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Characterisation and CPUE analyses for jack mackerels in the JMA 7 fishery up to 2022

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D. A. J. Middleton,
P. Neubauer,
R. H. Wells,
P. J. Starr

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Plain language summary

New Zealand's jack mackerel fisheries comprise three closely related species of small pelagic fish, two native species (yellowtail and greenback jack mackerels) and the Chilean jack mackerel that periodically arrives in New Zealand waters from the wider South Pacific stock. Although catch limits are set for the species group, the abundance of each species must be monitored separately.

Off the west of New Zealand (JMA 7), jack mackerels are caught by a midwater trawl fishery with target fishing focussed in the Taranaki Bight. Observer sampling information allows the catches of the three species to be separated, but previous assessments have encountered problems with data interpretation and quality.

As part of its management within the Quota Management System, jack mackerel abundance in JMA 7 is monitored using catch-per-unit-effort (CPUE) from the midwater trawl fishery. In this report, this information is given for 1990 to 2022, and concerns with data quality were addressed.

Stock targets were adopted for the two native species. Greenback jack mackerel was assessed as being likely to be at or above the target in 2022, while yellowtail jack mackerel was very likely to be at or above the target.

EXECUTIVE SUMMARY

Middleton, D.A.J.[1]; Neubauer, P.[2]; Wells, R.H.[3]; Starr, P.J.[4] (2024). Characterisation and CPUE analyses for jack mackerels in the JMA 7 fishery up to 2022.

***New Zealand Fisheries Assessment Report 2024/41*. 380 p.**

Since the early-2000s the jack mackerel fishery in JMA 7 has been primarily undertaken by a small fleet of large midwater trawl vessels, with target effort focussed in the Taranaki Bight. During the 1990s, bottom trawling and purse seining were also used to target jack mackerels in JMA 7, but catches using these methods have been low since the turn of the century.

Jack mackerels, while managed as a single stock within the Quota Management System, comprise three species: *Trachurus declivis*, *T. novaezelandiae*, and *T. murphyi*. It is necessary to use observer sampling data to disaggregate catches to species level in order to undertake species-specific stock assessments. Previously, fully quantitative stock assessments for jack mackerel species in JMA 7 were attempted but were inconclusive due to concerns with observer sampling data.

One concern was that fish may be stratified in the net and pounds, leading to bias if sampling was not undertaken throughout the processing period. However, additional sampling data suggested that jack mackerel catches appear to be sufficiently well-mixed, such that bias in species composition and length estimates is unlikely to be a significant concern even if sampling was not spread throughout catch processing.

However, there has also been concern about the reliability of observer identification of the individual species. This problem is primarily evident from age-length data, where otolith samples collected by observers have subsequently been aged. A range of other data quality metrics were investigated, but it was concluded that the age-length data provided the most reliable approach for identifying trips where some degree of misidentification had taken place. Catch per unit effort (CPUE) analyses were conducted with and without filtering for trips where misidentification was identified, but there was little difference in the resulting trends.

The CPUE analyses for the native jack mackerel species, *Trachurus declivis* and *T. novaezelandiae*, were used to undertake partial quantitative stock assessments. The geometric means of CPUE for the period 2004–2011 for *T. declivis*, and 2006–2012 for *T. novaezealandiae*, were adopted as the target reference levels. In 2022, *T. declivis* was assessed as being likely to be at or above the target while *T. novaezealandiae* was very likely to be at or above the target.

[1] Pisces Research, Wellington, New Zealand
[2] Dragonfly Data Science, Wellington, New Zealand
[3] ResourceWise, Nelson, New Zealand
[4] Trophia, Wellington, New Zealand

1. INTRODUCTION

Jack mackerels (JMA) were introduced to the Quota Management System (QMS) on 01 October 1987. The QMS stocks comprise three species, *Trachurus declivis, T. novaezelandiae, T. murphyi*, two of which (yellowtail jack mackerel, JMN, *T. novaezelandiae*, and greenback jack mackerel, JMD, *T. declivis*) are native species, while the slender, or Chilean, jack mackerel, JMM, *T. murphyi*, is considered a more recent arrival in New Zealand, first identified in 1987, and may not spawn locally (Taylor 2002). The species are not reported separately in the QMS data.

The jack mackerel fishery in JMA 7, which includes the area off the west coast of New Zealand (Figure 1), is primarily undertaken by deepwater vessels using midwater trawl gear. The JMA 7 stock is a Tier 1 fishstock under the National Fisheries Plan for Deepwater Fisheries (Fisheries New Zealand 2019), with the expectation that it will be monitored using fully quantitative stock assessments.

The Total Allowable Commercial Catch for JMA 7 has been constant since the mid-1990s, and no allowances for customary or recreational fisheries, or other fishing-related mortality, have been set (Table 1). Commercial catches have been around the TACC since the mid-2000s (Figure 2). Recreational catches are relatively small, estimated as 10.2 t in 2012 and 6.2 t in 2018 (Fisheries New Zealand 2022).

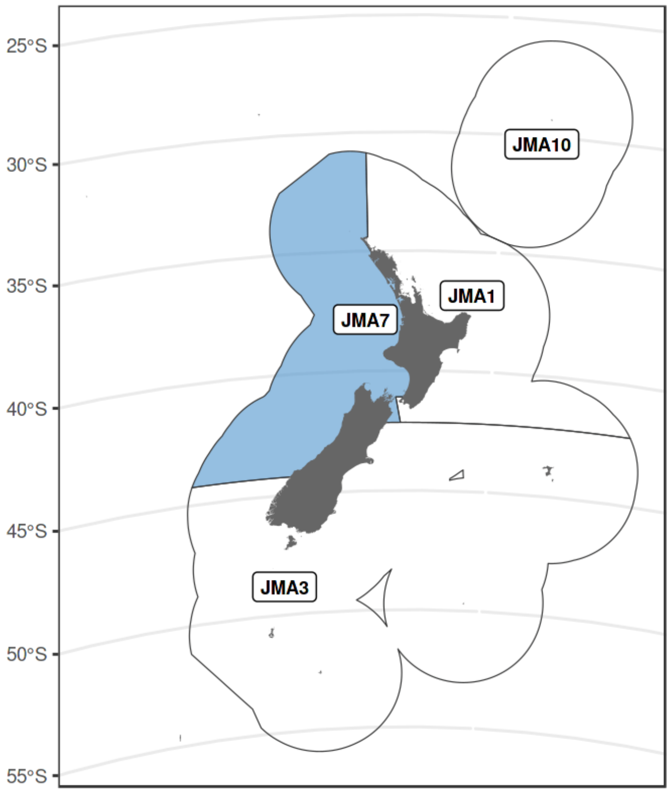

Figure 1: Quota Management Areas for jack mackerels with JMA 7 highlighted.

Table 1: Total Allowable Catch (TAC), Total Allowable Commercial Catch (TACC), and allowances (all tonnes) for JMA 7, as at 1 October 2023.

			Allowances		
Stock	TAC	TACC	Customary	Recreational	Other mortality
JMA 7	-	32 536.76	-	-	-

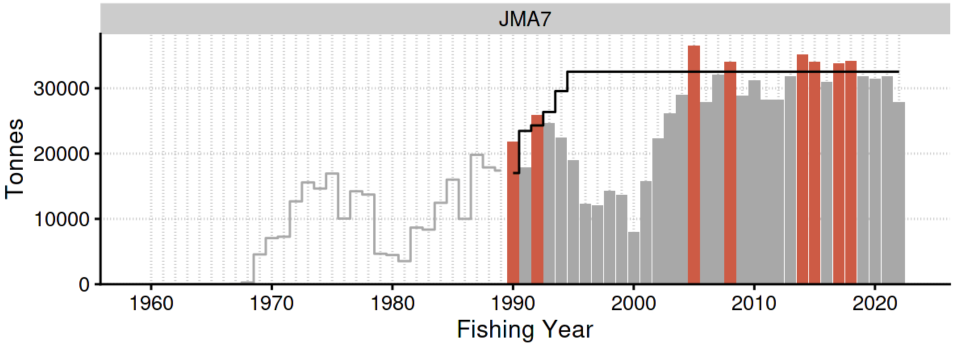

Figure 2: Total Allowable Commercial Catch (TACC; black line) and Monthly Harvest Return/Quota Management Report totals (bars) for JMA 7 from 1990 to 2022. Years where the TACC was exceeded are highlighted in red. Catches prior to 1990 are shown by the grey line using the information compiled in the Fisheries Assessment Plenary Report (Fisheries New Zealand 2022). Tabulated data are provided in Table B.1.

Preliminary stock assessments for *T. declivis* and *T. novaezealandiae* in JMA 7 were undertaken in 2007 (McKenzie 2009). These relied on CPUE indices (McKenzie 2008) where an average species composition was applied to individual tows within a stratum. Webber & Starr (2022) noted that applying average species proportions, derived using relatively large strata, to individual tows, instead of using the actual species proportions in the tow, will reduce the variability in a CPUE analysis and will likely lead to biased coefficient estimates because the model does not have access to the real variation by species relative to the covariate values. As a result, these previous CPUE analyses and the preliminary assessments are considered unreliable.

However, in attempting to develop new assessments, Webber & Starr (2022) identified a range of concerns about the data from observer sampling in JMA 7. As a result, their assessment was limited to a set of CPUE standardisations for all three species combined, and for positive catches only.

The key concern identified by Webber & Starr (2022) was that observer sampling for catch composition in the JMA 7 trawl fishery had not always been implemented as specified in the observer manual. There were reports which suggested that observers often took a single sample at the beginning of processing, instead of several throughout the processing period. They suggested that, if stratification of the catch within the trawl persisted through to when the catch was processed, then sampling at a single time would result in biased estimates of species composition.

The existing data collection procedures did not retain sub-sample information for jack mackerel length-frequency (LF) samples by species, so there was no way of using these data to assess whether the fish comprising a sample were collected at one time or as a series of sub-samples. To address concerns about potential stratification in the sampled catch, two observer trips were carried out where observers took up to four species-specific length-frequency sub-samples of jack mackerel during the processing of catches and recorded the sub-sample data separately. Middleton (2022) found differences between some sub-sample and tow-level estimates of species proportions, but these were not related to the time during processing when sub-samples were taken. As a result, it was concluded that there was only a limited risk of bias in tow-level estimates of species composition arising from sampling at a single point during processing.

In addition, misidentification of the three jack mackerel species in observer sampling of otoliths for ageing has been apparent in catch-at-age data from the JMA 7 fishery for some time. Based on the subset of fish aged, Saunders et al. (2022) reported that the rate of misidentification by observers was at least 8% for *T. novaezelandiae* and at least 3% for *T. declivis*.

The work undertaken in JMA2021-01 aimed to advance the stock assessment for JMA 7 by:

- undertaking a review of the observer data from the JMA 7 fishery, with a focus on developing methodologies for identifying tows or trips where observer species identifications were doubtful; and
- using the observer data, from cases where species identifications were considered reliable, to develop species specific CPUE-indices.

The expectation was that developing species-specific CPUE indices for the JMA 7 fishery would represent a step forward for stock assessments of the jack mackerel species in JMA 7, enabling stock status to be reported on the basis of the partial quantitative assessments, pending the potential redevelopment of fully quantitative assessments in future.

This report is structured as follows, where we:

- first characterise the JMA 7 fishery, based on combined-species data, including considering how this fishery fits into the annual operational patterns of the participating vessels;
- then examine the available observer data from the fishery, the issue of species misidentification, the prevalence of misidentified fish, and methods for identifying good data;
- next, use the observer data to investigate species composition in the JMA 7 fishery; and
- finally, construct species-specific CPUE indices and use these for partial quantitative assessments of the two native species.

2. METHODS

Extracts (report logs 13159, 15575) of statutory commercial catch, effort, and landings data were provided by Fisheries New Zealand and processed using standardised grooming routines (Appendix A).

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 D.

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; 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 2). 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 2).

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 JMA from a trip to the fishing event records from the trip using the hierarchical method of Starr (2007). If jack mackerels 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 jack mackerels 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 2: 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 JMA 7 and extracting the associated catch and effort data for fishing events within the JMA 7 Quota Management Area (Figure 1). Fishing events were selected based on start position (where available) or statistical area (Figure 3). The earlier QMS-era catch and effort data were reported at the resolution of statistical areas, and some statistical areas cannot be uniquely assigned to a single fishstock (Figure 3).

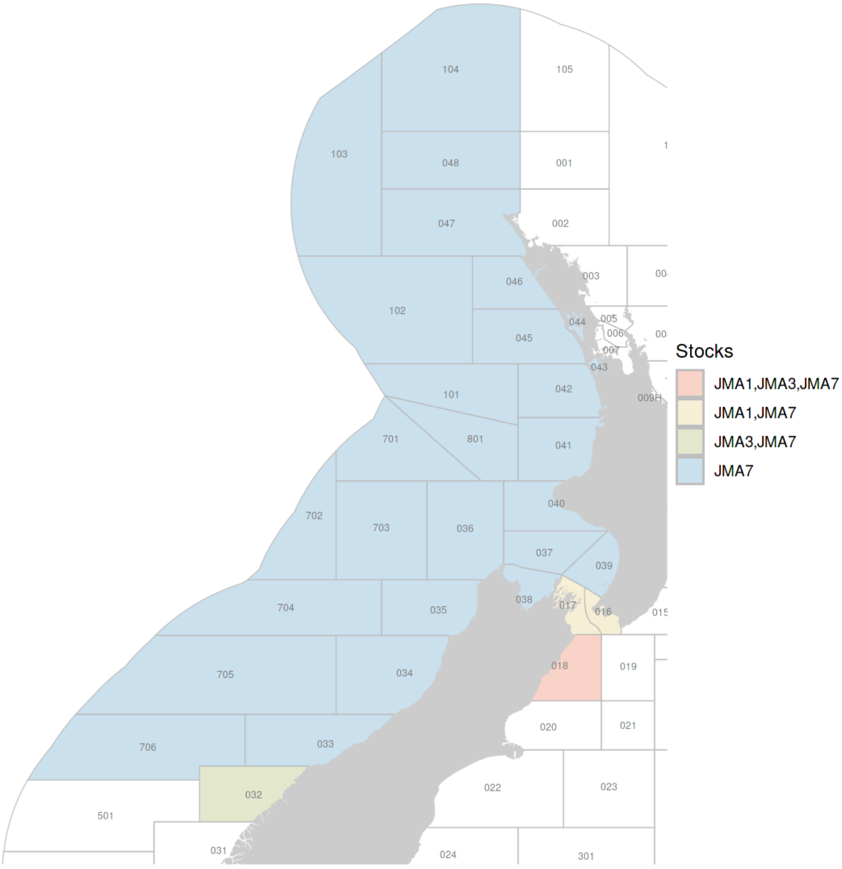

Figure 3: Statistical Areas that intersect the JMA 7 Quota Management Area.

2.6 CPUE methods

Fishing events for catch-per-unit-effort (CPUE) modelling were selected by a combination of some or all of:

- reporting form;
- fishing method;
- target species;
- area; and
- time period.

All fishing events matching the series definition were extracted, whether or not JMA were caught. Datasets for CPUE modelling were prepared at differing resolutions:

fishing event level where records represented individual fishing events such as trawls or longline sets;

daily (pseudo-CELR) resolution where finer scale records were aggregated to vessel-day resolution to provide data that mimic the resolution provided by the Catch, Effort and Landing Return (CELR), following the approach suggested by Langley (2014); or

trip level where each record was for a complete fishing trip with aggregated statistics summarising the fishing effort from the trip.

For the fishing event and daily resolution data, catches were allocated to fishing events following the approach of Starr (2007) as summarised above. For the fishing event resolution data, the catch allocation process was applied after restricting estimated catches to the top five species (`allockg_top5`; matching the resolution of the TCEPR form), the top eight species (`allockg_top8`; matching the resolution of the TCER, NCELR, LCER, and LTCER forms), or without restricting estimated catches (`allockg`, or `scaledkg` in cases where annual rather than trip level scaling was applied).

For the daily resolution data, catches were allocated after first restricting the estimated catches to include only the top five species estimated caught on the day, to match the resolution of the CELR data (`allockg`). For the daily resolution data, processed catch totals were also included (`prockg`); these included the summed greenweight of any processed catch records for the date of the fishing activity.

Trip resolution CPUE datasets included the aggregate, trip-level catches directly, without any allocation to fishing events (`landkg`) and sums, mean, and/or modal values of the effort variables for the trip.

2.7 CPUE series

The key CPUE series developed used tow-level, observer-collected catch and effort data for events where species-specific length-frequency samples were also collected, to allow separation of the catch by species (Table 3, where LF indicates the series with length-frequency samples, MW indicates midwater trawl only, and TR indicates multiple trawl methods). These models are described in detail below. Additionally, a wide range of sensitivity models were fitted. These are discussed later, with detailed diagnostics presented in Appendix C.

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 C.

Series name	Data resolution	Response variable	Explanatory variable selection process	Core fleet years	Core fleet trips	Assumed error distribution
JMD7 MW observer	observer	jmdkg	Stepwise	4	1	Weibull
JMN7 MW observer	observer	jmnkg	Stepwise	4	1	Weibull
JMM7 MW observer	observer	jmmkg	Stepwise	4	1	lognormal
JMA7 MW event	event	allockg_top5	All selected	4	1	Weibull
JMA7 MW observer	observer	obskg	Stepwise	4	1	Weibull
JMA7 MW observer LF	observer	obskg	Stepwise	4	1	Weibull
JMD7 MW observer no small samples	observer	jmdkg	Stepwise	4	1	Weibull
JMN7 MW observer no small samples	observer	jmnkg	Stepwise	4	1	Weibull
JMD7 MW observer no trip misID	observer	jmdkg	Stepwise	4	1	Weibull
JMN7 MW observer no trip misID	observer	jmnkg	Stepwise	4	1	Weibull
JMD7 MW observer zero misID	observer	jmdkg	Stepwise	4	1	Weibull
JMN7 MW observer zero misID	observer	jmnkg	Stepwise	4	1	Weibull
JMD7 MW observer split vessels	observer	jmdkg	Stepwise	4	1	Weibull
JMN7 MW observer split vessels	observer	jmnkg	Stepwise	4	1	Weibull
JMM7 MW observer split vessels	observer	jmmkg	Stepwise	4	1	lognormal
JMD7 TR observer	observer	jmdkg	Stepwise	2	1	Weibull
JMN7 TR observer	observer	jmnkg	Stepwise	2	1	gamma
JMM7 TR observer	observer	jmmkg	Stepwise	2	1	lognormal

3. FISHERY CHARACTERISATION

The fishery for jack mackerels off the west coast of New Zealand developed from the late-1960s (Figure 2), with peaks in catch occuring in the mid-1970s, then again around 1990, before the current levels of catch became established from the mid-2000s. For the first couple of years of the QMS-era data (the 1990 and 1991 fishing years) there was a shortfall in landings, relative to the MHR/QMR totals, but generally good correspondence thereafter (Figure 4). Landings directly to a Licensed Fish Receiver have comprised the majority of the JMA 7 landings since the mid-1990s, but transshipments accounted for the bulk of landings in the early-1990s (Figure 4).

Over the period from 1990 to 2022, the majority of jack mackerel landings have been of dressed fish (Figure 5), although fish landed in unprocessed (green) state have made up the majority of the landings from 2014 onwards. A small proportion of landings annually were of mealed fish. No significant changes in the conversion factors for jack mackerels have occurred (Figure 6). There was a good correspondence between total catches and catches that could be allocated to fishing events (Figure 7).

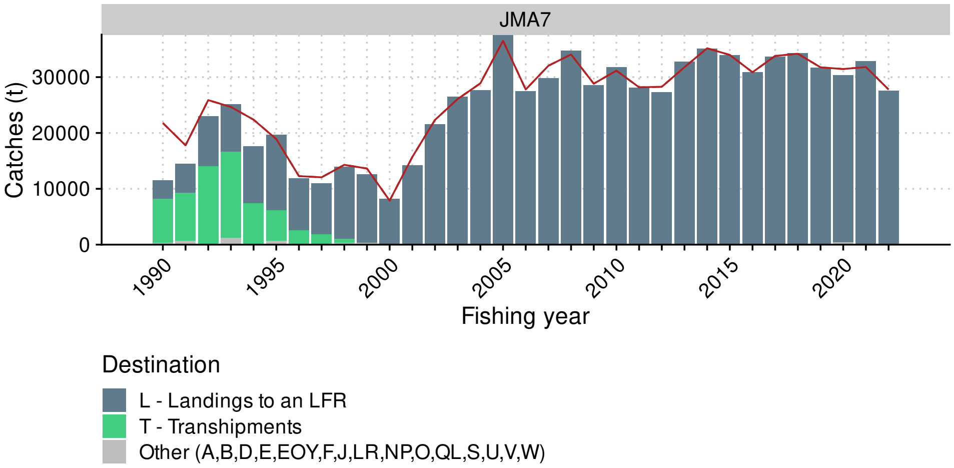

Figure 4: Catches of jack mackerels by destination (bars), compared with Monthly Harvest Return / Quota Management Report (MHR/QMR) totals (line), for Quota Management Area JMA 7. Destination codes are defined in Table 2 and tabulated catches are in Appendix B.

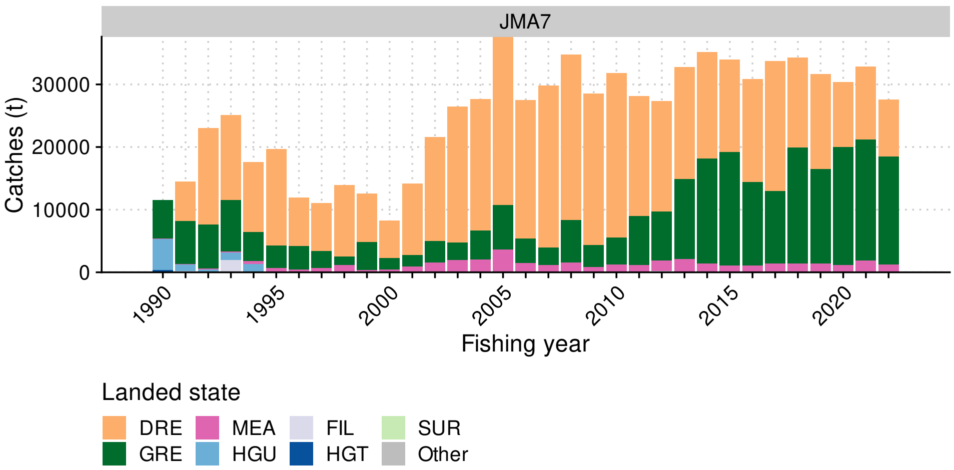

Figure 5: Landed state of jack mackerels from Quota Management Area JMA 7. Catches are tabulated in Appendix B, and landed state codes are defined in the glossary Table D.1.

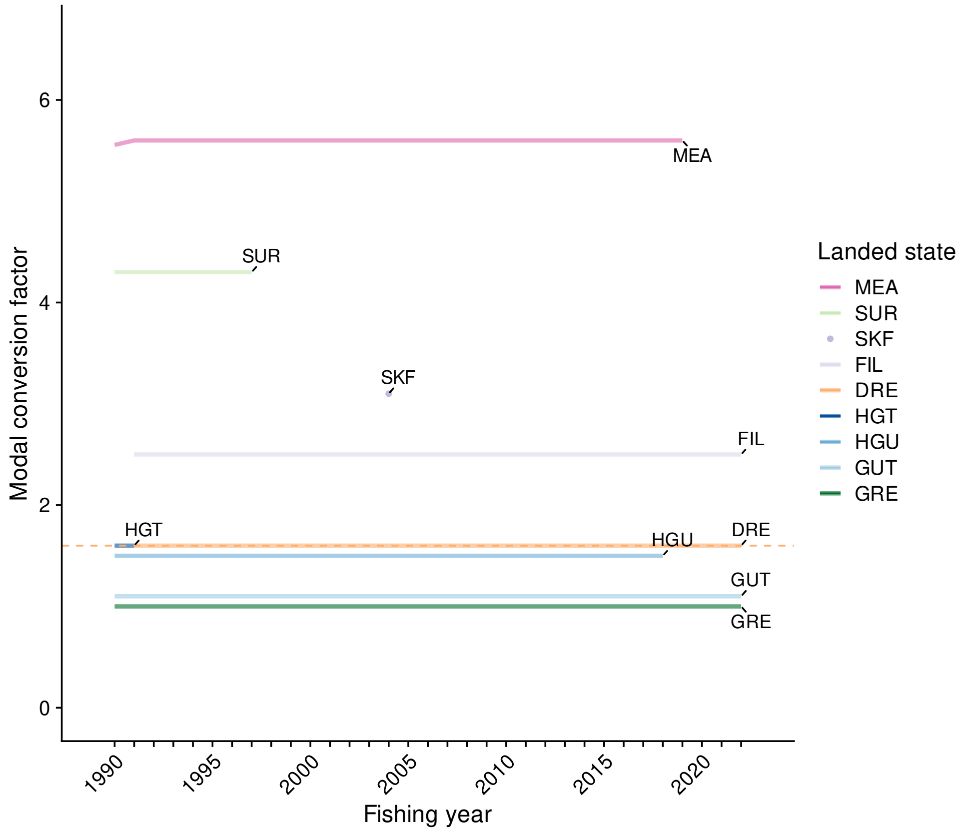

Figure 6: The modal annual conversion factor reported for the product states used in JMA 7 catches. The current statutory conversion factor is indicated by a dashed line for states where a species-specific value is defined. Tabulated results are provided in Table B.5, and landed state codes are defined in the glossary Table D.1.

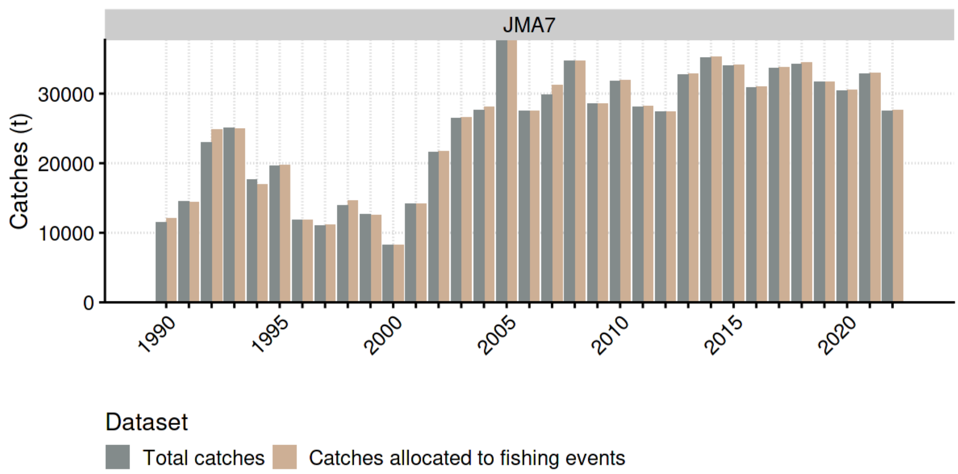

Figure 7: Total catches (t) of jack mackerels from JMA 7 in comparison with catches allocated to fishing events in the characterisation dataset.

Landings of JMA 7 were almost exclusively from trips which also recorded estimated catches; these estimates were scaled to landings by the allocation procedure (Figure 8a). With the exception of 1993, most landings are also recorded in daily processed catch data. Event-level estimated catches have averaged 97.1% of landings, with an average of 100% of landings in daily processing data (Figure 8a,b).

Jack mackerel are typically recorded in around a quarter of the fishing events associated with trips that land JMA 7 (Figure 8c). Increases in the proportion of days that had jack mackerel catches recorded are apparent in 2008 and from 2017 (Figure 8d); both these increases are likely to be related to higher-resolution reporting—the introduction of the TCER form in 2008 and the transition to Electronic Reporting from 2017. Electronic Reporting has been the dominant reporting method in the fishery since 2019 (Figure 9); prior to this most catch and effort was recorded via the TCEPR form.

The great majority of jack mackerel caught in JMA 7, whether by midwater trawl, bottom trawl, or purse seine, has been targeted catch (Figure 10, Figure 11, Table B.2), with a small bycatch from barracouta target trawling. Some of the early midwater catch, during the 1990s, arose from hoki target effort, and some of the purse seine catch came from kahawai target sets.

For target bottom and midwater trawling, jack mackerel is usually the first ranked species in the reported estimated catch and typically has an average rank of 2–3 when taken as bycatch of barracouta or hoki effort (Figure 12, Figure 13). Jack mackerel catches have a lower average rank for barracouta target bottom trawl effort reported via the TCER form and the ERS. The average rank of jack mackerel estimated from hoki target midwater trawl tows is also lower for ERS data, reflecting the ability to report estimated catches for more than the top five species.

All purse seine effort in the dataset preceded the introduction of Electronic Reporting and used the CELR form; jack mackerel was usually the first or second ranked species in the estimated catches (Figure 14).

There are no indications that the transition to Electronic Reporting resulted in a change in the resolution of effort reporting for trawling in JMA 7 (Figure 15).

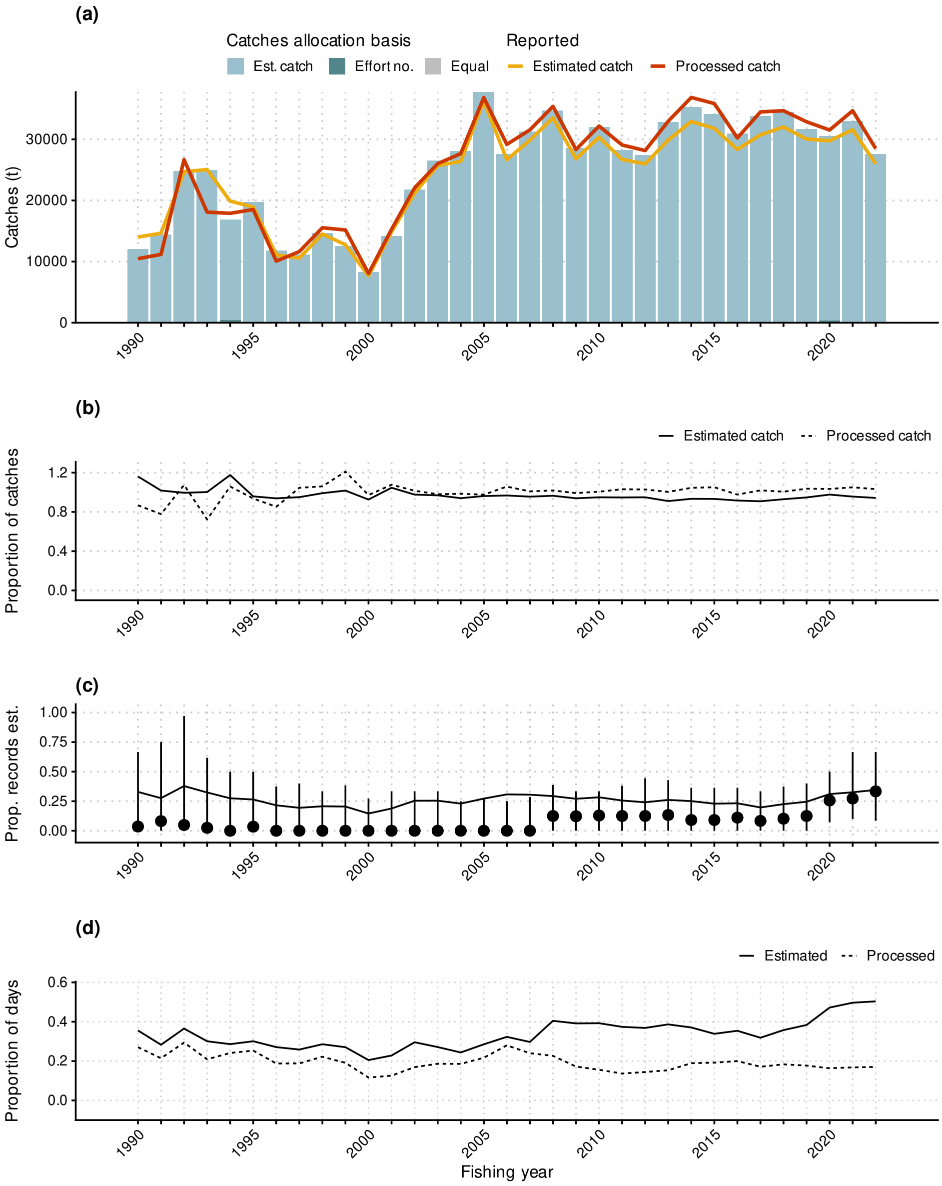

Figure 8: (a) bars: jack mackerels catches allocated to fishing events in the JMA 7 QMA with allocation method indicated by fill colour (see Section 2.3); lines: total estimated and processed catch of JMA; (b) the proportion of JMA 7 catches included in estimated and processed catch data; (c) the proportion of fishing event records with an estimated catch of JMA, with the line showing the overall proportion and the distributions illustrating the median and inter-quartile range by trip; (d) the proportion of vessel-days fished with a reported catch of JMA.

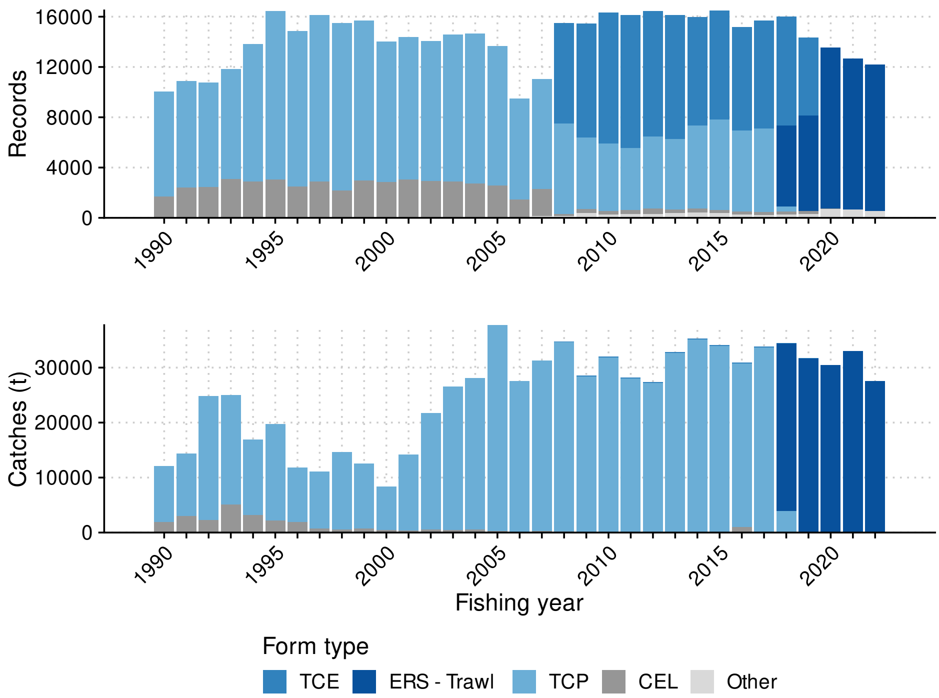

Figure 9: Reporting forms used on trips catching jack mackerels within the JMA 7 Quota Management Area, in terms of fishing event records and catches. Tabulated results are available in Appendix B. Form types grouped as Other include: ERS - Diving, ERS - Dredge, ERS - Lining, ERS - Netting, ERS - Other Lining, ERS - Potting, ERS - Seining, HTC, LCE, LTC, NCE, SJC. A list of the main form type codes is included in the glossary Table D.2.

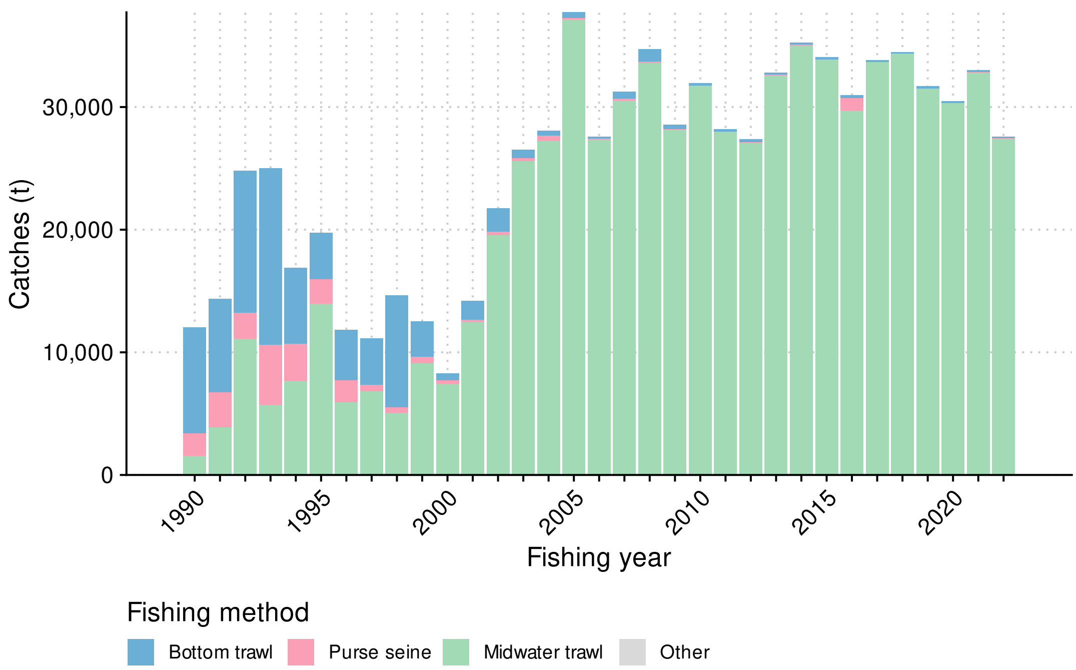

Figure 10: Catches of jack mackerels by fishing method, for events within the JMA 7 Quota Management Area. Methods grouped as Other include: BLL, BPT, BS, CP, CRP, D, DL, DN, DS, DV, FN, FP, HL, OCP, PL, PRB, PRM, PSH, RLP, RN, SJ, SN, T, TL. Tabulated results are provided in Appendix B, and a list of the main fishing method code types is included in the glossary Table D.3.

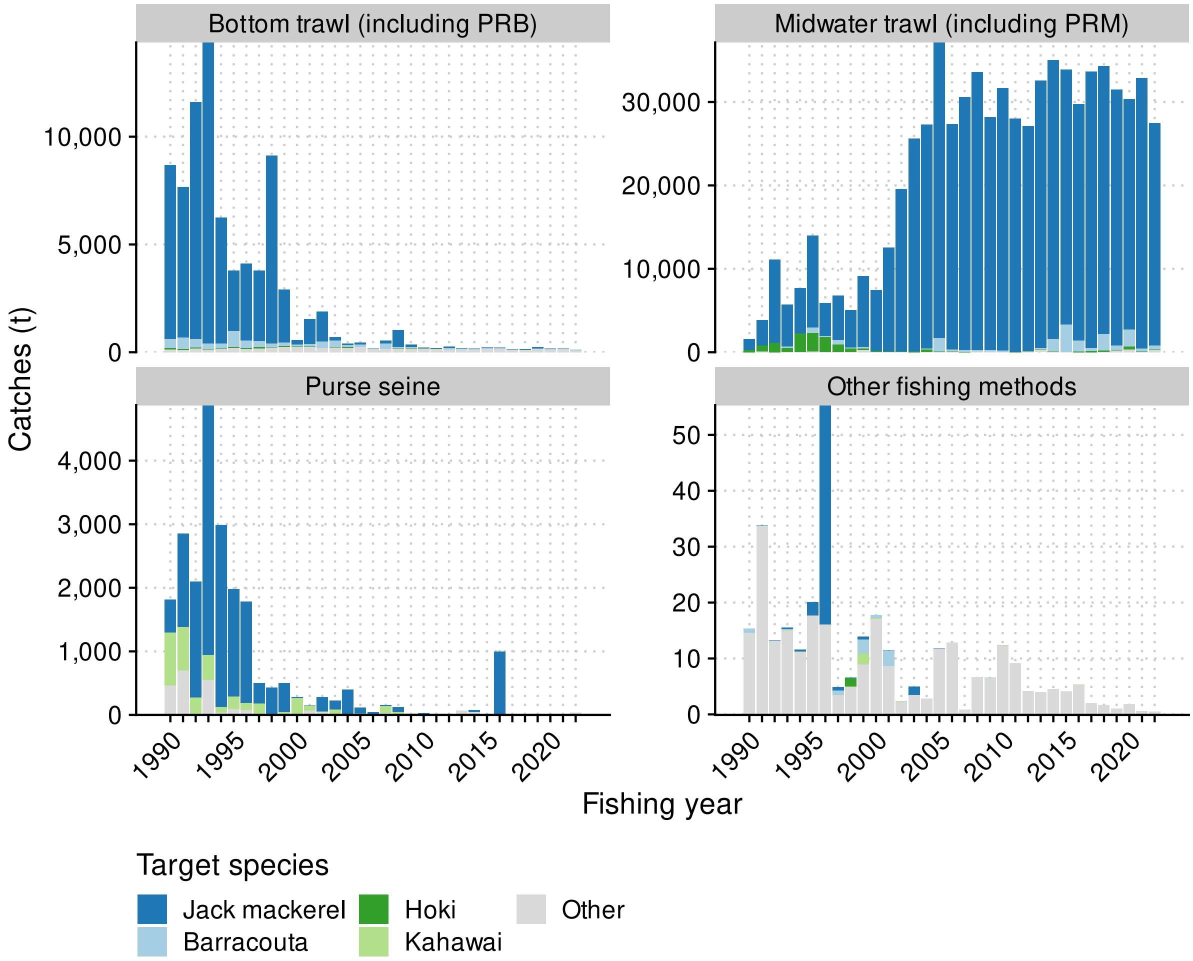

Figure 11: Catches of jack mackerels by fishing method and declared target species, for events within the JMA 7 Quota Management Area. Fishing Methods grouped as Other include: BLL, BPT, BS, CP, CRP, D, DL, DN, DS, DV, FN, FP, HL, OCP, PL, PSH, RLP, RN, SJ, SN, T, TL. Species grouped as Other include target species with less than 5% of the jack mackerels catch within the JMA 7 Quota Management Area in a fishing year.

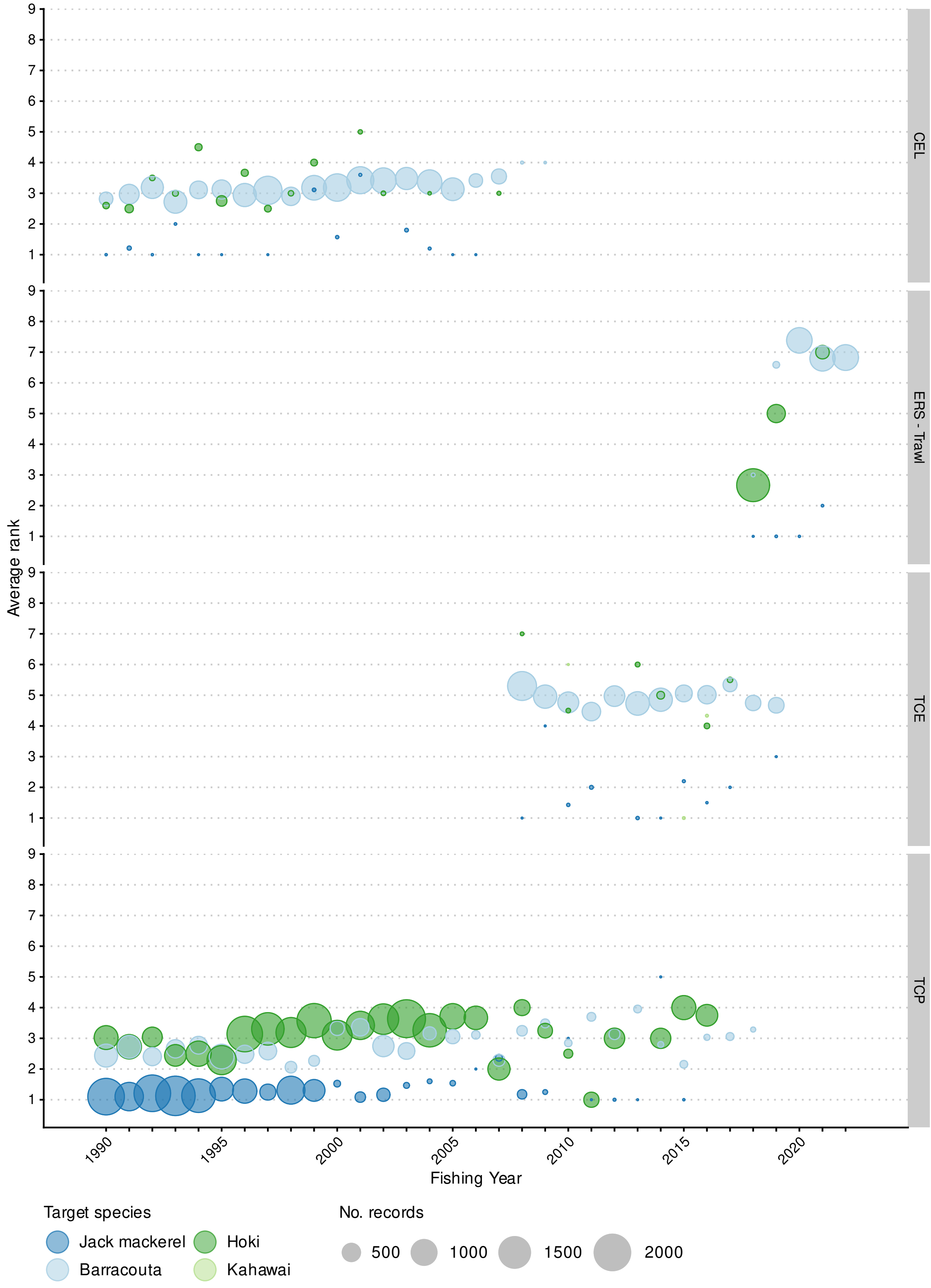

Figure 12: Average rank of jack mackerels in the estimated catch, by fishing method, form type and declared target species, for BT-PRB events with estimated catches within the JMA 7 Quota Management Area. The circle size scales with the number of records.

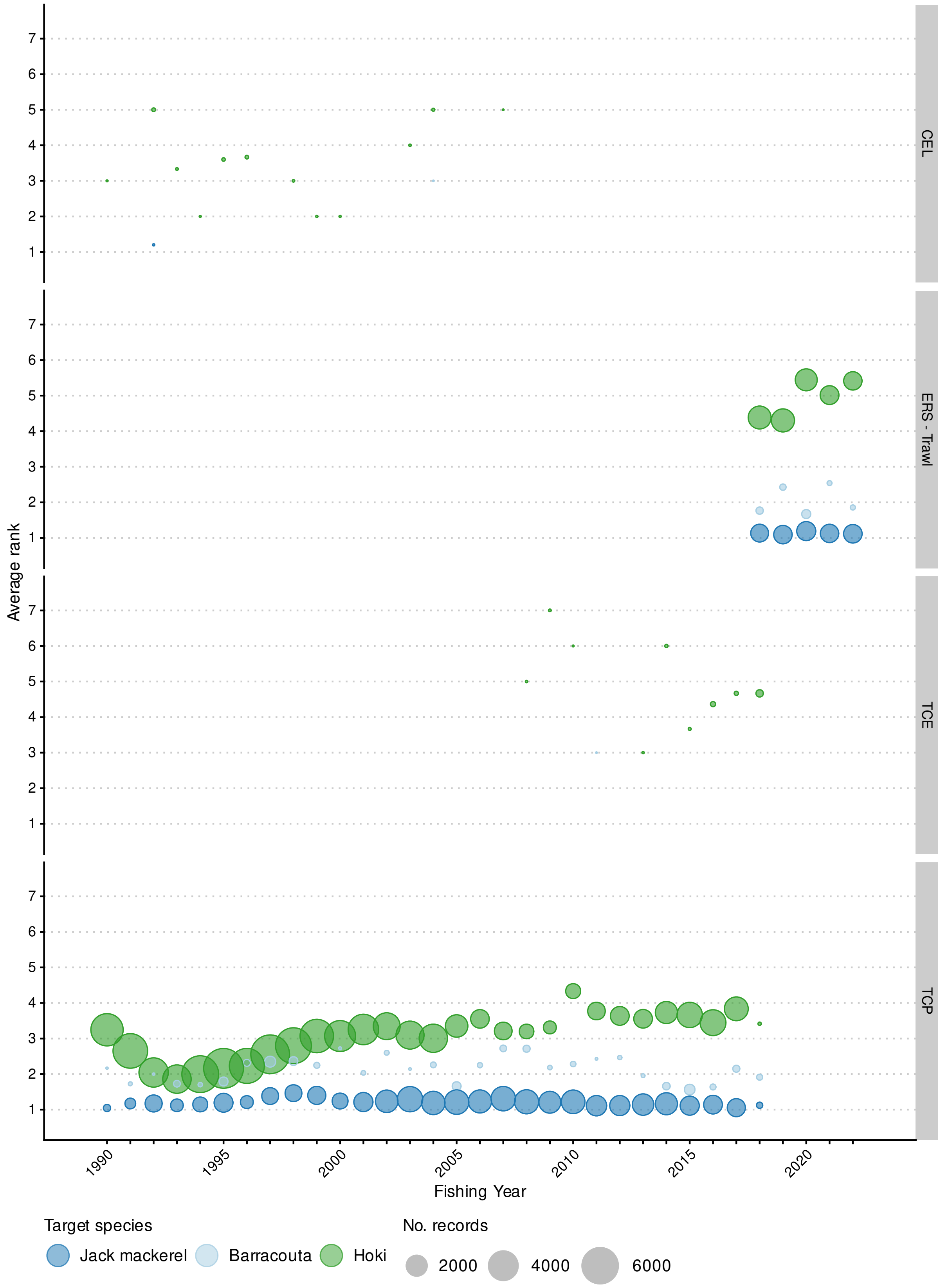

Figure 13: Average rank of jack mackerels in the estimated catch, by fishing method, form type and declared target species, for MW-PRM events with estimated catches within the JMA 7 Quota Management Area. The circle size scales with the number of records.

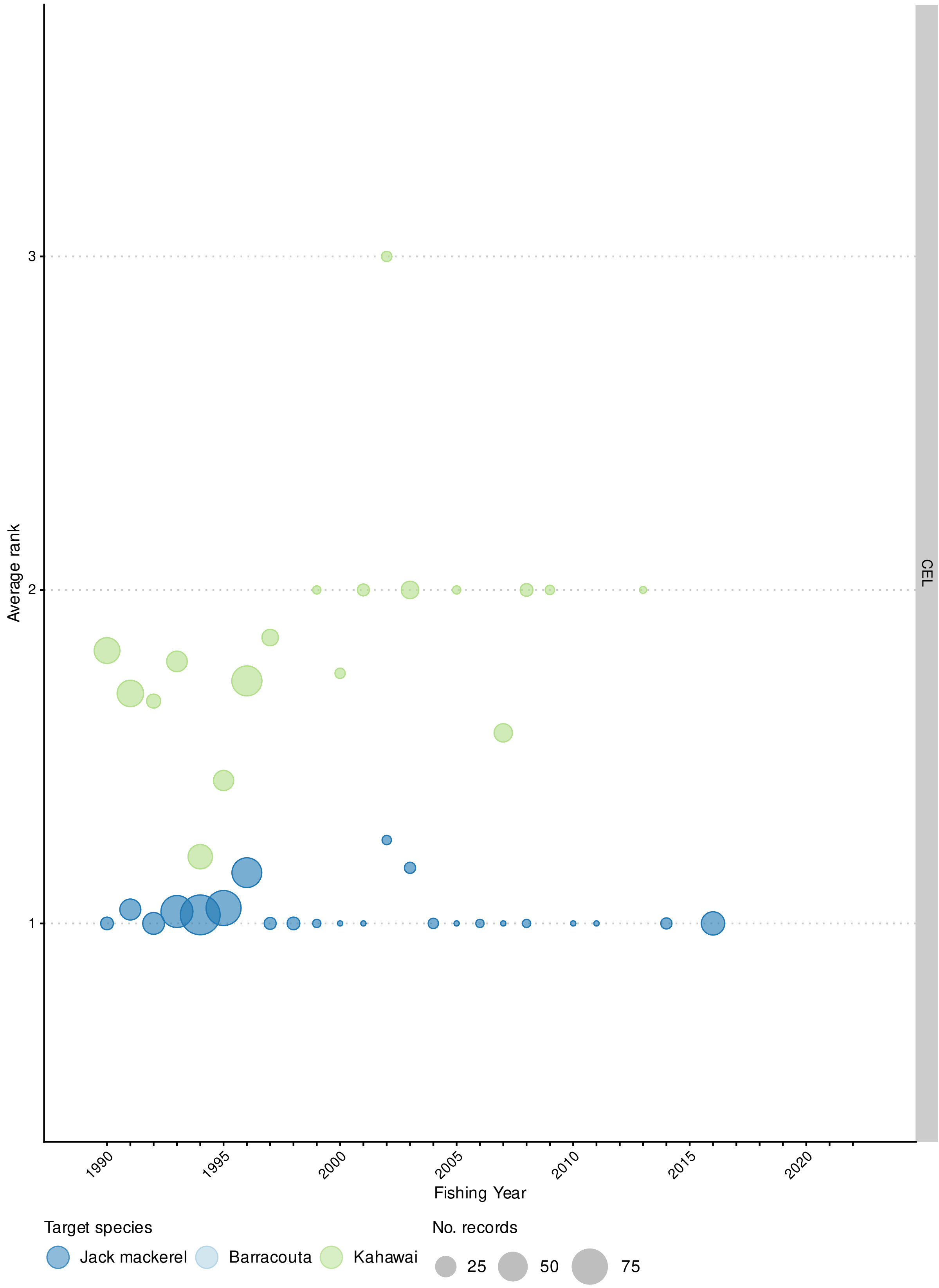

Figure 14: Average rank of jack mackerels in the estimated catch, by fishing method, form type and declared target species, for PS events with estimated catches within the JMA 7 Quota Management Area. The circle size scales with the number of records.

