385.25	470.32	213.52	225.15	85.78	209.61
1999	1545.00	356.08	529.84	854.63	233.91	425.18	150.51	327.38
2000	1369.01	440.86	509.94	822.36	289.42	349.34	89.80	212.57
2001	1976.39	455.26	1108.13	919.21	332.32	349.93	114.09	366.09
2002	2384.45	283.47	1011.16	884.03	325.82	462.78	60.63	407.18
2003	2264.96	191.92	851.52	619.28	221.21	399.28	42.97	368.94
2004	884.69	209.15	712.97	521.74	153.87	381.84	13.72	315.50
2005	497.51	159.22	705.04	316.49	103.12	253.05	30.04	158.60
2006	446.57	169.88	621.58	545.22	75.70	228.74	8.15	140.46
2007	278.35	195.15	492.32	367.69	69.79	229.49	18.54	97.00
2008	207.82	138.52	677.34	328.97	40.55	317.81	21.29	111.15
2009	414.83	234.32	775.76	386.40	78.47	413.58	4.85	124.93
2010	433.46	156.78	649.01	516.83	96.87	478.79	5.54	116.66
2011	315.21	180.08	738.49	706.70	113.21	553.49	2.41	150.87
2012	229.84	156.41	987.22	661.60	78.29	769.01	1.51	113.84
2013	296.76	111.00	701.49	750.58	80.65	725.65	0.43	122.58
2014	204.03	113.56	280.72	549.54	53.68	820.30	1.22	93.23
2015	149.68	80.38	582.99	699.41	30.75	909.49	13.98	108.75
2016	265.21	169.87	694.73	737.83	60.57	954.99	56.58	137.41
2017	211.52	104.54	603.71	470.41	54.73	914.16	6.84	83.60
2018	269.21	136.62	756.95	458.35	67.39	1002.90	22.03	143.83
2019	183.88	53.46	911.06	230.91	40.98	902.01	4.18	132.34
2020	178.97	58.61	730.87	187.18	46.30	855.79	8.57	200.87
2021	98.66	84.76	654.80	275.21	34.10	763.86	21.90	212.82
2022	90.29	27.01	459.18	102.94	16.76	862.06	1.72	80.46
2023	87.14	139.91	742.48	218.24	18.98	1118.63	33.28	200.62

Table H.2: Total effort (no. hooks/1000) by target species and fishing year, from 1990 to 2023, for the New Zealand surface longline fishery, for trips where the modal fishing method was surface longlining. Dashed line indicates no effort recorded for target species in a particular year.

Fishing year	Albacore tuna	Bigeye tuna	Swordfish	Southern bluefin tuna	Other
1990	4	61	-	37	11
1991	24	890	20	11579	979
1992	40	745	43	8719	160
1993	14	691	-	4703	148
1994	70	1097	0	1345	169
1995	189	1187	1	2380	299
1996	176	1483	-	695	-
1997	134	1353	-	1624	184
1998	435	2256	0	1303	83
1999	535	4296	19	1892	147
2000	647	5837	3	1734	-
2001	494	7140	3	1903	283
2002	859	6970	-	2805	269
2003	1966	5113	-	3494	169
2004	463	3467	-	3192	211
2005	134	1643	150	1656	99
2006	59	1856	238	1488	37
2007	13	1505	188	1929	41
2008	-	953	119	1102	41
2009	7	1550	37	1477	14
2010	19	1222	124	1551	26
2011	13	1636	156	1333	18
2012	-	1283	182	1590	17
2013	6	988	313	1503	42
2014	3	726	190	1586	19
2015	-	373	447	1565	10
2016	20	622	443	1231	31
2017	3	495	321	1230	22
2018	-	569	386	1300	31
2019	3	435	153	1422	35
2020	4	381	130	1392	37
2021	4	289	261	951	11
2022	47	138	101	853	-
2023	-	317	173	996	10

APPENDIX I: GLOSSARY

Table I.1: Product state codes used in this report.

Code	Description
DRE	Dressed
FIL	Fillets: skin-on
GGO	Gilled and gutted tail on
GGT	Gilled and gutted tail off
GGU	Gilled and gutted
GRE	Green (or whole)
GUT	Gutted
HGF	Headed, gutted, and finned
HGU	Headed and gutted
MEA	Fish meal
SKF	Fillets: skin-off

Table I.2: Form type codes used in this report.

Code	Description
CEL	Catch, Effort and Landing Return (CELR)
ERS - Trawl	Electronic Reporting System - Trawl
ERS - Netting	Electronic Reporting System - Netting
ERS - Lining	Electronic Reporting System - Lining
ERS - Potting	Electronic Reporting System - Potting
ERS - Diving	Electronic Reporting System - Diving
ERS - Seining	Electronic Reporting System - Seining
LCE	Lining Catch Effort Return (LCER)
NCE	Netting Catch, Effort and Landing Return (NCELR)
SJC	Squid Jigging Catch and Effort Return (SJCER)
TCE	Trawl Catch Effort Return (TCER)
TCP	Trawl Catch, Effort and Processing Return (TCEPR)
TUN	Tuna Longlinging Catch Effort Return (TLCER)
LTC	Lining Trip Catch Effort Return (LTCER)
HCE	High Seas Catch, Effort and Landing Return (HS CELR)
HTU	High Seas Tuna Longlinging Catch Effort Return (HS TLCER)
HLC	High Seas Lining Catch Effort Return (HS LCER)

Table I.3: Fishing method codes used in this report.

Code	Description
MW	Midwater trawl
PRM	Precision midwater trawl
SLL	Surface longline
T	Troll
TL	Trot line

Table I.4: Species codes used in this report.

Code	Common name	Scientific name
ALB	Albacore tuna	*Thunnus alalunga*
BIG	Bigeye tuna	*Thunnus obesus*
BWS	Blue shark	*Prionace glauca*
MAK	Mako shark	*Isurus oxyrinchus*
MOO	Moonfish	*Lampris guttatus*
POS	Porbeagle shark	*Lamna nasus*
SNA	Snapper	*Pagrus auratus* (*Chrysophrys auratus)*)
STN	Southern bluefin tuna	*Thunnus maccoyii*
SWO	Swordfish	*Xiphias gladius*
YFN	Yellowfin tuna	*Thunnus albacares*

Table I.5: Area codes for Observer data used in this report.

Code	Description
AKE	Auckland (East) (FMA 1)
AKW	Auckland (West) (FMA 9)
CEE	Central (East) (FMA 2)
CET	Challenger Plateau, beyond the EEZ
CEW	Central (Egmont) (FMA 8)
CHA	Challenger/Central (Plateau) (FMA 7)
ET	Outside NZ EEZ location unspecified
HOWE	Lord Howe Rise
KER	Kermadec (FMA 10)
LOUR	Louisville Ridge
SEC	South-East (Coast) (FMA 3)
SOE	South-East (Chatham Rise) (FMA 4)
SOU	Southland (FMA 5)
WANB	Wanganella Bank