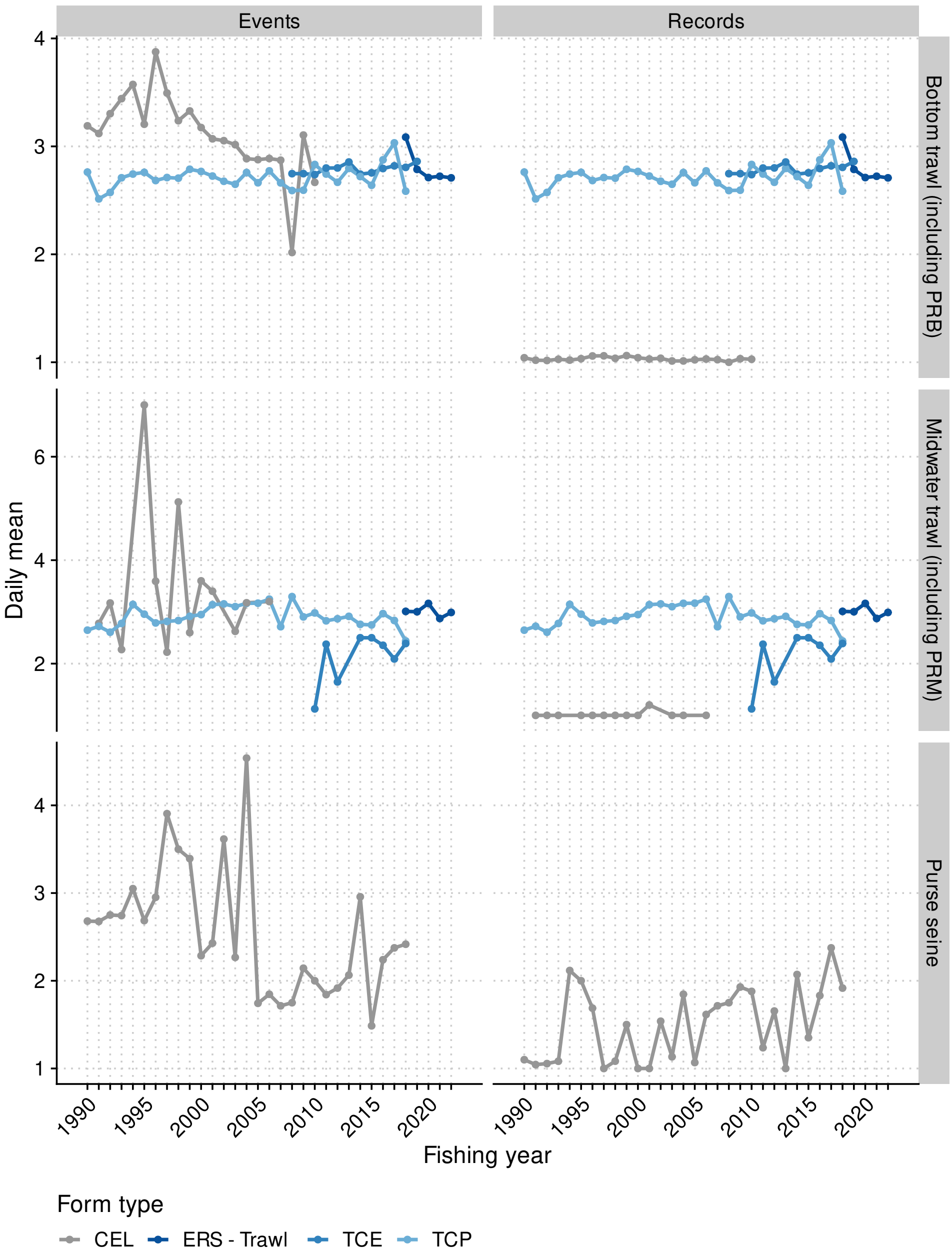

Figure 15: The mean number of fishing events and data records per vessel-day, by fishing method and reporting form, for effort within the JMA 7 QMA on trips landing catch from JMA 7. Data are included for years where a form was used on at least five vessel-days.

3.1 The midwater trawl (including PRM) fishery

All midwater trawl catch and effort in JMA 7 has been recorded with fine scale (tow-level latitude and longitude) spatial information since 1990 (Figure 16). Jack mackerel have been caught by midwater trawling from off Hokitika on the mid-west coast of the South Island (Statistical Area 034) to the mouth of the Kaipara Harbour on the North Island west coast (Statistical Area 045; Figure 17). In the early 1990s, catches were generally low, and the fishery did not extend north of the Taranaki Bight. By the mid-2000s, the fishery was more established in the Taranaki Bight and extended further up the west coast of the North Island; the highest catches were generally taken from the inshore areas of the fishery noting, however, that vessels over 46 m are prohibited from operating in the Territorial Sea (with the exclusion extending further offshore than the Territorial Sea limit in several parts of JMA 7). A similar fishery extent was apparent in the early-2020s but with the highest catches coming from the South Taranaki Bight. Catch rates have generally been higher in the northern parts of the fishery although, in 2020–2022, higher catch rates were also reported off the northern west coast of the South Island (Figure 18).

Jack mackerel have been targeted throughout the area, while midwater trawling targeting barracouta was mainly in the South Taranaki Bight, with hoki target effort off the west coast of the South Island (Figure 19). The overall fishery extents have remained stable over the last three decades (Figure 20).

Development of the fishery in the northern area is apparent from the early 2000s, with catches increasing first in the South Taranaki Bight (Statistical Areas 037 and 040) then developing further north (Statistical Areas 041, 042, 045; Figure 21). Jack mackerel catches were highest off the mid-west coast of the South Island (Statistical Areas 034 and 035) in the 1990s and decreased as the fishery developed in the Taranaki Bight. However, these southern parts of the fishery have supported increased catches from the mid-2010s.

Target jack mackerel catches have developed a clear seasonal pattern since the early 2000s (Figure 22); catches are high from October to January, peaking in December, then again from April to July, with peak catches shifting from June to July since 2020. The jack mackerel bycatch from hoki target midwater trawling in the 1990s was predominantly in the June to September period; catches from barracouta target effort have occurred throughout the year, albeit sporadically, since the mid-2010s.

There is some indication that catch rates of jack mackerels are higher from May to October but, in general, catch rates are reasonably consistent throughout the year (Figure 23) indicating that the seasonality in catches is primarily related to the annual cycle of fleet effort (see Section 3.4 below).

The majority of the midwater trawl effort on trips catching JMA 7 was carried out near the sea floor, although a proportion of effort involved tows up to 200 m off the seabed (Figure 24). Target jack mackerel effort was focussed in depths of 50 m to 250 m (Figure 25). Barracouta target effort had a similar depth range, although a small proportion extended to 500 m, with jack mackerel caught throughout the range. Most hoki target effort was deeper, from 300 m to 600 m; jack mackerels were caught throughout the depth range of the hoki fishery but the catch-weighted distribution illustrates that jack mackerel catches tended to be greater in the shallower parts of the hoki fishery.

For jack mackerel and hoki target effort, jack mackerel catch rates were similar for all depths; however, catch rates from barracouta target effort were higher in tows shallower than 150 m (Figure 26). The depth distribution of the target fishery became noticeably truncated from the early 2000s, associated with the fishery becoming established in the Taranaki Bight; however, there was an indication that the depths fished became slightly deeper after 2012 (Figure 27).

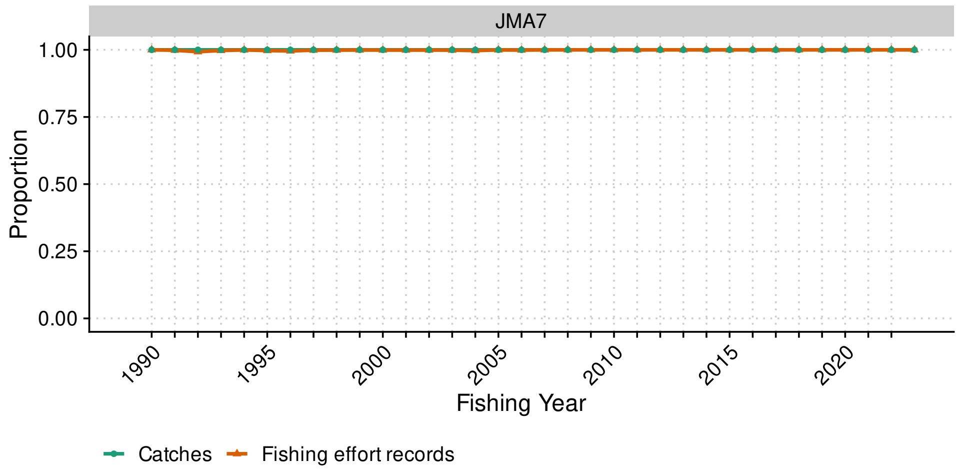

Figure 16: The proportion of records and catches reported with a latitude/longitude for the JMA 7 midwater trawl (including PRM) fishery.

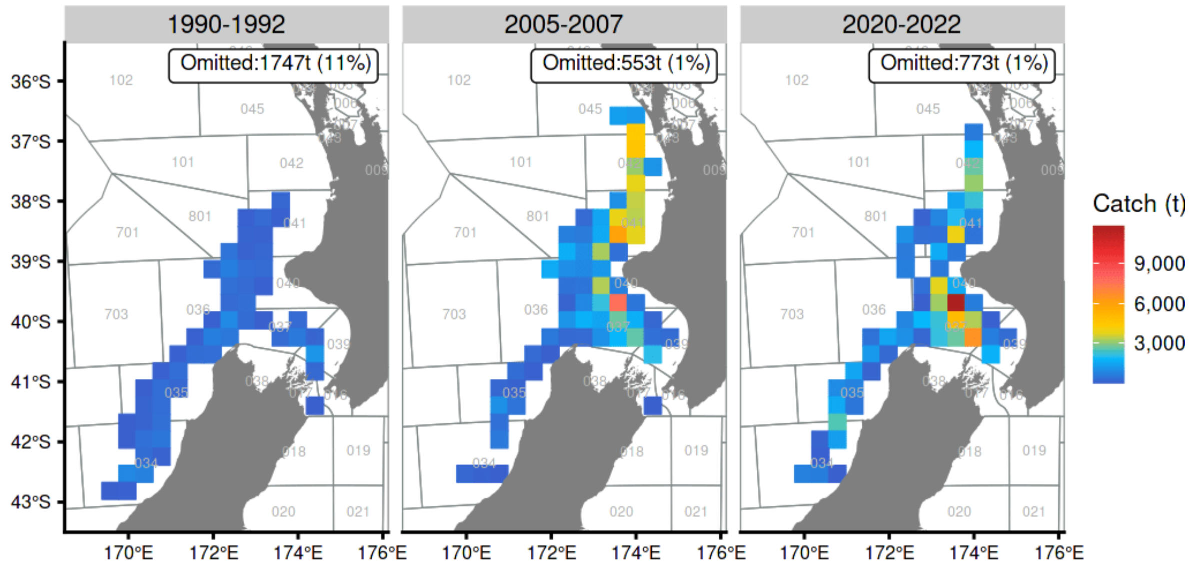

Figure 17: Catches (t) for the JMA 7 midwater trawl (including PRM) fishery, for 3-year periods within the era during which at least 80% of catch was reported with spatial information. These plots use a 32 km grid and include records where catches were allocated in proportion to estimated catch. Cells with data from less than three vessels or permit holders are omitted; the quantity of catch affected is indicated on each panel.

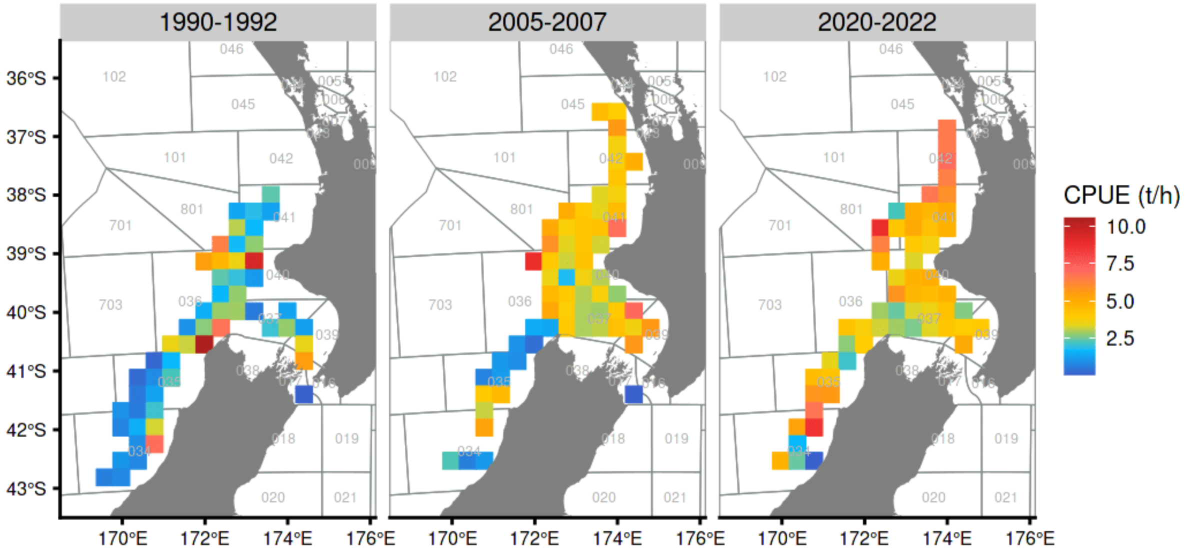

Figure 18: Raw aggregate CPUE (t/h) for the JMA 7 midwater trawl (including PRM) fishery, for 3-year periods within the era during which at least 80% of catch was reported with spatial information. These plots use a 32 km grid and include records where catches were allocated in proportion to estimated catch. Cells with data from less than three vessels or permit holders are omitted.

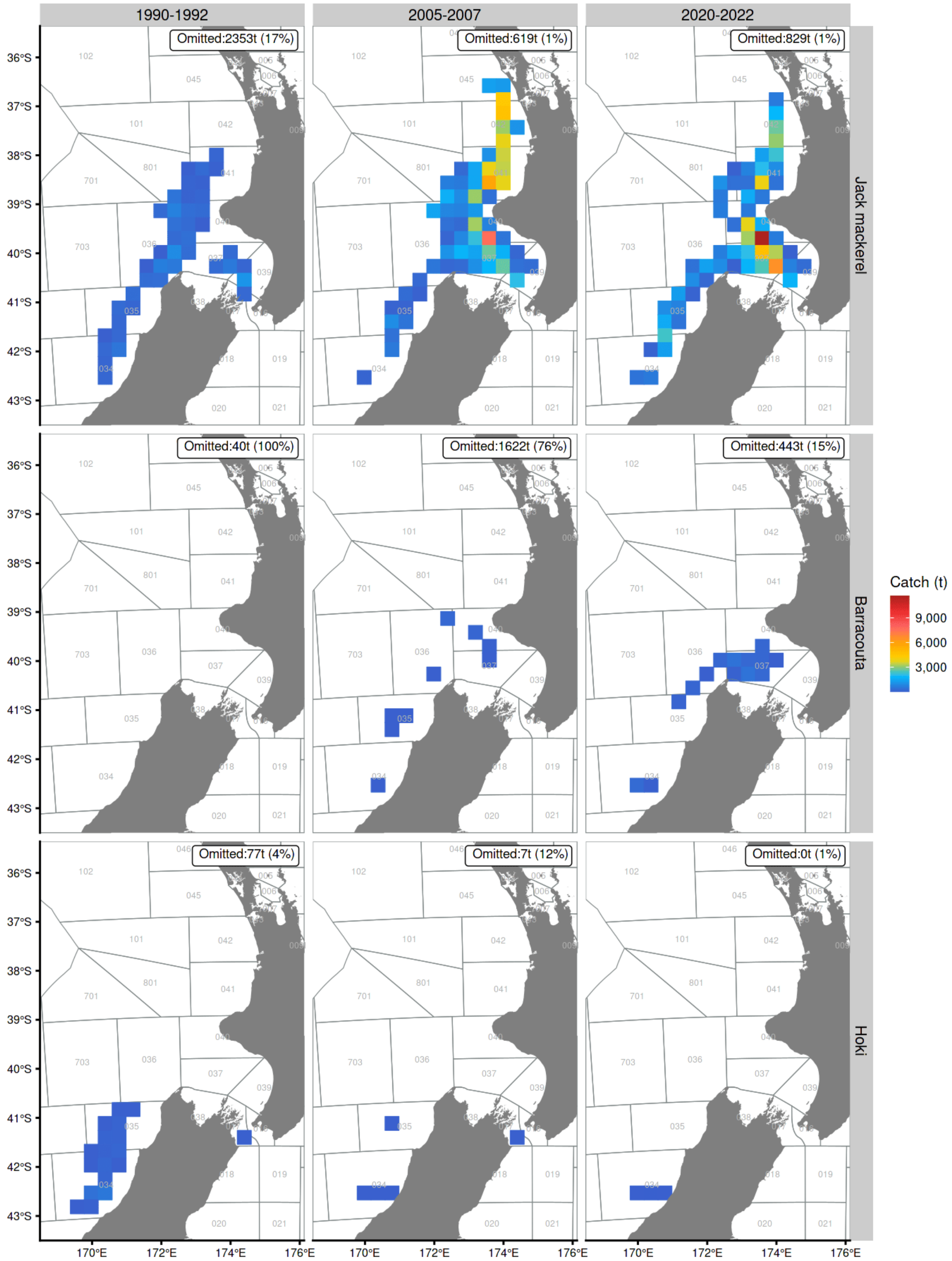

Figure 19: Catches of jack mackerels from the midwater trawl (including PRM) fishery by key target species. These plots use a 32 km grid and include records where landings were allocated in proportion to estimated catch. Cells with data from less than three vessels or permit holders are omitted; the quantity of catch affected is indicated on each panel.

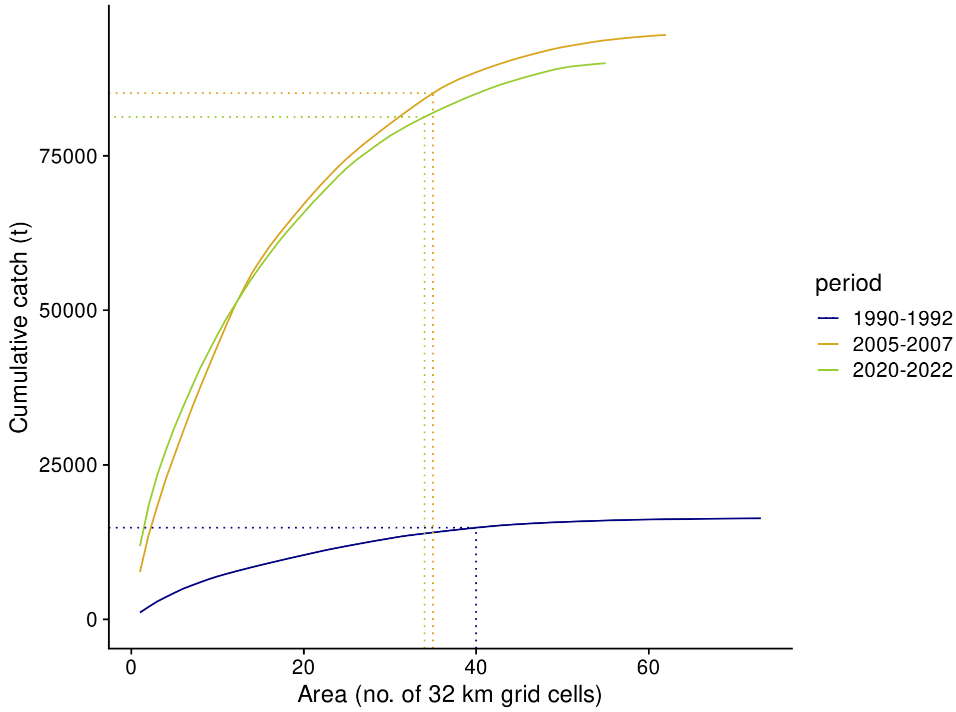

Figure 20: Cumulative JMA 7 catch by area (grid cells) for the midwater trawl (including PRM) fishery, aggregated for the first, middle, and last 3-year period of reporting. Dotted lines indicate the 90th percentile for the first, middle, and last 3-year period of reporting.

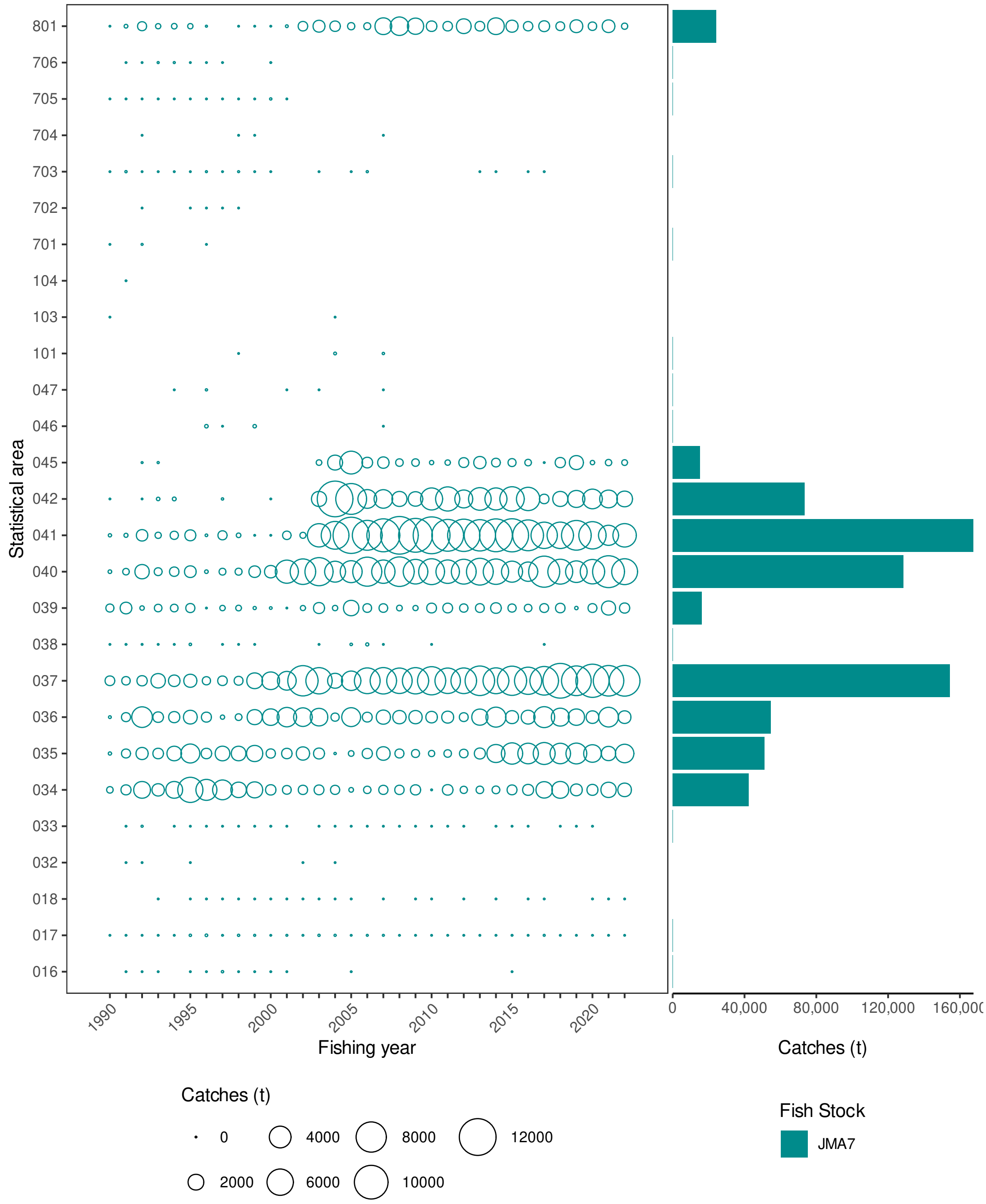

Figure 21: Annual JMA 7 catches (t) by statistical area for the midwater trawl (including PRM) fishery. The circle size scales with the catches by statistical area. The bar plot (right) shows the total catches of JMA 7 for each statistical area.

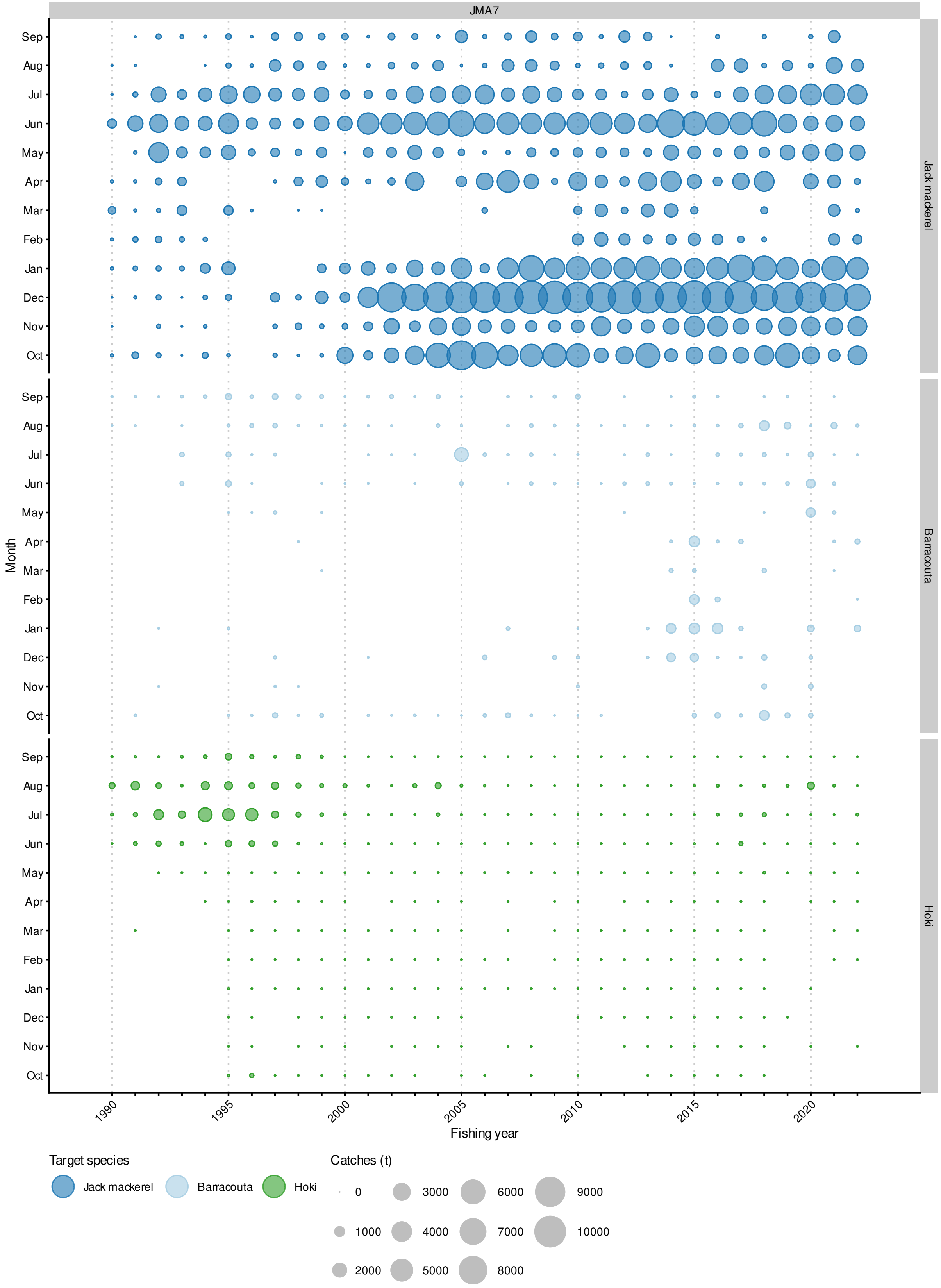

Figure 22: Seasonal distribution of JMA 7 catches by month and fishing year for the midwater trawl (including PRM) target fisheries. The area of the circle scales with the monthly catches.

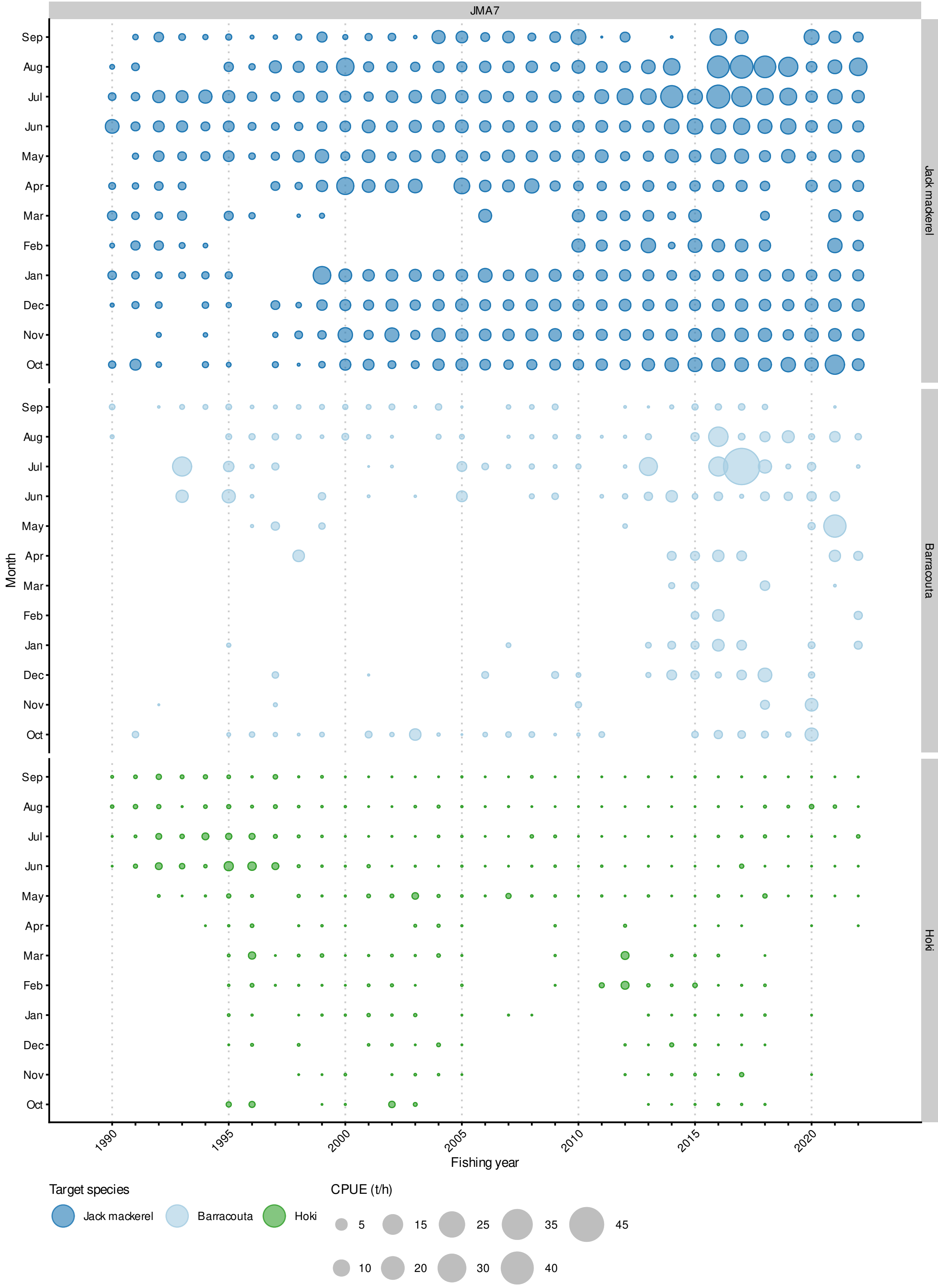

Figure 23: Seasonal distribution of JMA 7 raw aggregate CPUE (t/h) by month and fishing year for the midwater trawl (including PRM) target fisheries. The area of the circle scales with the monthly raw aggregate CPUE (t/h).

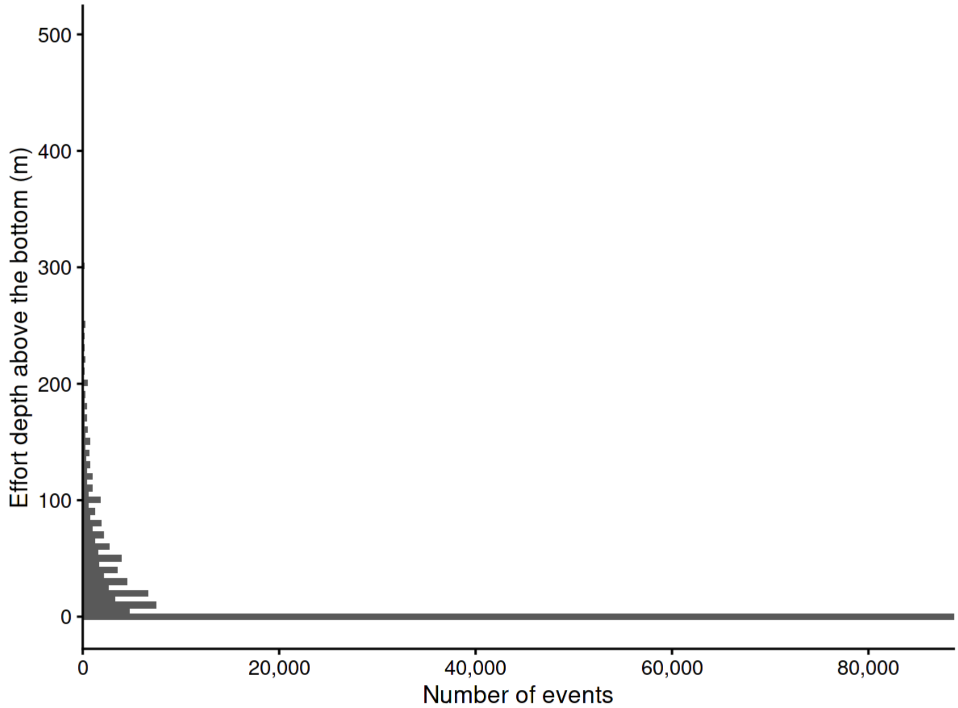

Figure 24: Distribution of the distance of fishing effort from the bottom for trips landing JMA 7 from the midwater trawl (including PRM) fishery.

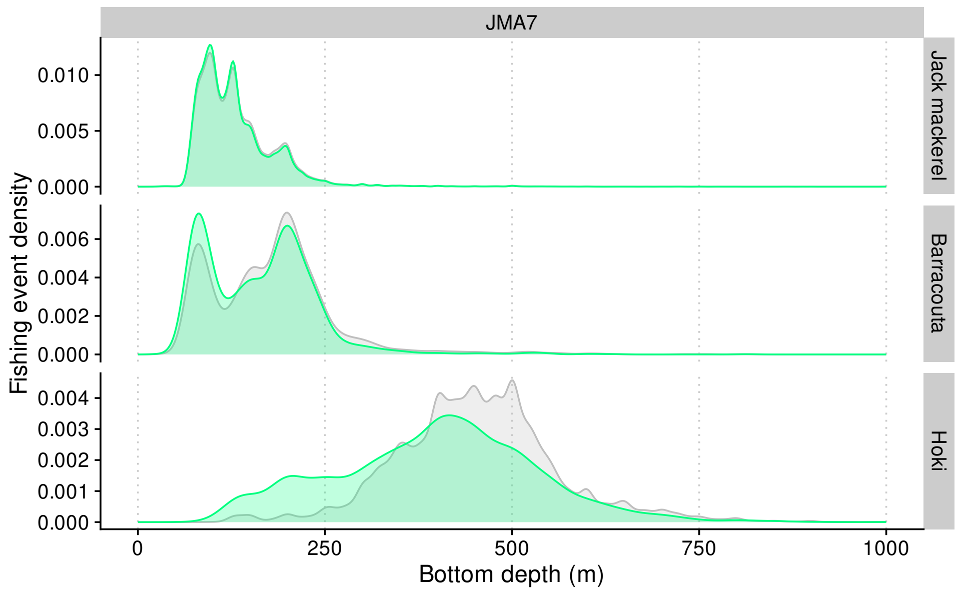

Figure 25: Effort depth distribution by target species for trips landing JMA 7 from the midwater trawl (including PRM) fishery. Target species are included if they are represented in at least 30 events. Grey fill = total effort, Green fill = positive effort (i.e., estimated catch > 0).

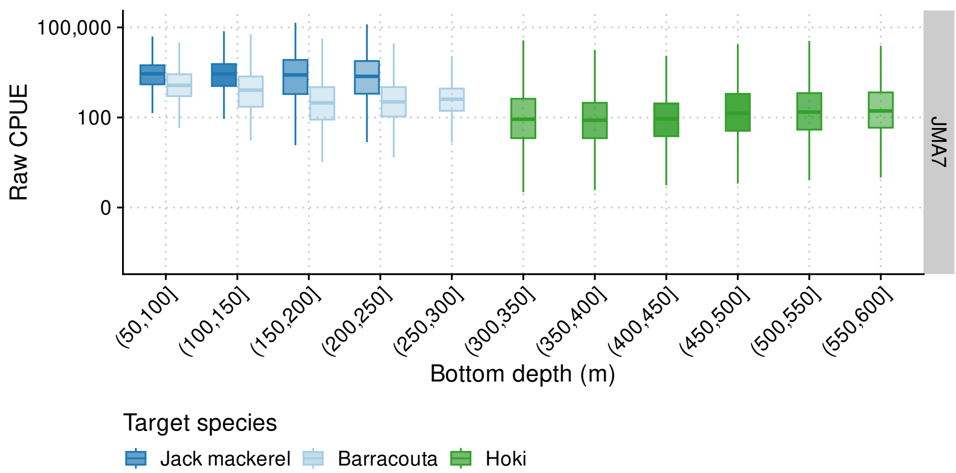

Figure 26: Raw CPUE (t/h) by depth bin and target species for events catching jack mackerels from the midwater trawl (including PRM) target fisheries in JMA 7. Boxplots are included for depth bins that include at least 5% of the events in the dataset for a particular target species, and events with a raw CPUE greater than the 99.9th percentile have been removed. The box indicates the median and quartiles, while the whiskers extend to the largest and smallest values no more than 1.5 times the inter-quartile range from the hinge.

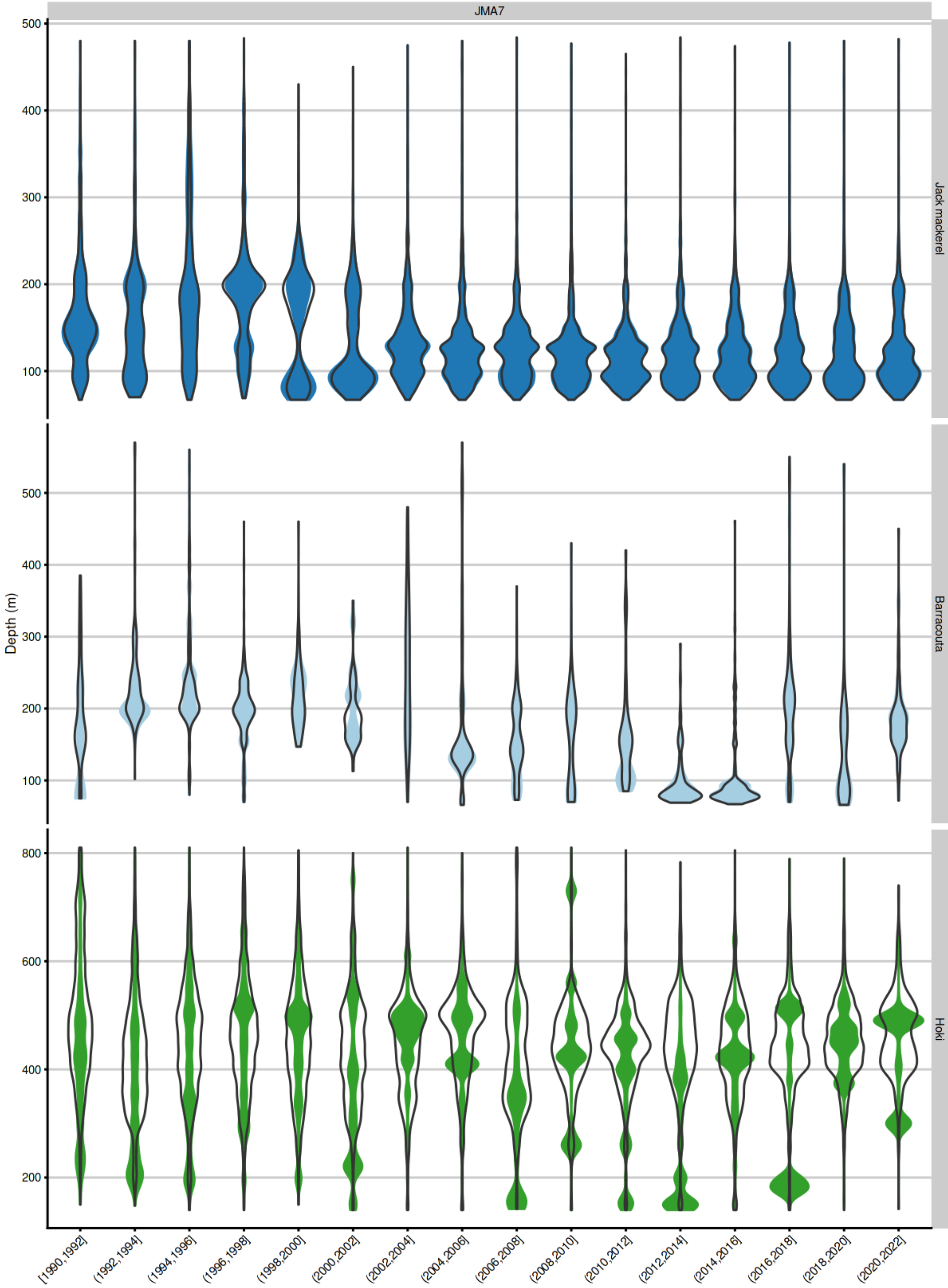

Figure 27: Catch-weighted (coloured) and unweighted (unfilled) effort depth distribution by target species for trips landing JMA 7 from the midwater trawl (including PRM) fishery.

3.2 The bottom trawl (including PRB) fishery

Prior to the introduction of the TCER form in 2008, only 60% to 75% of bottom trawl effort on trips landing JMA 7 was recorded with spatial information (Figure 28); however, during the 1990s—when bottom trawl catches were a significant part of the fishery (Figure 10)—the majority of the catch was from events which had spatial information. Bottom trawl catches during 1990–1992 were highest in the Taranaki Bight, the same areas where the midwater fishery became established in the early 2000s (Figure 29). In later periods, bottom trawl catches were uniformly low throughout the fishery.

Catch patterns by target species for bottom trawl effort were similar to those for midwater trawling, with jack mackerel targeted throughout the area, bottom trawling targeting barracouta in the South Taranaki Bight and off the northern west coast of the South Island, and hoki target effort off the west coast of the South Island (Figure 30). Bottom trawl catches declined in most statistical areas at the end of the 1990s, although some bottom trawl catch was evident in Statistical Areas 037 and 040 in the mid-late 2000s (Figure 31). Target jack mackerel catches occurred year-round during the 1990s (Figure 32) with no seasonality evident in catch rates (Figure 33).

Target jack mackerel bottom trawling effort was more depth-constrained than that of the midwater fishery, focussed in depths of 50 m to 150 m (Figure 34). Barracouta target bottom trawl effort had a wider depth range, from 25 m to 300 m, with jack mackerels caught throughout that range. Most hoki target effort was deeper, from 350 m to 700 m, but with most jack mackerel bycatch shallower than 500 m.

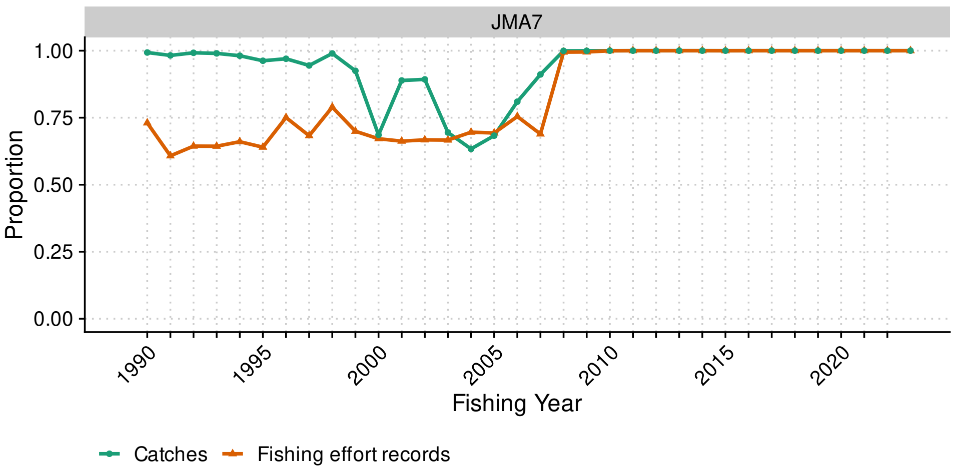

Figure 28: The proportion of records and catches reported with a latitude/longitude for the JMA 7 bottom trawl (including PRB) fishery.

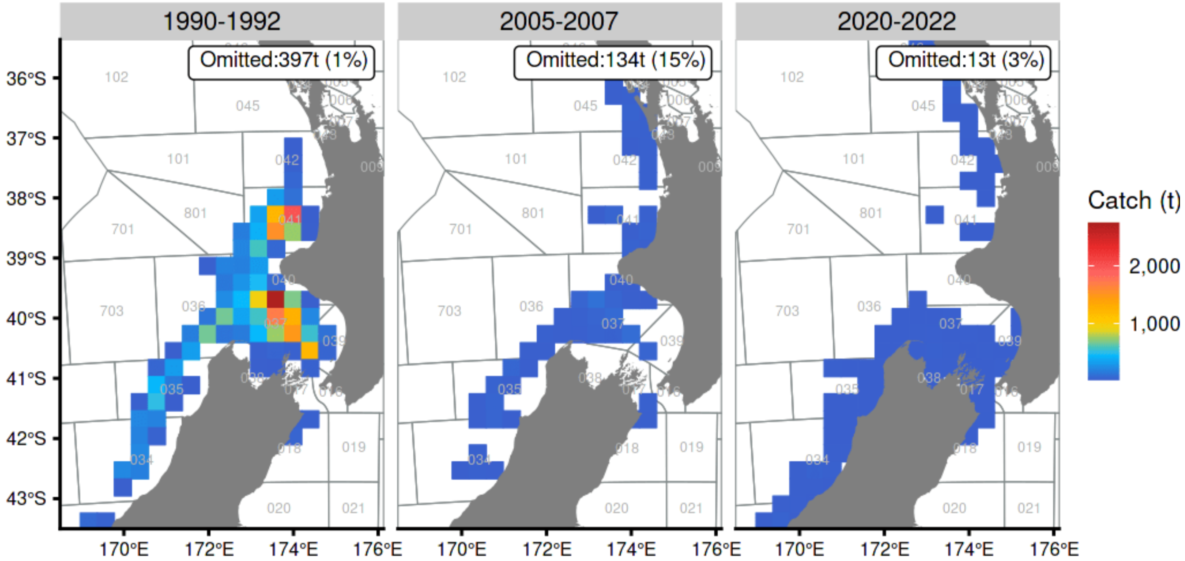

Figure 29: Catches (t) for the JMA 7 bottom trawl (including PRB) fishery, for 3-year periods within the era during which at least 80% of catch was reported with spatial information. These plots use a 32 km grid and include records where catches were allocated in proportion to estimated catch. Cells with data from less than three vessels or permit holders are omitted; the quantity of catch affected is indicated on each panel.

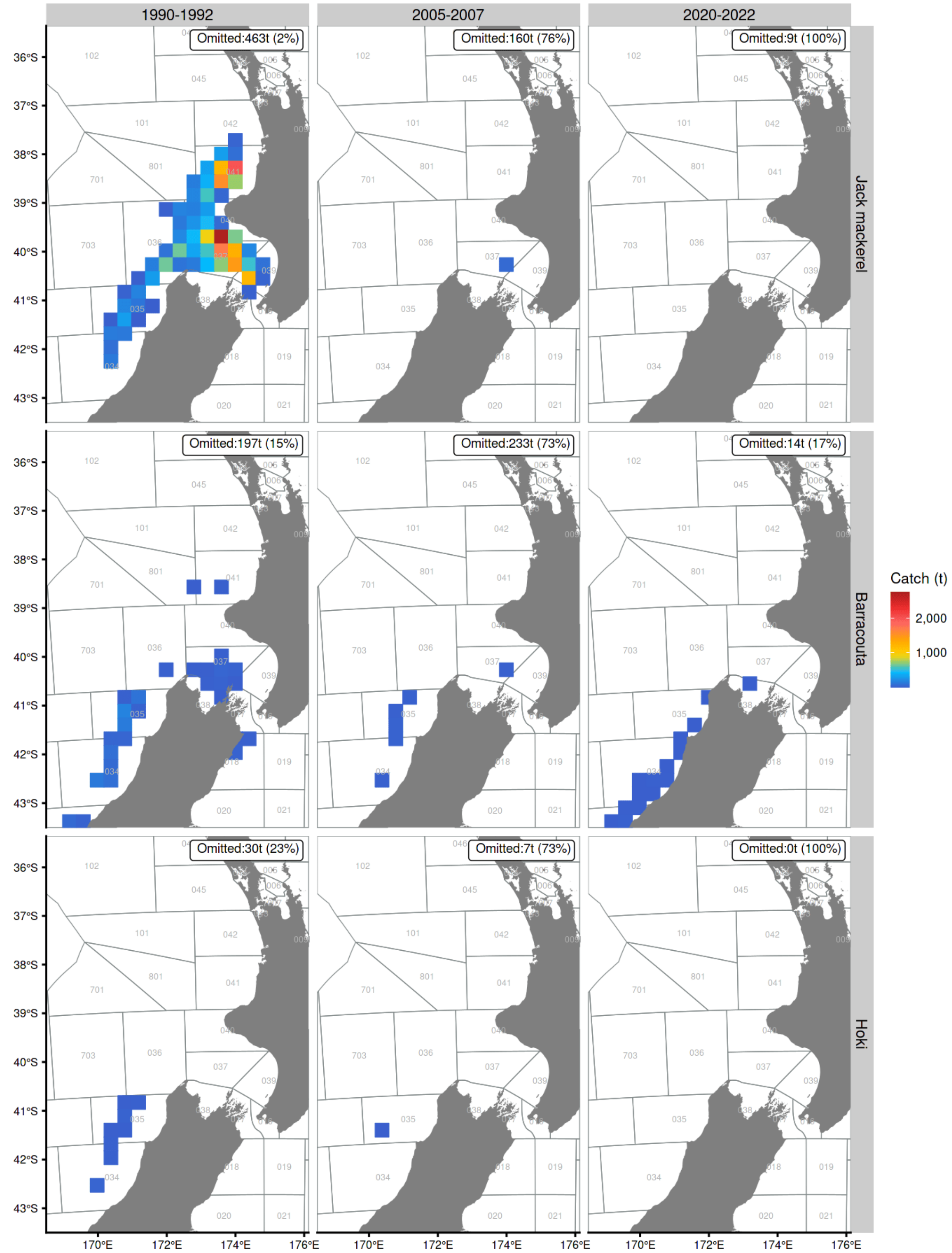

Figure 30: Catches of jack mackerels from the bottom trawl (including PRB) fishery by key target species. These plots use a 32 km grid and include records where landings were allocated in proportion to estimated catch. Cells with data from less than three vessels or permit holders are omitted; the quantity of catch affected is indicated on each panel.

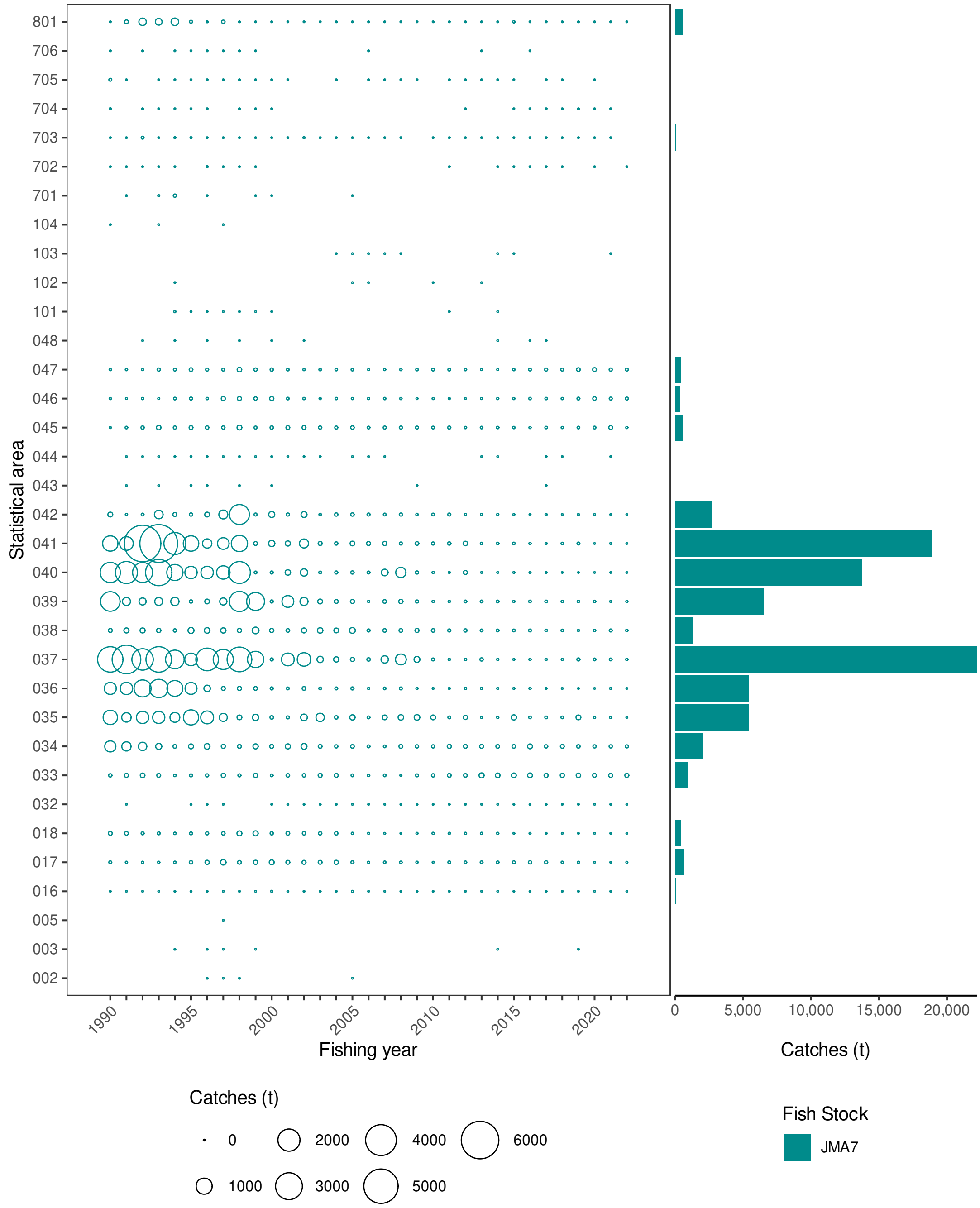

Figure 31: Annual JMA 7 catches (t) by statistical area for the bottom trawl (including PRB) fishery. The circle size scales with the catches by statistical area. The bar plot (right) shows the total catches of JMA 7 for each statistical area.

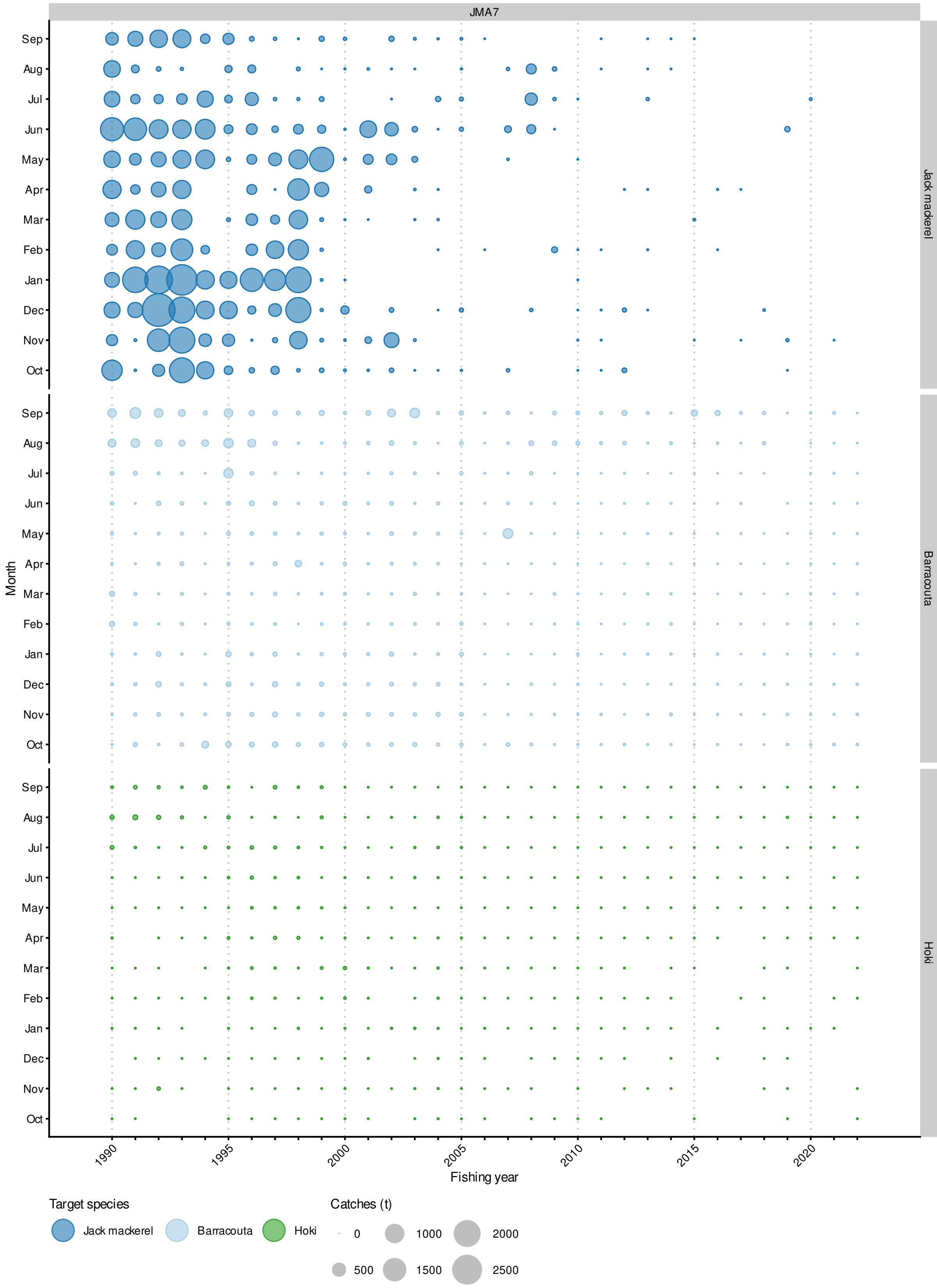

Figure 32: Seasonal distribution of JMA 7 catches by month and fishing year for the bottom trawl (including PRB) target fisheries. The area of the circle scales with the monthly catches.

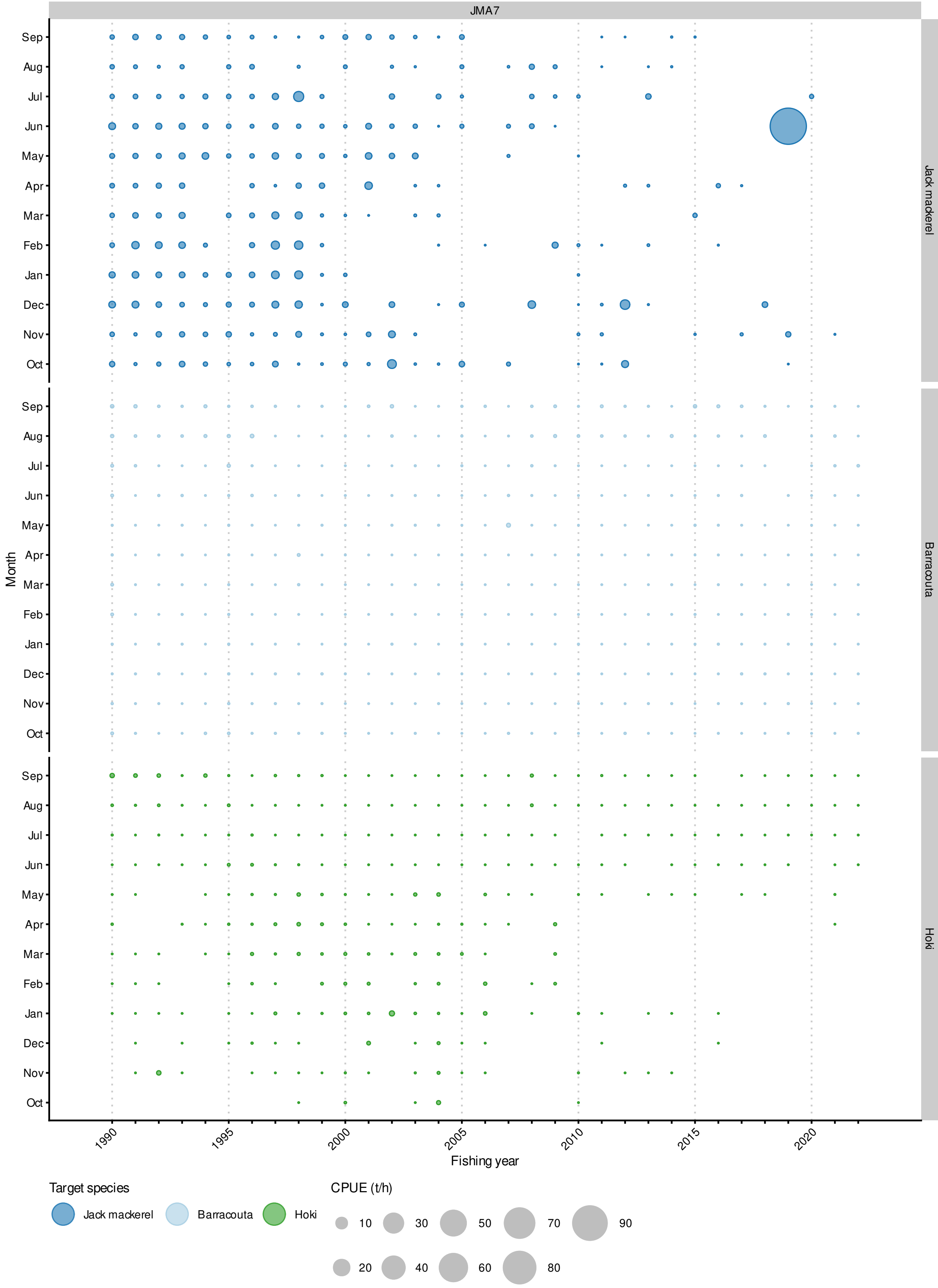

Figure 33: Seasonal distribution of JMA 7 raw aggregate CPUE (t/h) by month and fishing year for the bottom trawl (including PRB) target fisheries. The area of the circle scales with the monthly raw aggregate CPUE (t/h).

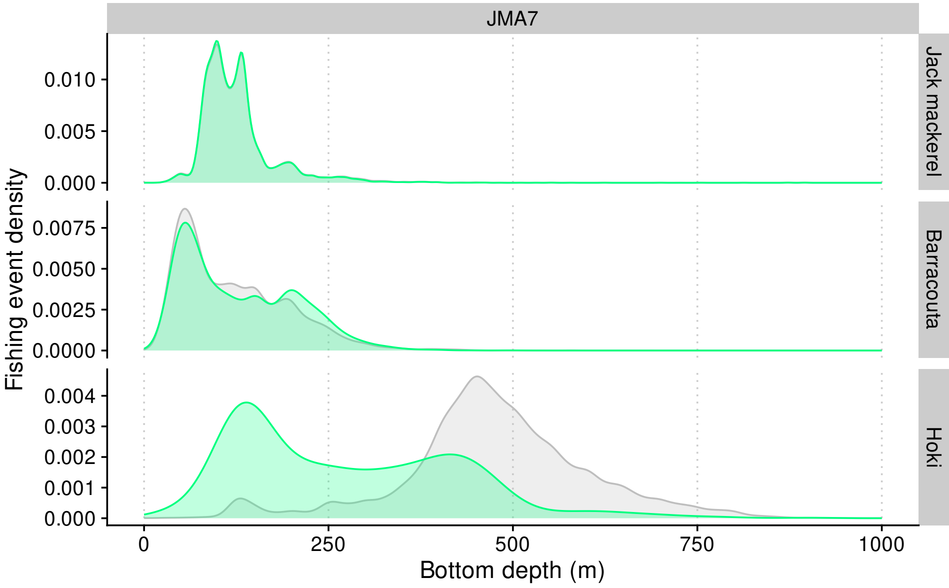

Figure 34: Effort depth distribution by target species for trips landing JMA 7 from the bottom trawl (including PRB) fishery. Target species are included if they are represented in at least 30 events. Grey fill = total effort, Green fill = positive effort (i.e., estimated catch > 0).

3.3 The purse seine fishery

Purse seine catches of JMA 7 were predominantly reported in the early 1990s and, although some purse seine effort extended to the mid-west coast of the South Island, most catches were taken in the Cook Strait, off the north east of the South Island (Statistical Areas 017 and 018; Figure 35).

Target jack mackerel catches occurred year-round, other than July, with bycatch in kahawai target sets primarily occurring from October to July (Figure 36).

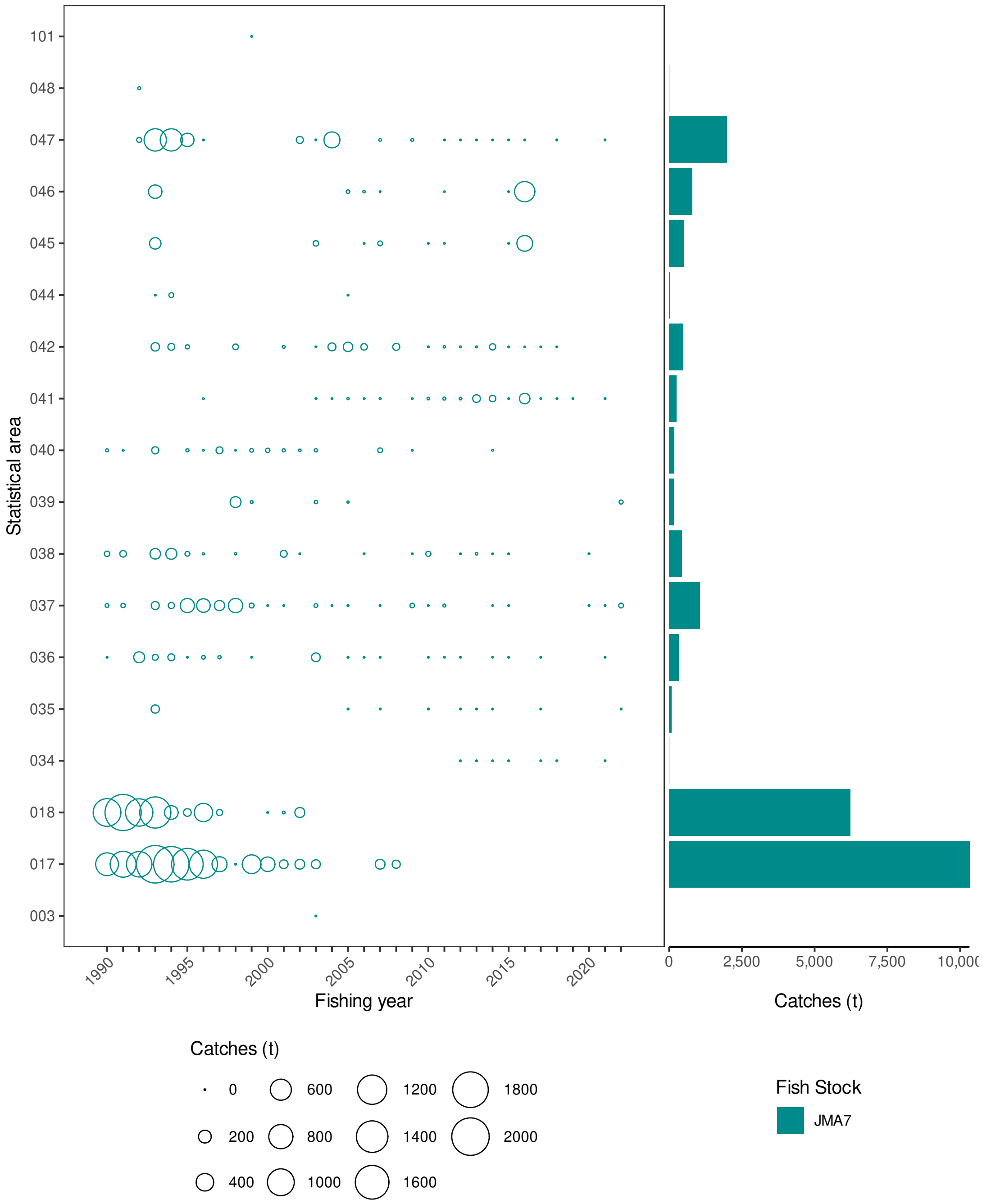

Figure 35: Annual JMA 7 catches (t) by statistical area for the purse seine fishery. The circle size scales with the catches by statistical area. The bar plot (right) shows the total catches of JMA 7 for each statistical area.

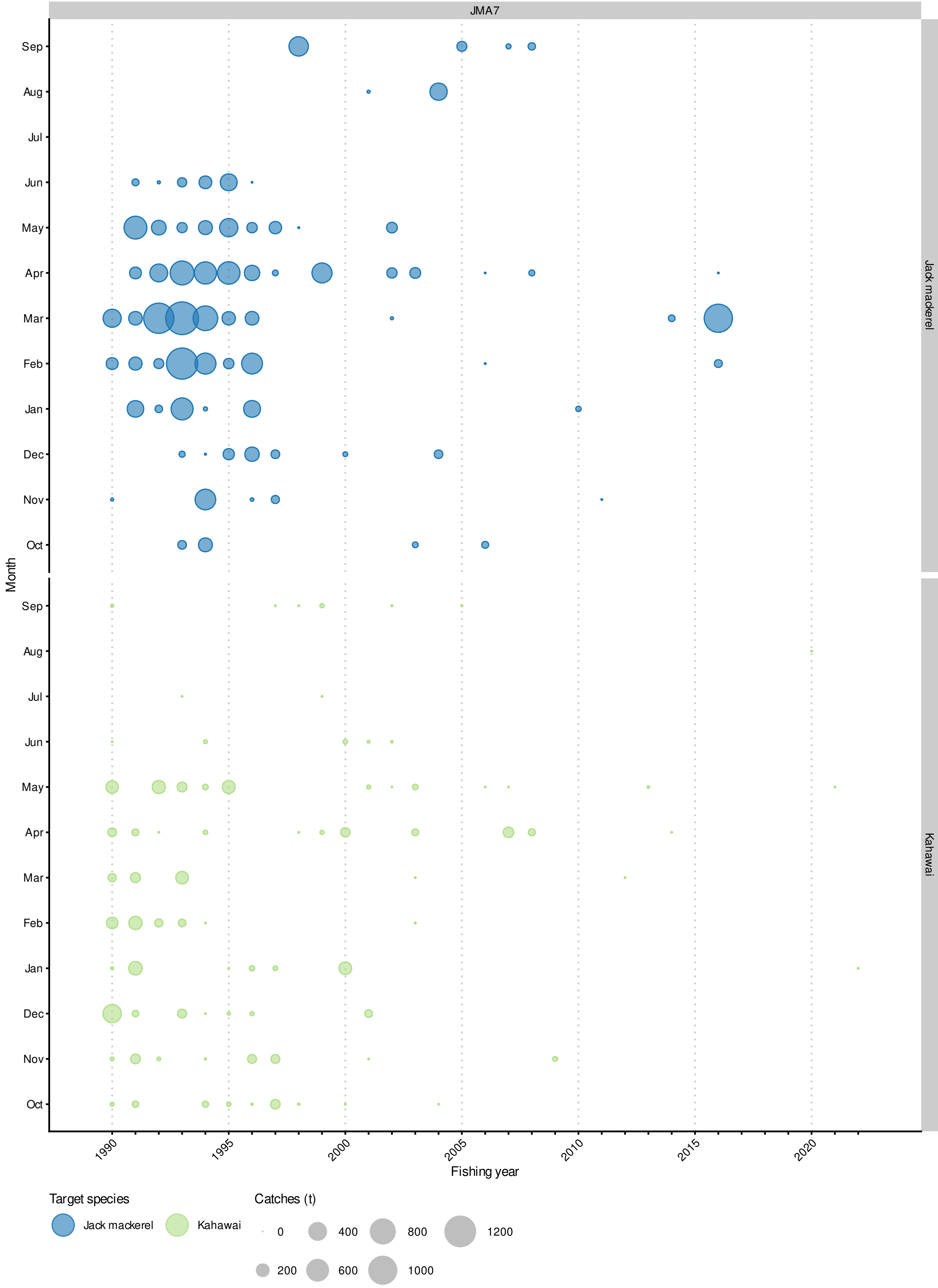

Figure 36: Seasonal distribution of JMA 7 catches by month and fishing year for the purse seine target fisheries. The area of the circle scales with the monthly catches.

3.4 Fleet patterns

A notable feature of the JMA 7 catch history is the reduction in landings from 1994 to 2001. An increasing trend in landings is apparent from 1981 (Figure 2); this continues to around 1993, spanning the period of QMS introduction. However, despite the TACC increasing to the current level in 1995 and so providing some scope for continued growth in the fishery, catches decreased in the period from 1994 to 2000, before increasing to the level of the TACC in the mid-2000s.

As described above, the period from the late 1990s to mid-2000s saw a transition in the JMA 7 fishery; in the 1990s, the midwater trawl fleet was operating primarily in the southern part of the fishery, while the target fishery in the Taranaki Bight was undertaken by bottom trawling. However, by the mid-2000s, the bottom trawl catch had decreased significantly and the midwater fishery was established in the Taranaki Bight, noting that different vessels were involved in the different methods. From the perspective of stock assessments for JMA 7, it is useful to understand if the drop in catch is largely attributable to these changing fishery dynamics, or if there is also an indication of reduced abundance in jack mackerels in this period.

Figure 37 illustrates the annual JMA 7 catch for vessels that caught at least 500 t of JMA 7 in a year. Key vessels are then defined as those that caught at least 10 000 t over the period from 1990 to 2022. Three groups of such ‘key vessels’ are apparent: (i) a group of seven vessels that had limited catches prior to 2000, but then formed the core fleet operating in the fishery in the next two decades; (ii) a group of four vessels that have joined the fishery since 2012, apparently replacing some of the vessels in the first group; and (iii) a group of four vessels that had the highest JMA 7 catches in the early 1990s. Two of the latter group stopped operating in 1994 and 1995, and the remaining two had their last substantial catches of JMA 7 in 1999.

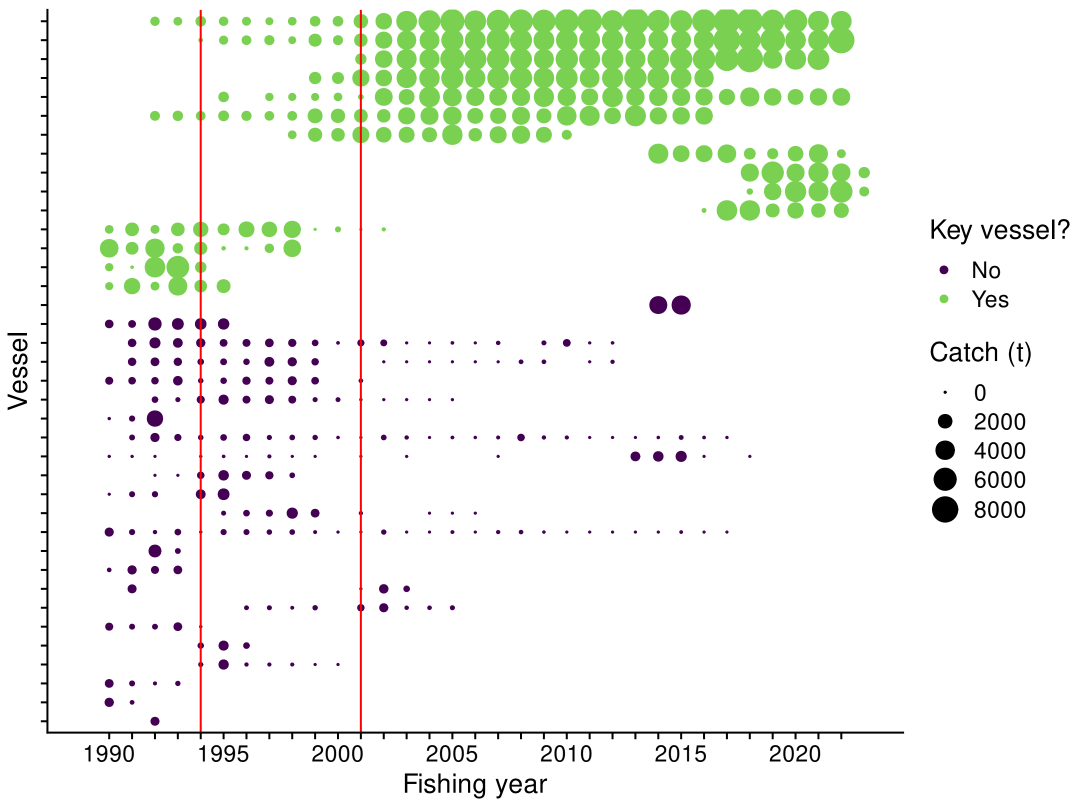

Figure 37: Annual catch for vessels that caught more than 500 t of JMA 7 in at least one year. Key vessels are those that caught more than 10 000 t over the course of the series. The red vertical lines delimit the period from 1994 to 2001 when JMA 7 catches were reduced.

Discussions with members of the seafood industry familiar with the JMA 7 fishery confirmed that the third group of vessels were Japanese trawlers contracted to one New Zealand seafood company; these vessels were responsible for the targeting of jack mackerels in the Taranaki Bight with 'high opening' bottom trawls. Changes in contractual arrangements saw these vessels largely exit the New Zealand fishery in the late 1990s.

The first and second group of key vessels have been dominated by 'BATM' vessels (specifically Pulkovskiy Meridian/BATM-1288 vessels), a class of 104 m factory trawlers constructed in eastern Europe and designed for distant-water fisheries with a high processing capacity focussed on whole or headed and gutted product. These vessels have comprised the core JMA 7 fleet from 2000 to 2022; however, at least some of these vessels were operating – to a more limited exent – in the JMA 7 fishery prior to 2000. The seasonal operating patterns of the key JMA 7 vessels are illustrated in Figure 38, in terms of effort by month and target species.

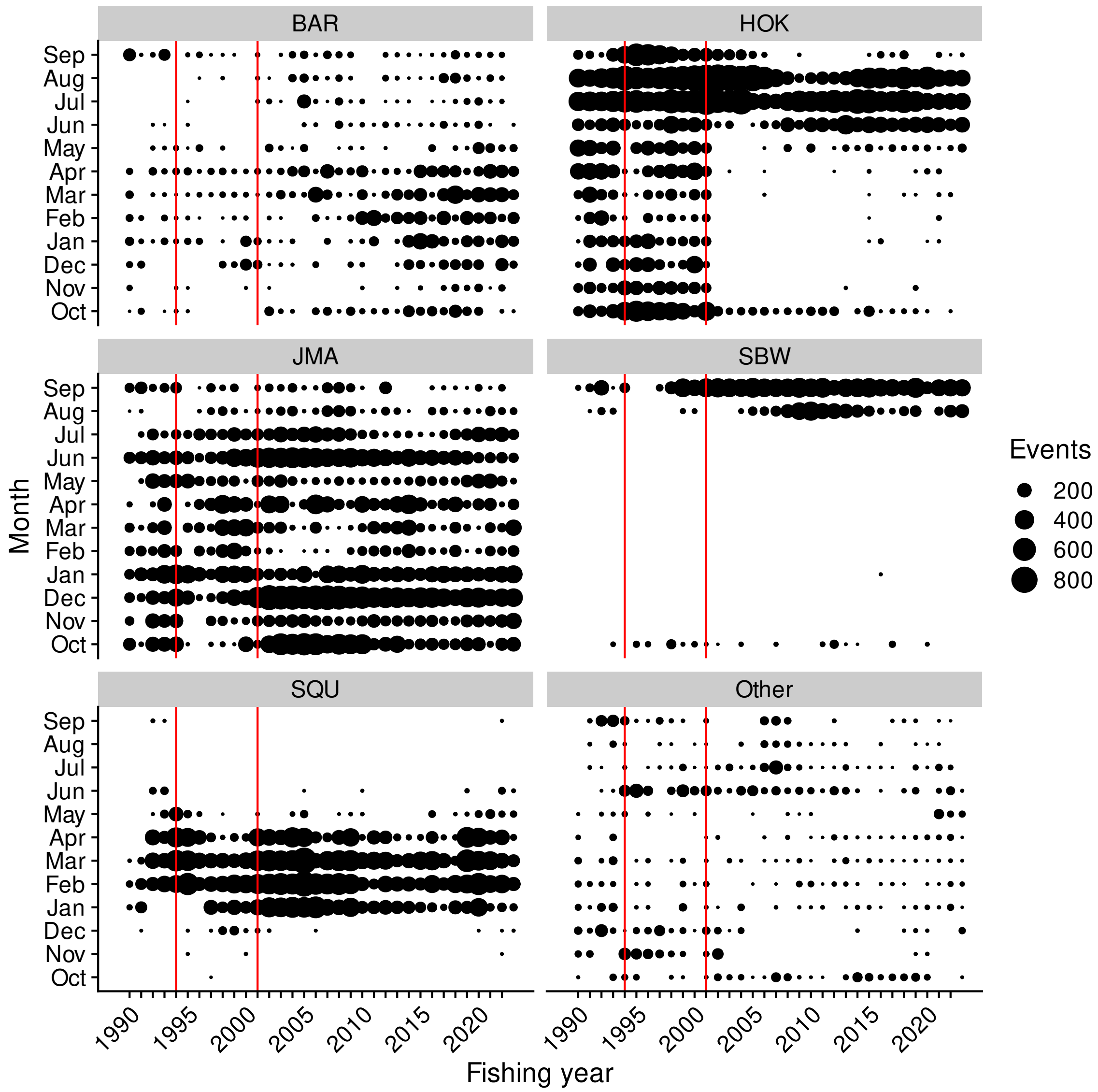

Figure 38: Monthly target species for tows by key JMA 7 vessels (those that caught more than 10 000 t over the course of the series). The red vertical lines delimit the period from 1994 to 2001 when JMA 7 catches were reduced.

Prior to 2001, including during the period of reduced catches in JMA 7, the key vessels were involved year-round in the hoki fishery. However, from 2002 onwards their hoki fishing became much more seasonal, largely restricted to the May to October period. This appears to have been the key change that allowed the development of the JMA 7 midwater fishery from the mid-2000s; it was only after moving to seasonal operation in the hoki fishery that the JMA 7 fishery could be fully developed, taking advantage of the catching opportunities (including availability of annual catch entitlement, ACE) that emerged after the departure of the Japanese vessels.

Since 2001, the key JMA 7 vessels have operated across a range of bulk fisheries. Many of these are seasonal, such as the hoki and southern blue whiting spawning fisheries, and the squid fishery that targets the feeding period of the main annual arrow squid cohort. The seasonality of jack mackerel catches, noted previously, is therefore primarily driven by the fact that the key vessels operate in the biologically seasonal fisheries of various other target species and target jack mackerels in the temporal gaps.

4. OBSERVER SAMPLING

Because the QMS data from the jack mackerel fisheries report all catches against the JMA species-group code, additional data are required to separate catches into the three jack mackerel species. In JMA 7, these data are provided by Fisheries New Zealand observers. During the processing of jack mackerel catches, observers take random samples of the jack mackerel catch and record the species and the length of the fish in the sample (sampling protocols are available as appendices given by Middleton 2022).

Observer data are labelled with the observer Fisheries Management Area (FMA) in which they were collected; there are three such FMAs within the JMA 7 Quota Management Area (Figure 39). A summary of the observer length-frequency sampling for jack mackerels in JMA 7 to 2022 (Table 4) shows that sampling, particularly from the midwater trawl fishery, has been extensive. A small number of samples are identified only as being taken from trawl (TWL) fishing, and only one sample is available from the purse seine fishery.

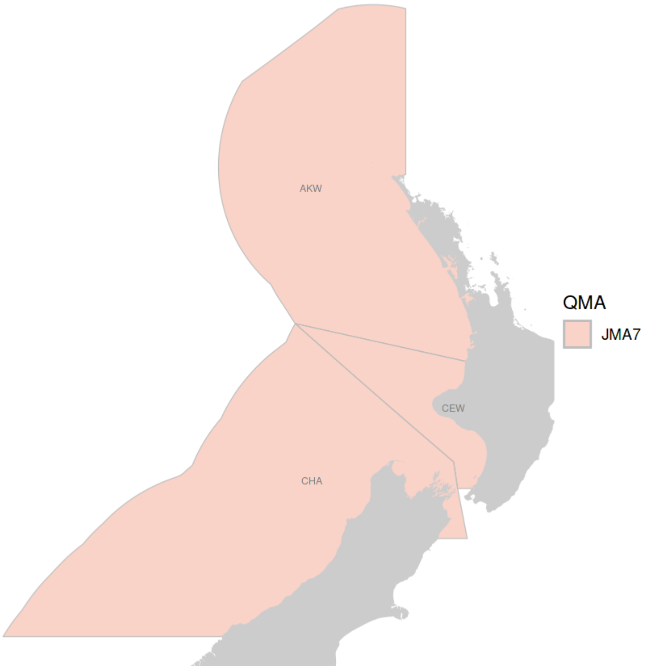

Figure 39: Observer Fisheries Management Areas in relation to the Quota Management Areas (QMA) for jack mackerels.

During the 1990s, observers recorded data from an average of 730 tows per annum with jack mackerel catches and obtained species-specific length-frequency samples from 22% of recorded events (Figure 40). From 2000 to 2004, the reduced effort in the fishery saw sampling drop to an average of 310 tows per annum. However, as the midwater fishery became established, sampling increased to an average of 840 tows per annum from 2005 to 2011, with length-frequency sampling increasing to 52% of observed tows. Coverage levels were increased again from 2012, with an average of 1660 tows observed each year from 2012 to 2022; however, the number with length-frequency samples did not increase to the same extent with sampling from 30% of observed tows in this period.

Table 4: Length-frequency samples of jack mackerels by area and method, sampled by the Observer Programme from fishing years 1987 to 2022. Observer Fisheries Management Area (FMA) codes and method codes are defined in the glossary.

QMA	Observer FMA	Method	Sampled events	Number of fish
JMA7	AKW	BT	95	10 542
JMA7	AKW	MW	1 505	219 988
JMA7	AKW	TWL	8	472
JMA7	CEW	BT	709	78 900
JMA7	CEW	MW	4 693	647 547
JMA7	CEW	PS	1	45
JMA7	CEW	TWL	30	2 067
JMA7	CHA	BT	323	38 319
JMA7	CHA	MW	3 262	378 932
JMA7	CHA	TWL	3	167

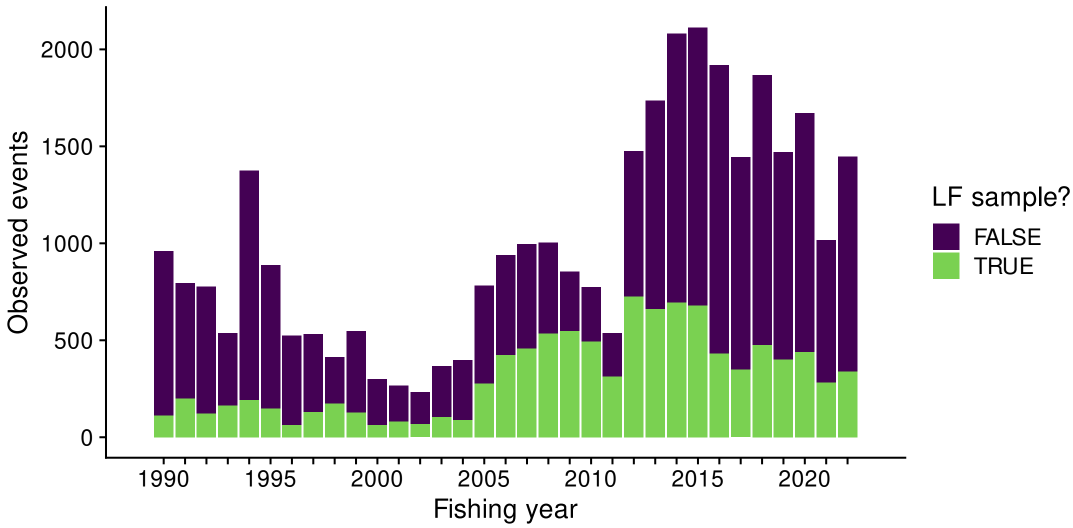

Figure 40: Observed trawl fishing events in JMA 7 where JMA was caught, with and without length-frequency sampling, by fishing year.

4.1 Sampling representativeness

The representativeness of observer length-frequency sampling of the midwater trawl fishery is illustrated for month in Figures 41 and 42, and for latitude in Figures 43 and 44. Representativeness was poor in the early 1990s, and then variable until the mid-2000s, with reasonable coverage in 1994 and 1999, for example, but poorer coverage in 2002 and 2003. Representativeness of coverage has been reasonable since 2005, although late season coverage and coverage of the southern extents of the fishery has been consistently more limited than throughout the rest of the fishery season and area. The jack mackerel catches at the southern extents are primarily small amounts of bycatch in the hoki fishery, whereas coverage of the core fishery in the Taranaki Bight has been very good.

Representativeness of sampling of the bottom trawl fishery by month (Figures 45 and 46) has been generally poor throughout the period, although the very limited bottom trawl catches after 2000 imply that coverage in the later period is less important. Better seasonal coverage was achieved for a few years in the 1990s, notably 1991, 1992, and 1994. Spatial representativeness (Figures 43 and 44) was reasonable for the core bottom trawl fishery in the early 1990s, but poorer in the late 1990s as jack mackerels were caught over a wider latitude range. Bottom trawl catches in the last decade have primarily been from the south of the area (i.e., the hoki fishery) and have not been sampled very consistently.

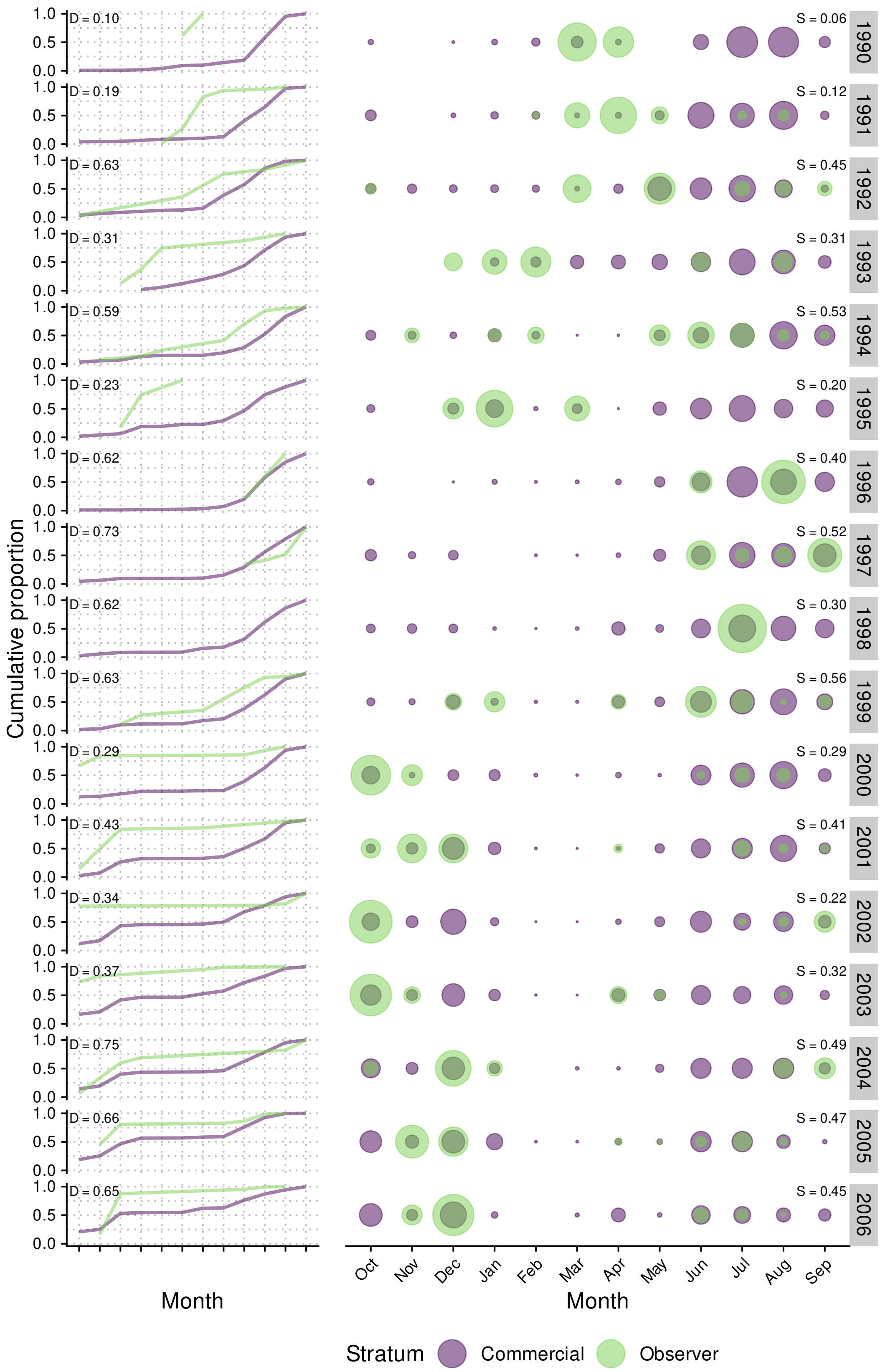

Figure 41: Representativeness of observer sampling coverage of midwater trawl fishing events that caught jack mackerels in 1990 to 2006 by fishing year and month. Observer data are for observed events with length sampling. Circle area is proportional to the proportion of events in a month, with proportions summing to one within each fishing year. D: Kolmogorov-Smirnov maximum absolute difference; S: Manhattan block distance.

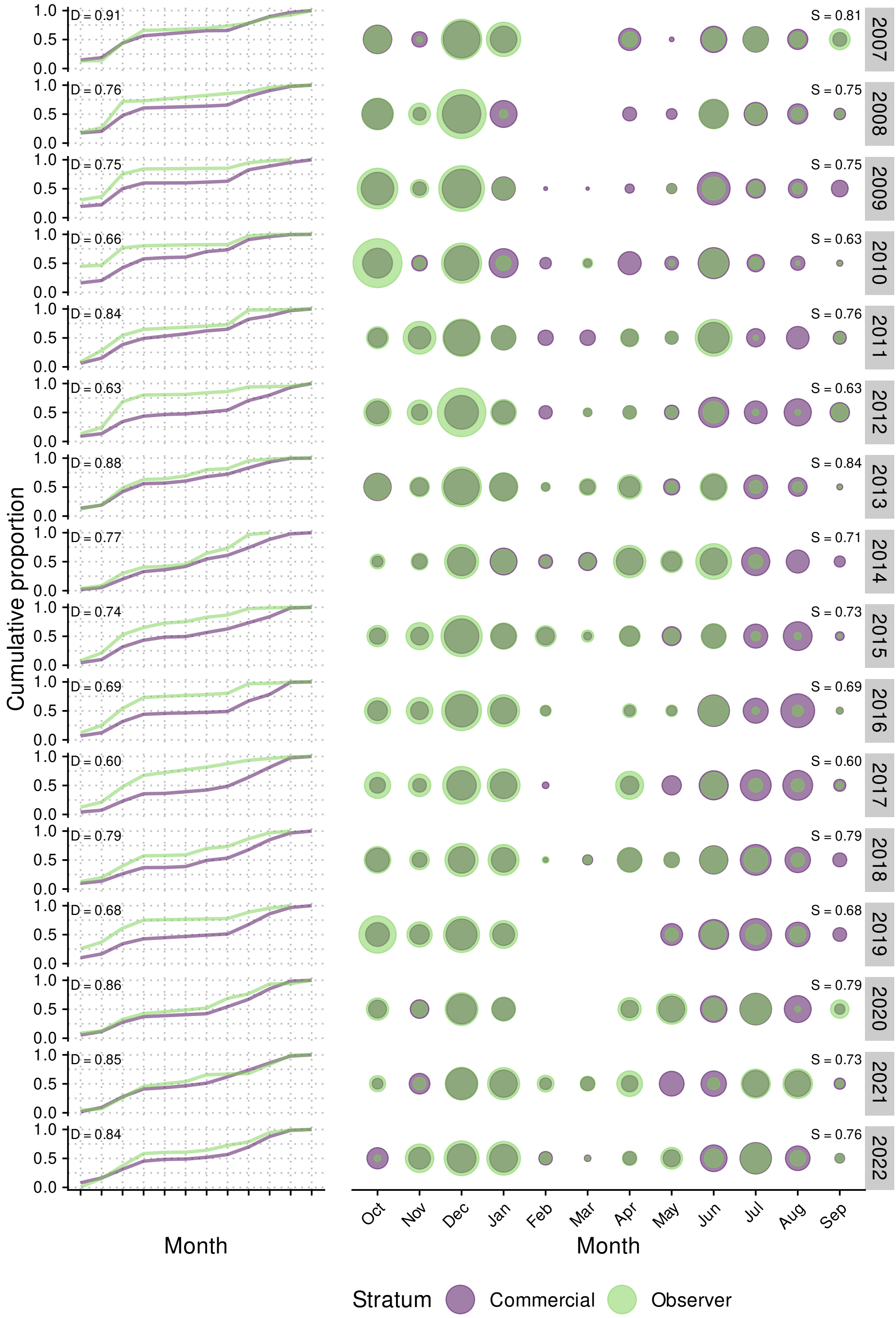

Figure 42: Representativeness of observer sampling coverage of midwater trawl fishing events that caught jack mackerels in 2007 to 2022 by fishing year and month. Observer data are for observed events with length sampling. Circle area is proportional to the proportion of events in a month, with proportions summing to one within each fishing year. D: Kolmogorov-Smirnov maximum absolute difference; S: Manhattan block distance.

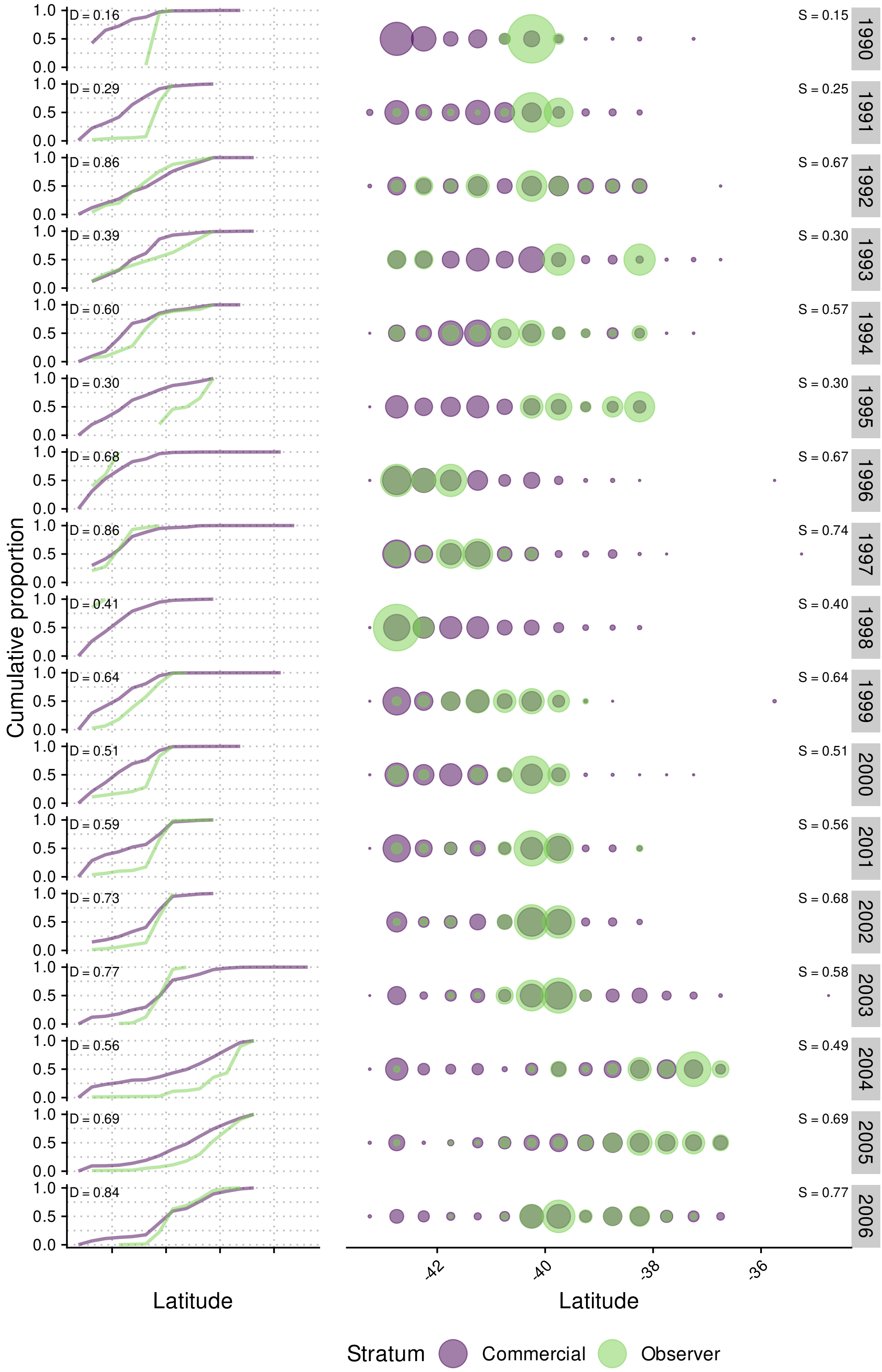

Figure 43: Representativeness of observer sampling coverage of midwater trawl fishing events that caught jack mackerels in 1990 to 2006 by fishing year and latitude. Observer data are for observed events with length sampling. Circle area is proportional to the proportion of events in a latitude bin, with proportions summing to one within each fishing year.

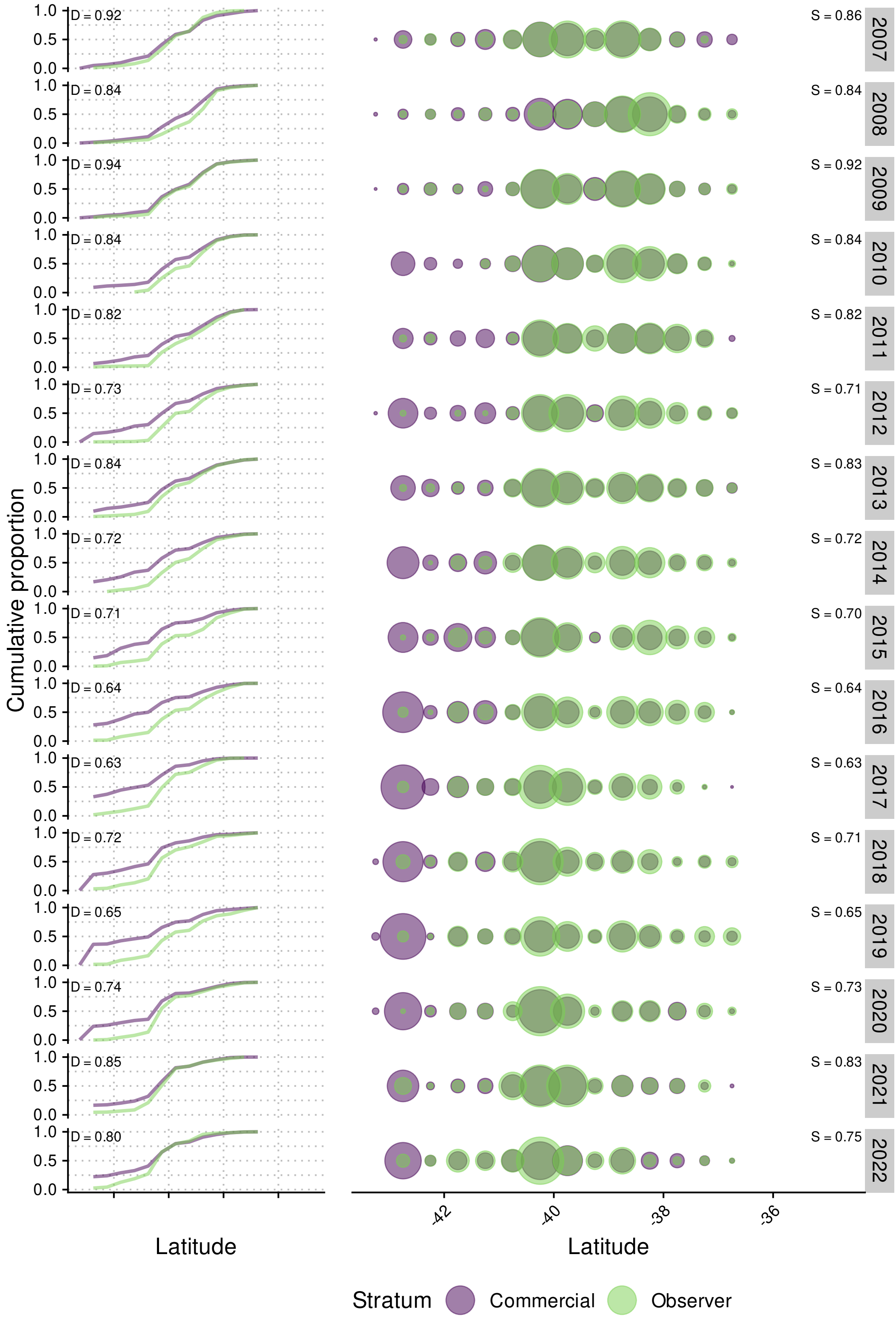

Figure 44: Representativeness of observer sampling coverage of midwater trawl fishing events that caught jack mackerels in 2007 to 2022 by fishing year and latitude. Observer data are for observed events with length sampling. Circle area is proportional to the proportion of events in a latitude bin, with proportions summing to one within each fishing year.

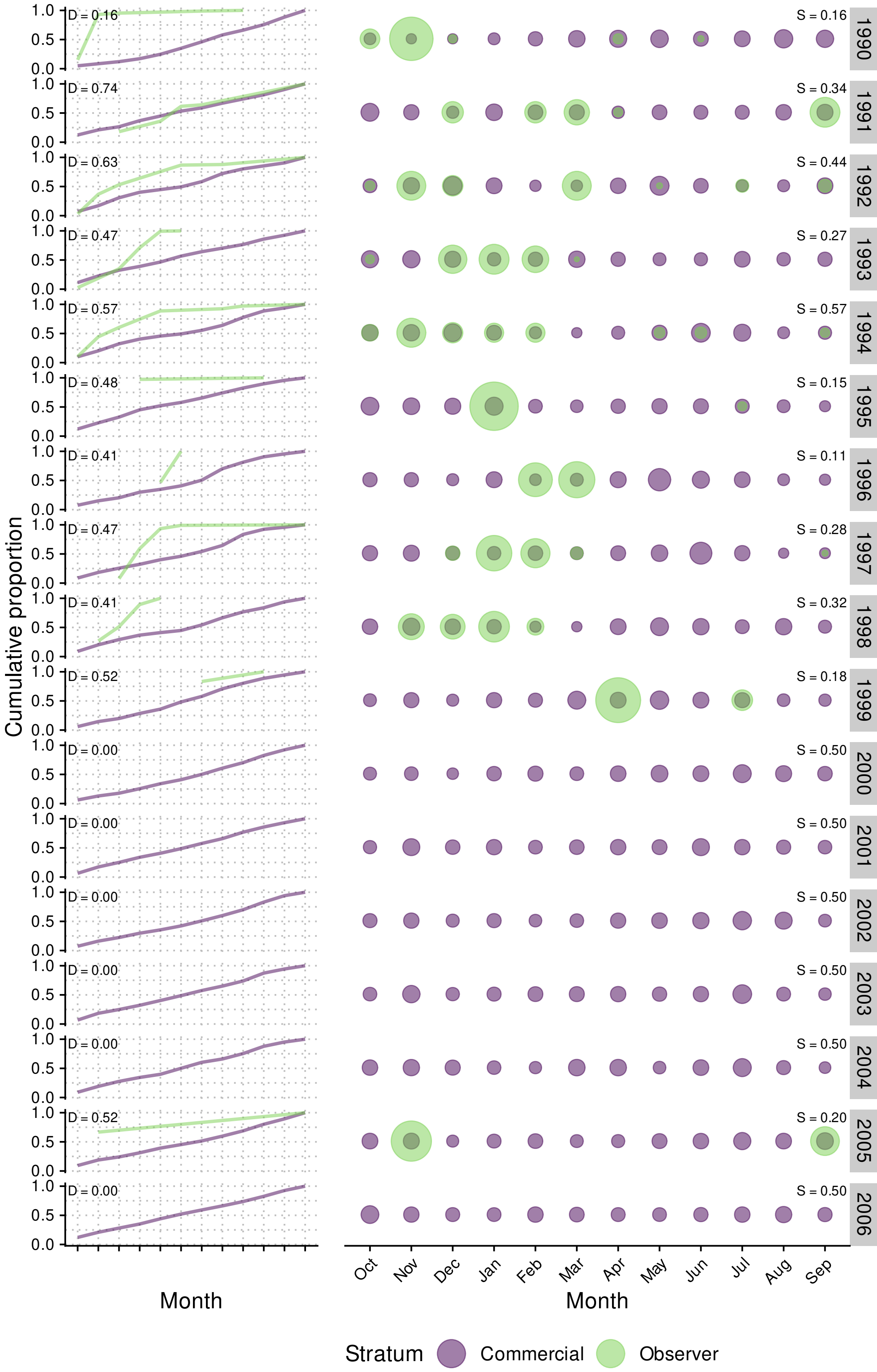

Figure 45: Representativeness of observer sampling coverage of bottom trawl fishing events that caught jack mackerels in 1990 to 2006 by fishing year and month. Observer data are for observed events with length sampling. Circle area is proportional to the proportion of events in a month, with proportions summing to one within each fishing year. D: Kolmogorov-Smirnov maximum absolute difference; S: Manhattan block distance.

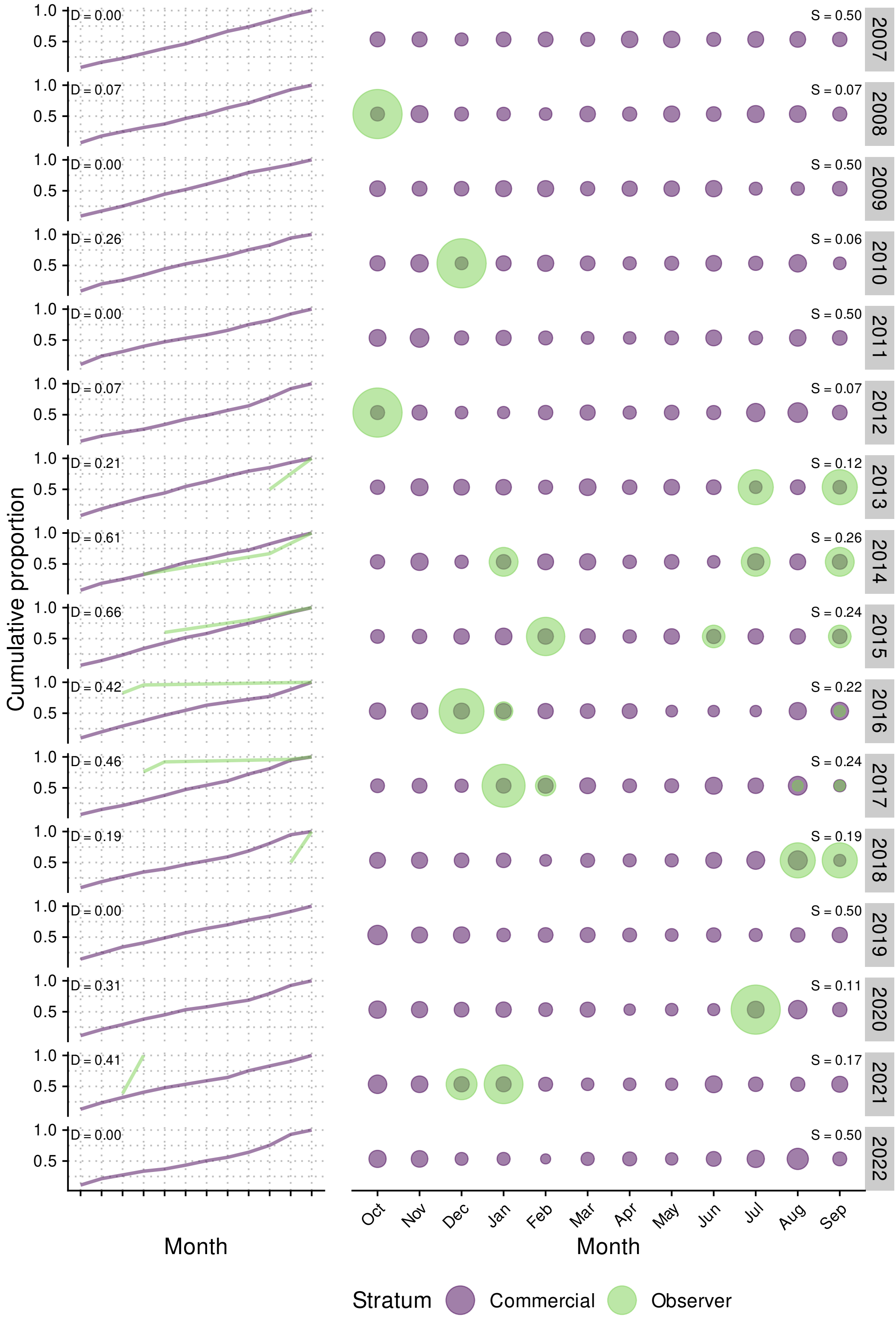

Figure 46: Representativeness of observer sampling coverage of bottom trawl fishing events that caught jack mackerels in 2007 to 2022 by fishing year and month. Observer data are for observed events with length sampling. Circle area is proportional to the proportion of events in a month, with proportions summing to one within each fishing year. D: Kolmogorov-Smirnov maximum absolute difference; S: Manhattan block distance.

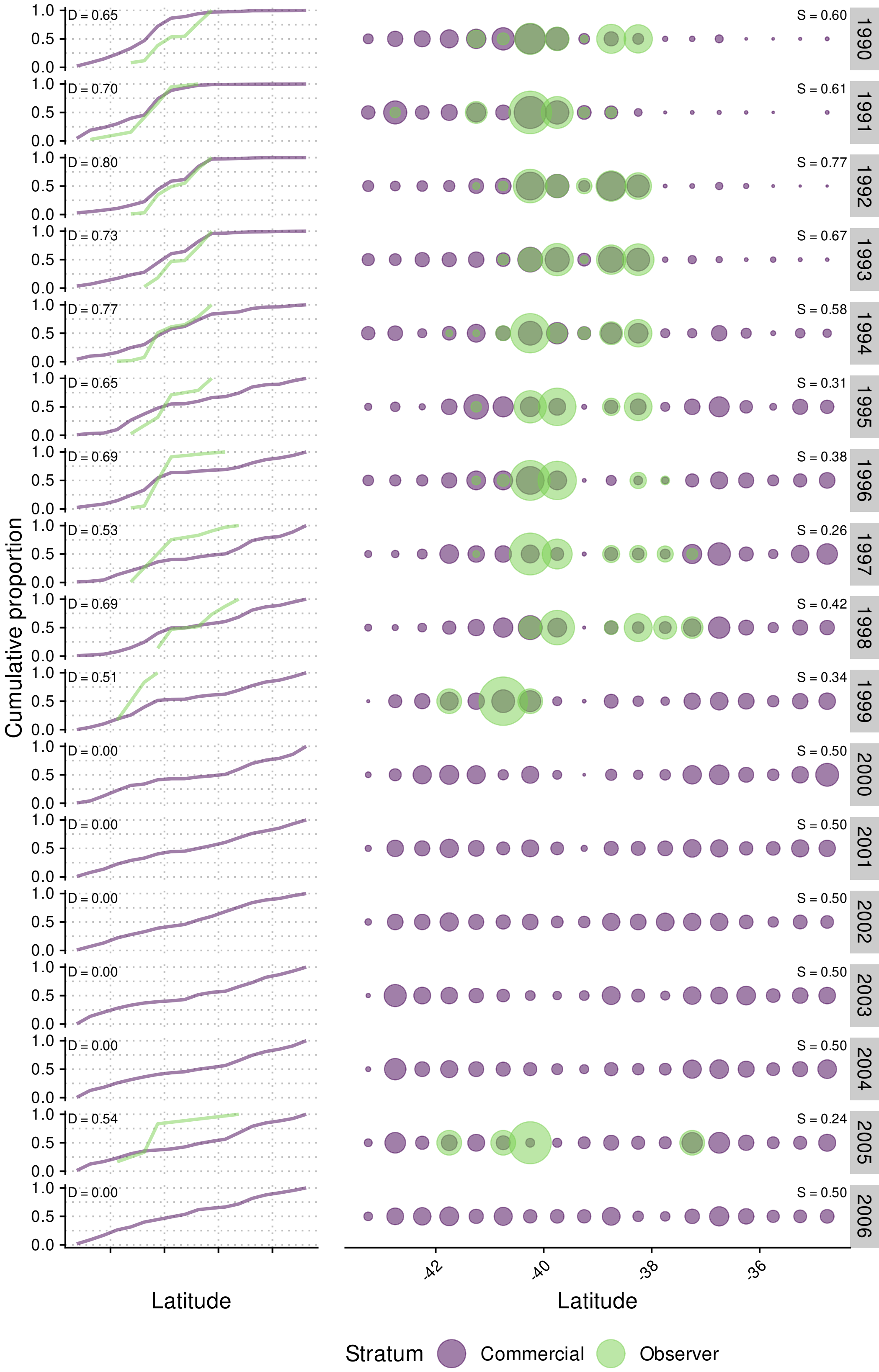

Figure 47: Representativeness of observer sampling coverage of bottom trawl fishing events that caught jack mackerels in 1990 to 2006 by fishing year and latitude. Observer data are for observed events with length sampling. Circle area is proportional to the proportion of events in a latitude bin, with proportions summing to one within each fishing year.

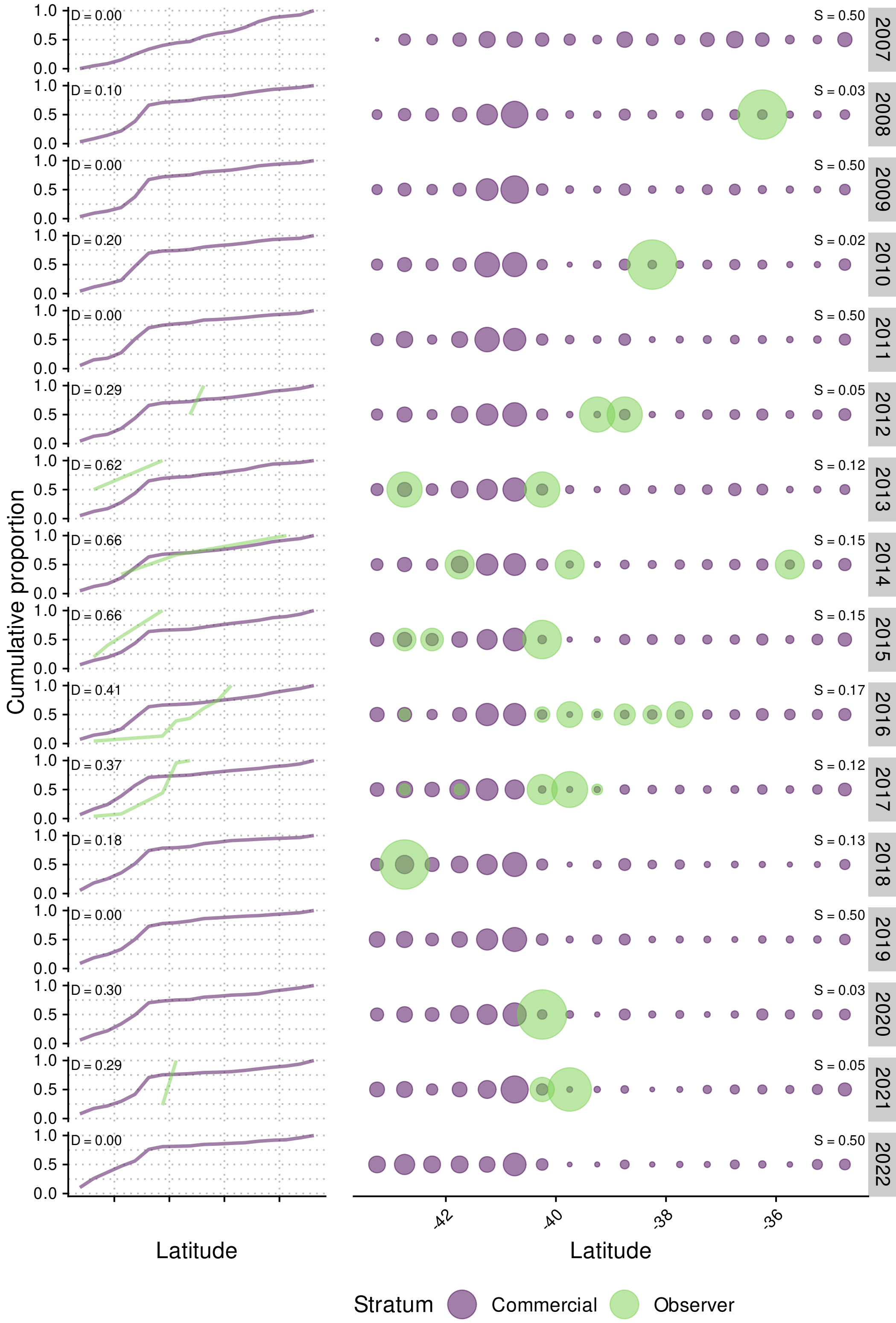

Figure 48: Representativeness of observer sampling coverage of bottom trawl fishing events that caught jack mackerels in 2007 to 2022 by fishing year and latitude. Observer data are for observed events with length sampling. Circle area is proportional to the proportion of events in a latitude bin, with proportions summing to one within each fishing year.

4.2 Length sampling

During 1990 to 2004, the typical sample size of observer length-frequency samples from the JMA 7 fishery was around 100 fish (of all jack mackerel species combined; Figure 49). Sample sizes increased from 2005, which is likely to be related to the direction for observers to obtain multiple samples throughout the processing period. However, each year, some tows have only small length-frequency samples recorded. The reason for small samples being taken is unclear, but it is plausible that these are occasions when observers were unable to collect a full length-frequency sample, but nevertheless sampled a few fish—for example, to fill out an age-length key. It is likely that these small samples are not representative of the full catch of jack mackerel on the sampled tow; fortunately the number of such samples is small. The impact of small samples on estimates of species composition and CPUE indices is considered below.

Because the length-frequency samples for jack mackerels require the species, as well of the length, of each fish in the sample to be recorded, observer protocols specify that data should be recorded on forms which provide a row per fish (i.e., the Middle Depth Biological Data form), rather than a tally format (Middleton 2022). However, jack mackerel length-frequency data are largely stored in the Centralised Observer Database (COD) in a tally format (Figure 50), although a minority of the records have been stored in a fish by fish format since 2008.

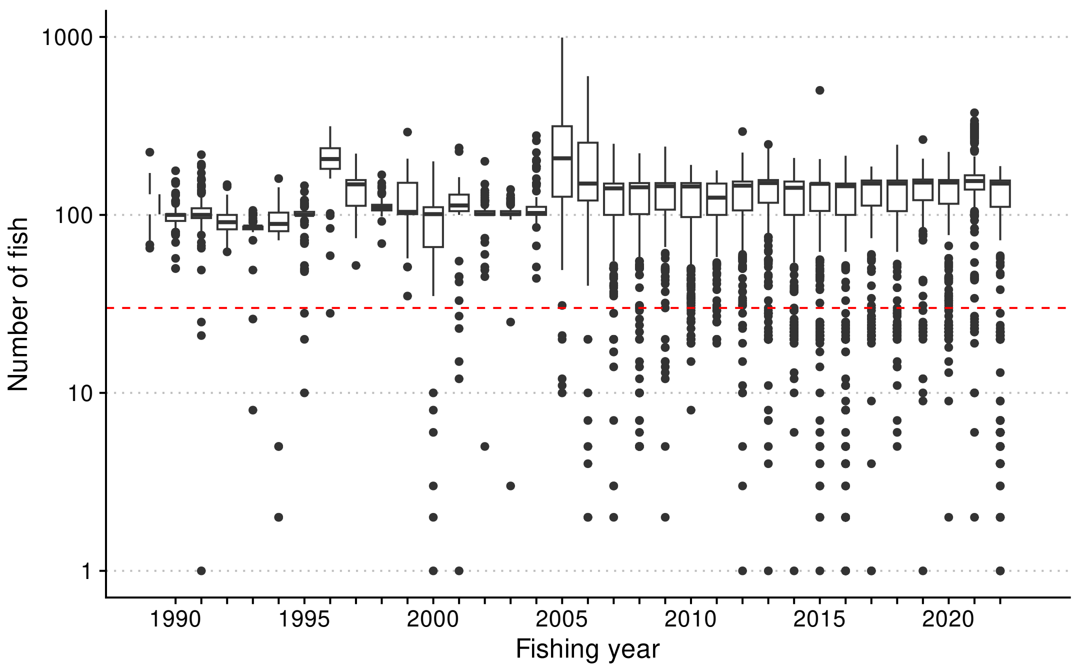

Figure 49: Length-frequency sample sizes for observed fishing events in JMA 7 where jack mackerels were sampled. The red dashed line indicates a sample size of 30 fish.

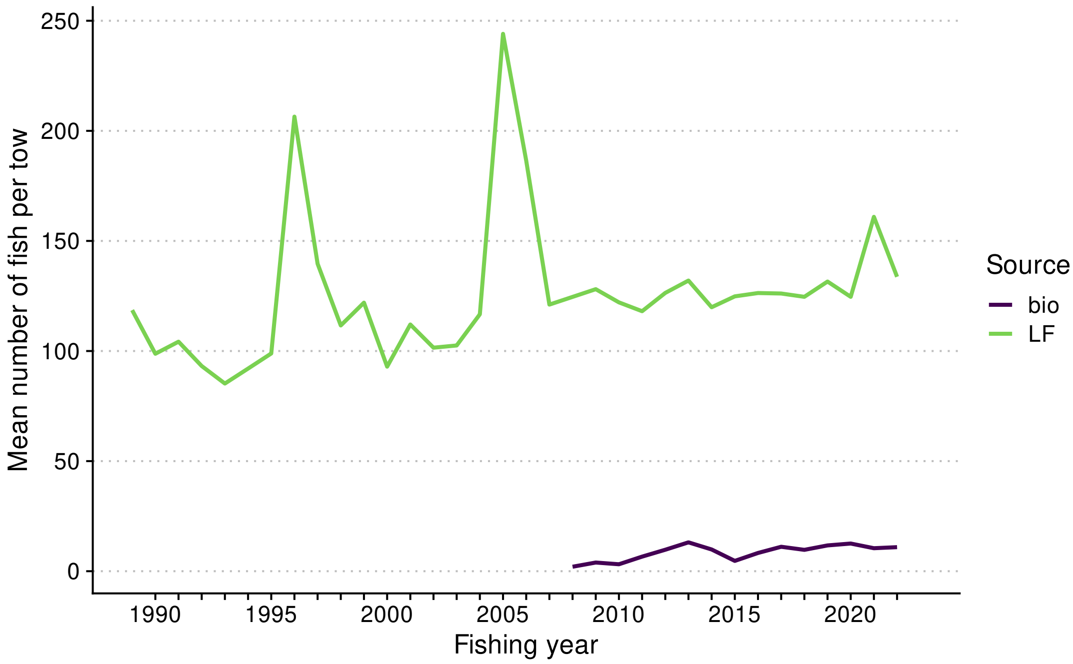

Figure 50: Storage of jack mackerel length-frequency sampling data in the Centralised Observer Database. Data with a source of `LF` are stored in the `x_length_frequency` table in a tally format, while a source of `bio` indicates data stored in the `x_fishing_event_biological` table with a row per fish.

4.3 Observer experience

The experience of individual observers may be relevant to the potential for jack mackerel species to be misidentified. Many of the observers who have provided data from the JMA 7 fishery have only undertaken a single trip in the fishery (Figure 51). However, in the JMA 7 fishery it is common for more than one observer to be placed on a vessel, and it is relatively unusual for all observers on a trip in the JMA 7 fishery to be undertaking their first trip in that fishery (Figure 52). Furthermore, all observers undertaking their first trip in the JMA 7 fishery had some prior experience in other fisheries (Figure 53).

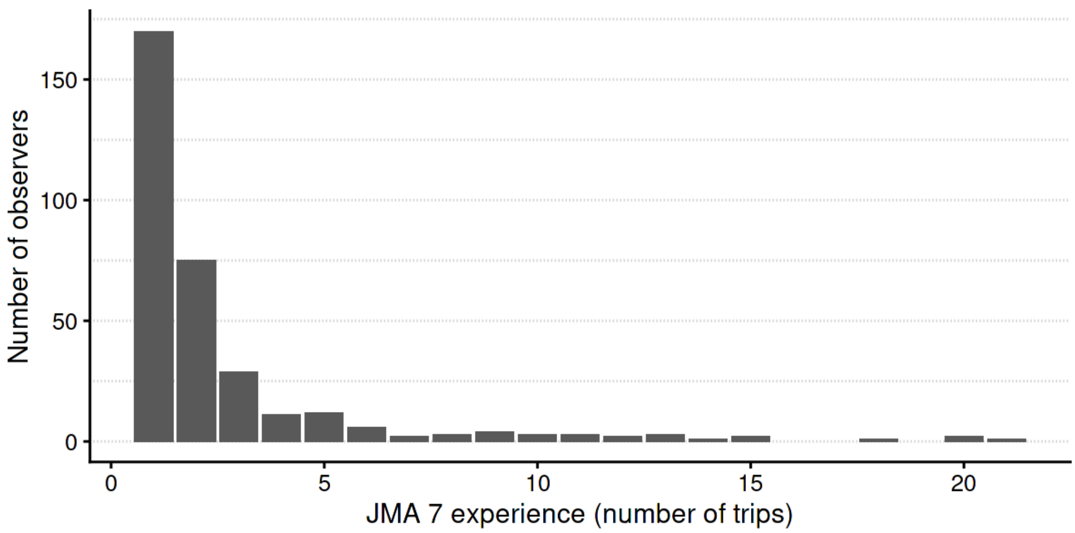

Figure 51: Experience of observers in the JMA 7 trawl fishery from 1987 to 2022.

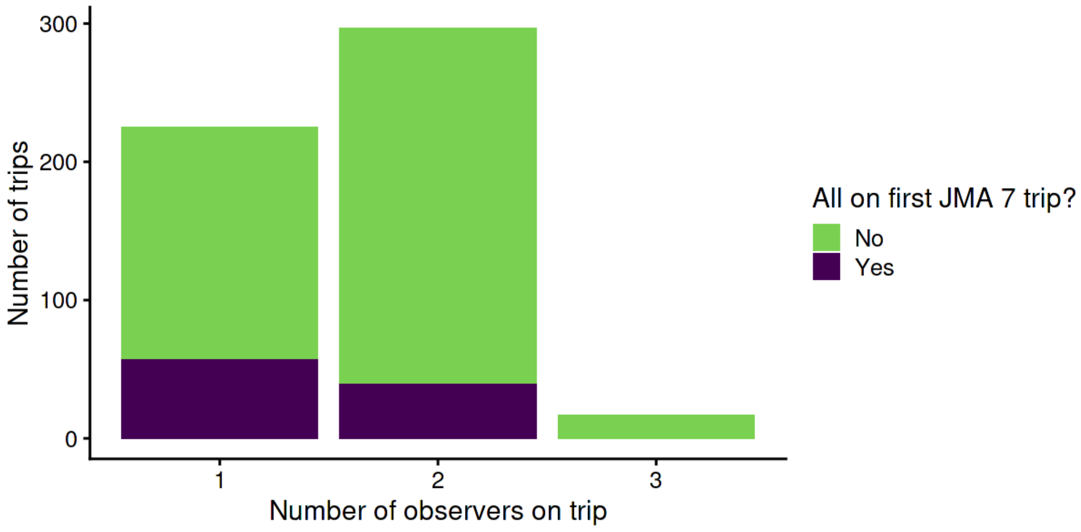

Figure 52: Number of observers on JMA 7 trips providing length-frequency samples, categorised by whether all observers were on their first JMA 7 trip.

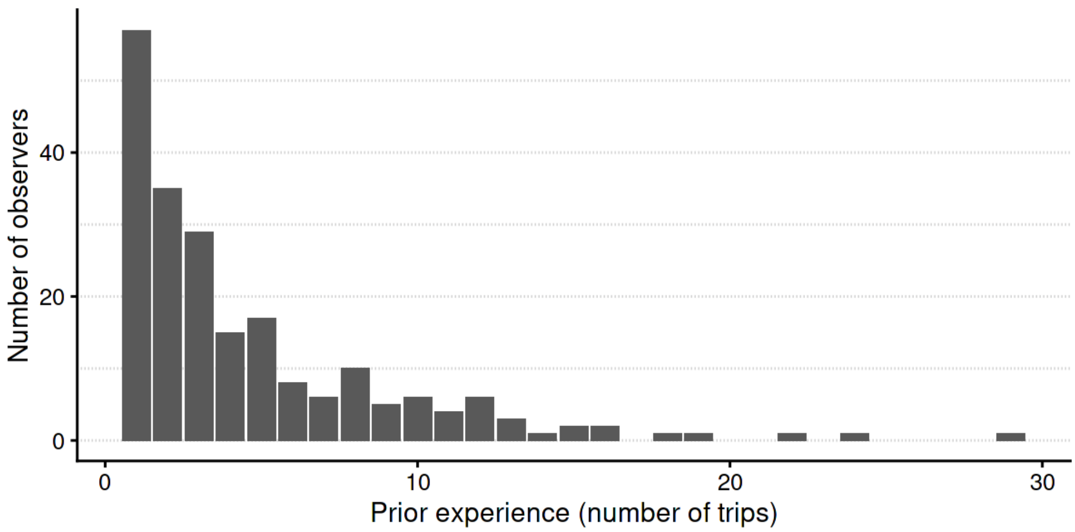

Figure 53: Number of trips undertaken by observers prior to their first trip in the JMA 7 fishery, for trips undertaken from 1987 to 2022.

4.4 Age sampling

In addition to undertaking species-specific length-frequency sampling in the JMA 7 fishery, observers also collect otoliths for subsequent ageing. It is primarily through analyses of age-length data for jack mackerels that the issue of misidentification of the jack mackerel species has been identified (see, for example, Saunders et al. 2022), although discrepancies in the recorded lengths have also been noted (for example, Middleton 2022, appendix C).

Observers have collected otoliths from all three species of jack mackerel, throughout the JMA 7 fishery (Table 5). However, regular otolith sampling has only been undertaken since 2005 (Figure 54).

Table 5: Otolith sampling of jack mackerels by area and observer-assigned species, by the Observer Programme from 1995 to 2020. Areas are defined in Appendix D.

	Species			
Area	JMD	JMM	JMN	Total
AKW	1 155	1 100	1 987	4 242
CEW	3 775	2 285	4 101	10 161
CHA	2 814	1 684	1 732	6 230
Total	7 744	5 069	7 820	20 633

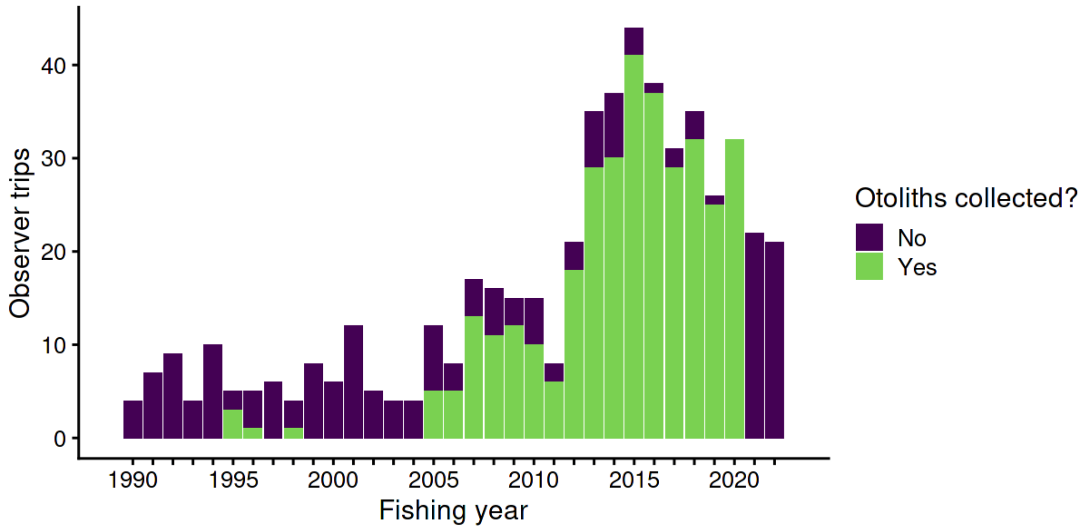

Figure 54: Observer trips with and without age sampling, by fishing year. Trips are assigned to the fishing year in which they commenced. It is assumed that otolith sampling was continued in 2021 and 2022 but that these otoliths are yet to be catalogued.

5. MISIDENTIFICATION OF JACK MACKERELS

5.1 Patterns in age-length data

Ageing data were available for 19 074 jack mackerels sampled from JMA 7 from 1995–2020; the agreed age from the otolith reading process is plotted against the recorded length in Figure 55. A number of *T. declivis* (JMD) that had been aged were recorded as having a length of 3 cm (Figure 55); these otoliths, which were from a single trip (2125) and also had no sex information, were excluded from further analyses. Ignoring this group of implausibly small JMD, there are other groups of points evident in Figure 55, especially for *T. declivis* (JMD) and *T. novaezelandiae* (JMN), that do not follow the main trend in age at length. In the case of JMN, the age at length appears to be monotonically increasing until around 40 cm; however the fish identified as JMN but with a fork length greater than 40 cm appear to be following a different growth trajectory altogether. Likewise, for JMD, there is a group of points for fish around 30 cm in length that are substantially older than the majority of JMD at this length.

Differential growth by sex is one mechanism that could give rise to the patterns seen in Figure 55. However, there does not appear to be evidence for substantial differences in the growth of male and female jack mackerels (Figure 56); rather it appears that the age-length data for JMD are contaminated with some JMN, and likewise that the data for JMN include some JMD or JMM (Figure 57).

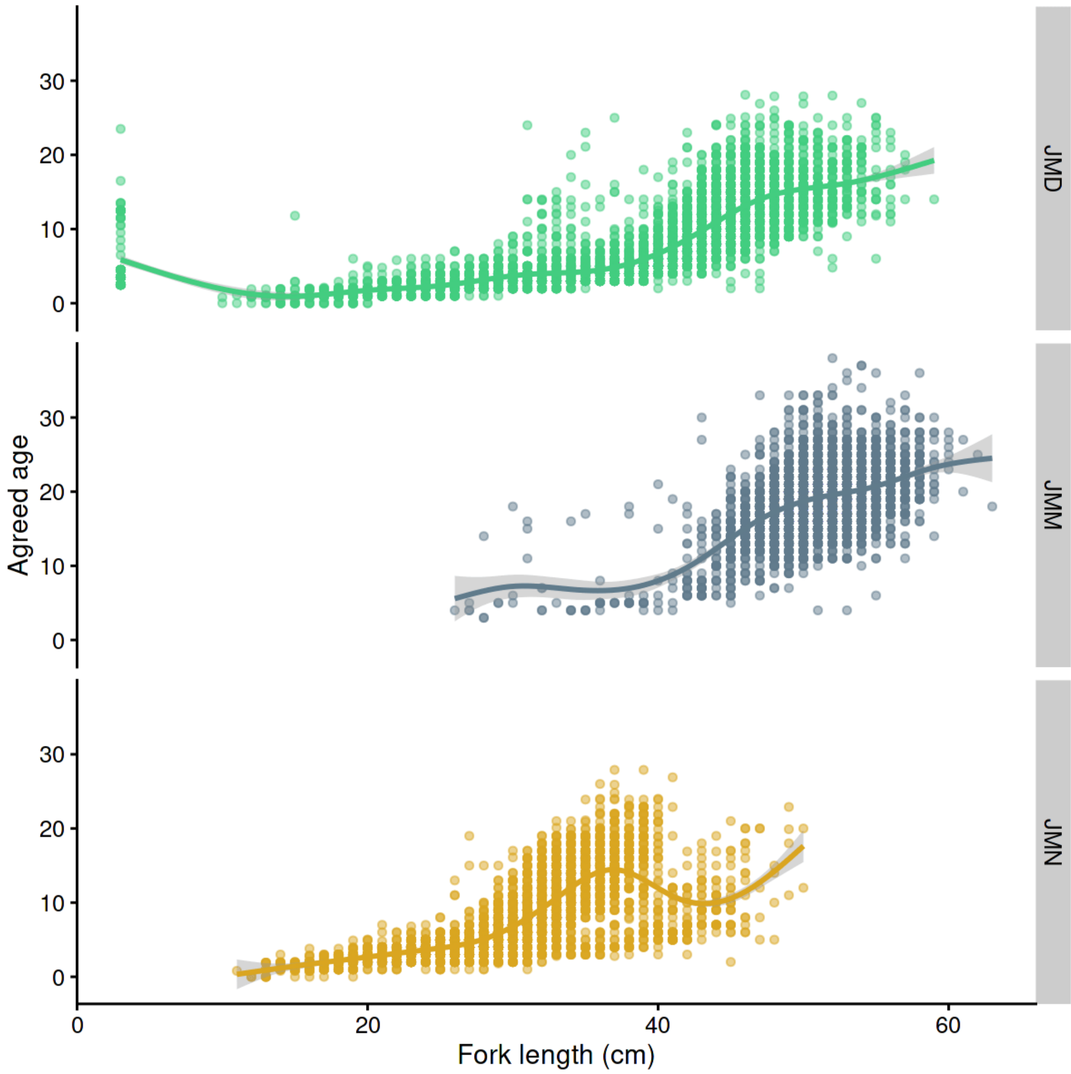

Figure 55: Agreed age at length for otoliths collected from jack mackerels in JMA 7, grouped by the observer-assigned species and with loess smooths fitted to illustrate the trend.

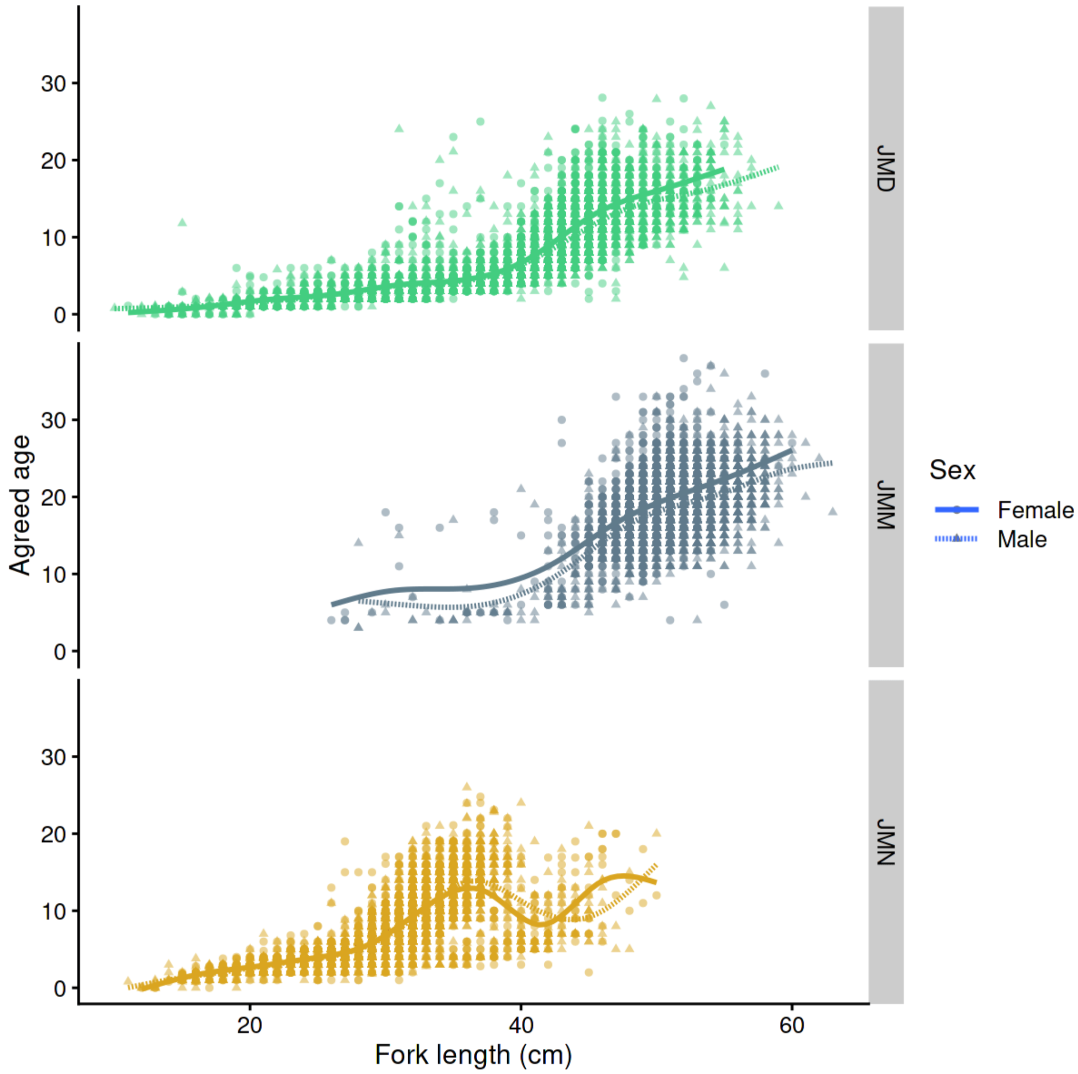

Figure 56: Agreed age at length for otoliths collected from male and female jack mackerels in JMA 7, grouped by the observer-assigned species and with loess smooths fitted separately by sex to illustrate the trend.

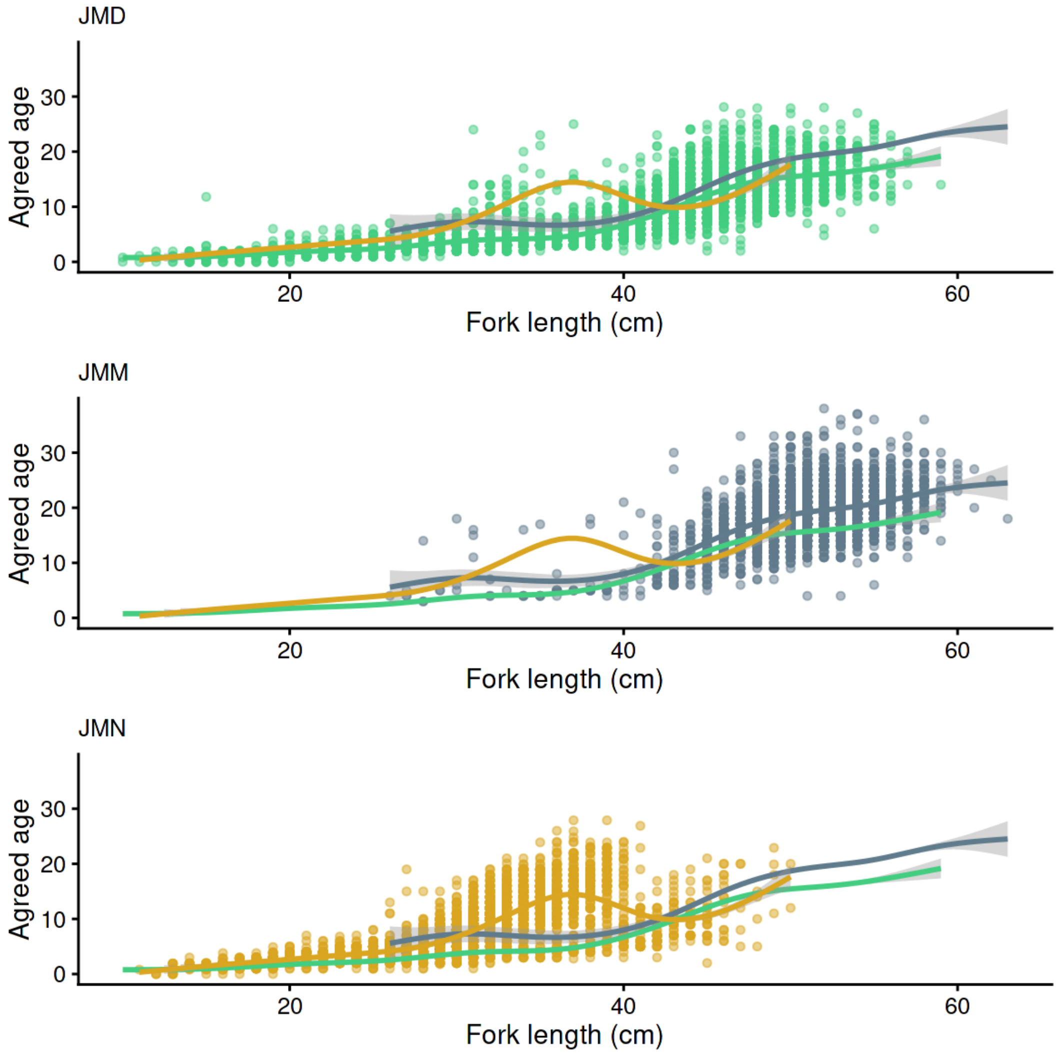

Figure 57: Agreed age at length for otoliths collected from jack mackerels in JMA 7, grouped by the observer-assigned species. Loess smooths have been fitted separately by species but are plotted on each panel to illustrate that outlying points tend to be more closely associated with the mean age at length for other jack mackerel species.

The typical sizes of the three jack mackerel species are quite distinct; *T. novaezelandiae* are the smallest species, with a modal length just above 30 cm and fish rarely recorded over 40 cm, *T. declivis* have a modal length between 40 cm and 50 cm, while the modal length of *T. murphyi* is over 50 cm (Figure 58). The aggregate length-frequency distributions all show some bimodality, with modes suspiciously aligned with the modal sizes of other species; however, in the case of the two larger species, this could clearly be attributed to the presence of younger year classes.

The aggregate length-frequency distributions for aged fish are generally broader than for those from normal length-frequency sampling, reflecting additional sampling of large fish to fill out age-length keys.

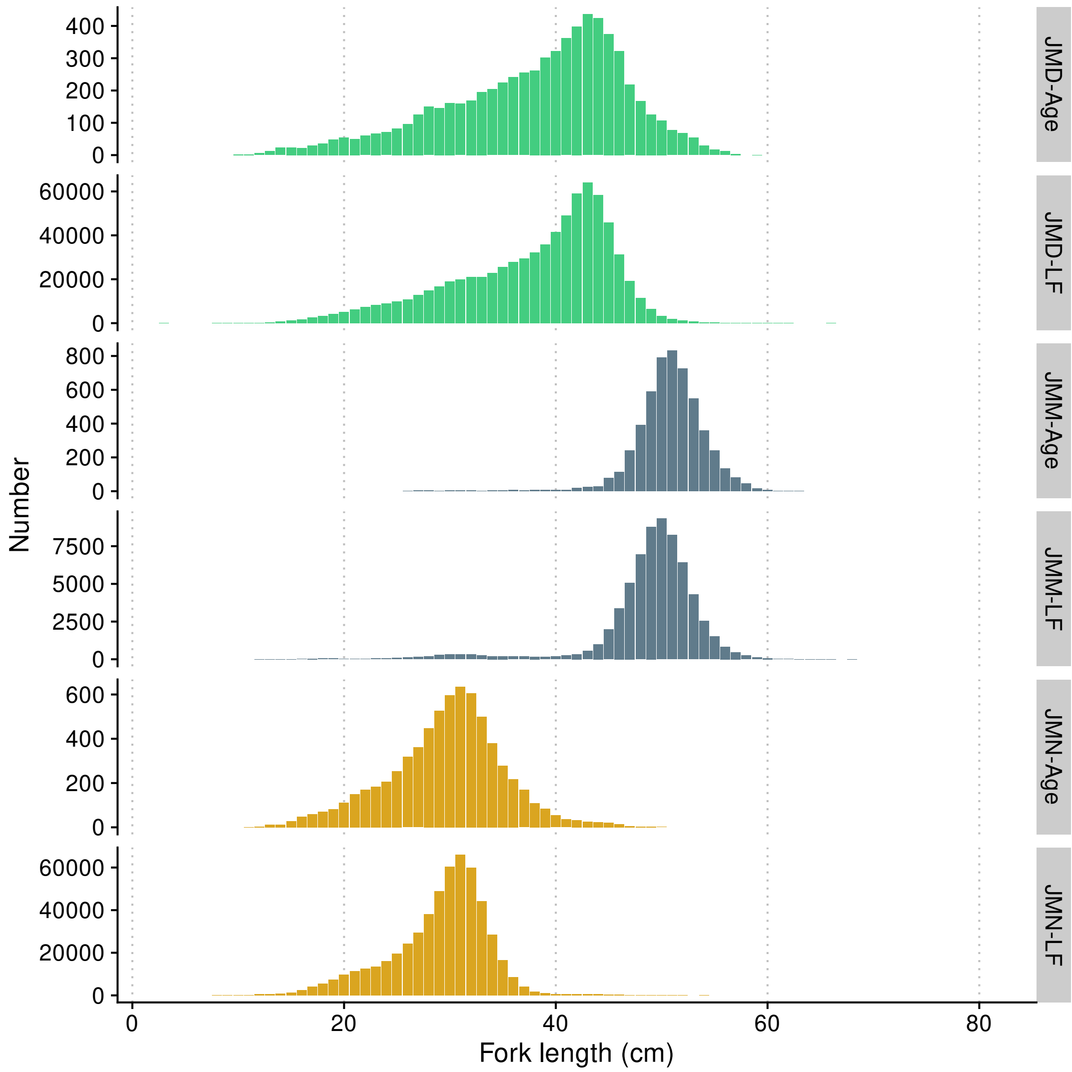

Figure 58: Length-frequency distributions for the three jack mackerel species sampled from JMA 7, and aggregated across years. The distributions labelled Age reflect the length distributions of aged fish, while those labelled LF are from the regular observer length-frequency sampling. JMD = *T. declivis*, JMM = *T. murphyi*, JMN = *T. novaezelandiae*.

Further evidence of misidentified fish in the aged jack mackerel data is illustrated in Figure 59. For *T. novaezelandiae* there are larger fish in each age class that lie closer to the fitted growth curves for *T. declivis* and *T. murphyi*. Likewise, both these species have some smaller fish that lie closer to the *T. novaezelandiae* growth curve. However, while the size at age data for *T. novaezelandiae* are relatively distinct, the sizes at age of *T. declivis* and *T. murphyi* are generally similar.

Because the datasets are large, and there are multiple fish sampled at similar sizes and ages that are overplotted in Figure 59, it is difficult to assess the prevalence of misidentified fish. An alternative visualisation of these data is given in Figures 60 and 61 which show kernel density estimates of the distribution of size at age for each of the three species. Bimodality in the length at particular age for a species may be indicative that the data are contaminated with another species, although other explanations for bimodal distributions include ageing error, or between year variation in growth rates.

In general, these exploratory plots suggest that the degree of data contamination arising as a result of species misidentification is small. For example, other than for fish at age zero, the secondary mode in the length at age density distributions for *T. novaezelandiae* is much smaller than the primary mode, and much lower than the corresponding density of *T. declivis* at that size. However, there are specific ages where the prevalence of misidentified fish may be greater. For example, for *T. murphyi* at age 10, almost half of the density of the length distribution lies in a lower model that is aligned with the modal size of JMD.

The density curves in Figures 60 and 61 are plotted on age-specific axes to facilitate the comparison between species at a given age. In many cases bimodality in the kernel density distributions of length at age provide a clear indication that misidentified fish are likely to be present. However, in other cases the potential contamination is more subtle; at ages one and two, for example, there is apparent bimodality in the length densities of *T. novaezelandiae*, but less evidence of bimodality for *T. declivis*. Nevertheless, the distributions of length for *T. declivis* are broad, and it is possible that some of the smaller fish may be misidentified *T. novaezelandiae*.

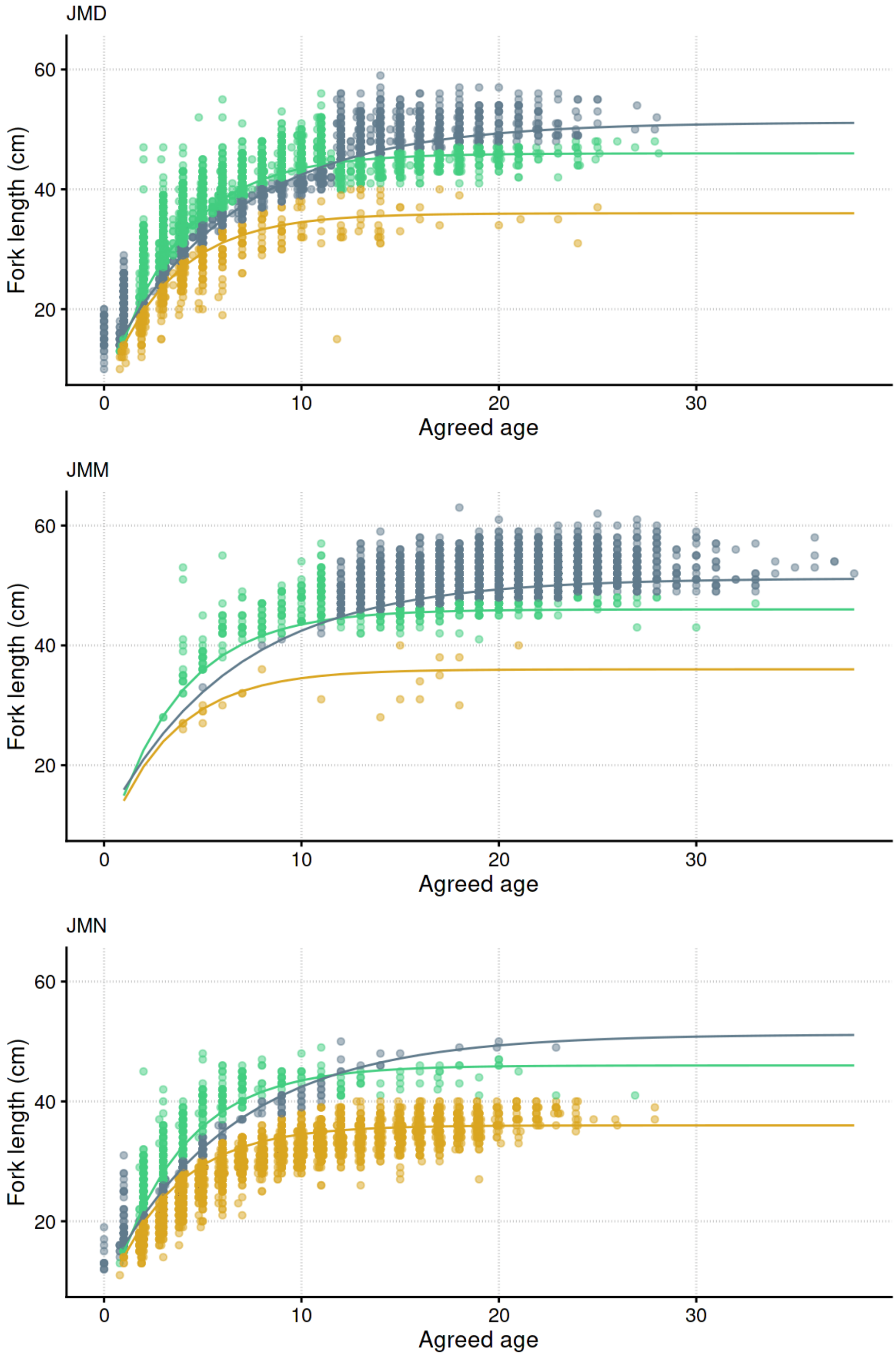

Figure 59: Length at age of jack mackerels sampled from JMA 7. The three panels separate the sampled fish according to the observer-assigned species code. In each panel, the standard von Bertalanffy growth curves (Fisheries New Zealand 2022) are plotted for all three species, and points are coloured to reflect the nearest curve. Points nearest the JMD growth curve are plotted in green, those nearest the JMM curve in blue, and those nearest the JMN curve in yellow. Nearness refers to the closest mean length at age from the growth curves, to the measured length.

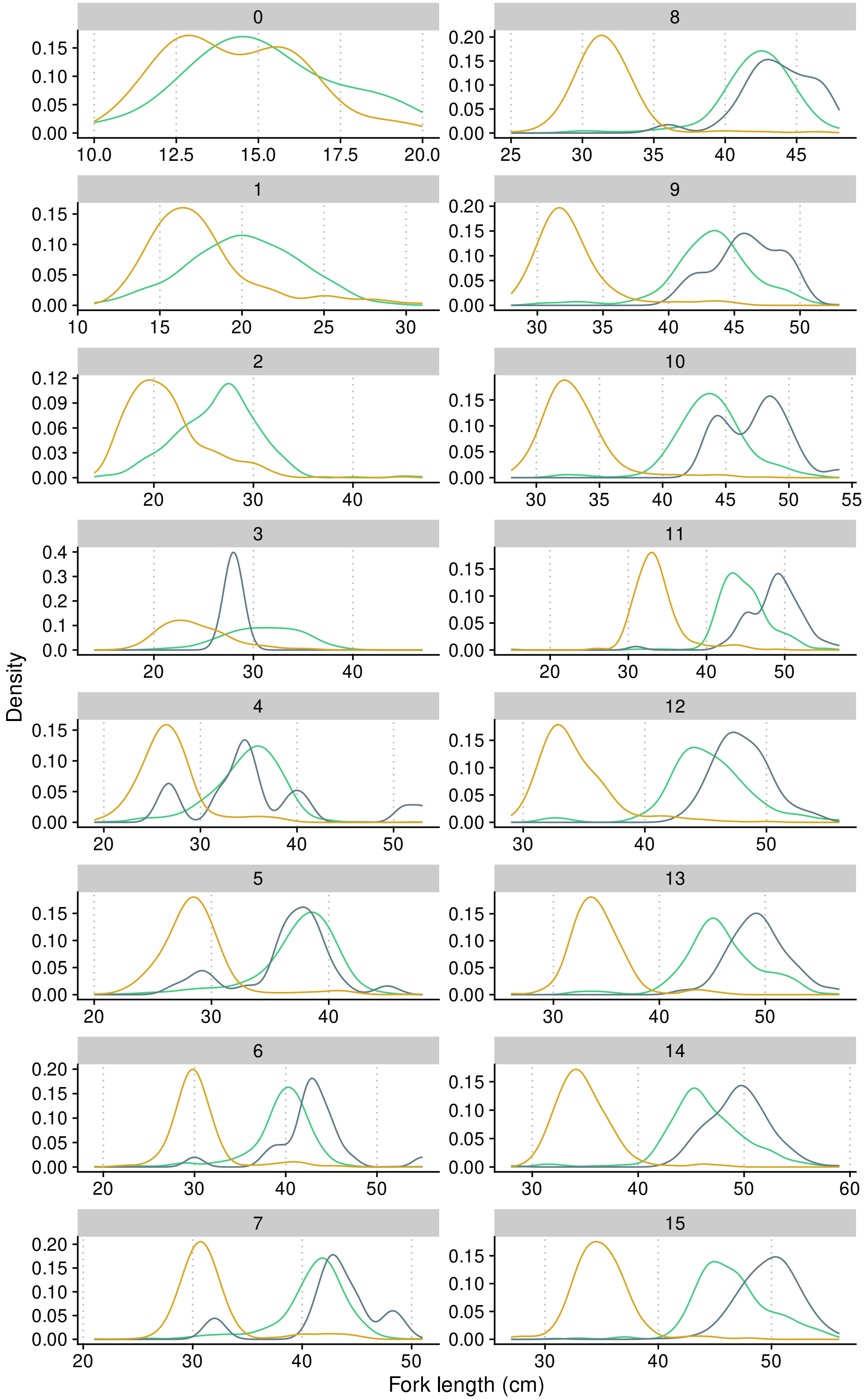

Figure 60: Kernel density estimates of the distribution of size at age of JMN (yellow curves), JMD (green curves), and JMD (blue curves) for fish aged 0 to 15 (assigned age, rounded down to integer age). Species identifications are the observer assigned species IDs.

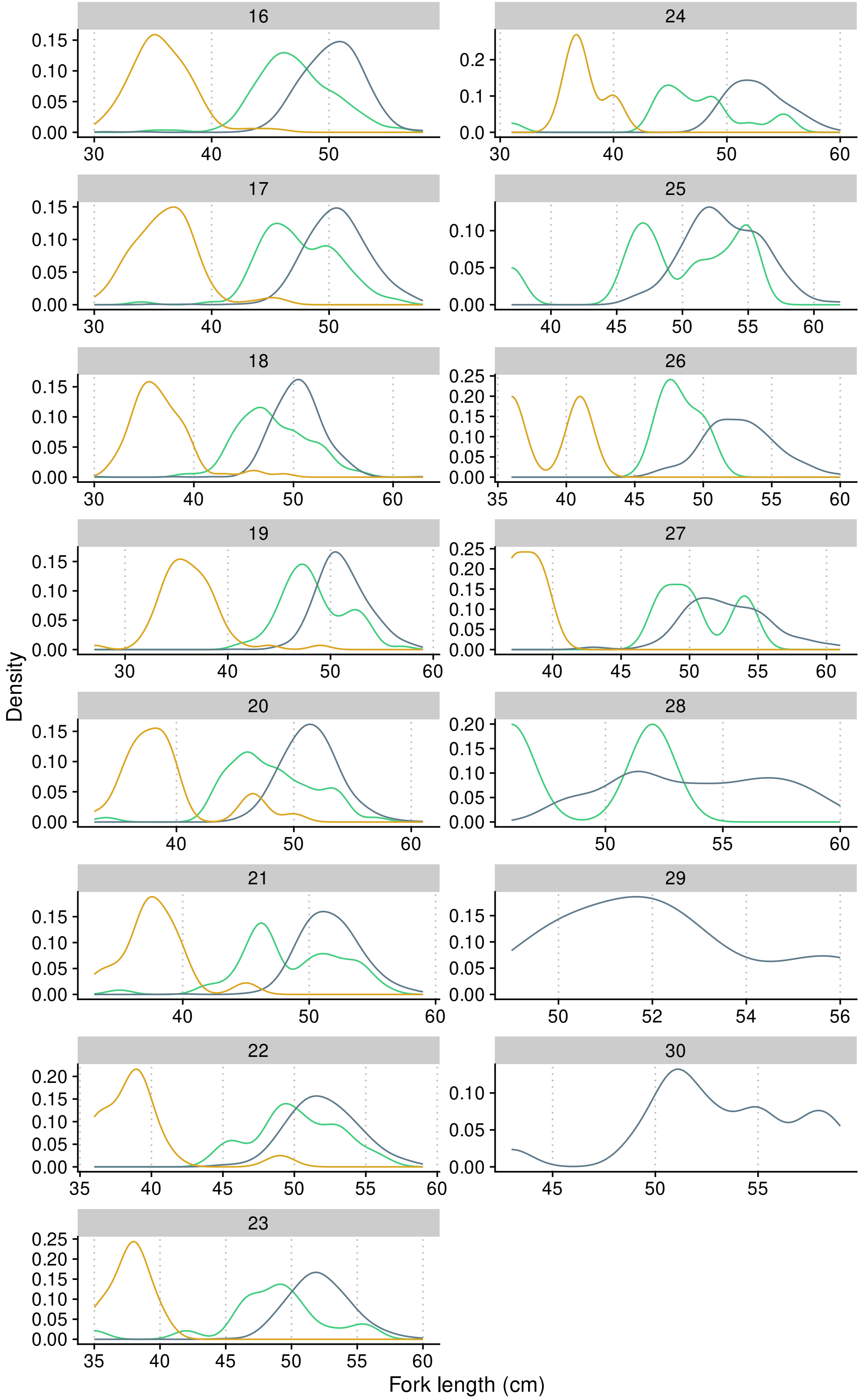

Figure 61: Kernel density estimates of the distribution of size at age of JMN (yellow curves), JMD (green curves), and JMD (blue curves) for fish aged 16 to 30 (assigned age, rounded down to integer age). Species identifications are the observer assigned species IDs.

5.2 Classifying misidentified fish

Visually, misidentified jack mackerel are clear in the age-length data. It is useful to be able to classify fish into those where the observer-identification is (probably) ‘good’ and those where it is (probably) ‘bad’. Such a classification has a variety of uses, including (i) leaving bad data out of analyses, in case they introduce bias, and (ii) identifying whether there are correlates of, or explanations for, poor identifications—for example, if poor identifications are attributable to just a few observers, then other data they have collected may also be considered unreliable.

5.3 An *ad hoc* approach

Building on the ‘closest growth curve’ approach, illustrated in Figure 59, it is possible to identify where a fish has most likely been misidentified. An *ad hoc* approach was initially developed; this involved calculating the expected mean length for each aged fish, according to the von Bertalanffy growth curves documented by Fisheries New Zealand (2022), and calculating the difference from the measured fish length. If this difference, ΔL, for one of the other two species was less than 55% of the ΔL for the observer-assigned species, then the fish was considered likely to have been misidentified.

In addition to the *ad hoc* nature of the approach, using the closest growth curve had other limitations. It could only usefully be applied to the two native jack mackerels, as the growth curve for *T. murphyi* was very close to that for *T. declivis*. Furthermore, it could only be applied to fish greater than 5 years of age, as the growth curves for the three species showed little separation at younger ages. Nevertheless, the approach had visually reasonable results for fish greater than 5 years old (Figure 62); equally, it is clear that misidentification of younger fish is also likely. Tabulating the numbers of fish that were classified as likely to have been misidentified (Table 6) serves to confirm that misidentified fish are relatively rare.

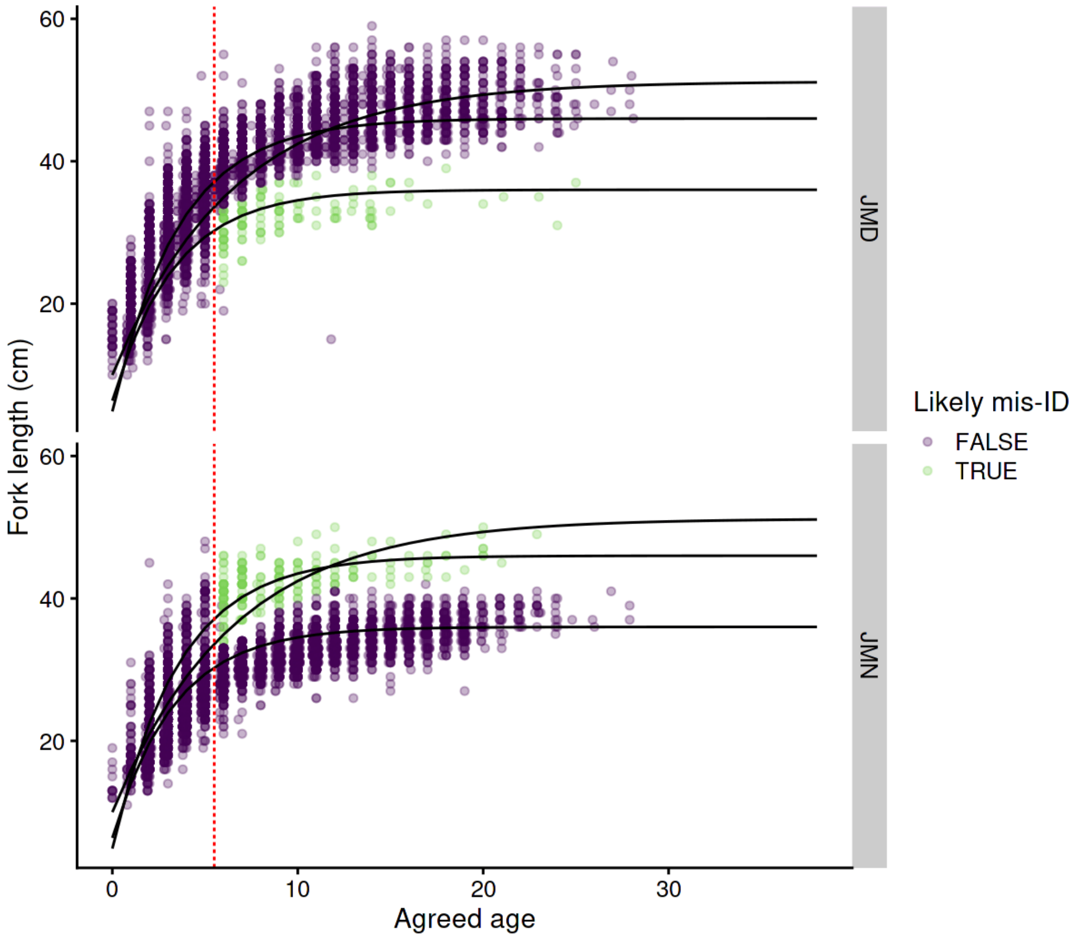

Figure 62: Results of applying the *ad hoc* approach for classifying fish where the observer-assigned species is likely to have been incorrect (see text). The red dashed line indicates that the algorithm was not applied to fish aged 5 years old, or younger.

Table 6: Numbers of otoliths sampled by the observer programme with potential misidentified fish according to the *ad hoc* approach described in the text.

	JMD, possible mis-ID		JMN, possible mis-ID	
Age	No	Yes	No	Yes
0	70		21	
1	267		138	
2	446		377	
3	879		765	
4	775		840	
5	701		872	
6	439	27	591	44
7	367	21	457	43
8	362	14	389	12
9	325	15	398	22
10	281	7	332	13
11	303	4	257	13
12	267	7	241	10
13	225	7	202	7
14	235	6	162	4
15	184	3	164	5
16	130	2	155	4
17	93	1	98	4
18	84	1	69	4
19	75		54	2
20	54	1	25	5
21	47	1	17	1
22	25		15	1
23	18	1	9	
24	15	1	4	
25	7	1	1	
26	3		2	
27	3		2	
28	2			

5.4 Applying a mixture model

To provide a more robust approach for classifying whether fish were likely to have been misidentified, Neubauer & Middleton (in prep.) developed a Bayesian mixture model for fish size at age. This was fitted to the age-length data for jack mackerels sampled in JMA 7 from 1995 to 2020. Each of the 18 987 observations had a measured fork length, an age from otolith reading, and an observer-assigned species. The mixture model estimated the von Bertalanffy growth parameters for each species (combined sexes) and made predictions of the true species for each observation, accounting for potential ageing error (Figure 63).

The mixture model results provided information on the probability that the observer-assigned species was correct (Figure 64). For each fish, the model provided an estimate of the probability that a particular fish should be assigned to a particular species. Because the growth curve for *T. declivis* lies between that of the other two species, the model tended to be less confident about species assignment for these fish. Using a threshold for likely misidentification of < 50% probability (that the observer-assigned species was correct, given the model) for *T. novaezelandiae* and *T. murphyi*, and < 25% for *T. declivis*, led to estimated misidentification rates of 8.3% for *T. declivis*, 5.9% for *T. novaezelandiae*, and < 1% for *T. murphyi* (Figure 65; Table 7).

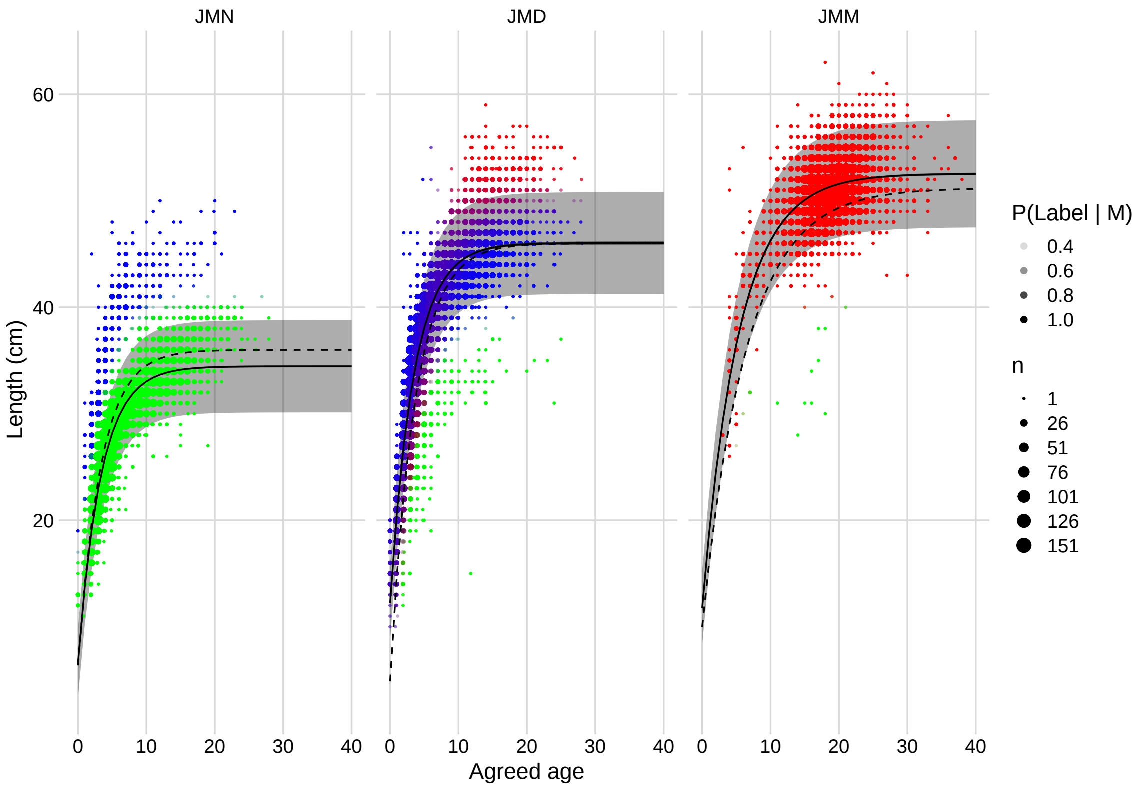

Figure 63: Estimated growth curves for jack mackerels in JMA 7 (JMN, *T. novaezelandiae*; JMD, *T. declivis*; JMM, *T. murphyi*). Solid lines indicate the median and 95% interval for predicted size at age, in comparison to the growth curves based on parameters previously reported by Fisheries New Zealand (2022, dashed lines). The three panels group the data according to the observer assigned species, and points are coloured by the model predicted species (JMN = green, JMD = blue, JMM = red), and shaded by the estimated probability of that prediction.

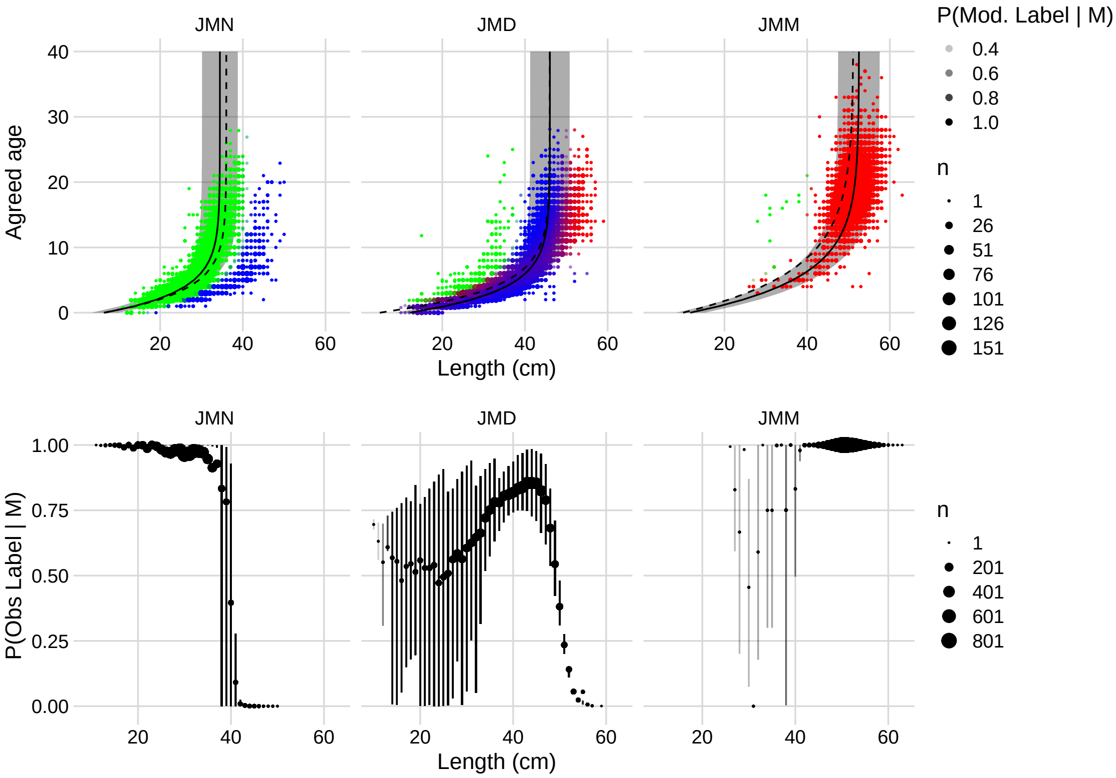

Figure 64: Top: estimated growth curves for jack mackerel species in JMA 7 plotted as agreed age, from the otolith readings, at measured size and with panels grouping the data by observer-assigned species (JMN, *T. novaezelandiae*; JMD, *T. declivis*; JMM, *T. murphyi*). Solid lines indicate the median and 95% interval for predicted size at age, in comparison to the growth curves based on parameters previously reported by Fisheries New Zealand (2022, dashed lines), and points are coloured by the model predicted species (JMN = green, JMD = blue, JMM = red), and shaded by the estimated probability of that prediction. Bottom: median (points) and 95% interval (lines) for the probability that the observer assigned species label is correct, given the model predicted species, grouped by 1 cm length intervals.

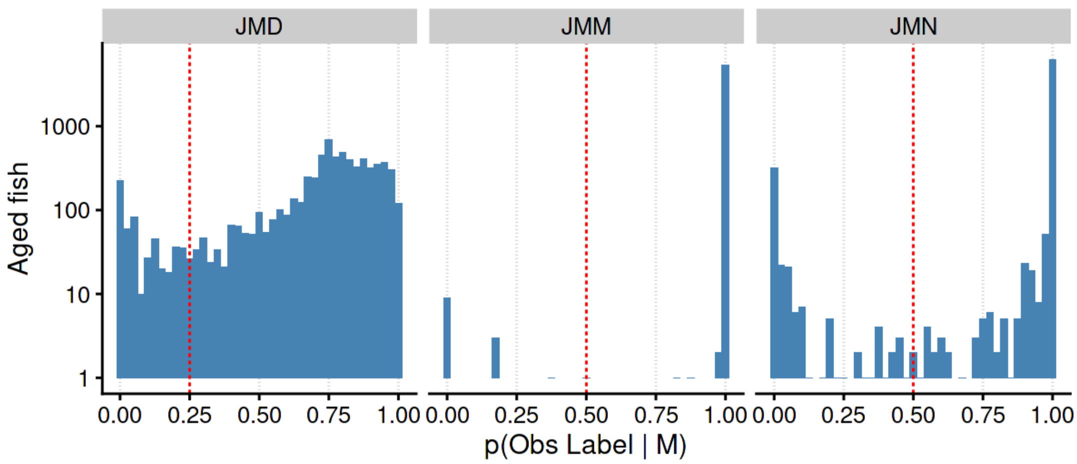

Figure 65: Histograms for the probability that the observer-assigned species identity is correct, given the fitted mixture model, and the thresholds used for classifying fish into those likely to have been correctly identified (probability >= threshold) or misidentified (probability < threshold). Note the log scale on the y-axis.

Table 7: Numbers of otoliths sampled by the observer programme with potential mmisidentified fish on the basis of the mixture model, and applying the thresholds noted in Figure 65.

	JMD, possible mis-ID		JMM, possible mis-ID		JMN, possible mis-ID	
Age	No	Yes	No	Yes	No	Yes
0	70				19	2
1	246	21			124	14
2	417	29			323	54
3	803	76	2		703	62
4	725	50	17		792	48
5	661	40	24	1	833	39
6	442	24	19	1	599	36
7	367	21	16	2	461	39
8	365	11	23		390	11
9	327	13	21		400	20
10	278	10	26		332	13
11	287	20	61	1	257	13
12	250	24	75		237	14
13	197	35	139		202	7
14	206	35	210	1	161	5
15	158	29	335	1	164	5
16	109	23	491	2	154	5
17	76	18	522	2	98	4
18	65	20	539	2	69	4
19	59	16	593		54	2
20	44	11	535		25	5
21	34	14	446	1	17	1
22	17	8	380		15	1
23	15	4	285		9	
24	12	4	202		4	
25	4	4	123		1	
26	3		68		2	
27	2	1	69		2	
28	1	1	32			
29			15			
30			17			
31			14			
32			3			
33			9			
34			2			
35			1			
36			3			
37			2			
38			1			

5.5 Related classifiers of data quality

The mixture model provides a robust method for classifying the observer-assigned species identifications into those that are likely correct, and those considered incorrect. However, it is only applicable to cases where age-length data are available. We therefore considered whether other potential variables showed a strong relationship to the misclassification rate identified from age-length data.

A particularly obvious feature of the age-length data (e.g., Figure 55) is that any fish over 40 cm that are identified as *T. novaezelandiae* appear to lie on a different growth curve. The mixture modelling results (Figure 64) support the interpretation that such fish are unlikely to be *T. novaezelandiae*. The presence of larger fish identified as *T. novaezelandiae* is also a feature of jack mackerel length-frequency data that has led to doubt about observer identifications (Middleton 2022, Appendix C). As a result, we assessed whether, at a trip level for trips that also had age-length data, there is evidence of a relationship between the proportion of *T. novaezelandiae* recorded in length-frequency samples, and the proportion of aged fish that the mixture model indicated were likely to have been misidentified.

There is a tendency for high proportions of *T. novaezelandiae* over 40 cm to have been reported from trips that also had a high proportion of likely misidentified fish based on the mixture model results (Figure 66). However, the relationship is not very strong, with some trips that recorded a high proportion of large *T. novaezelandiae* having quite low levels of misidentified fish suggested by the mixture model. Likewise, misidentification rates of up to 25% were associated with quite low proportions of *T. novaezelandiae* over 40 cm.

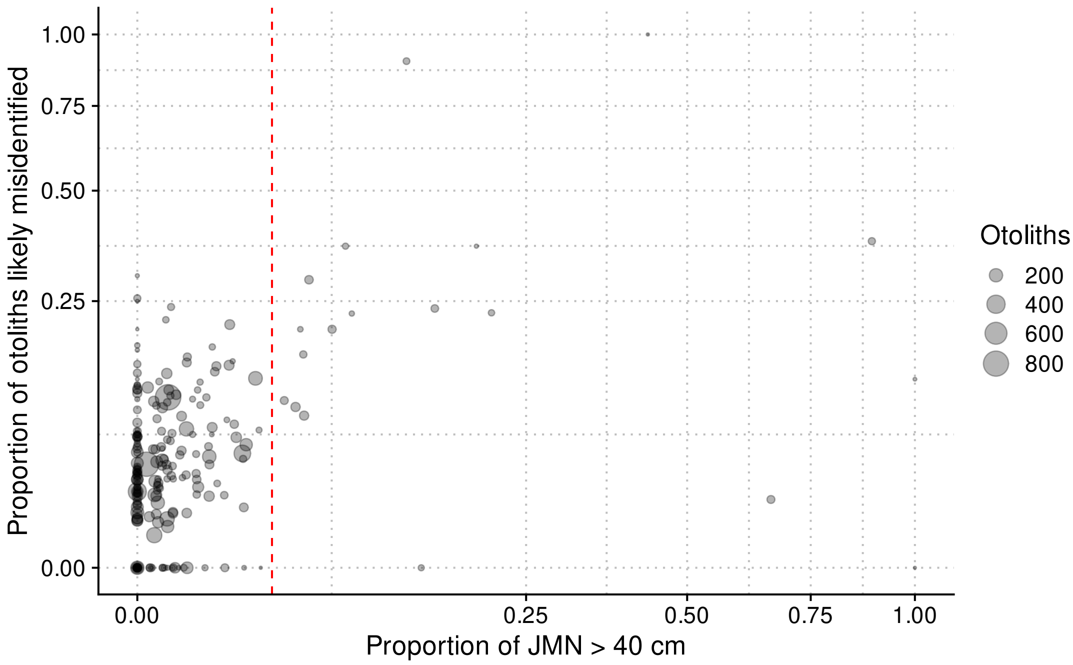

Figure 66: Observer trip-level comparisons between the proportion of *T. novaezelandiae* (JMN) greater than 40 cm in length-frequency samples, and the proportion of aged fish considered likely to have been misidentified using the mixture modelling results. The data are plotted on square-root transformed axes, and the red, dashed reference line indicates a proportion of 0.03.

We next explored whether there was any relationship between observer experience and the misidentification rates suggested by the mixture model. Because multiple observers may be present on a trip, and individual samples are not attributable to a particular observer, we considered the aggregate experience of observers on a trip, expressed as the number of trips they had undertaken in the JMA 7 fishery. No relationship between observer experience and misidentification rates was apparent (Figure 67).

Although it is often not possible to attribute data from observer trips in the JMA 7 fishery to an individual observer, an indication of the variation in skill between observers can be gained by calculating the mean error rate for all trips where a particular observer was present (Figure 68). This suggests that there are a small number (three) observers with a notably elevated rate of misidentification and, while some observers are not associated with any likely misidentified fish, mean error rates of up to 20% are not unusual.

Within an observed trip, there was typically a wide range of misidentification rates between samples from individual tows (Figure 69); this suggests that further exploration of the situations in which misidentification occurs would be beneficial. A fuller understanding of how data are collected on trips with multiple observers would assist in identifying observer effects.

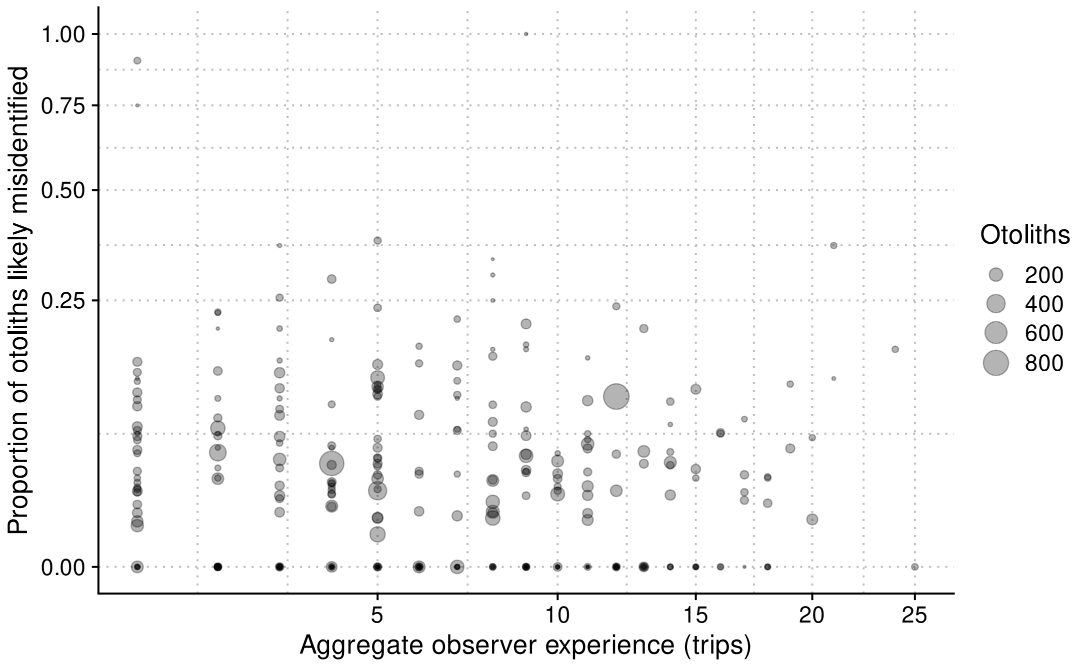

Figure 67: Observer trip-level comparisons between aggregate observer experience (number of trips in the JMA 7 fishery) and the proportion of aged fish considered likely to have been misidentified using the mixture modelling results. The data are plotted on square-root transformed axes.

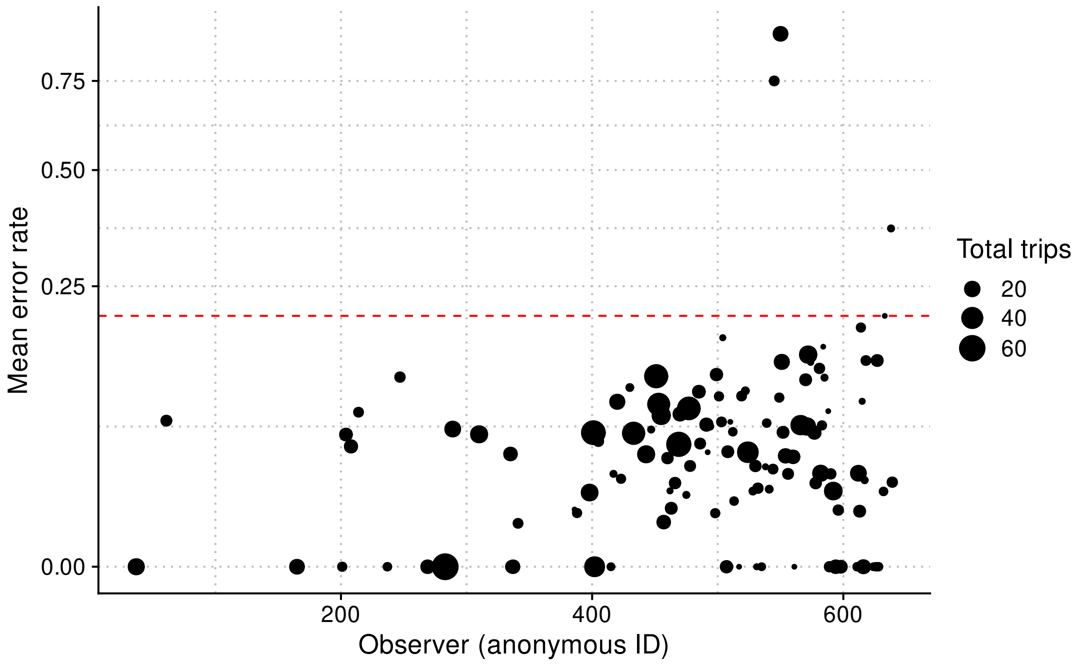

Figure 68: Mean error rates for individual observers in the JMA 7 fishery. The mean error rate is the mean proportion of fish likely to have been misidentified, based on the mixture model, across all trips on which a given observer was present. Note that the y- axis is square-root transformed, and the red, dashed reference line indicates a mean error rate of 20%.

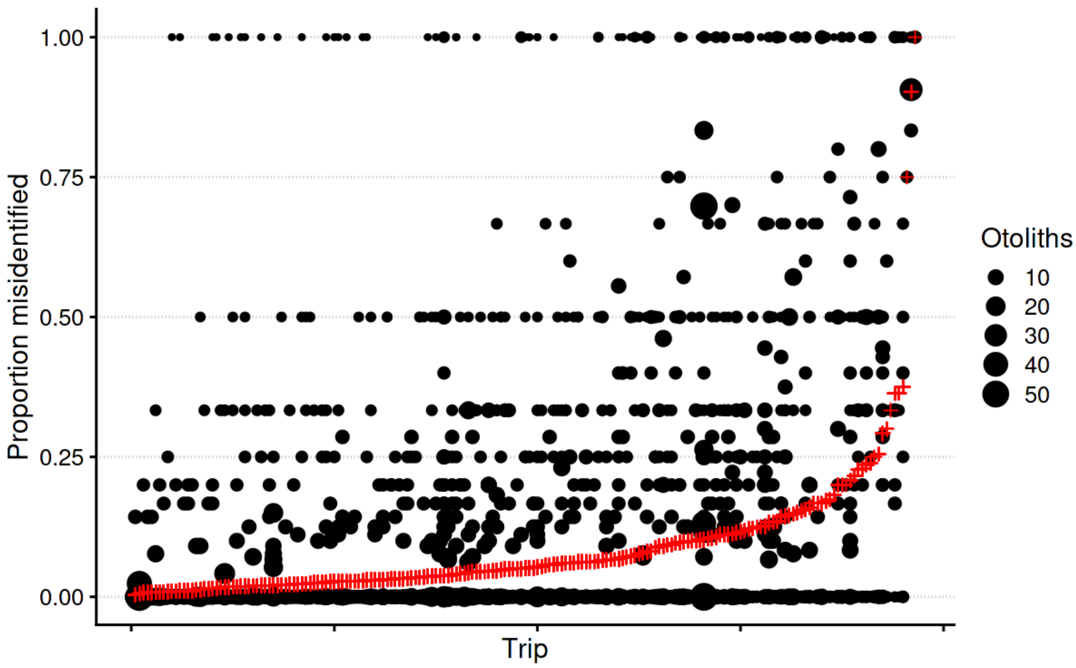

Figure 69: Misidentification rates for individual tows (black points) and aggregated at the trip level (red crosses) for all observed trips where the overall trip misidentification rate was positive.

5.6 Summary

Misidentification of jack mackerel species in the observer data is a persistent problem but, overall, less than 10% of age-length data are affected. Misidentification rates are related to fish size (Figure 64) and may therefore be higher in the age-length data (which is influenced by increased collection of otoliths from the tails of the length distribution; Figure 58) than in the standard length-frequency sampling.

Although there are indications that some observers are especially good, and others especially poor, at discriminating the jack mackerel species, this did not seem to be related to experience in the fishery. Likewise, despite the fact that *T. novaezelandiae* over 40 cm are expected to be very unusual, the rate at which these fish were recorded in the length-frequency data was not especially well correlated with the misidentification rate assessed from the age-length data.

In the CPUE analyses (below), therefore, the potential impact of misidentified fish on the index was assessed simply by dropping trips where misidentified fish were apparent in the associated age-length data. However, in future, more sophisticated approaches that use the mixture probabilities directly, rather than via a *post hoc* classification, could be developed.

6. JACK MACKEREL SPECIES AND SIZE COMPOSITION

This section uses the observer length-frequency samples to characterise the species and size composition in the JMA 7 fishery. Species proportions are calculated for each sampled tow, as follows:

- The total catch of jack mackerels in the tow is calculated by summing entries in the COD table `x_fishing_event_catch`. Catches recorded under codes `JMA`, `JMD`, `JMM`, and `JMN` are included. The species-specific totals are ignored, and treated as if they were records of aggregate jack mackerels.

- The proportion of each species by weight is estimated by applying the length-weight relationships for each species (Fisheries New Zealand 2022) to the fish in the length-frequency sample for the tow.

- Tow level estimates of catch by species are derived by multiplying the total jack mackerel catch by the species proportions by weight.

Length-frequency sampling has been carried out across the JMA 7 fleet, and vessels are often observed each year they participate in the fishery (Figure 70). However, the key purpose of this section is to explore patterns in the spatial and depth distributions of the three species, and to examine size compositions, by species, over time. As such, the data presentation is restricted to the sampled tows, rather than scaled to the fleet level.

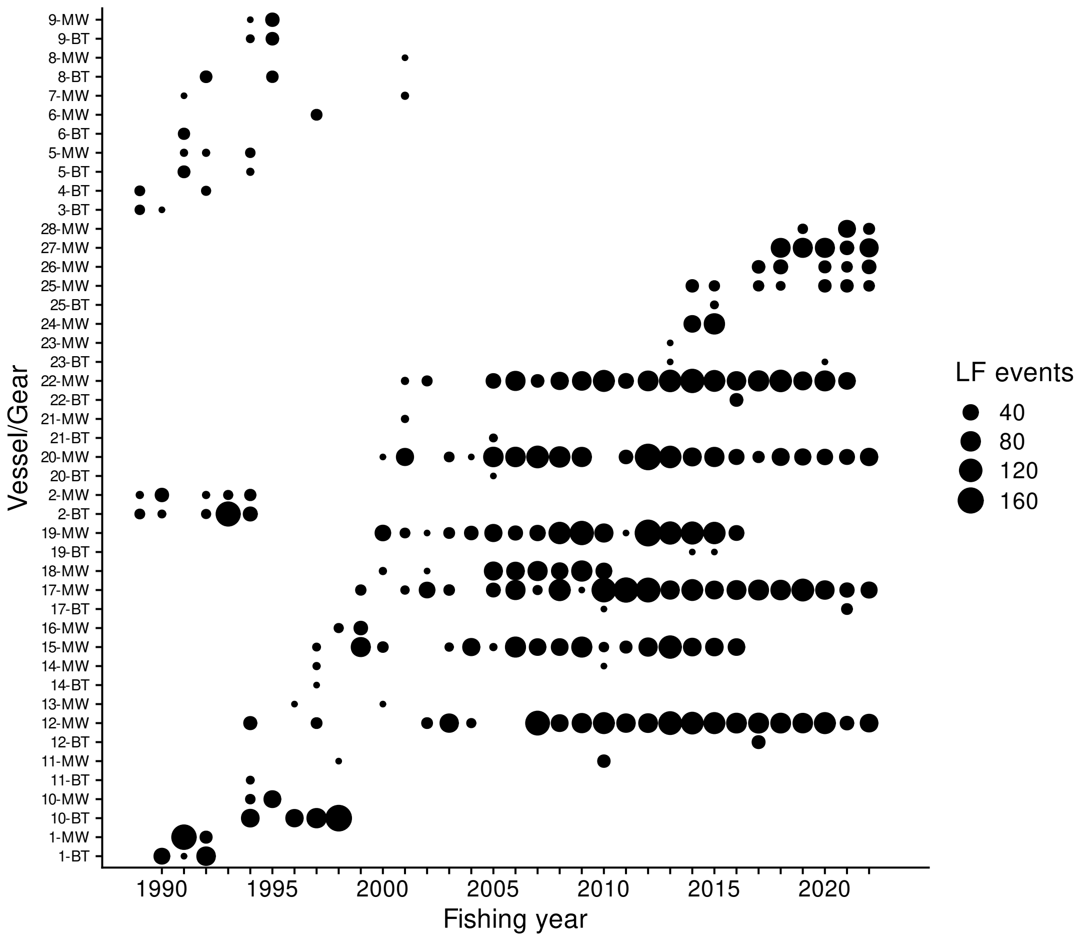

Figure 70: Number of fishing events with observer length-frequency sampling and a sample size of at least thirty fish, by vessel and gear type (bottom, BT, or midwater, MW, trawl). Vessels that were only observed on one trip or in one fishing year are excluded.

Annual distributions of tow-level proportions of the three species are illustrated in Figure 71. Median proportions of *T. declivis* (JMD) and *T. novaezelandiae* (JMN) showed considerable interannual variability in the 1990s, although this settled to approximately 50/50 in the late 1990s. The pattern has been more stable since the mid-2000s with median annual proportions of approximately 70% *T. declivis* and the remainder mostly *T. novaezelandiae*. Proportions of *T. murphyi* (JMM) have been generally low since the mid-1990s, although were sometimes higher in the early 1990s. *Trachurus murphyi* proportions showed some signs of an increase from 2018 to 2021 but were much lower in sampled tows in 2022.

The depth distribution of *T. novaezelandiae* is more constrained than that of the other two species (Figure 72), with the majority of catches shallower than 150 m, whereas the distributions for *T. declivis* and *T. murphyi* extend to around 300 m (although some catches occur over seabed depths up to 600 m).

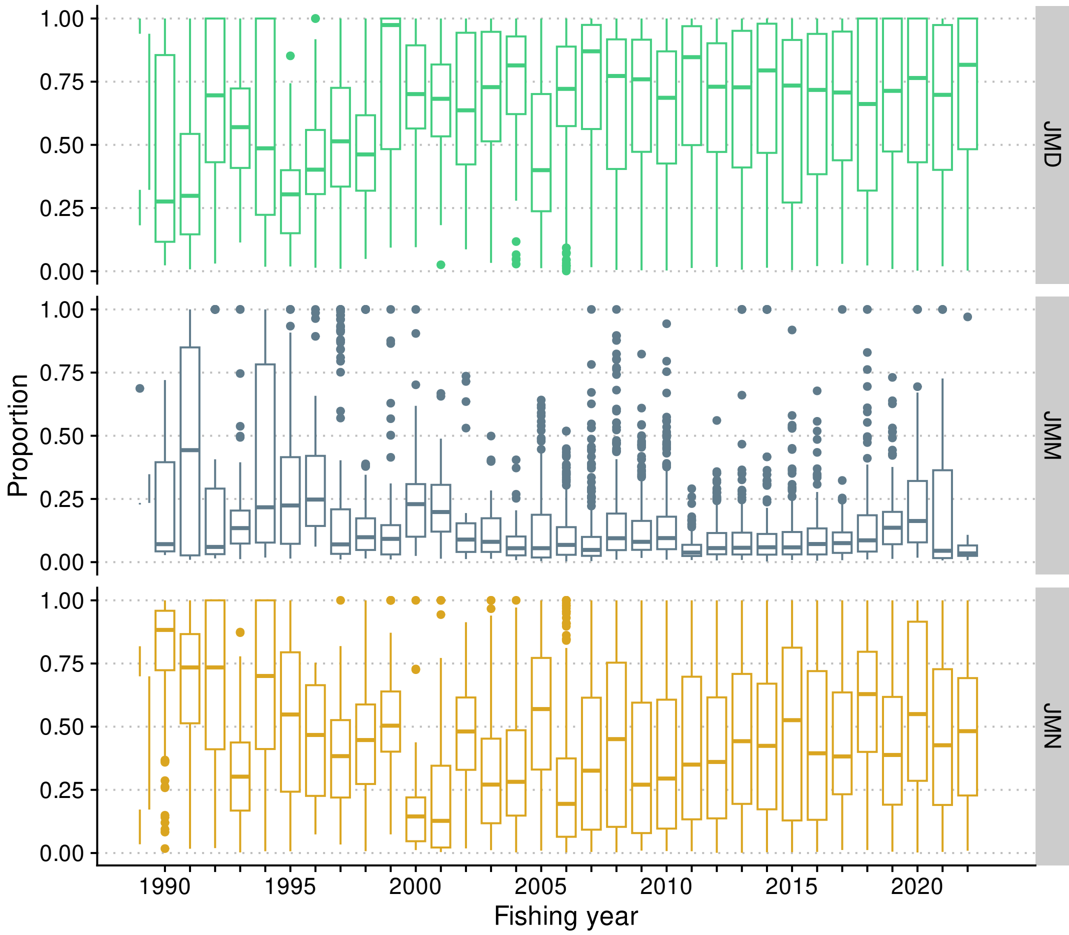

Figure 71: Box-plots of tow-level proportions of jack mackerel species by year, for tows with a length-frequency sample of thirty or more fish.

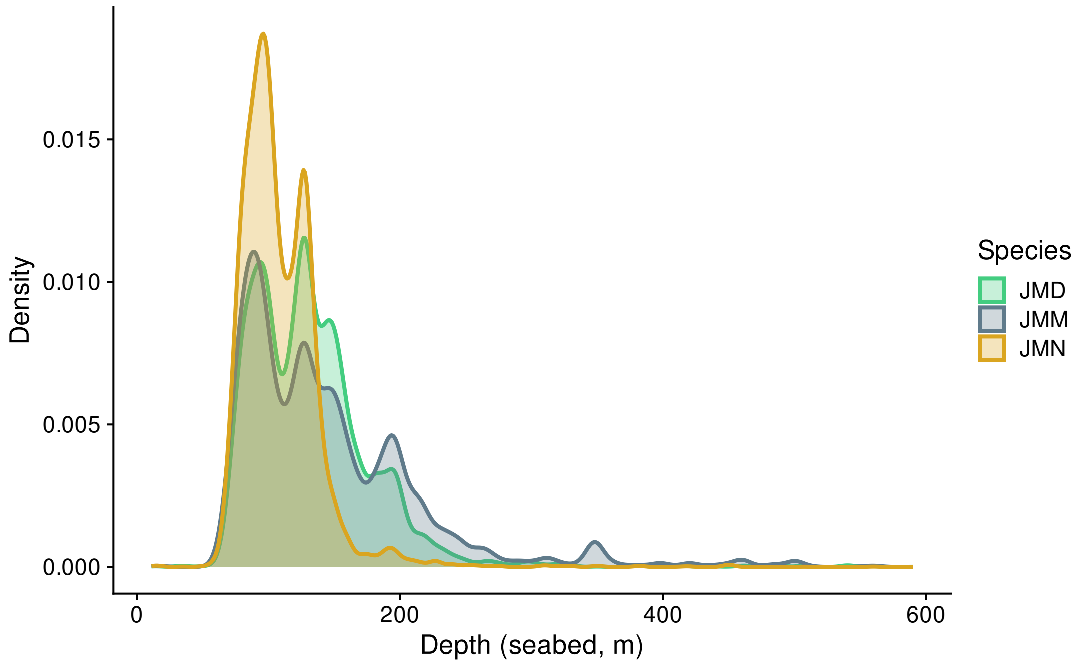

Figure 72: Density plots of the seabed depth distribution of sampled tows, weighted by the catch of the three jack mackerel species.

6.1 Spatial distributions

Annual maps, from 1987 to 2022, of the estimated catches of each species in sampled tows were examined. *Trachurus murphyi* appears to have been absent from the fishery in 1987 and 1988 and was initially detected in a small number of tows in 1989. The greatest catches of *T. murphyi* were from 1993 to 1995, with the distribution varying between years—focussed in the Taranaki Bight in 1993 and 1995, but the northern west coast of the South Island in 1994. In the subsequent five years catches of *T. murphyi* were frequent, but small, and were lessening in the early 2000s. However, catches were more prevalent from 2005. After 2020, catches of *T. murphyi* appear to have become less frequent but with larger quantities per tow.

The native jack mackerels, *T. declivis* and *T. novaezelandiae*, are the key species taken in the fishery. There is some spatial segregation between the species (Figure 73); *T. novaezelandiae* is generally restricted to the Taranaki Bight, and its distribution tends to extend further east in the South Taranaki Bight. Catches are predominantly of *T. declivis* off the northern west coast of the South Island, and in offshore areas of the Taranaki Bight. Proportions of *T. novaezelandiae* are greater in the inshore areas of the Taranaki Bight, but the two native species appear to co-occur throughout much of this area, with some variation in overlap from year-to-year.

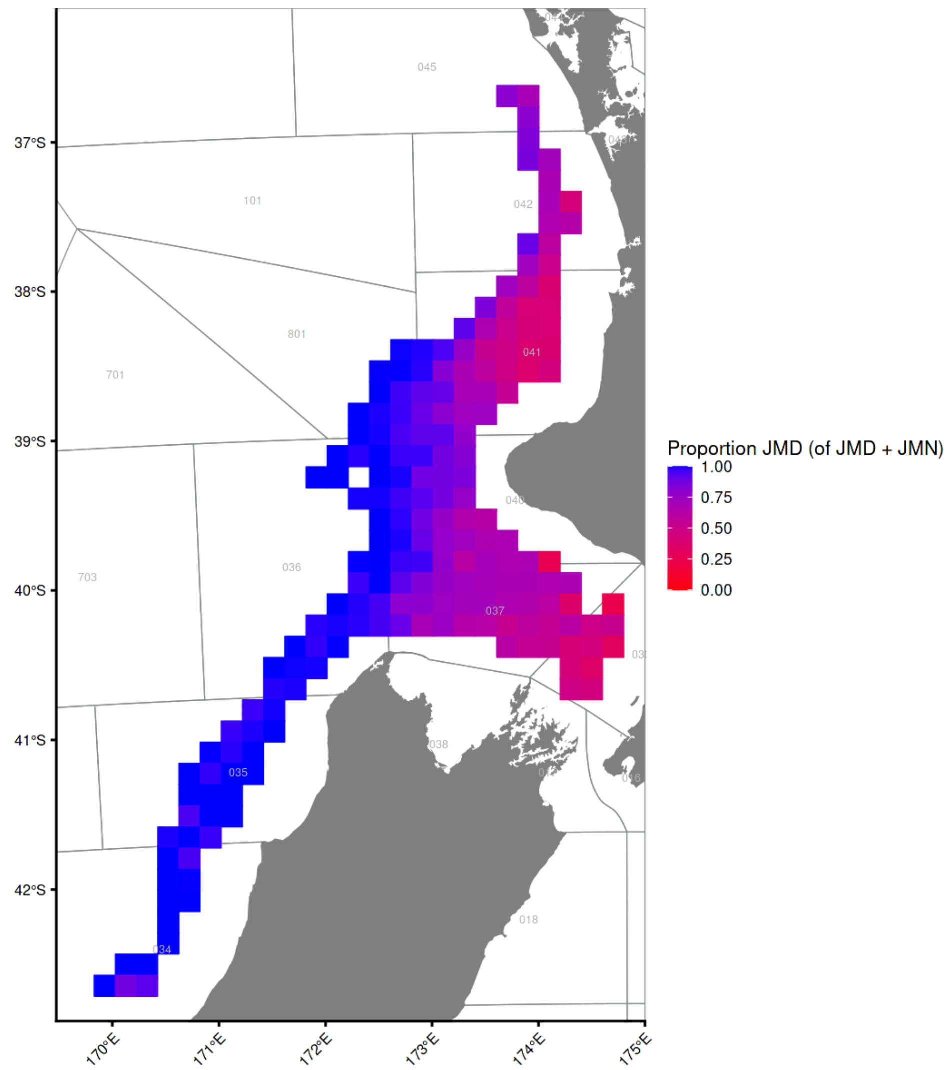

Figure 73: Proportion of *T. declivis*, of the total observed catch of the native jack mackerels (*T. novaezelandiae* and *T. declivis*), on observed tows from the 1987 to 2022 fishing years. Tows with age-length data where species misidentification was indicated by the mixture model were excluded, as were cells with data from less than three vessels.

6.2 Length-frequency distributions

Annual length-frequency distributions for the three jack mackerel species in JMA 7 are provided in Figure 74 (*T. declivis*), Figure 75 (*T. murphyi*), and Figure 76 (*T. novaezelandiae*). The sampled tows were scaled to the estimated catch of each species in a tow, and summed across sampled tows, but were not stratified or scaled to the fleet total catch. The data were classified according to whether or not aged otoliths were available from the sampled tow, and—if so—whether the mixture modelling suggested that some misidentification had occurred. A visual assessment suggested that there was little evidence that the misidentified fish were especially influential in determining the shapes of the distributions.

For *T. declivis* (Figure 74), a mode – assumed to be adult fish – is evident at 40 cm to 50 cm in most years. In many years, modes at smaller lengths are also evident; in some cases these are expected to be individual recruiting year classes. For example, the modes centered around 20 cm and just under 30 cm, correspond to the estimated sizes of 1 and 2 year old fish from the mixture modelling growth curve (Neubauer & Middleton in prep.), although this interpretation differs from that of the previously published growth curve (Fisheries New Zealand 2022). For 2019–2022, the ‘adult’ mode has been less evident in the length distributions; these are dominated by a wider mode centred under 40 cm and probably represent the accumulation of a number of recent year classes.

Length distributions of *T. murphyi* (Figure 75) show a single mode in most years, centered from 45 cm to 55 cm. Some systematic trends in mean length are apparent, for example, a decrease in mean length from 1989 to 1995. In some years, the distributions show evidence of a new, smaller group of *T. murphyi* arriving in the fishery, and in some years (2013, 2014, 2018, 2021) there are sampled fish with lengths below 20 cm, which would be expected to be just a year old. In 2014, however, fish of this size came from tows with misidentified fish, and in the other years the small fish were from tows without age samples. Ensuring that any small *T. murphyi* encountered by observers are retained for sampling (and species verification) ashore would assist in confirming whether the presence of small *T. murphyi* indicated some local spawning, or if the periodic arrival of fish from the wider Pacific population is more likely to be responsible for ongoing catches of *T. murphyi* in New Zealand waters.

For *T. novaezelandiae* (Figure 76), a mode of adult fish at 30 cm to 35 cm is present in most years, with evidence of recruiting year classes also evident in a subset of years. In some cases (e.g., 1997, 2015, 2021) one year old fish (expected to be 14 cm) appear to be sampled.

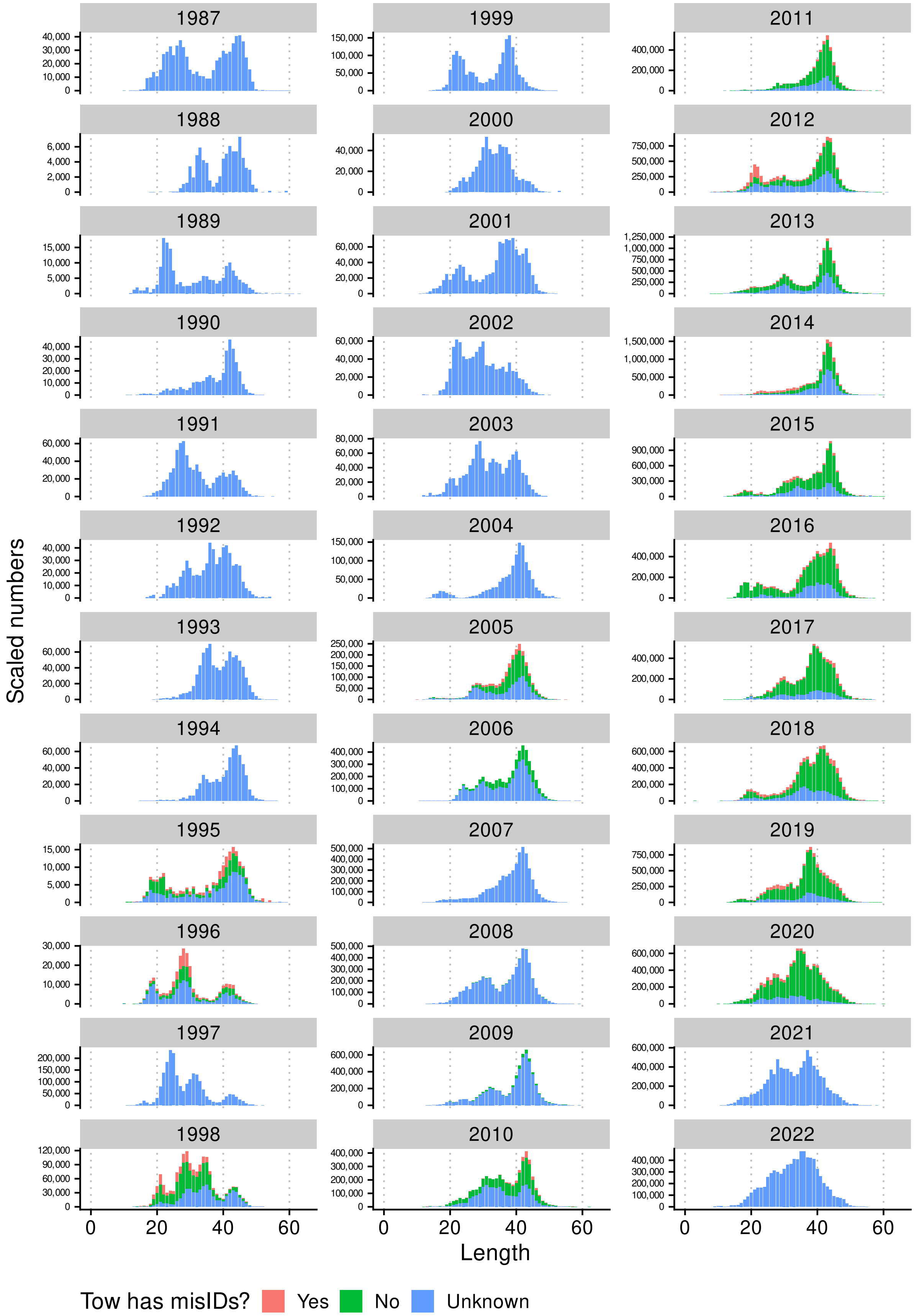

Figure 74: Scaled length-frequency samples of *T. declivis*. Data from tows with aged otoliths were classified according to whether or not the mixture modelling indicated some species misidentification had occurred.

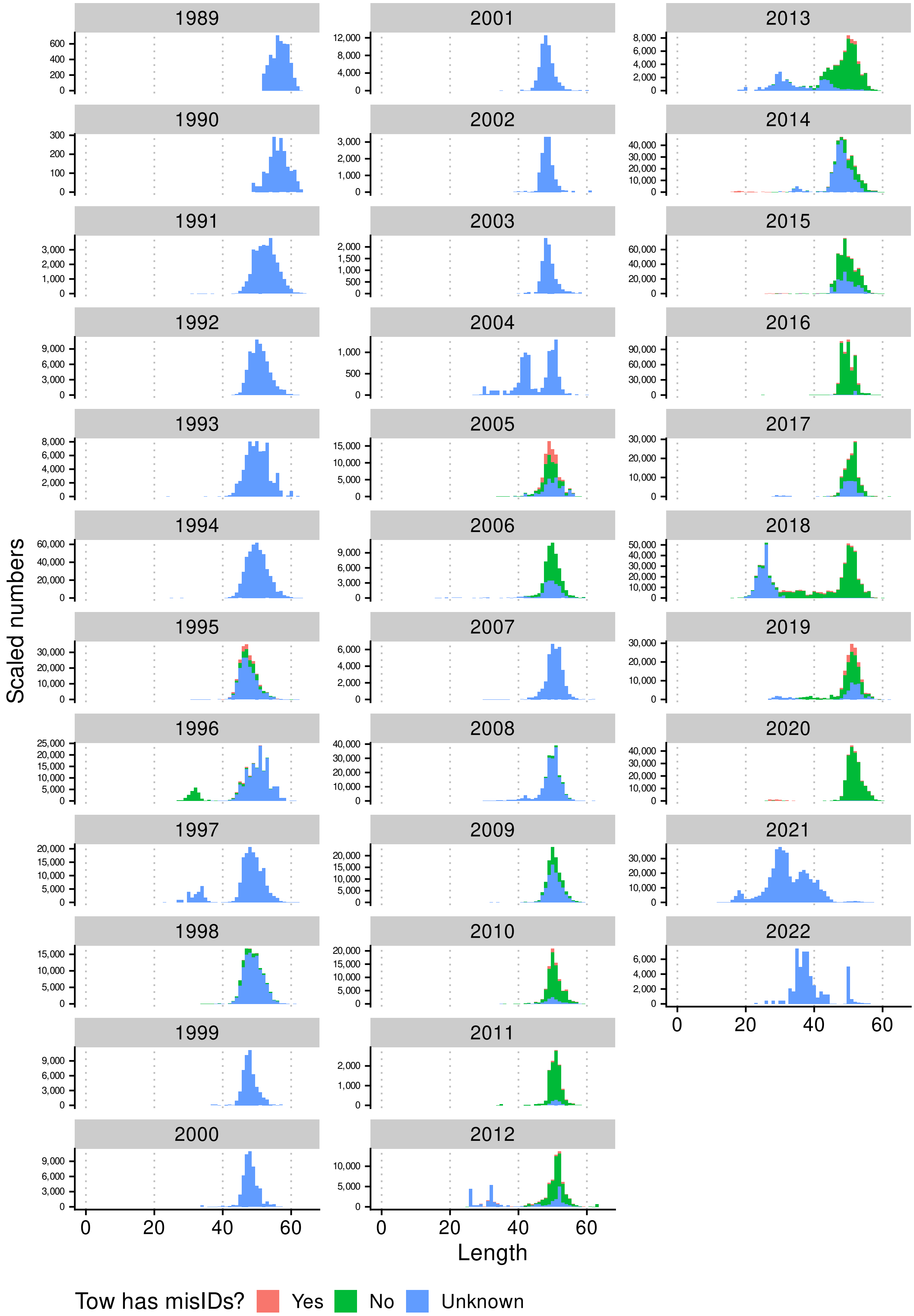

Figure 75: Scaled length-frequency samples of *T. murphyi*. Data from tows with aged otoliths were classified according to whether or not the mixture modelling indicated some species misidentification had occurred.

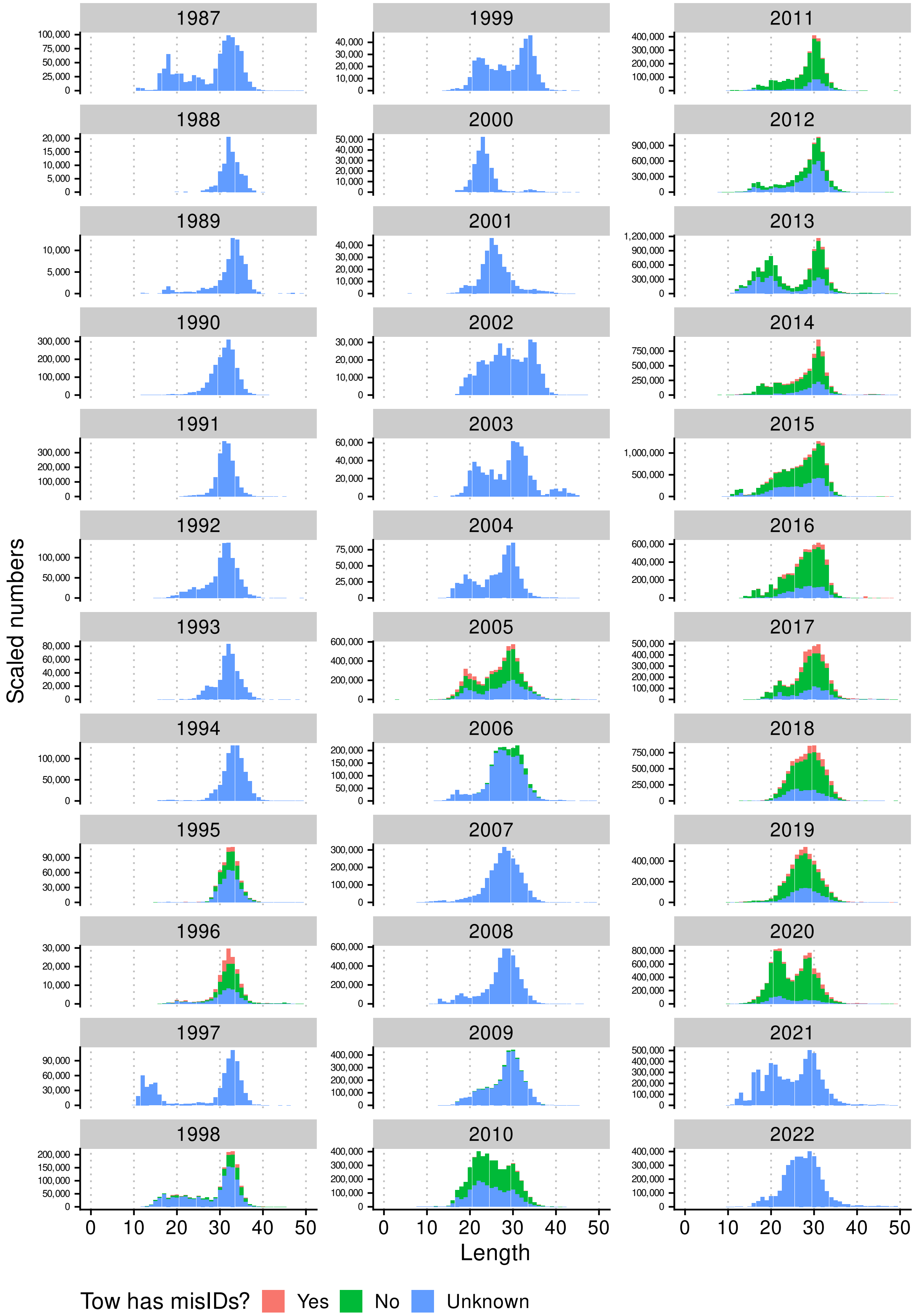

Figure 76: Scaled length-frequency samples of *T. novaezelandiae*. Data from tows with aged otoliths were classified according to whether or not the mixture modelling indicated some species misidentification had occurred.

7. CATCH-PER-UNIT-EFFORT

The three main CPUE series developed are described in the following sections. All are based on event-level catch and effort data collected by observers where event-level sampling has allowed decomposition of the aggregate jack mackerel catch into that of the three species. CPUE for each of the three species is modelled separately, but the datasets are essentially the same for each model, other than the use of a more restricted spatial area for *T. novaezelandiae*.

7.1 JMD7 MW observer

The key CPUE series for *T. declivis*, the JMD7 MW observer series, is defined in Table 8. Data were selected from observed midwater tows, targeting either jack mackerels generically or any of the three jack mackerel species, and from statistical areas extending from the mid-west coast of the South Island to the mid-west coast of the North Island. Only one observed trip per year was required, but vessels had to be observed for at least four years to be included in the core fleet. The core vessel selection retained 94.2% of the catch while reducing the core fleet in the modelling dataset to 10 vessels (Figure 77).

The core fleet showed good overlap and moderate fleet turnover (Figure 78), although the dataset was clearly more sparse prior to the 2005 increase in observer coverage of the fishery. The annual effect of core fleet selection, and other data filters, on the data retained for modelling is summarised in Table 9.

The core fleet dataset (Table 10) comprised just two vessels in 1999 and 2000, but between four and seven vessels thereafter, with increases in observer coverage, together with the establishment of the midwater fishery, resulting in an increase in both effort and catch in the dataset until this stabilised from 2006 onwards. *Trachurus declivis* were typically caught in at least 90% of tows, including all tows in 1999, 2001, and 2002. As a result, a binomial model was not fitted, although there is some indication of a decreasing trend in the occurrence of tows with *T. declivis* (Figure 79).

In the Weibull model for positive catches, stepwise selection retains depth, month, headline height, fishing duration, and statistical area, in addition to the required fishing year term (Table 11). Diagnostics for the model suggest the Weibull model fits well (Figure 80) although a gamma model would also have been acceptable (Figure 81).

The main impact of standardisation is a flattening of the CPUE series, with the standardised index lying somewhat above the unstandardised index until 2011, and below it thereafter (Figure 82). Most of the selected covariates have some influence on the standardised series, though the impact of statistical area is minimal (Figure 83).

The fitted effect for seabed depth suggests catches of *T. declivis* are greatest over depths of around 200 m (Figure 84). Patterns in the depths fished indicated a bimodal distribution in the early years of the series, becoming unimodal in the mid-2000s, with indication of the fishery operating over a wider depth range from 2014. Monthly coefficients suggest that the lowest catch rates occur in April (Figure 85), with reduced catches also occurring in October. Increased headline height is generally associated with increased catches (Figure 86); an increase in catch rates at lower headline heights is likely to be an artefact of the small amount of data at very low headline heights, and potentially the constraints of the spline term. However, the low number of tows with headline heights less than 25 m means this has little impact.

A similar effect was apparent in the fitted spline for the effect of fishing duration (Figure 87), although there are more data at shorter tow lengths suggesting that this could be a real effect—potentially arising when large schools are encountered early in some tows. Tows generally last several hours, with the right tail of the distribution of tow lengths increasing from 1999 to 2011. In the 1990s, the fishery tended to operate in areas with somewhat higher catch rates, although the influence of statistical area is not especially high (Figure 88).

Residual implied coefficients by statistical area (Figure 89) suggest some interannual variation between areas, but no systematic differences from the overall trend. The final, positive-catch only, indices (Figure 90, Table 12) suggest that the abundance of *T. declivis* fluctuated without trend from 1999 to 2010, then showed a generally increasing trend to 2017. After five years at this higher level, abundance decreased towards the long-term mean in 2022.

Table 8: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the JMD7 MW observer CPUE series.

Series	JMD7 MW observer
QMS stock	JMA7
Reporting forms	
Fishing methods	MW
Target species	JMA, JMD, JMM, JMN
Statistical Areas	034, 035, 036, 037, 039, 040, 041, 042, 045, 801
Period	1998-10-01, 2022-09-30
Resolution	Observed event
Core fleet years	4
Core fleet trips	1
Default model	jmdkg ~ fyear + vessel_key + month + stat_area + ns(log(fishing_duration), 3) + ns(log(start_time), 3) + ns(log(start_seabed_depth), 3) + ns(log(headline_height), 3) + ns(fishing_speed, 3)
Stepwise selection	Yes
Positive catch distribution	Weibull

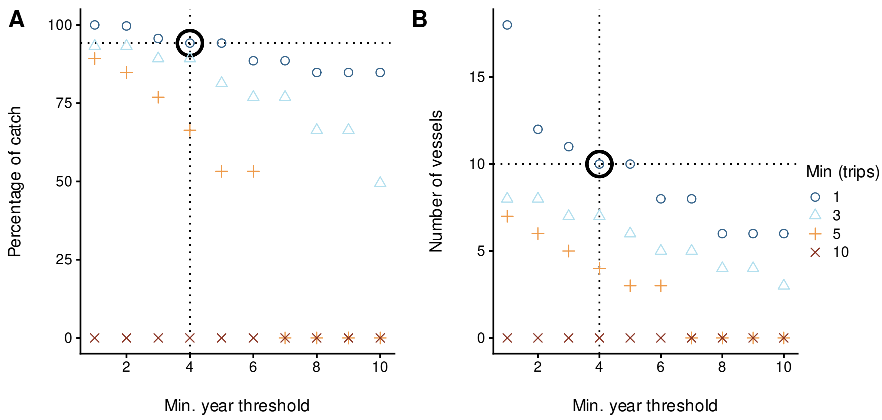

Figure 77: Percentage of catch and number of vessels for different core vessel selection criteria for the JMD7 MW observer CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel was observed in the fishery and the number of observed trips per year.

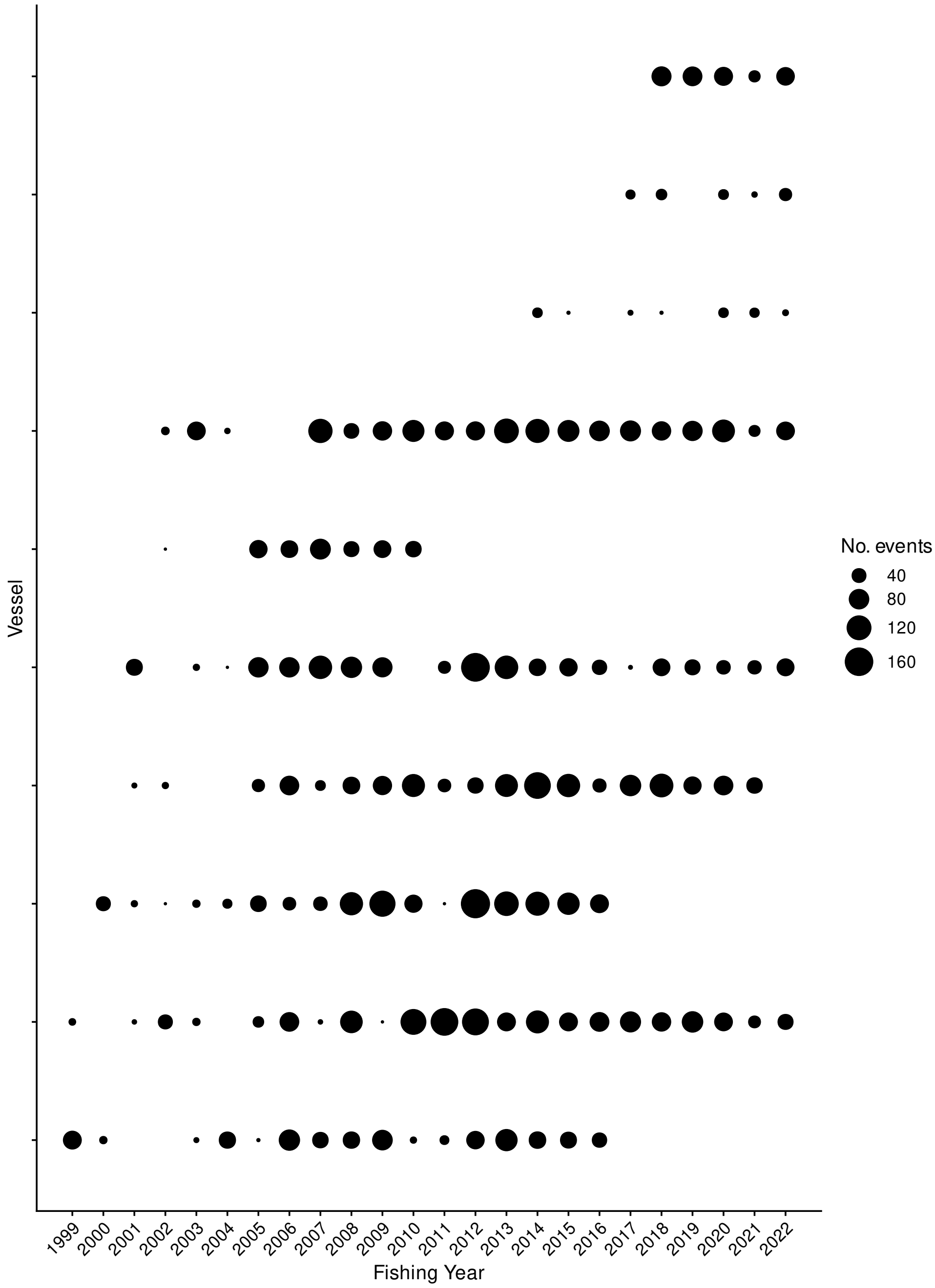

Figure 78: Number of events by fishing year for core vessels. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table 9: Summary of the JMD7 MW observer 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	1999	2000	2001	2002	2003	2004	2005	2006	2007
Ungroomed data	974 (100%) n: 116	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	687 (100%) n: 103	1171 (100%) n: 79	2467 (100%) n: 258	4706 (100%) n: 409	4247 (100%) n: 427
Fishing speed not null	926 (100%) n: 112	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	687 (100%) n: 103	1171 (100%) n: 79	2435 (100%) n: 256	4706 (100%) n: 409	4247 (100%) n: 427
Start date not null	926 (100%) n: 112	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	687 (100%) n: 103	1171 (100%) n: 79	2435 (100%) n: 256	4706 (100%) n: 409	4247 (100%) n: 427
End date not null	926 (100%) n: 112	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	687 (100%) n: 103	1171 (100%) n: 79	2435 (100%) n: 256	4706 (100%) n: 409	4247 (100%) n: 427
Start depth not null	926 (100%) n: 112	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	687 (100%) n: 103	1171 (100%) n: 79	2435 (100%) n: 256	4706 (100%) n: 409	4247 (100%) n: 427
Headline height not null	919 (94%) n: 111	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	679 (100%) n: 102	1171 (100%) n: 79	2435 (100%) n: 256	4706 (100%) n: 409	4247 (100%) n: 427
Fishing speed >3.5kn	919 (94%) n: 111	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	679 (100%) n: 102	1171 (100%) n: 79	2435 (100%) n: 256	4706 (100%) n: 409	4247 (100%) n: 426
Headline height >15m	919 (94%) n: 111	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	676 (100%) n: 101	1171 (100%) n: 79	2434 (100%) n: 255	4697 (100%) n: 408	4213 (100%) n: 422
Headline height <90m	919 (94%) n: 111	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	676 (100%) n: 101	1171 (100%) n: 79	2434 (100%) n: 255	4697 (100%) n: 408	4213 (100%) n: 422
Fishing duration >15mins	898 (92%) n: 109	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	676 (100%) n: 101	1171 (100%) n: 79	2433 (100%) n: 254	4628 (100%) n: 407	4159 (100%) n: 421
Seabed depth >50m	898 (92%) n: 109	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	676 (100%) n: 101	1171 (100%) n: 79	2433 (100%) n: 254	4628 (100%) n: 407	4159 (100%) n: 421
Seabed depth <400m	885 (91%) n: 108	390 (100%) n: 53	838 (100%) n: 75	474 (100%) n: 66	676 (100%) n: 101	1171 (100%) n: 79	2423 (100%) n: 252	4628 (100%) n: 407	4159 (100%) n: 421
Start time >0	883 (91%) n: 107	388 (100%) n: 52	838 (100%) n: 75	438 (92%) n: 63	676 (100%) n: 101	1171 (100%) n: 79	2399 (100%) n: 249	4613 (100%) n: 403	4073 (100%) n: 415
Core fleet selection	710 (73%) n: 76	388 (100%) n: 52	834 (100%) n: 70	438 (92%) n: 63	676 (100%) n: 101	1171 (100%) n: 79	2399 (100%) n: 249	4613 (100%) n: 403	4073 (100%) n: 415

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	4954 (100%) n: 511	5884 (100%) n: 526	4425 (100%) n: 487	4219 (100%) n: 310	9664 (100%) n: 713	9872 (100%) n: 643	11383 (100%) n: 669	9856 (100%) n: 593	6348 (100%) n: 389
Fishing speed not null	4895 (100%) n: 510	5884 (100%) n: 526	4406 (100%) n: 486	4219 (100%) n: 310	9664 (100%) n: 713	9834 (100%) n: 642	11383 (100%) n: 669	9856 (100%) n: 593	6333 (100%) n: 388
Start date not null	4895 (100%) n: 510	5884 (100%) n: 526	4406 (100%) n: 486	4219 (100%) n: 310	9664 (100%) n: 713	9834 (100%) n: 642	11383 (100%) n: 669	9856 (100%) n: 593	6333 (100%) n: 388
End date not null	4895 (100%) n: 510	5884 (100%) n: 526	4406 (100%) n: 486	4219 (100%) n: 310	9664 (100%) n: 713	9834 (100%) n: 642	11383 (100%) n: 669	9856 (100%) n: 593	6333 (100%) n: 388
Start depth not null	4884 (100%) n: 508	5628 (100%) n: 501	4358 (100%) n: 483	4146 (100%) n: 306	9122 (94%) n: 677	9346 (95%) n: 621	11338 (100%) n: 666	9786 (100%) n: 577	6333 (100%) n: 388
Headline height not null	4884 (100%) n: 508	5606 (100%) n: 499	4269 (100%) n: 475	4104 (100%) n: 305	9018 (93%) n: 670	9291 (94%) n: 617	11249 (100%) n: 663	9786 (100%) n: 576	6333 (100%) n: 388
Fishing speed >3.5kn	4884 (100%) n: 508	5606 (100%) n: 499	4269 (100%) n: 475	4104 (100%) n: 305	9018 (93%) n: 670	9291 (94%) n: 617	11249 (100%) n: 663	9786 (100%) n: 576	6331 (100%) n: 387
Headline height >15m	4884 (100%) n: 508	5586 (95%) n: 497	4233 (100%) n: 474	4104 (100%) n: 305	8954 (93%) n: 669	9216 (93%) n: 614	11249 (100%) n: 663	9786 (100%) n: 576	6331 (100%) n: 387
Headline height <90m	4884 (100%) n: 508	5586 (95%) n: 497	4233 (100%) n: 474	4094 (100%) n: 304	8943 (93%) n: 668	9216 (93%) n: 614	11231 (100%) n: 662	9771 (100%) n: 575	6331 (100%) n: 387
Fishing duration >15mins	4884 (100%) n: 507	5586 (95%) n: 497	4233 (100%) n: 474	4016 (100%) n: 301	8922 (92%) n: 667	9178 (93%) n: 612	11226 (100%) n: 660	9771 (100%) n: 575	6328 (100%) n: 386
Seabed depth >50m	4884 (100%) n: 507	5573 (95%) n: 495	4226 (100%) n: 473	4016 (100%) n: 301	8922 (92%) n: 666	9159 (93%) n: 611	11226 (100%) n: 660	9755 (100%) n: 574	6328 (100%) n: 386
Seabed depth <400m	4865 (100%) n: 504	5573 (95%) n: 495	4217 (100%) n: 472	4016 (100%) n: 301	8809 (91%) n: 659	9134 (93%) n: 609	11222 (100%) n: 659	9675 (100%) n: 571	6328 (100%) n: 386
Start time >0	4675 (94%) n: 495	5549 (94%) n: 492	4137 (93%) n: 468	4002 (95%) n: 298	8778 (91%) n: 652	9075 (92%) n: 606	11067 (100%) n: 649	9618 (100%) n: 568	6287 (100%) n: 383
Core fleet selection	4675 (94%) n: 495	5549 (94%) n: 492	3937 (89%) n: 445	4002 (95%) n: 298	8778 (91%) n: 652	9075 (92%) n: 606	8856 (78%) n: 598	7232 (73%) n: 478	5407 (85%) n: 344

Filter	2017	2018	2019	2020	2021	2022
Ungroomed data	5899 (100%) n: 309	8658 (100%) n: 433	8557 (100%) n: 380	6557 (100%) n: 397	5650 (100%) n: 259	5498 (100%) n: 328
Fishing speed not null	5820 (100%) n: 307	8658 (100%) n: 433	8557 (100%) n: 380	6477 (100%) n: 395	5497 (100%) n: 255	5497 (100%) n: 327
Start date not null	5820 (100%) n: 307	8658 (100%) n: 433	8557 (100%) n: 380	6477 (100%) n: 395	5497 (100%) n: 255	5497 (100%) n: 327
End date not null	5820 (100%) n: 307	8658 (100%) n: 433	8557 (100%) n: 380	6477 (100%) n: 395	5497 (100%) n: 255	5497 (100%) n: 327
Start depth not null	5764 (100%) n: 304	8646 (100%) n: 432	8557 (100%) n: 380	6477 (100%) n: 389	5438 (100%) n: 249	4579 (83%) n: 289
Headline height not null	5646 (100%) n: 300	8618 (100%) n: 430	8557 (100%) n: 380	6447 (100%) n: 387	5438 (100%) n: 249	4579 (83%) n: 289
Fishing speed >3.5kn	5646 (100%) n: 300	8618 (100%) n: 430	8557 (100%) n: 380	6447 (100%) n: 387	5438 (100%) n: 249	4579 (83%) n: 289
Headline height >15m	5636 (100%) n: 299	8618 (100%) n: 430	8557 (100%) n: 380	6447 (100%) n: 387	5438 (100%) n: 249	4579 (83%) n: 289
Headline height <90m	5636 (100%) n: 299	8577 (100%) n: 428	8557 (100%) n: 380	6447 (100%) n: 387	5438 (100%) n: 249	4579 (83%) n: 289
Fishing duration >15mins	5624 (100%) n: 298	8577 (100%) n: 428	8522 (100%) n: 379	6447 (100%) n: 387	5438 (100%) n: 249	4579 (83%) n: 289
Seabed depth >50m	5624 (100%) n: 298	8532 (100%) n: 427	8522 (100%) n: 379	6447 (100%) n: 387	5438 (100%) n: 249	4579 (83%) n: 289
Seabed depth <400m	5624 (100%) n: 298	8510 (100%) n: 425	8406 (100%) n: 377	6447 (100%) n: 387	5438 (100%) n: 249	4579 (83%) n: 289
Start time >0	5546 (94%) n: 296	8505 (100%) n: 424	8366 (100%) n: 376	6401 (100%) n: 384	5374 (100%) n: 247	4579 (83%) n: 289
Core fleet selection	5421 (92%) n: 282	7749 (90%) n: 411	7672 (90%) n: 349	6401 (100%) n: 384	4211 (75%) n: 191	4219 (77%) n: 276

Table 10: Summary of the JMD7 MW observer dataset after core fleet selection. 'Records' indicates the number of rows (events) in the dataset, and 'Records caught' indicates the percentage of events with catches of jack mackerels.

Fishing year	Vessels	Trips	Records	Hrs	Catch (t)	Records caught
1999	2	3	76	165.32	709.60	100.00
2000	2	2	52	137.25	387.78	98.08
2001	4	6	70	184.40	833.85	100.00
2002	5	5	63	221.45	437.53	100.00
2003	5	5	101	365.42	675.58	98.02
2004	4	4	79	333.28	1 171.09	96.20
2005	6	9	249	847.98	2 399.42	98.80
2006	6	8	403	1 479.25	4 613.02	97.52
2007	7	15	415	1 505.27	4 072.75	96.39
2008	7	16	495	1 925.52	4 675.39	94.55
2009	7	15	492	2 046.68	5 549.46	96.14
2010	6	10	445	1 957.63	3 936.90	97.53
2011	6	8	298	1 368.33	4 002.27	96.98
2012	6	20	652	3 372.07	8 777.71	96.17
2013	6	31	606	2 907.90	9 074.99	94.88
2014	7	32	598	2 795.87	8 856.25	93.65
2015	7	32	478	2 361.98	7 232.21	93.93
2016	6	29	344	1 611.68	5 406.64	92.73
2017	6	25	282	1 483.97	5 420.54	95.04
2018	7	30	411	2 455.30	7 749.00	89.78
2019	5	23	349	1 854.87	7 671.65	97.99
2020	7	30	384	1 995.42	6 401.29	87.50
2021	7	19	191	1 080.73	4 210.92	96.86
2022	6	16	276	1 301.97	4 219.16	91.67

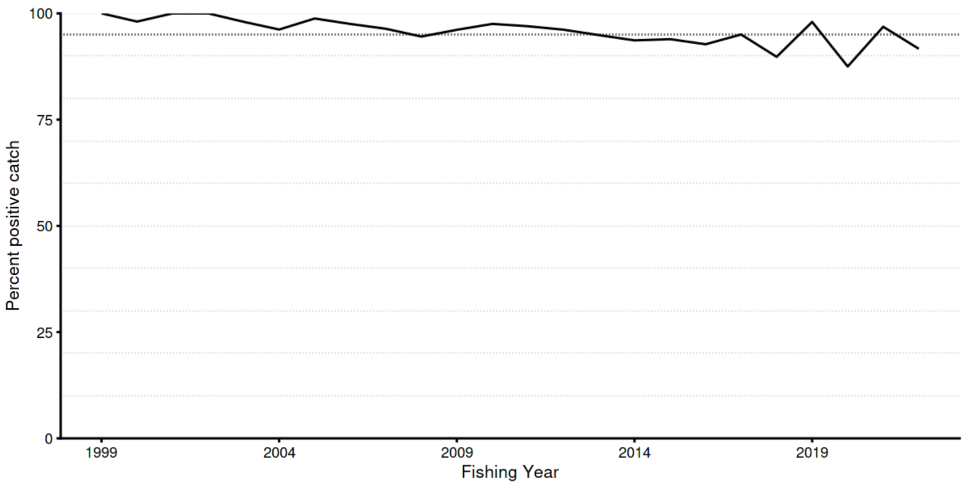

Figure 79: Percentage of positive catch records in the JMD7 MW observer catch-per-unit-effort dataset.

Table 11: Summary of stepwise selection for the Weibull model. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	25	156 602	6.9	6.9	*
+ ns(log(start seabed depth), 3)	3	156 080	13.0	6.1	*
+ month	11	155 891	15.5	2.4	*
+ ns(log(headline height), 3)	3	155 757	17.1	1.6	*
+ ns(log(fishing duration), 3)	3	155 654	18.4	1.3	*
+ stat area	9	155 564	19.6	1.2	*
+ vessel key	9	155 534	20.2	0.6	
+ ns(log(start time), 3)	3	155 527	20.3	0.1	

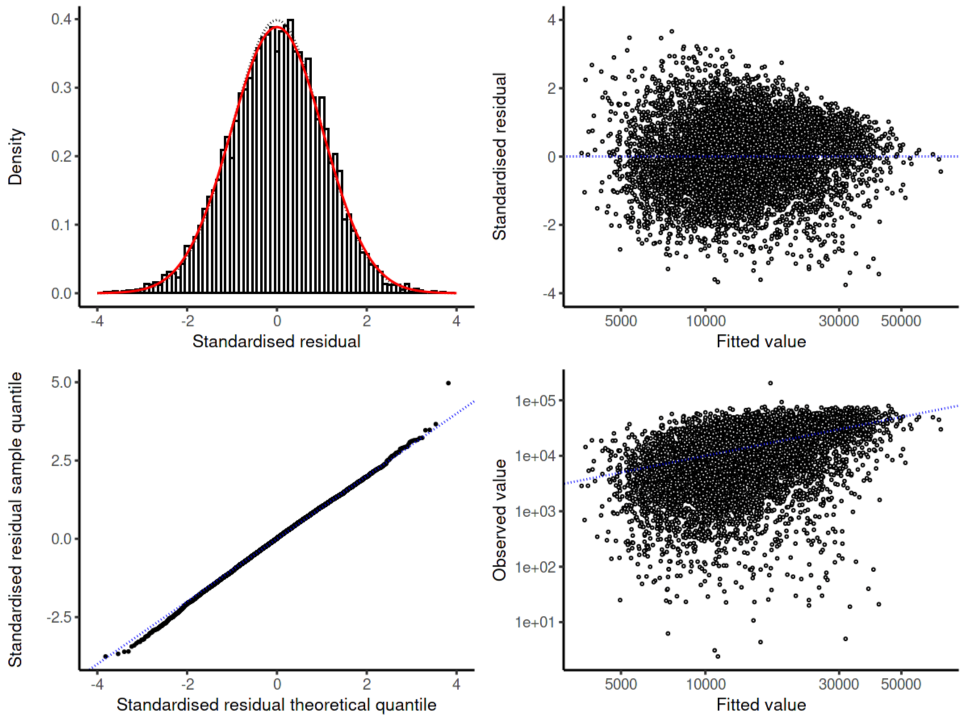

Figure 80: Diagnostic plots for the Weibull model for the JMD7 MW observer dataset.

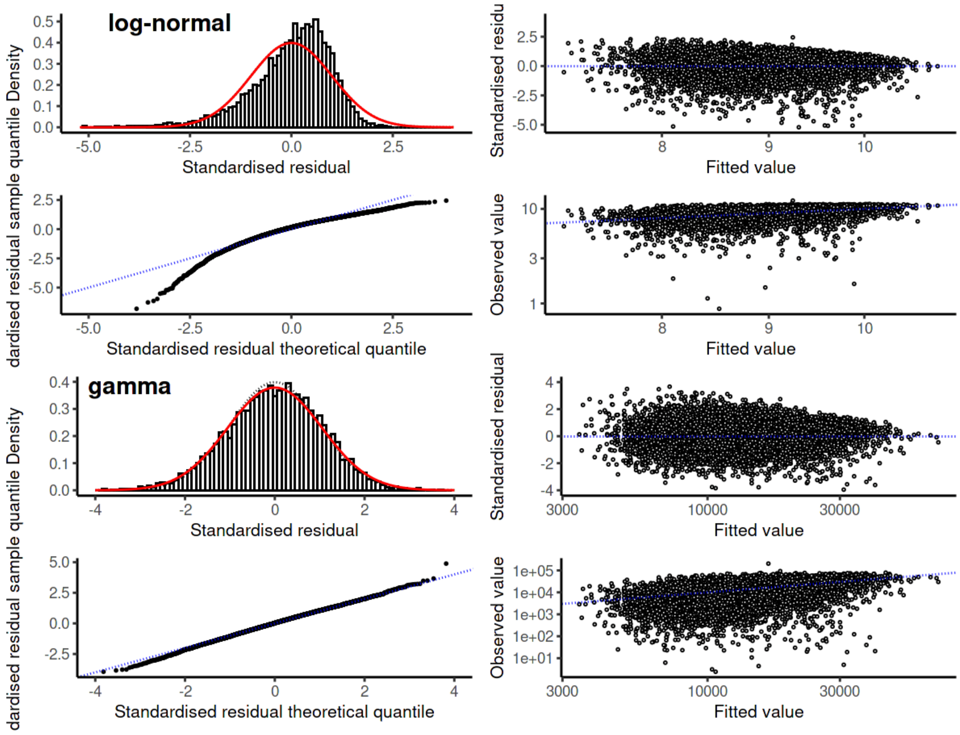

Figure 81: Diagnostic plots for the log-normal and gamma model for the JMD7 MW observer dataset.

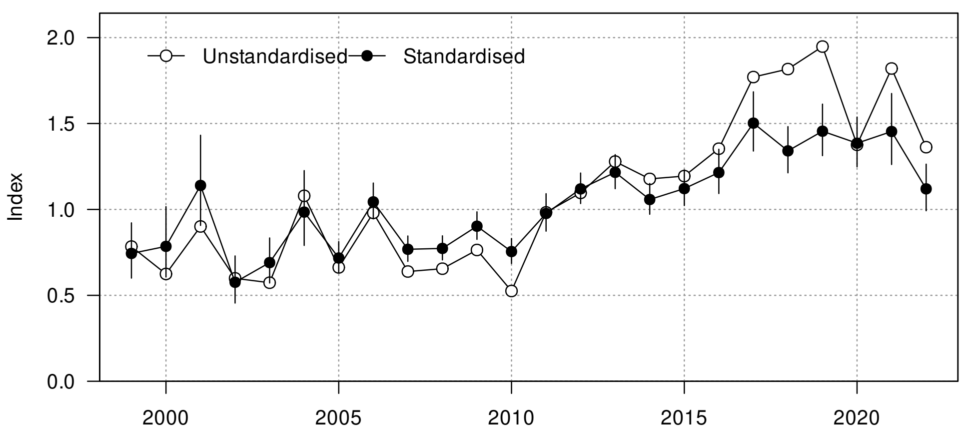

Figure 82: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch in the JMD7 MW observer dataset.

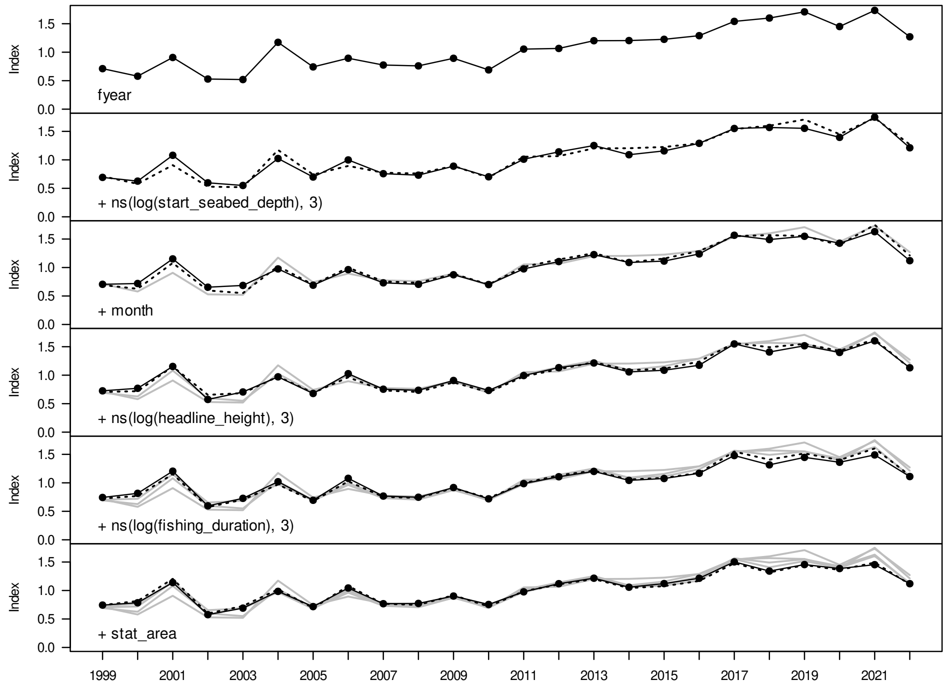

Figure 83: Changes to the JMD7 MW observer positive catch index as terms are successively entered into the model.

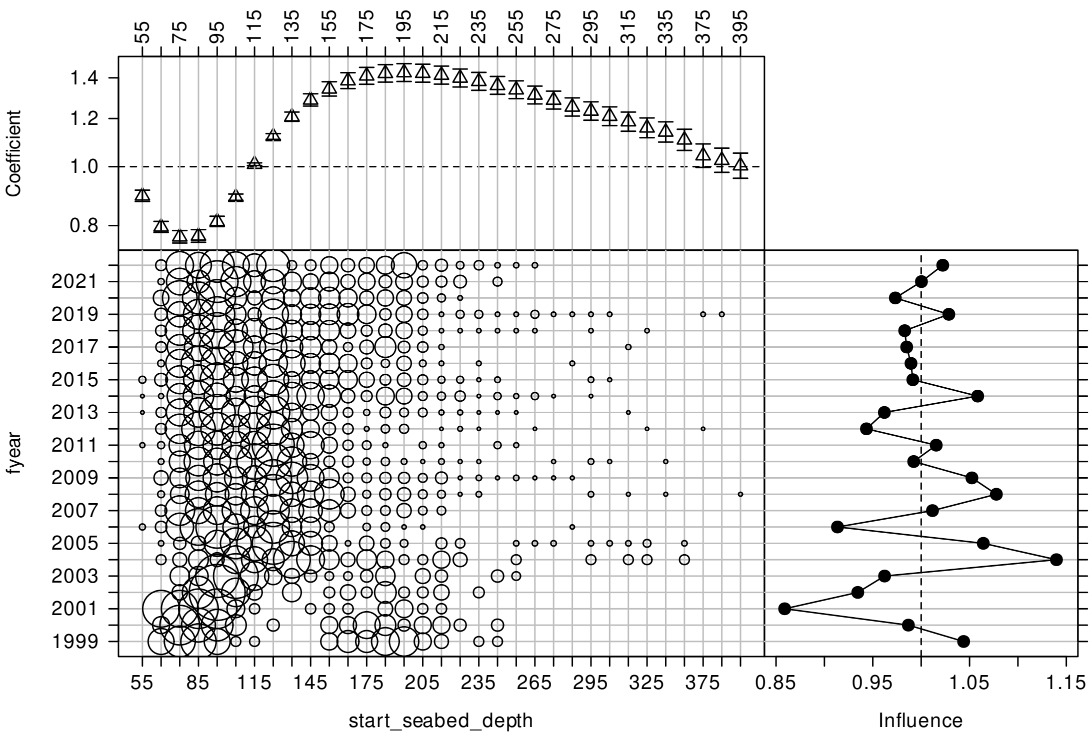

Figure 84: CDI plot for start seabed depth (m) for the positive catch JMD7 MW observer catch-per-unit-effort dataset.

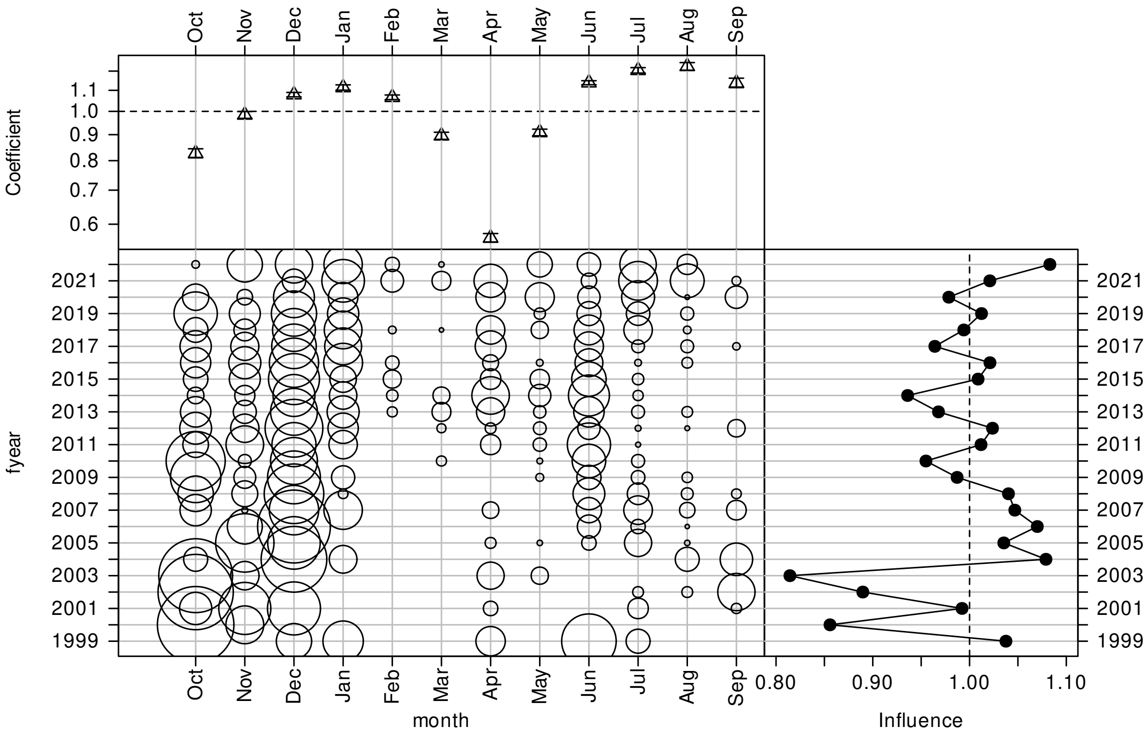

Figure 85: CDI plot for month for the positive catch JMD7 MW observer catch-per-unit-effort dataset.

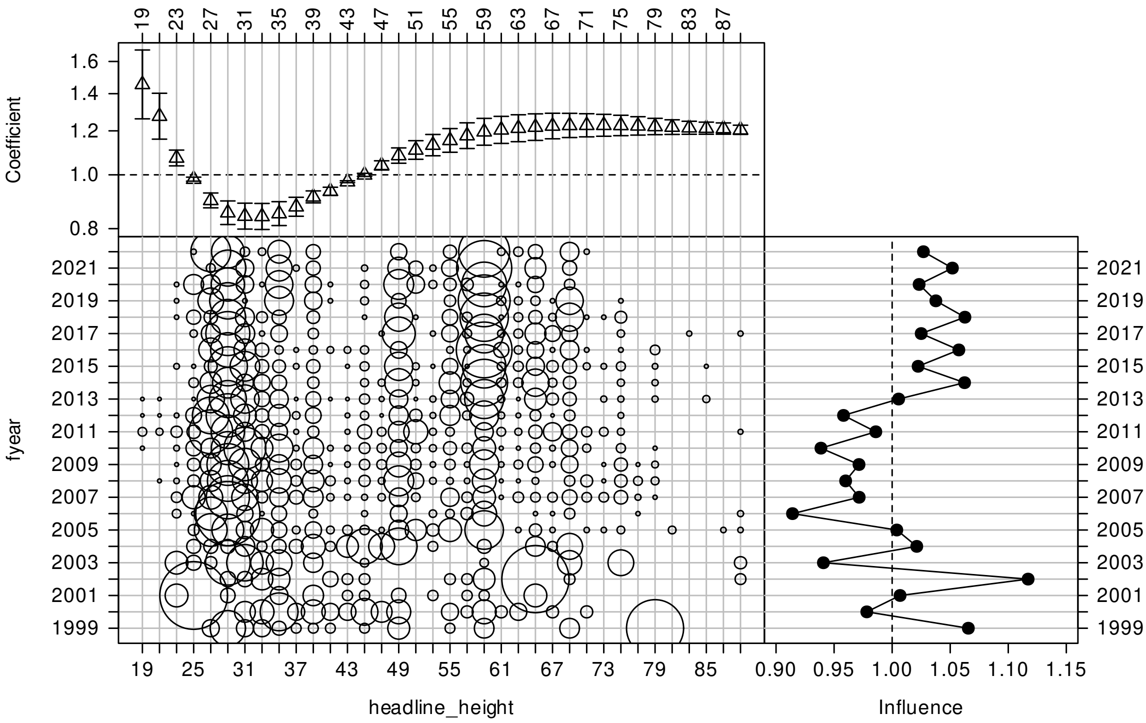

Figure 86: CDI plot for headline height (m) for the positive catch JMD7 MW observer catch-per-unit-effort dataset.

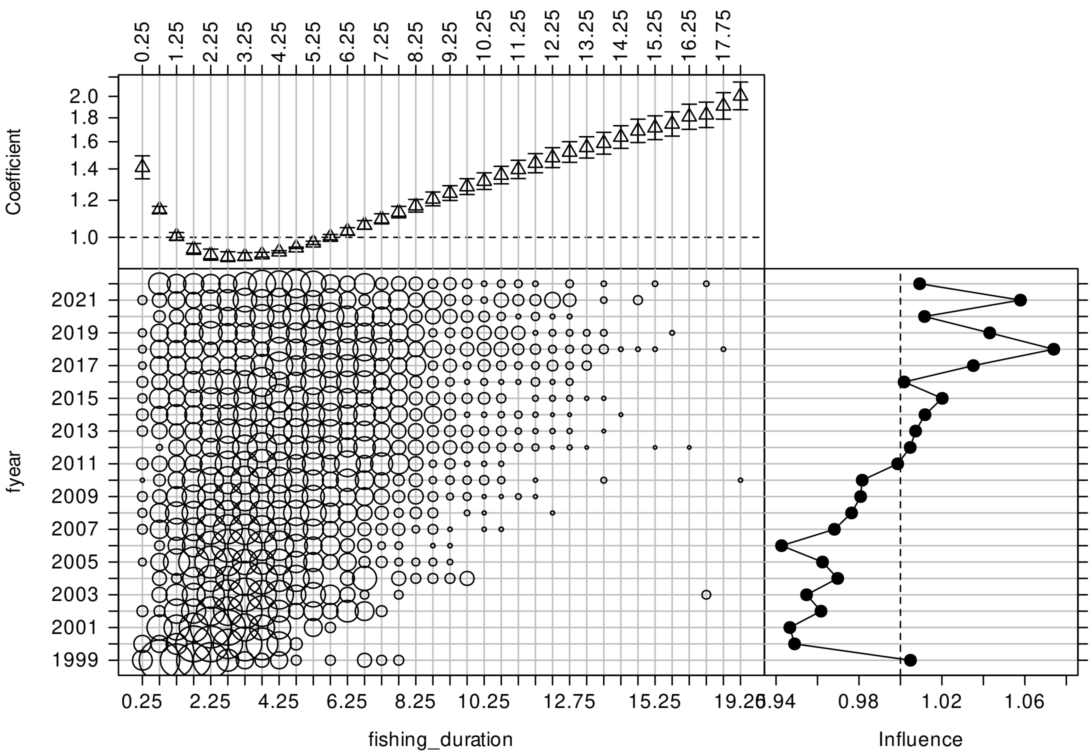

Figure 87: CDI plot for fishing duration (h) for the positive catch JMD7 MW observer catch-per-unit-effort dataset.

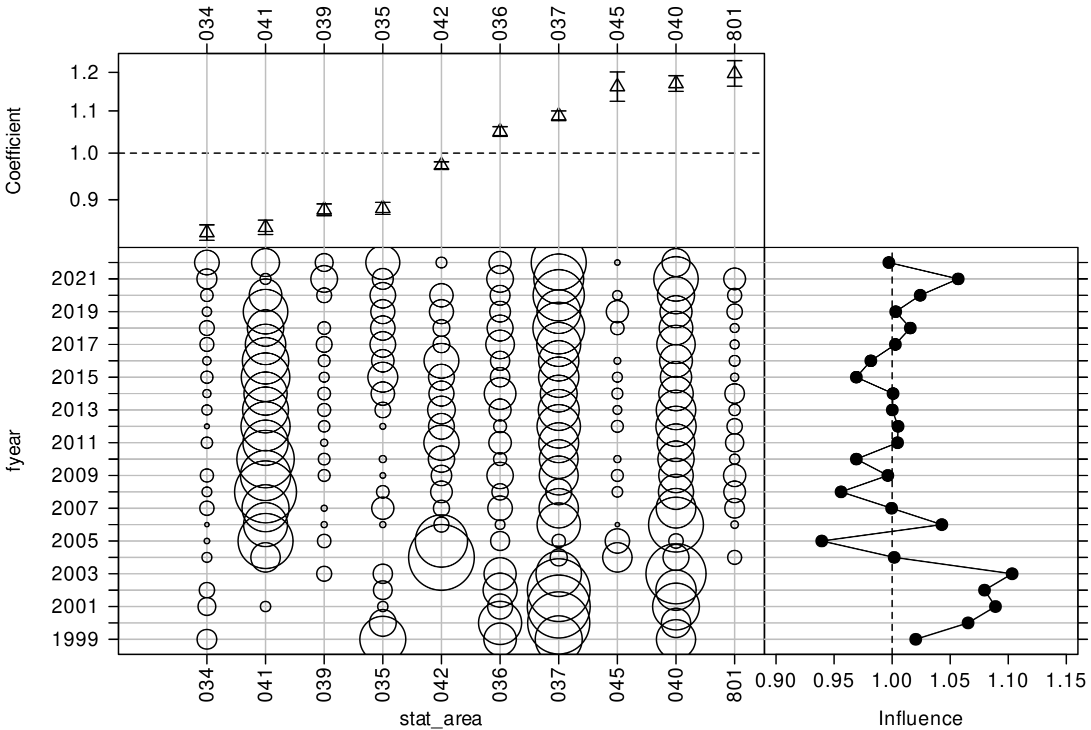

Figure 88: CDI plot for statistical area for the positive catch JMD7 MW observer catch-per-unit-effort dataset.

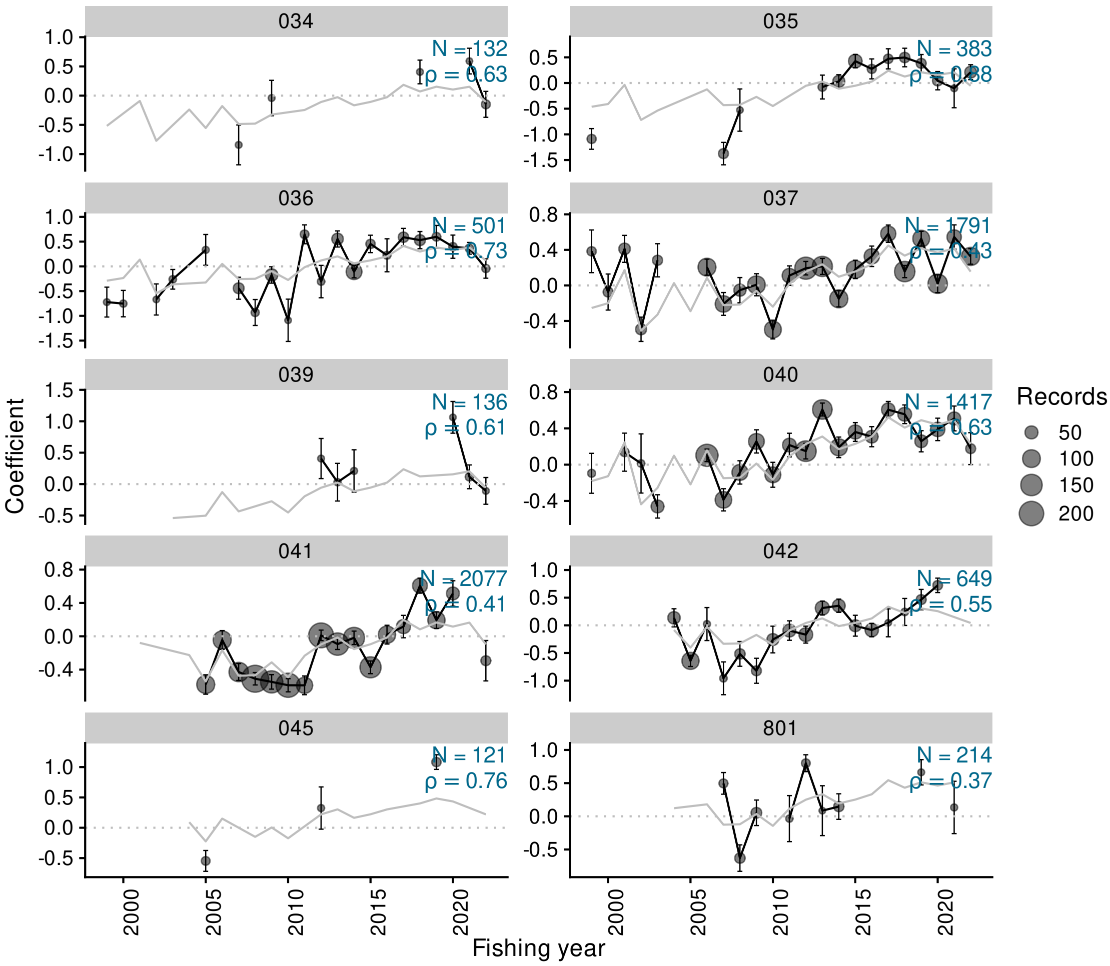

Figure 89: Residual implied coefficients for area-year in the Weibull positive catch model for the JMD7 MW observer dataset.

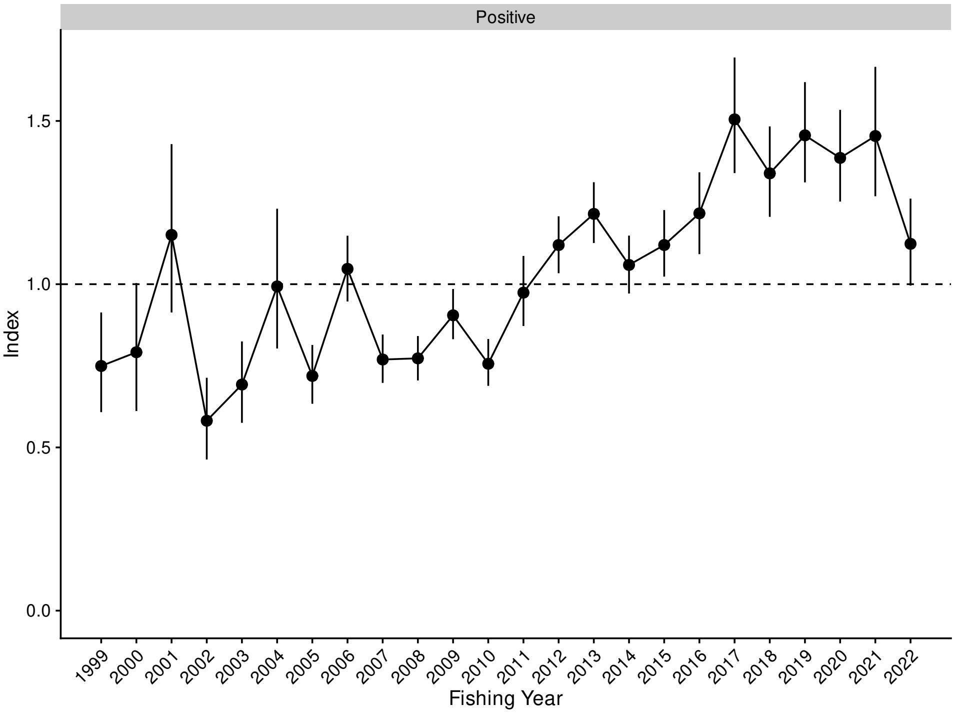

Figure 90: Standardised indices and 95% confidence intervals for the JMD7 MW observer dataset.

Table 12: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in JMD7 MW observer.

	Positive			
Fishing year	index	SE	LCI	UCI
1999	0.749	0.078	0.608	0.913
2000	0.792	0.100	0.611	1.003
2001	1.151	0.132	0.913	1.429
2002	0.582	0.064	0.463	0.713
2003	0.693	0.064	0.575	0.825
2004	0.993	0.109	0.803	1.231
2005	0.719	0.046	0.634	0.814
2006	1.047	0.051	0.947	1.148
2007	0.769	0.038	0.698	0.846
2008	0.773	0.035	0.705	0.841
2009	0.905	0.039	0.831	0.985
2010	0.756	0.037	0.689	0.832
2011	0.974	0.055	0.872	1.087
2012	1.120	0.044	1.034	1.208
2013	1.215	0.048	1.126	1.312
2014	1.059	0.045	0.971	1.149
2015	1.120	0.052	1.023	1.227
2016	1.217	0.064	1.092	1.343
2017	1.505	0.090	1.340	1.694
2018	1.339	0.071	1.206	1.483
2019	1.456	0.078	1.312	1.619
2020	1.387	0.072	1.253	1.534
2021	1.454	0.101	1.269	1.666
2022	1.124	0.068	0.996	1.262

7.2 JMN7 MW observer

The JMN7 MW observer series, for *T. novaezelandiae*, is defined in Table 13. The only difference in the data selection approach, from that used for the *T. declivis* series, was to exclude the west coast South Island statistical areas. The core vessel selection again retained a high percentage of the catch (96.5%) and 10 vessels (Figure 91).

Unsurprisingly, the pattern of effort by the observed core fleet (Figure 92), is similar to that seen in the *T. declivis* model, although with a reduced amount of effort due to the exclusion of the southern area. The annual effect of core fleet selection, and other data filters, on the data retained for modelling is summarised in Table 14.

The core fleet dataset (Table 15) showed much the same patterns as the *T. declivis*, the key difference being that *T. novaezelandiae* is caught in a lower proportion of observed trawls, ranging from 70% to 90% of events annually. As a result, a combined binomial-Weibull model was developed.

Stepwise selection for the binomial model retained depth, area, and month (Table 16). The effect of standardisation was small (Figure 93), with depth having the greatest impact on the annual indices, although this was mitigated by the other covariates (Figure 94).

The probability of catching *T. novaezelandiae* was greatest around 85 m depths, with little change in the depths fished apparent after the mid-2000s (Figure 95). Catches were more likely in the North Taranaki Bight and the nearer-shore areas of the South Taranaki Bight (Statistical Areas 039, 041, 042 and 045; Figure 96). As a result of the change in the fishing effort patterns in the early 2000s, the probability of catching *T. novaezelandiae* was lower before 2003. Catch probability showed a seasonal pattern with January to April having higher occurrence of *T. novaezelandiae* catches (Figure 97).

Stepwise selection for a Weibull model of positive catches retained statistical area, month, depth, fishing duration, and headline height (Table 17). Diagnostics for the model suggest the Weibull model fits reasonably well (Figure 98), although not as well as in the *T. declivis* model. Again, a gamma model would also have been acceptable (Figure 99).

The effect of standardisation was quite marked, producing an overall flattening of the CPUE series, with the standardised index generally raised from 1999 to 2006 (other than 2004 and 2005) and lower than the unstandardised index from 2013 to 2021 (Figure 100). The standardisation also reduces some of the year to year variation in the unstandardised index. Most of effect of standardisation is attributable to the area and month effects (Figure 101).

As with the probability of catch occurrence, catch rates of *T. novaezelandiae* were estimated to be highest in the North Taranaki Bight (Statistical Areas 041, 042, 045; Figure 102) with low influence in the first four years of the series, and also from 2017 to 2022, due to a more southern operation of the fishery. However, increased effort in Statistical Areas 042 and 045 led to high influence in 2004 and 2005. The month effect suggests higher postive catch rates are expected for *T. novaezelandiae* from March to September, although most positive effort has been in October to January (Figure 103). Catch rates, like catch occurrence, for *T. novaezelandiae* are highest around 85 m depths (Figure 104). Increased fishing durations were associated with increased catches although, as for *T. declivis*, there is also a slight increase at the shortest tow durations (Figure 105). The increasing right tail of the distribution of fishing duration is also, naturally, evident for the *T. novaezelandiae* model. The highest catches of *T. novaezelandiae* are associated with intermediate headline heights (Figure 106), potentially reflecting the fact that the shallower distribution of *T. novaezelandiae* precludes use of larger headline openings where it is most abundant.

Residual implied coefficients by statistical area (Figure 107) are generally consistent with the overall trend. The final, combined indices (Figure 108, Figure 109) have little influence from the rather flat binomial index, and so mirror the trend in the positive index. Interannual variation is reasonably high, but *T. novaezelandiae* abundance is estimated to have followed a declining trend from 1999 to 2007, then a more steeply increasing trend from 2010 to 2018, fluctuating without trend to 2022 at a level higher than that at the start of the series in 1999 (Table 18).

Table 13: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the JMN7 MW observer CPUE series.

Series	JMN7 MW observer
QMS stock	JMA7
Reporting forms	
Fishing methods	MW
Target species	JMA, JMD, JMM, JMN
Statistical Areas	037, 039, 040, 041, 042, 045
Period	1998-10-01, 2022-09-30
Resolution	Observed event
Core fleet years	4
Core fleet trips	1
Default model	jmnkg ~ fyear + vessel_key + month + stat_area + ns(log(fishing_duration), 3) + ns(log(start_time), 3) + ns(log(start_seabed_depth), 3) + ns(log(headline_height), 3) + ns(fishing_speed, 3)
Stepwise selection	Yes
Positive catch distribution	Weibull

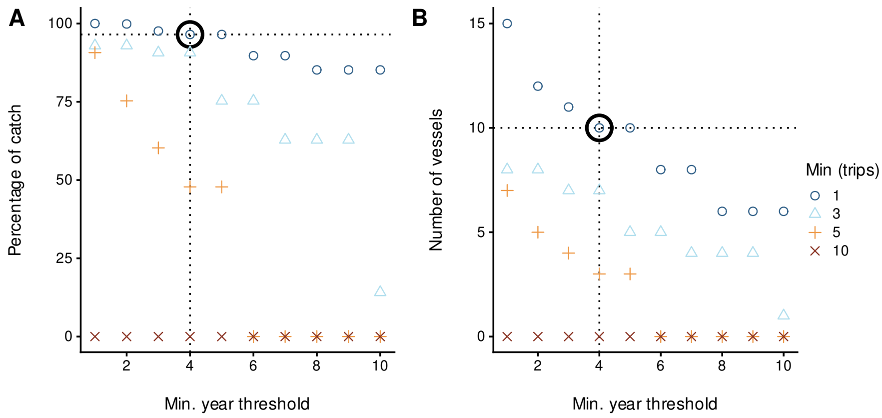

Figure 91: Percentage of catch and number of vessels for different core vessel selection criteria for the JMN7 MW observer CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel was observed in the fishery and the number of observed trips per year.

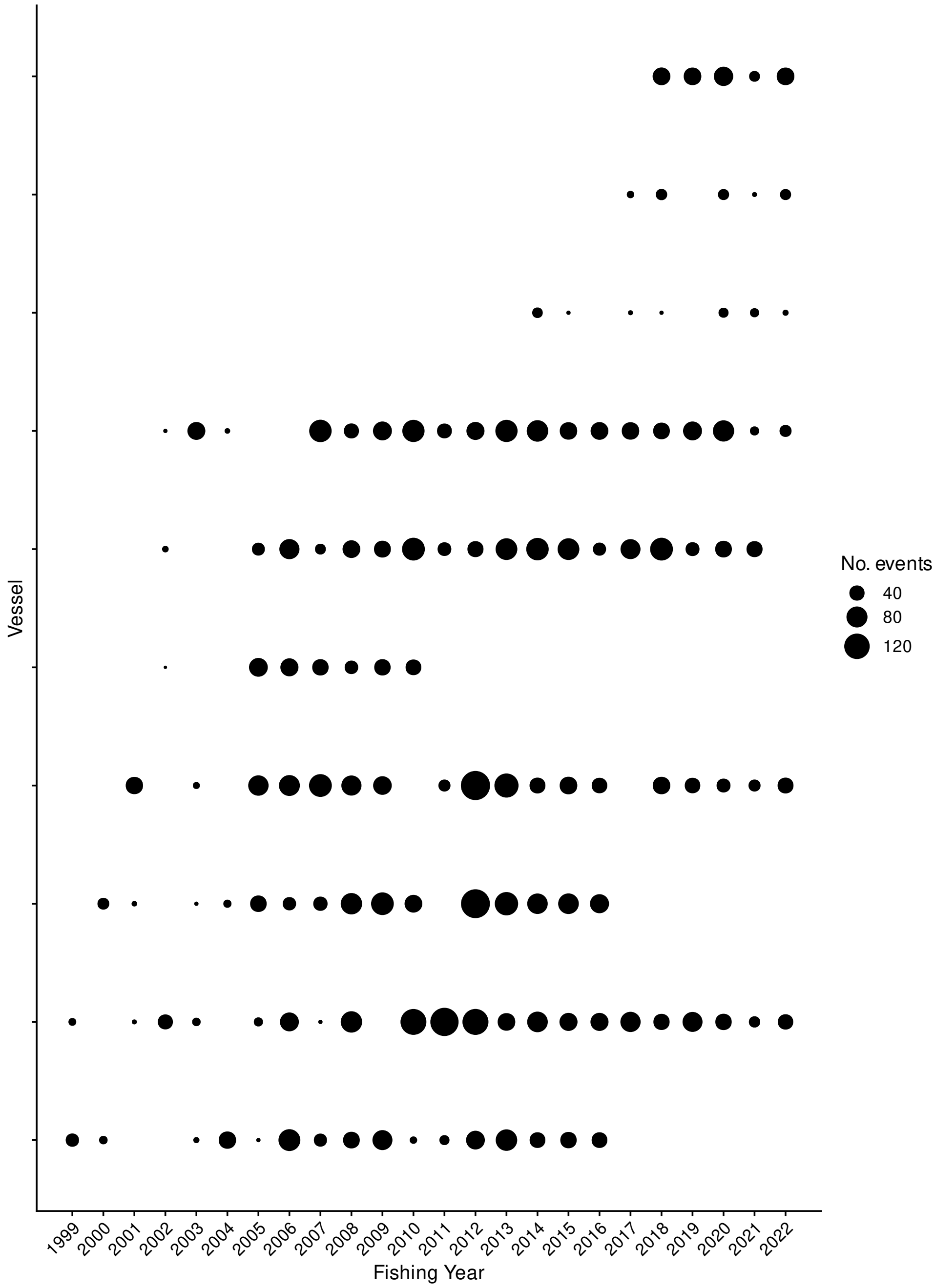

Figure 92: Number of events by fishing year for core vessels. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table 14: Summary of the JMN7 MW observer 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	1999	2000	2001	2002	2003	2004	2005	2006	2007
Ungroomed data	304 (100%) n: 45	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 84	403 (100%) n: 76	2571 (100%) n: 243	1541 (100%) n: 397	1331 (100%) n: 327
Fishing speed not null	304 (100%) n: 44	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 84	403 (100%) n: 76	2568 (100%) n: 241	1541 (100%) n: 397	1331 (100%) n: 327
Start date not null	304 (100%) n: 44	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 84	403 (100%) n: 76	2568 (100%) n: 241	1541 (100%) n: 397	1331 (100%) n: 327
End date not null	304 (100%) n: 44	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 84	403 (100%) n: 76	2568 (100%) n: 241	1541 (100%) n: 397	1331 (100%) n: 327
Start depth not null	304 (100%) n: 44	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 84	403 (100%) n: 76	2568 (100%) n: 241	1541 (100%) n: 397	1331 (100%) n: 327
Headline height not null	294 (100%) n: 43	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 83	403 (100%) n: 76	2568 (100%) n: 241	1541 (100%) n: 397	1331 (100%) n: 327
Fishing speed >3.5kn	294 (100%) n: 43	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 83	403 (100%) n: 76	2568 (100%) n: 241	1541 (100%) n: 397	1331 (100%) n: 326
Headline height >15m	294 (100%) n: 43	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	386 (100%) n: 82	403 (100%) n: 76	2566 (100%) n: 240	1539 (100%) n: 396	1307 (100%) n: 322
Headline height <90m	294 (100%) n: 43	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	386 (100%) n: 82	403 (100%) n: 76	2566 (100%) n: 240	1539 (100%) n: 396	1307 (100%) n: 322
Fishing duration >15mins	289 (95%) n: 42	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	386 (100%) n: 82	403 (100%) n: 76	2566 (100%) n: 239	1539 (100%) n: 396	1307 (100%) n: 322
Seabed depth >50m	289 (95%) n: 42	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	386 (100%) n: 82	403 (100%) n: 76	2566 (100%) n: 239	1539 (100%) n: 396	1307 (100%) n: 322
Seabed depth <200m	289 (95%) n: 42	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	386 (100%) n: 82	394 (100%) n: 67	2417 (94%) n: 230	1539 (100%) n: 395	1307 (100%) n: 322
Start time >0	289 (95%) n: 42	100 (100%) n: 34	178 (100%) n: 60	228 (88%) n: 48	386 (100%) n: 82	394 (100%) n: 67	2400 (93%) n: 229	1519 (100%) n: 391	1261 (95%) n: 319
Core fleet selection	268 (88%) n: 39	100 (100%) n: 34	178 (100%) n: 60	228 (88%) n: 48	386 (100%) n: 82	394 (100%) n: 67	2400 (93%) n: 229	1519 (100%) n: 391	1261 (95%) n: 319

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	2365 (100%) n: 435	2171 (100%) n: 428	2177 (100%) n: 464	1501 (100%) n: 271	4646 (100%) n: 669	4978 (100%) n: 563	3725 (100%) n: 480	5772 (100%) n: 485	3096 (100%) n: 312
Fishing speed not null	2363 (100%) n: 434	2171 (100%) n: 428	2176 (100%) n: 463	1501 (100%) n: 271	4646 (100%) n: 669	4978 (100%) n: 562	3725 (100%) n: 480	5772 (100%) n: 485	3096 (100%) n: 311
Start date not null	2363 (100%) n: 434	2171 (100%) n: 428	2176 (100%) n: 463	1501 (100%) n: 271	4646 (100%) n: 669	4978 (100%) n: 562	3725 (100%) n: 480	5772 (100%) n: 485	3096 (100%) n: 311
End date not null	2363 (100%) n: 434	2171 (100%) n: 428	2176 (100%) n: 463	1501 (100%) n: 271	4646 (100%) n: 669	4978 (100%) n: 562	3725 (100%) n: 480	5772 (100%) n: 485	3096 (100%) n: 311
Start depth not null	2363 (100%) n: 433	2046 (94%) n: 405	2171 (100%) n: 460	1476 (100%) n: 267	4285 (92%) n: 634	4879 (100%) n: 542	3705 (100%) n: 478	5512 (100%) n: 469	3096 (100%) n: 311
Headline height not null	2363 (100%) n: 433	2007 (92%) n: 404	2114 (100%) n: 452	1476 (100%) n: 266	4265 (92%) n: 627	4847 (100%) n: 538	3705 (100%) n: 477	5508 (100%) n: 468	3096 (100%) n: 311
Fishing speed >3.5kn	2363 (100%) n: 433	2007 (92%) n: 404	2114 (100%) n: 452	1476 (100%) n: 266	4265 (92%) n: 627	4847 (100%) n: 538	3705 (100%) n: 477	5508 (100%) n: 468	3076 (100%) n: 310
Headline height >15m	2363 (100%) n: 433	2007 (92%) n: 403	2111 (100%) n: 451	1476 (100%) n: 266	4265 (92%) n: 627	4845 (100%) n: 535	3705 (100%) n: 477	5508 (100%) n: 468	3076 (100%) n: 310
Headline height <90m	2363 (100%) n: 433	2007 (92%) n: 403	2111 (100%) n: 451	1454 (100%) n: 265	4265 (92%) n: 626	4845 (100%) n: 535	3705 (100%) n: 477	5508 (100%) n: 468	3076 (100%) n: 310
Fishing duration >15mins	2363 (100%) n: 432	2007 (92%) n: 403	2111 (100%) n: 451	1425 (95%) n: 263	4265 (92%) n: 626	4835 (100%) n: 533	3704 (100%) n: 475	5508 (100%) n: 468	3076 (100%) n: 309
Seabed depth >50m	2363 (100%) n: 432	2005 (92%) n: 401	2086 (100%) n: 450	1425 (95%) n: 263	4264 (92%) n: 625	4835 (100%) n: 532	3704 (100%) n: 475	5504 (100%) n: 467	3076 (100%) n: 309
Seabed depth <200m	2347 (100%) n: 419	1936 (89%) n: 390	2074 (100%) n: 438	1425 (95%) n: 262	4250 (91%) n: 612	4820 (100%) n: 524	3690 (100%) n: 472	5474 (95%) n: 457	3000 (100%) n: 305
Start time >0	2332 (100%) n: 414	1936 (89%) n: 389	2074 (100%) n: 435	1416 (94%) n: 259	4160 (90%) n: 606	4801 (100%) n: 522	3630 (100%) n: 465	5427 (94%) n: 454	2931 (95%) n: 302
Core fleet selection	2332 (100%) n: 414	1936 (89%) n: 389	2023 (93%) n: 416	1416 (94%) n: 259	4160 (90%) n: 606	4801 (100%) n: 522	3465 (93%) n: 434	4420 (77%) n: 379	2925 (94%) n: 293

Filter	2017	2018	2019	2020	2021	2022
Ungroomed data	2640 (100%) n: 238	4601 (100%) n: 346	2822 (100%) n: 302	2942 (100%) n: 329	2320 (100%) n: 205	2359 (100%) n: 241
Fishing speed not null	2638 (100%) n: 236	4601 (100%) n: 346	2822 (100%) n: 302	2942 (100%) n: 328	2299 (100%) n: 201	2359 (100%) n: 240
Start date not null	2638 (100%) n: 236	4601 (100%) n: 346	2822 (100%) n: 302	2942 (100%) n: 328	2299 (100%) n: 201	2359 (100%) n: 240
End date not null	2638 (100%) n: 236	4601 (100%) n: 346	2822 (100%) n: 302	2942 (100%) n: 328	2299 (100%) n: 201	2359 (100%) n: 240
Start depth not null	2605 (100%) n: 234	4587 (100%) n: 345	2822 (100%) n: 302	2879 (100%) n: 323	2177 (94%) n: 195	2026 (86%) n: 204
Headline height not null	2605 (100%) n: 230	4582 (100%) n: 343	2822 (100%) n: 302	2879 (100%) n: 322	2177 (94%) n: 195	2026 (86%) n: 204
Fishing speed >3.5kn	2605 (100%) n: 230	4582 (100%) n: 343	2822 (100%) n: 302	2879 (100%) n: 322	2177 (94%) n: 195	2026 (86%) n: 204
Headline height >15m	2582 (100%) n: 229	4582 (100%) n: 343	2822 (100%) n: 302	2879 (100%) n: 322	2177 (94%) n: 195	2026 (86%) n: 204
Headline height <90m	2582 (100%) n: 229	4582 (100%) n: 343	2822 (100%) n: 302	2879 (100%) n: 322	2177 (94%) n: 195	2026 (86%) n: 204
Fishing duration >15mins	2564 (100%) n: 228	4582 (100%) n: 343	2822 (100%) n: 302	2879 (100%) n: 322	2177 (94%) n: 195	2026 (86%) n: 204
Seabed depth >50m	2564 (100%) n: 228	4573 (100%) n: 342	2822 (100%) n: 302	2879 (100%) n: 322	2177 (94%) n: 195	2026 (86%) n: 204
Seabed depth <200m	2564 (100%) n: 226	4403 (100%) n: 332	2758 (100%) n: 279	2878 (100%) n: 317	2176 (94%) n: 194	2019 (86%) n: 202
Start time >0	2558 (100%) n: 225	4393 (100%) n: 331	2758 (100%) n: 279	2823 (100%) n: 314	2114 (91%) n: 193	2019 (86%) n: 202
Core fleet selection	2428 (92%) n: 211	4393 (100%) n: 323	2674 (95%) n: 266	2823 (100%) n: 314	1630 (70%) n: 138	1990 (84%) n: 189

Table 15: Summary of the JMN7 MW observer dataset after core fleet selection. 'Records' indicates the number of rows (events) in the dataset, and 'Records caught' indicates the percentage of events with catches of jack mackerels.

Fishing year	Vessels	Trips	Records	Hrs	Catch (t)	Records caught
1999	2	2	39	80.15	267.96	76.92
2000	2	2	34	89.50	99.83	88.24
2001	3	4	60	156.45	178.19	85.00
2002	4	4	48	181.12	228.40	79.17
2003	5	5	82	285.33	386.14	87.80
2004	3	3	67	277.55	393.81	73.13
2005	6	8	229	778.45	2 400.03	89.52
2006	6	8	391	1 430.92	1 519.19	89.26
2007	7	15	319	1 200.18	1 260.50	72.41
2008	7	15	414	1 648.47	2 331.50	69.81
2009	6	11	389	1 644.73	1 935.68	84.06
2010	6	10	416	1 848.45	2 023.50	83.17
2011	5	7	259	1 220.35	1 416.43	71.81
2012	6	18	606	3 091.70	4 159.54	81.68
2013	6	28	522	2 615.75	4 800.95	82.38
2014	7	32	434	2 213.28	3 464.87	82.03
2015	7	26	379	1 987.15	4 419.83	82.85
2016	6	23	293	1 480.42	2 925.40	79.52
2017	5	19	211	1 236.70	2 427.90	89.10
2018	7	23	323	2 120.23	4 392.70	76.78
2019	5	18	266	1 554.73	2 673.63	83.08
2020	7	29	314	1 637.30	2 823.50	71.02
2021	7	17	138	845.38	1 630.08	86.23
2022	6	14	189	987.28	1 989.90	86.24

Table 16: Summary of stepwise selection for occurrence of positive catch. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	22.00	6 177	2.30	2.30	*
+ ns(log(start_seabed_depth), 3)	3.00	5 826	7.90	5.70	*
+ stat_area	5.00	5 564	12.30	4.30	*
+ month	11.00	5 468	14.20	1.90	*
+ ns(log(fishing_duration), 3)	3.00	5 445	14.60	0.50	
+ vessel_key	9.00	5 426	15.20	0.60	
+ ns(log(headline_height), 3)	3.00	5 421	15.40	0.20	
+ ns(fishing_speed, 3)	3.00	5 417	15.60	0.20	

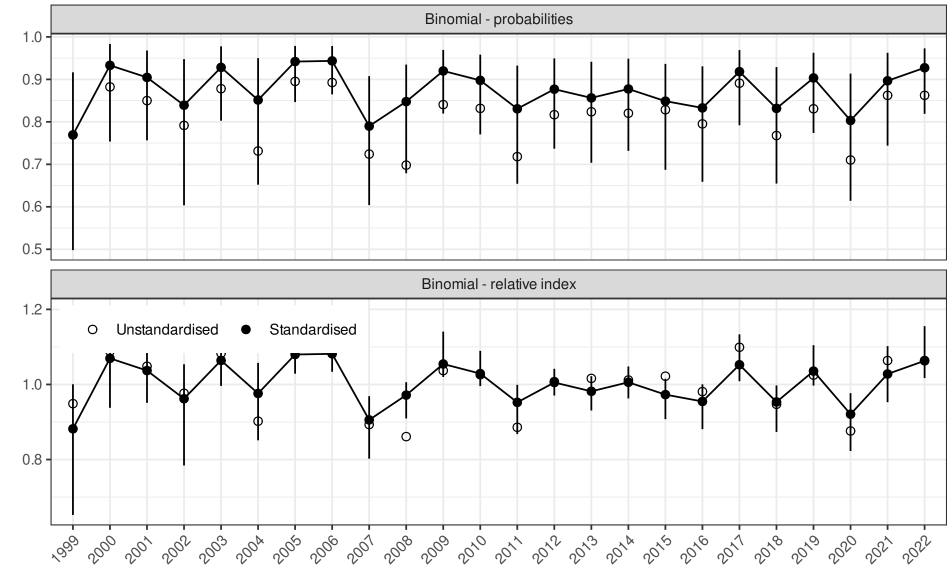

Figure 93: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the JMN7 MW observer dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

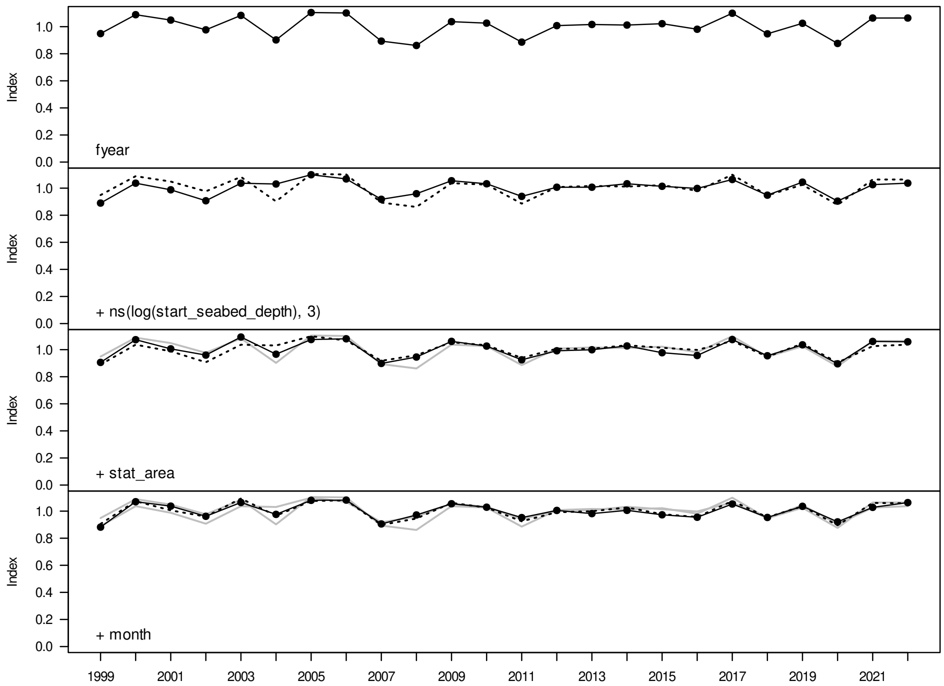

Figure 94: Step plot for occurrence of catch in the JMN7 MW observer dataset.

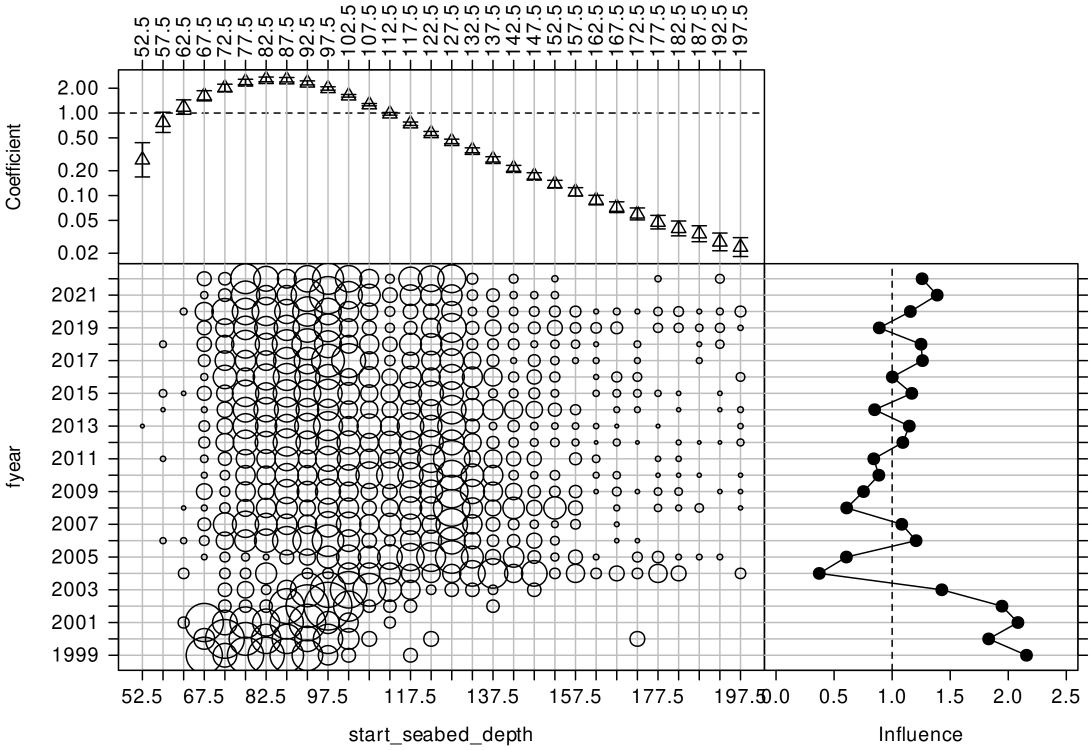

Figure 95: CDI plot for start seabed depth (m) for the occurrence of positive catch JMN7 MW observer catch-per-unit-effort dataset.

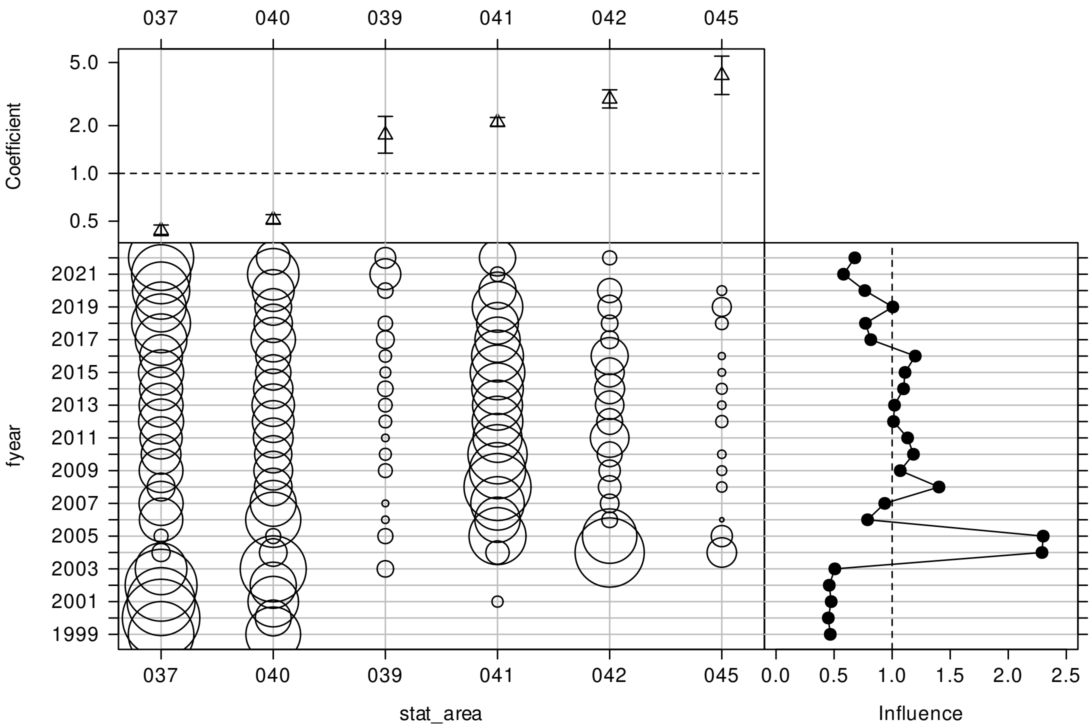

Figure 96: CDI plot for statistical area for the occurrence of positive catch JMN7 MW observer catch-per-unit-effort dataset.

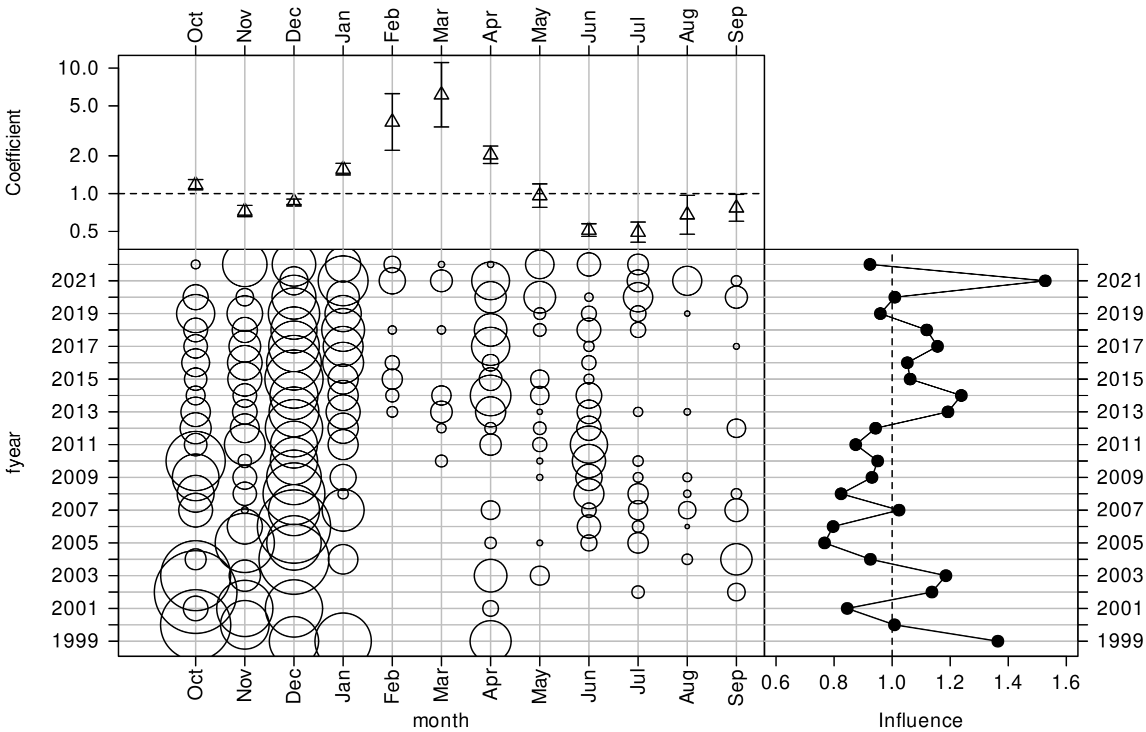

Figure 97: CDI plot for month for the occurrence of positive catch JMN7 MW observer catch-per-unit-effort dataset.

Table 17: Summary of stepwise selection for the Weibull model. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	25	104 627	9.3	9.3	*
+ stat area	5	104 326	14.3	5.0	*
+ month	11	104 104	18.2	3.9	*
+ ns(log(start seabed depth), 3)	3	104 004	19.9	1.7	*
+ ns(log(fishing duration), 3)	3	103 925	21.2	1.4	*
+ ns(log(headline height), 3)	3	103 853	22.5	1.3	*
+ vessel key	9	103 829	23.2	0.7	
+ ns(log(start time), 3)	3	103 823	23.4	0.2	
+ ns(fishing speed, 3)	3	103 819	23.5	0.2	

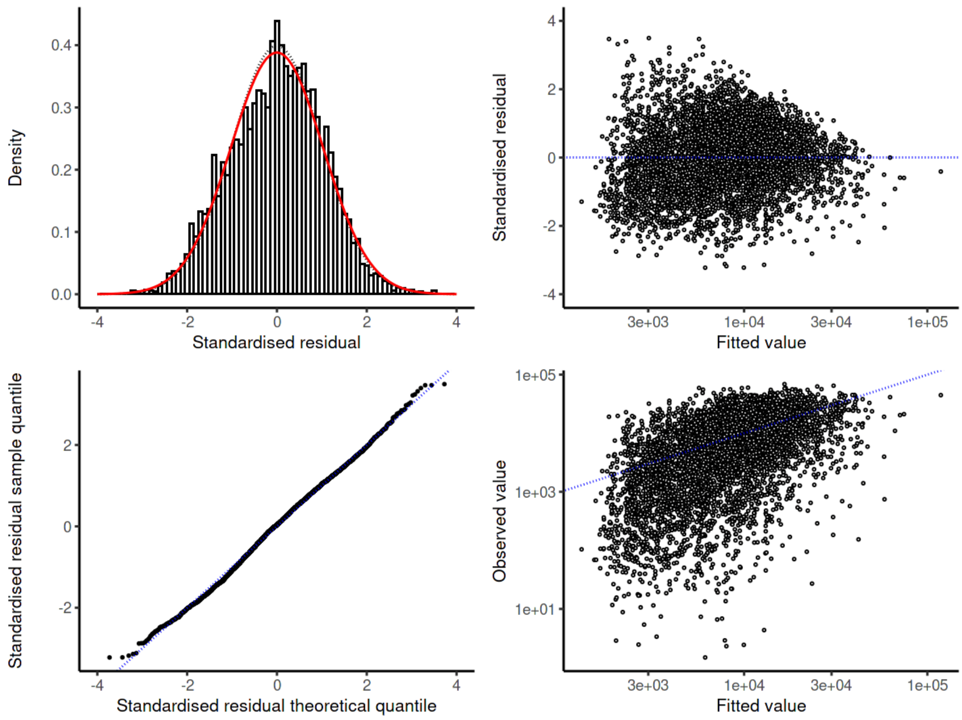

Figure 98: Diagnostic plots for the Weibull model for the JMN7 MW observer dataset.

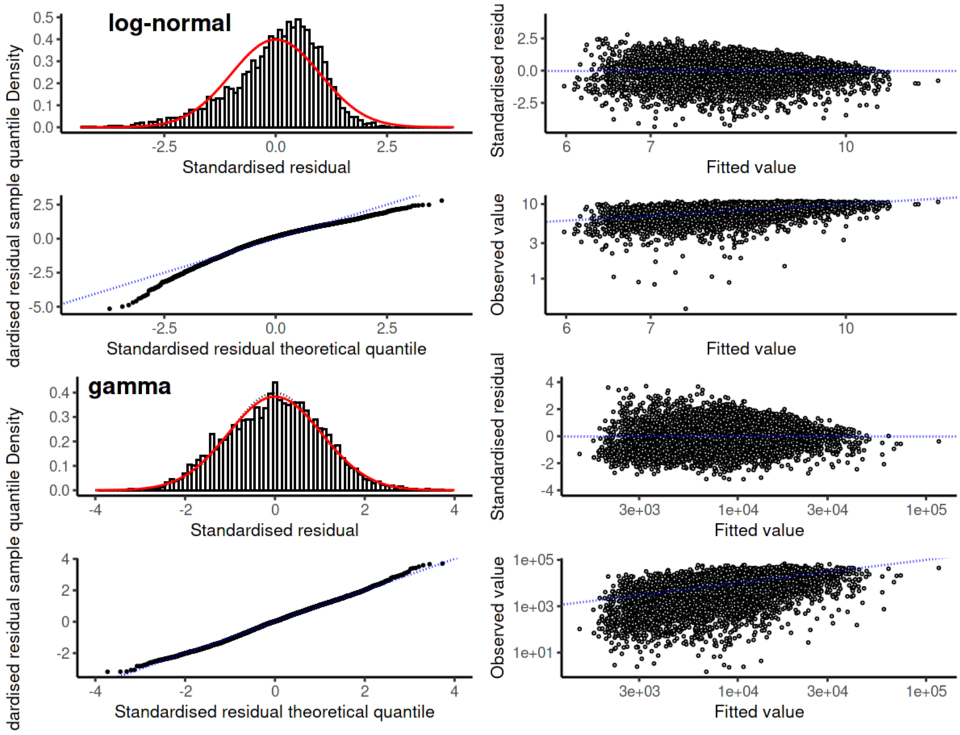

Figure 99: Diagnostic plots for the log-normal and gamma model for the JMN7 MW observer dataset.

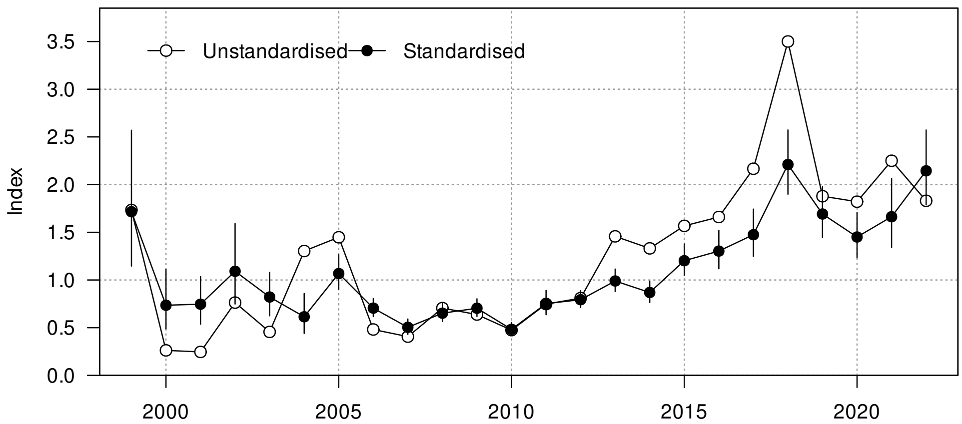

Figure 100: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch in the JMN7 MW observer dataset.

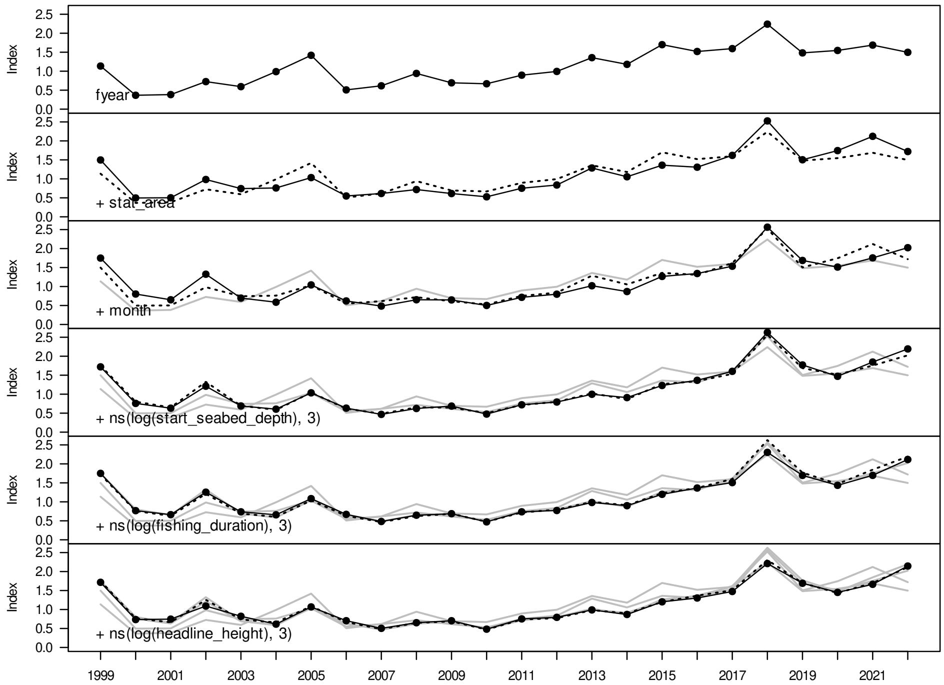

Figure 101: Changes to the JMN7 MW observer positive catch index as terms are successively entered into the model.

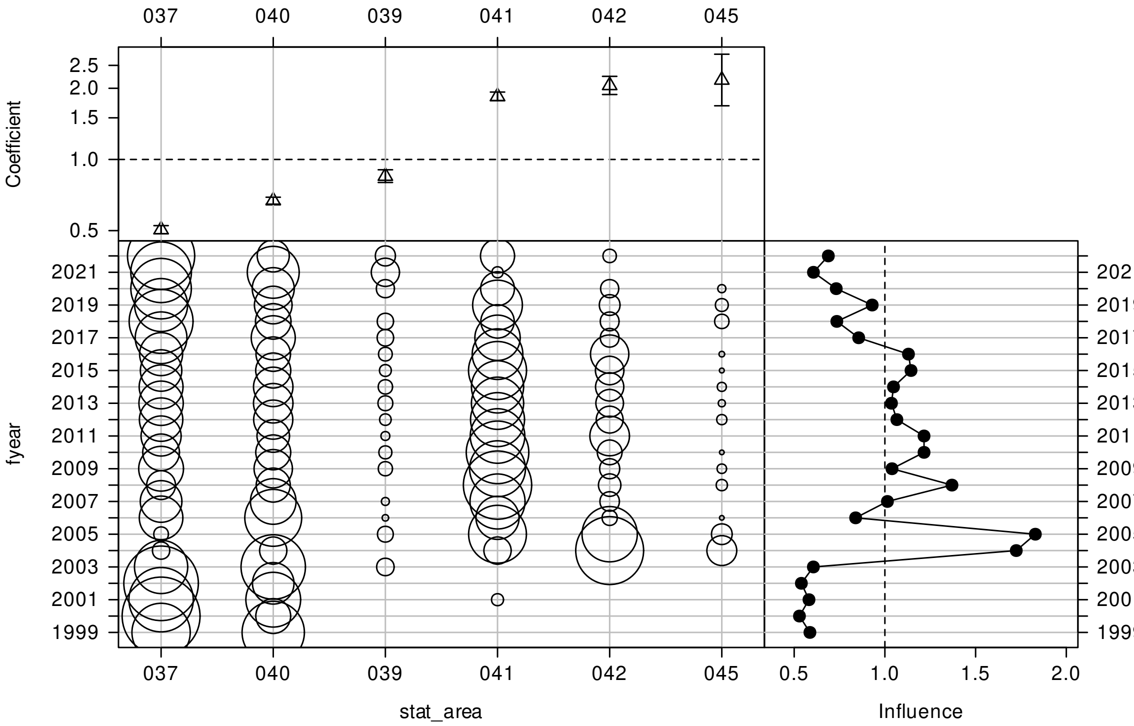

Figure 102: CDI plot for statistical area for the positive catch JMN7 MW observer catch-per-unit-effort dataset.

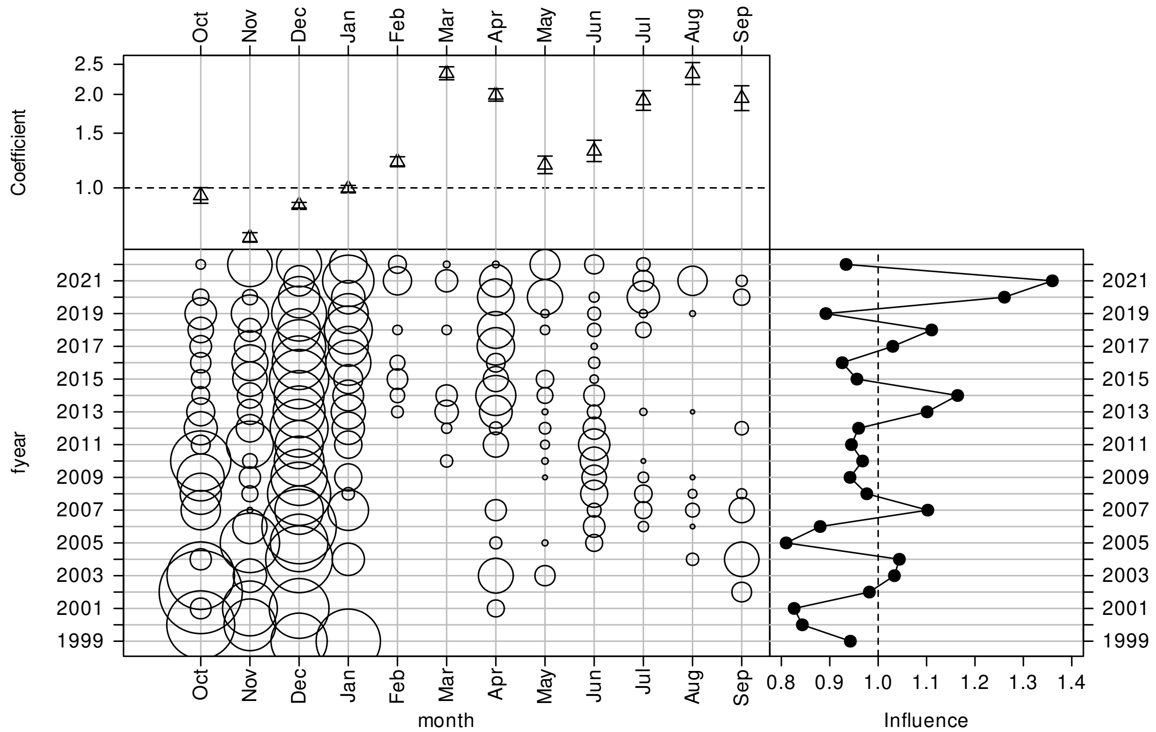

Figure 103: CDI plot for month for the positive catch JMN7 MW observer catch-per-unit-effort dataset.

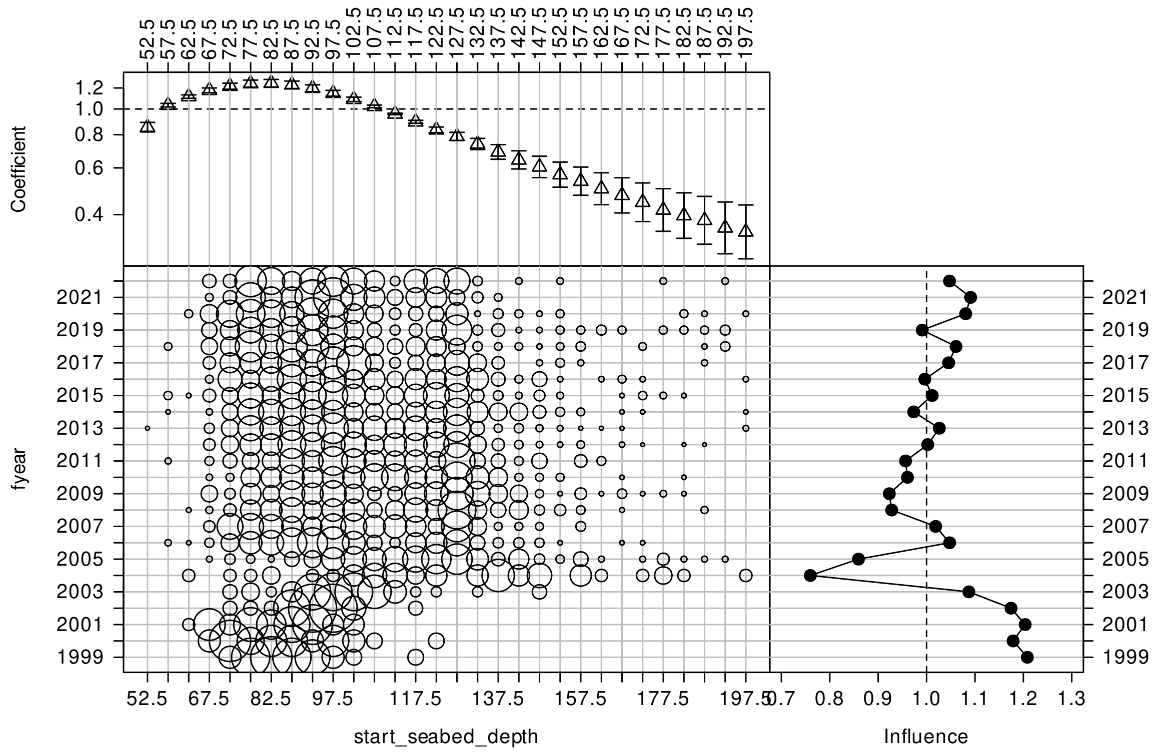

Figure 104: CDI plot for start seabed depth (m) for the positive catch JMN7 MW observer catch-per-unit-effort dataset.

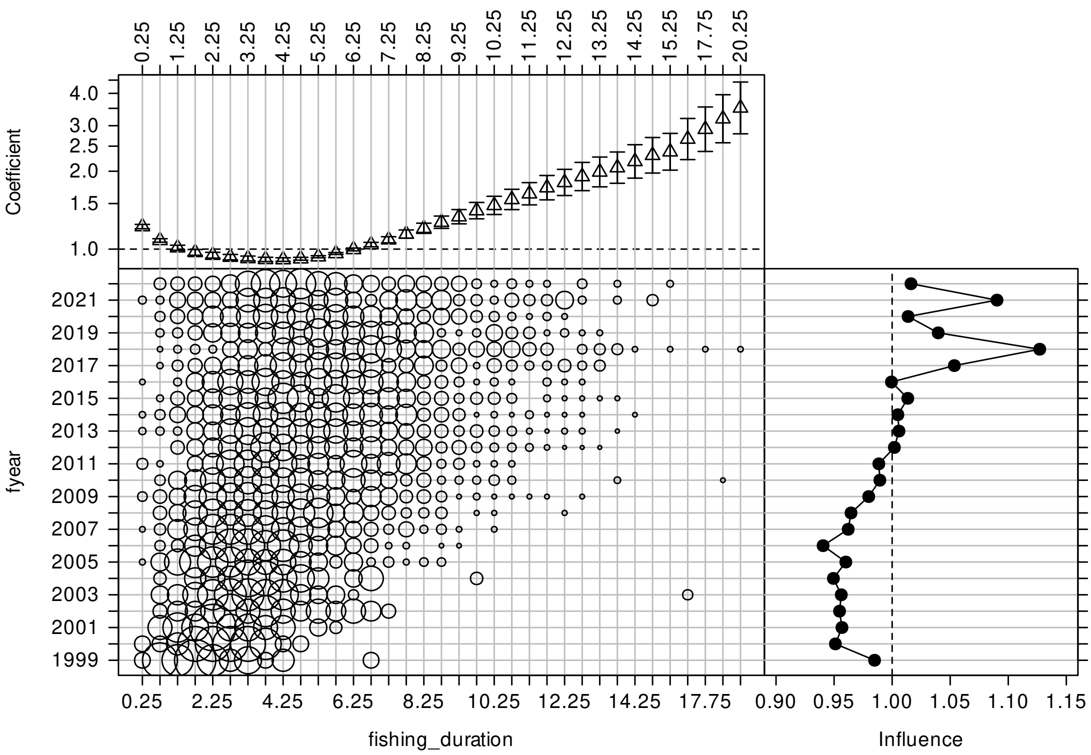

Figure 105: CDI plot for fishing duration (h) for the positive catch JMN7 MW observer catch-per-unit-effort dataset.

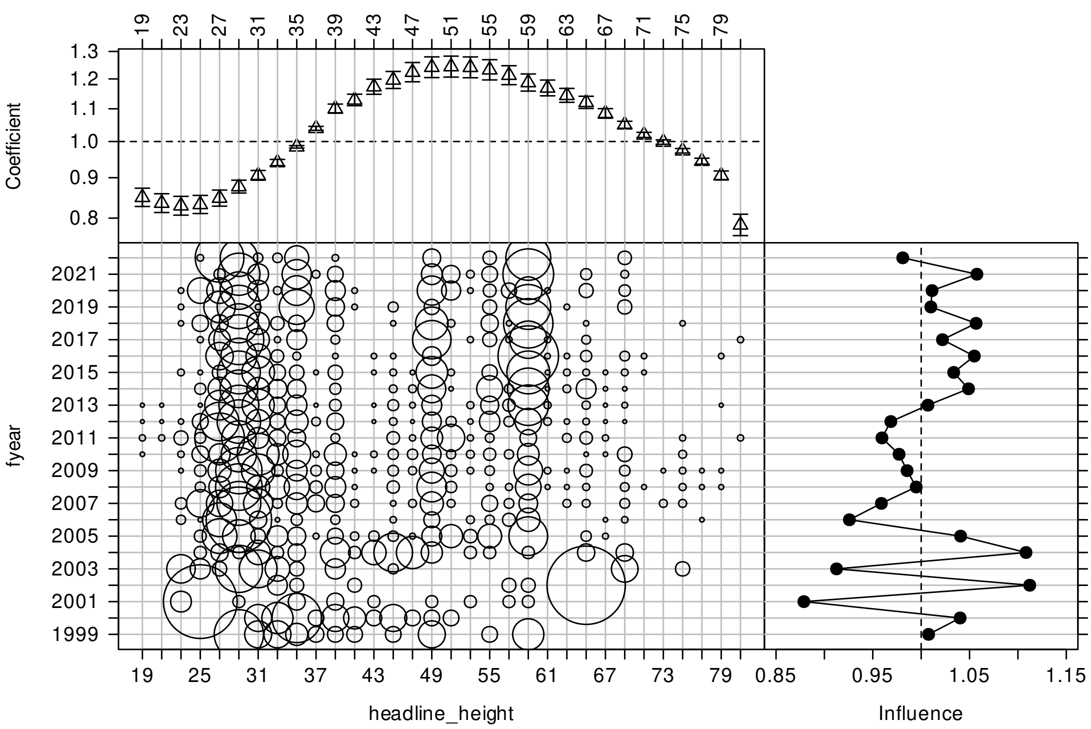

Figure 106: CDI plot for headline height (m) for the positive catch JMN7 MW observer catch-per-unit-effort dataset.

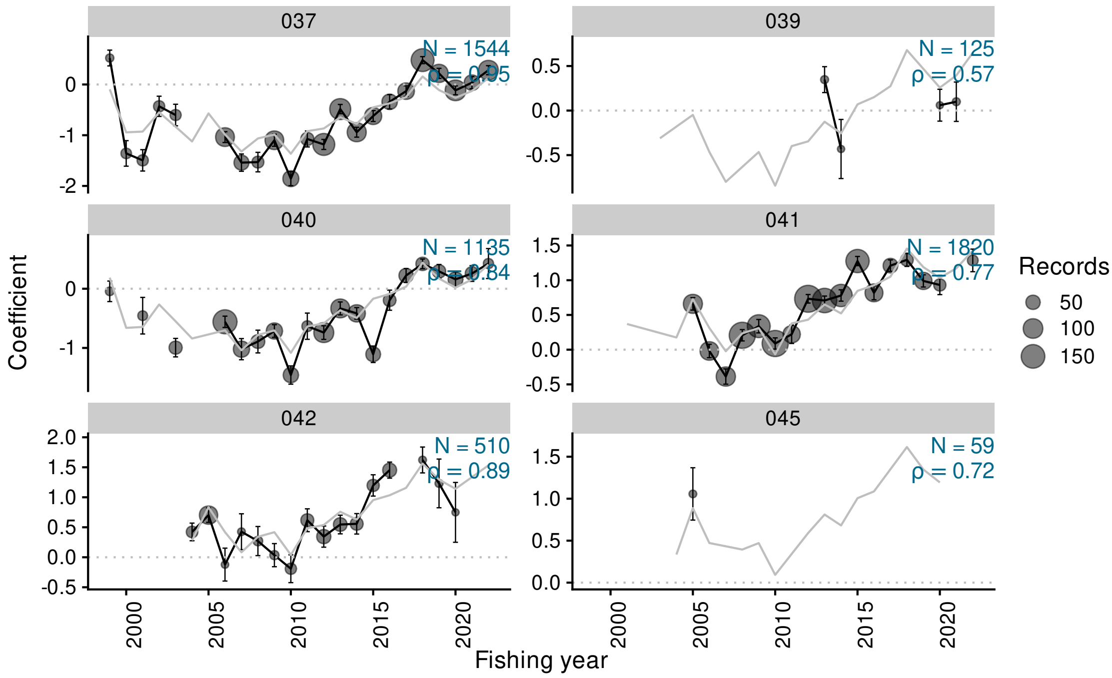

Figure 107: Residual implied coefficients for area-year in the Weibull positive catch model for the JMN7 MW observer dataset.

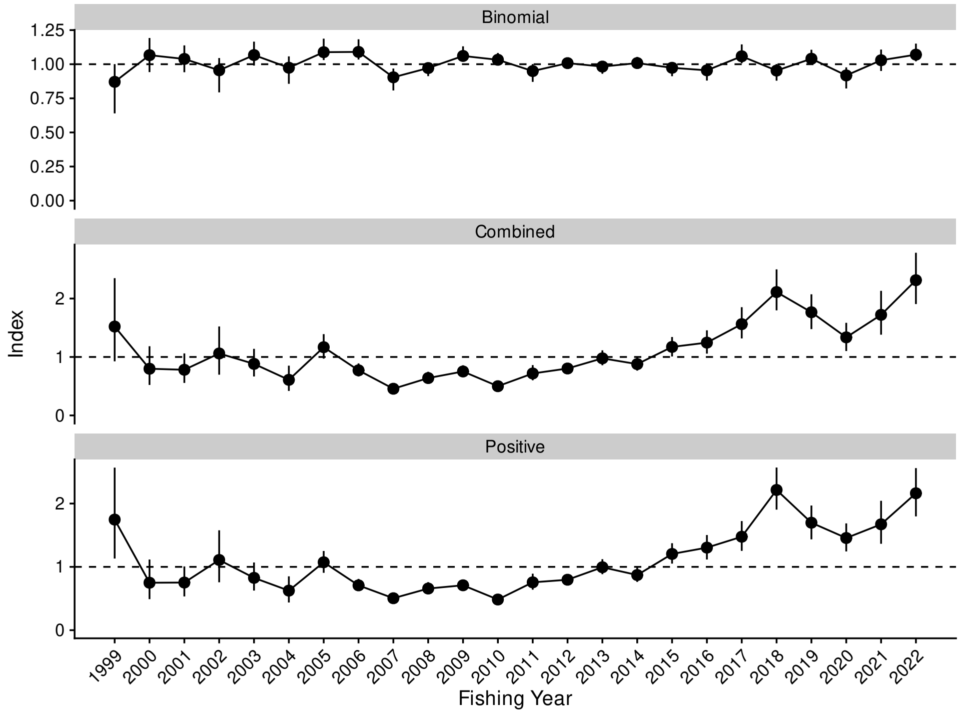

Figure 108: Standardised indices and 95% confidence intervals for the JMN7 MW observer dataset.

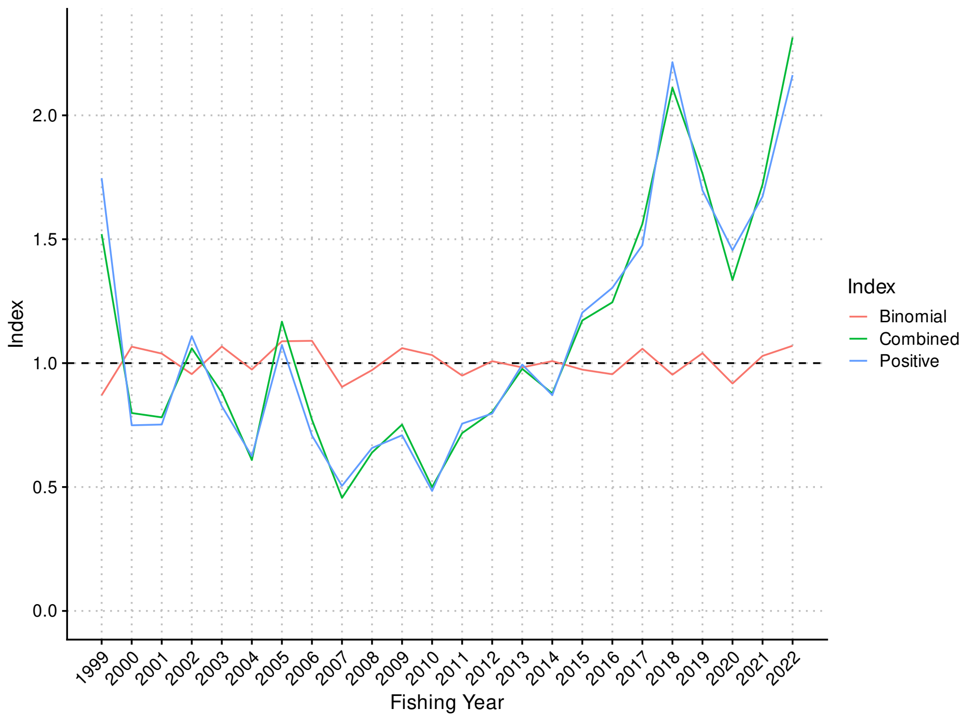

Figure 109: Standardised indices for the JMN7 MW observer dataset.

Table 18: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in JMN7 MW observer.

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
1999	0.871	0.092	0.640	1.001	1.521	0.363	0.926	2.349	1.747	0.366	1.131	2.567
2000	1.066	0.064	0.942	1.192	0.799	0.169	0.521	1.184	0.749	0.160	0.490	1.116
2001	1.039	0.050	0.941	1.138	0.781	0.129	0.556	1.061	0.752	0.121	0.533	1.007
2002	0.956	0.064	0.794	1.045	1.060	0.211	0.697	1.522	1.109	0.209	0.757	1.578
2003	1.067	0.045	0.990	1.165	0.882	0.121	0.666	1.139	0.826	0.113	0.626	1.069
2004	0.974	0.051	0.856	1.057	0.609	0.110	0.419	0.851	0.625	0.105	0.437	0.850
2005	1.088	0.040	1.030	1.187	1.167	0.107	0.972	1.391	1.073	0.088	0.906	1.251
2006	1.090	0.038	1.034	1.183	0.772	0.057	0.667	0.890	0.708	0.048	0.622	0.810
2007	0.904	0.041	0.808	0.968	0.456	0.042	0.376	0.542	0.505	0.038	0.435	0.586
2008	0.972	0.024	0.913	1.006	0.639	0.049	0.553	0.747	0.658	0.048	0.570	0.758
2009	1.061	0.029	1.019	1.131	0.752	0.052	0.655	0.858	0.709	0.045	0.620	0.797
2010	1.032	0.022	0.995	1.082	0.500	0.037	0.433	0.576	0.484	0.035	0.419	0.557
2011	0.950	0.033	0.871	1.001	0.718	0.066	0.601	0.861	0.756	0.065	0.639	0.892
2012	1.008	0.018	0.976	1.044	0.803	0.046	0.715	0.897	0.797	0.043	0.715	0.884
2013	0.983	0.024	0.930	1.023	0.977	0.065	0.859	1.114	0.994	0.060	0.884	1.121
2014	1.008	0.022	0.967	1.053	0.878	0.060	0.766	1.000	0.871	0.058	0.762	0.990
2015	0.974	0.027	0.912	1.016	1.172	0.085	1.008	1.342	1.204	0.082	1.051	1.374
2016	0.955	0.031	0.880	1.002	1.245	0.102	1.057	1.456	1.304	0.099	1.116	1.503
2017	1.058	0.035	1.007	1.145	1.562	0.136	1.317	1.852	1.476	0.120	1.253	1.723
2018	0.953	0.031	0.879	1.001	2.111	0.179	1.798	2.499	2.215	0.170	1.904	2.569
2019	1.040	0.028	0.997	1.106	1.765	0.152	1.477	2.073	1.697	0.136	1.435	1.969
2020	0.918	0.039	0.822	0.977	1.336	0.123	1.102	1.585	1.456	0.113	1.244	1.686
2021	1.029	0.040	0.950	1.107	1.721	0.191	1.381	2.132	1.672	0.173	1.365	2.043
2022	1.070	0.033	1.021	1.151	2.314	0.224	1.906	2.783	2.162	0.195	1.797	2.560

7.3 JMM7 MW observer

The *T. murphyi* CPUE series, JMM7 MW observer, has an identical set-up to the *T. declivis* model, with the exception that the estimated catch of *T. murphyi* is modelled. The core vessel selection again retained a high percentage of the catch (96.7%) and the same 10 vessels (Figure 110) used in the series for the other two species, with a fleet effort pattern identical to the JMD7 MW observer model (Figure 78).

Catch of *T. murphyi* by the core fleet (Table 20) was an order of magnitude lower than that of the two native jack mackerels, but *T. murphyi* were nevertheless reasonably prevalent for much of the series, with catches in 36% to 87% of tows from 1999 to 2019. However, in 2021 and 2022 *T. murphyi* were caught in under 20% of tows by the core fleet.

Stepwise selection for the binomial model retained month, statistical area, and depth (Table 21). Standardisation did not change the trend of the unstandardised index but did flatten the index somewhat in the period from 1999 to 2016 (Figure 111), with month and area having the greatest impact on the indices (Figure 112).

The probability of catching *T. murphyi* was highest from October to January, with the lowest probability of occurrence in March (Figure 113). Occurrence is estimated to be highest at the southern (Statistical Area 034) and northern (Statistical Area 045) extents of the fishery area (Figure 114) with the result that the influence of area is high from 1999 to 2003, and then again from 2017 to 2022. Occurrence of *T. murphyi* is estimated to increase with greater seabed depths, but also at shallower depths, although there are limited data at this end of the distribution (Figure 115).

Stepwise selection for a lognormal model of positive catches retained statistical area, fishing duration and month (Table 22), with diagnostics suggesting the lognormal model fits reasonably well (Figure 116), although a gamma model or Weibull model were similar (Figure 117). There was little impact of standardisation (Figure 118) with all selected covariates having a small impact (Figure 119).

Similarly to the probability of catch occurrence, catch rates of *T. murphyi* were estimated to be highest at the northern and southern extents of the fishery, although Statistical Area 042 was also estimated to have higher catch rates, contributing to high influence in 2004 and 2005 (Figure 120). The impact of fishing duration on catch rates of *T. murphyi* (Figure 121) was similar to that estimated for the two native species. The estimated effect of month was dominated by a very low estimated catch rate in March (Figure 122); however, there were few data in this month.

Residual implied coefficients by statistical area (Figure 123) are generally consistent with the overall trend, although it is notable that the substantial drop in catch rates estimated in 2022 is primarily driven by data from Statistical Area 037.

The final indices showed contrary trends in the binomial and positive catch models, with a decreasing trend in the binomial model from 2010 to 2022 but an increasing trend in positive catch from 2011 to 2021, before a marked decrease in 2022 (Figure 124, Figure 125, Table 23). A combined index was therefore much flatter, other than in 2001 when both component indices show a peak that was amplified in the combined index. The drop in the 2022 index was also consistent between the binomial and positive catch models, although with very different trends prior to that point.

Table 19: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the JMM7 MW observer CPUE series.

Series	JMM7 MW observer
QMS stock	JMA7
Reporting forms	
Fishing methods	MW
Target species	JMA, JMD, JMM, JMN
Statistical Areas	034, 035, 036, 037, 039, 040, 041, 042, 045, 801
Period	1998-10-01, 2022-09-30
Resolution	Observed event
Core fleet years	4
Core fleet trips	1
Default model	jmmkg ~ fyear + vessel_key + month + stat_area + ns(log(fishing_duration), 3) + ns(log(start_time), 3) + ns(log(start_seabed_depth), 3) + ns(log(headline_height), 3) + ns(fishing_speed, 3)
Stepwise selection	Yes
Positive catch distribution	Lognormal

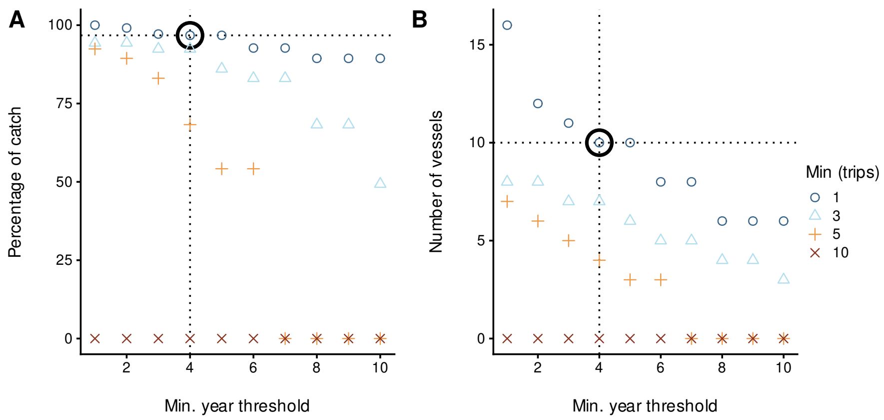

Figure 110: Percentage of catch and number of vessels for different core vessel selection criteria for the JMM7 MW observer CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel was observed in the fishery and the number of observed trips per year.

Table 20: Summary of the JMM7 MW observer dataset after core fleet selection. 'Records' indicates the number of rows (events) in the dataset, and 'Records caught' indicates the percentage of events with catches of jack mackerels.

Fishing year	Vessels	Trips	Records	Hrs	Catch (t)	Records caught
1999	2	3	76	165.32	66.31	56.58
2000	2	2	52	137.25	66.23	78.85
2001	4	6	70	184.40	203.41	87.14
2002	5	5	63	221.45	31.97	36.51
2003	5	5	101	365.42	55.31	64.36
2004	4	4	79	333.28	69.97	72.15
2005	6	9	249	847.98	303.40	63.86
2006	6	8	403	1 479.25	362.97	73.70
2007	7	15	415	1 505.27	167.80	53.98
2008	7	16	495	1 925.52	574.37	62.02
2009	7	15	492	2 046.68	611.53	70.93
2010	6	10	445	1 957.63	452.16	65.17
2011	6	8	298	1 368.33	147.33	49.33
2012	6	20	652	3 372.07	537.12	52.61
2013	6	31	606	2 907.90	460.18	40.76
2014	7	32	598	2 795.87	683.82	41.47
2015	7	32	478	2 361.98	732.49	48.95
2016	6	29	344	1 611.68	988.10	59.30
2017	6	25	282	1 483.97	357.56	37.59
2018	7	30	411	2 455.30	828.56	39.17
2019	5	23	349	1 854.87	719.11	43.27
2020	7	30	384	1 995.42	562.93	23.18
2021	7	19	191	1 080.73	255.80	16.23
2022	6	16	276	1 301.97	45.21	15.94

Table 21: Summary of stepwise selection for occurrence of positive catch. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	22.00	10 058	7.50	7.50	*
+ month	11.00	9 090	16.70	9.10	*
+ stat_area	9.00	8 689	20.50	3.90	*
+ ns(log(start_seabed_depth), 3)	3.00	8 574	21.70	1.10	*
+ vessel_key	9.00	8 557	22.00	0.30	
+ ns(log(start_time), 3)	3.00	8 548	22.10	0.10	
+ ns(log(fishing_duration), 3)	3.00	8 541	22.30	0.10	

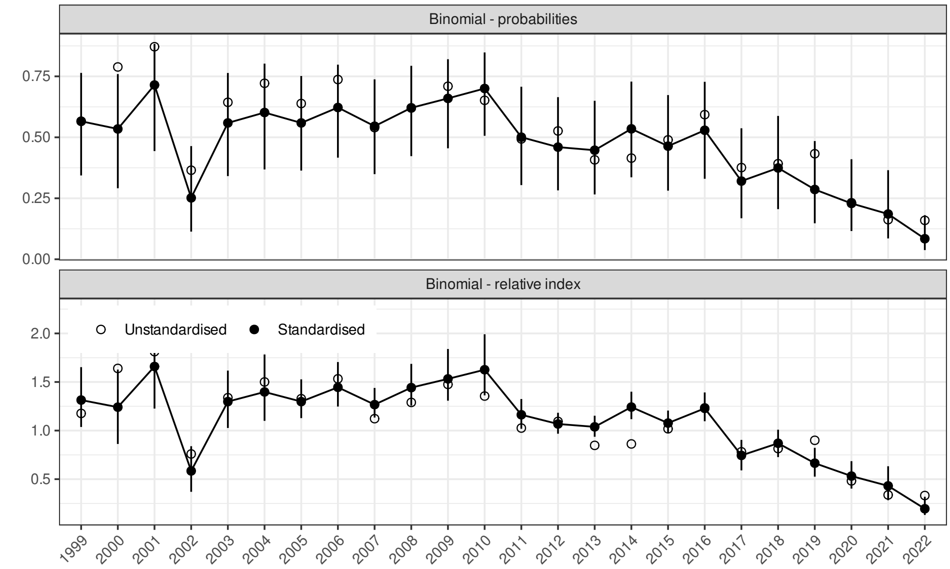

Figure 111: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the JMM7 MW observer dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

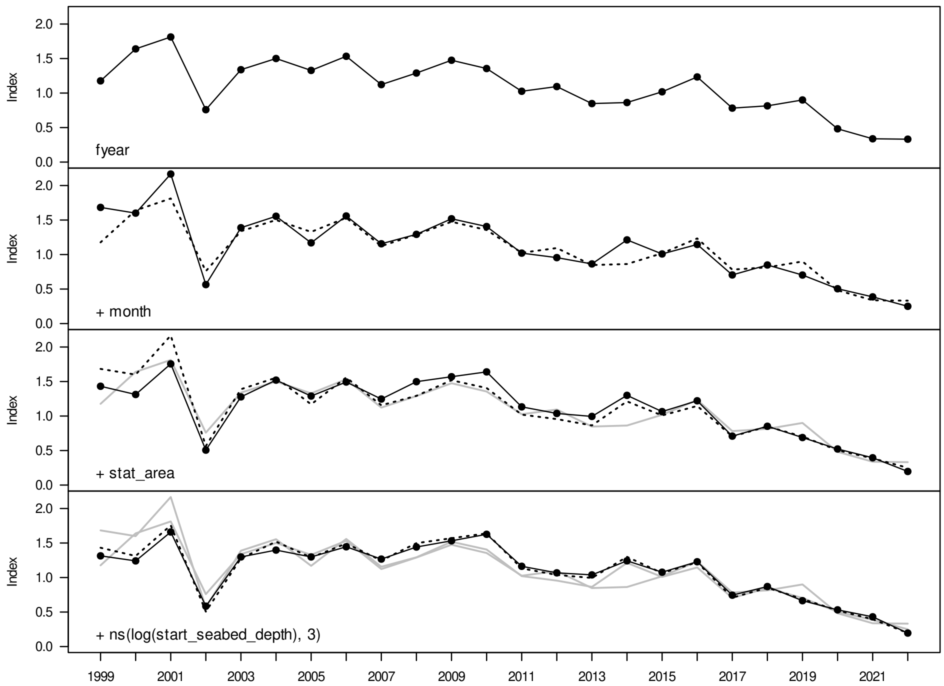

Figure 112: Step plot for occurrence of catch in the JMM7 MW observer dataset.

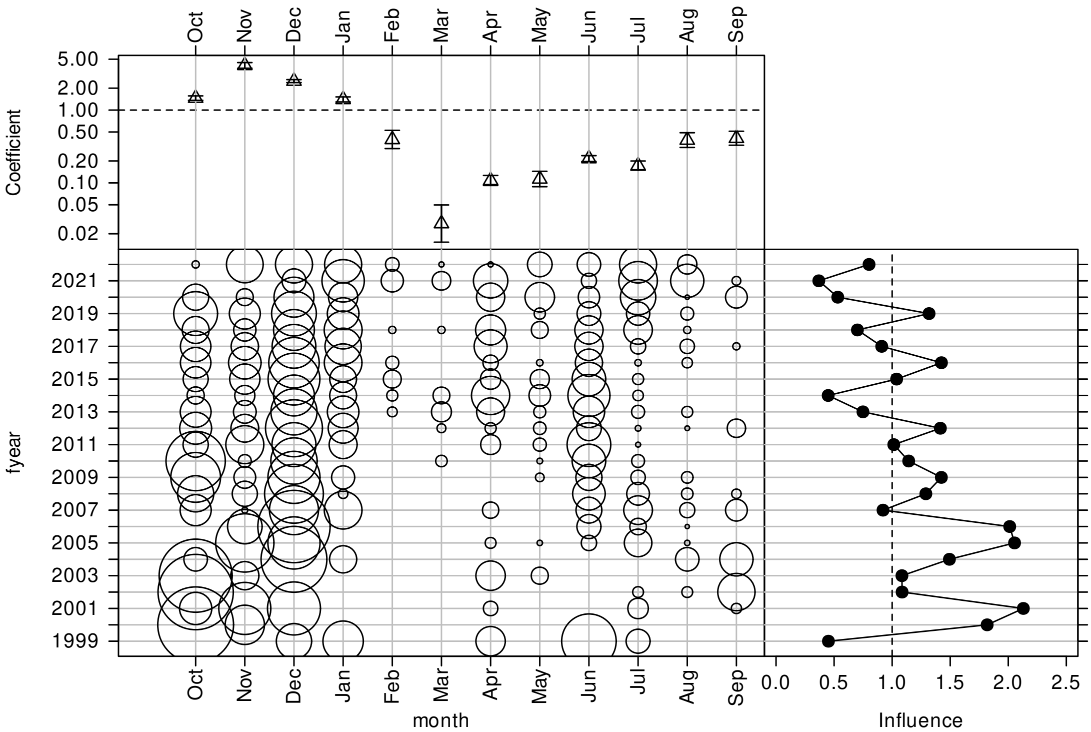

Figure 113: CDI plot for month for the occurrence of positive catch JMM7 MW observer catch-per-unit-effort dataset.

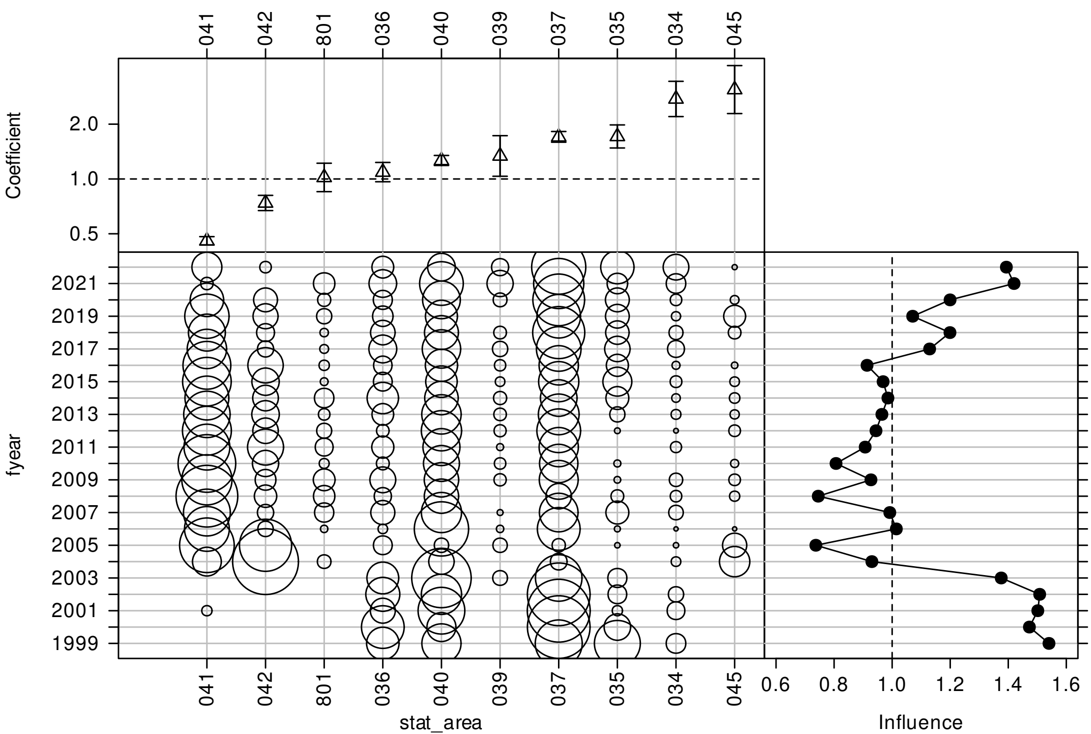

Figure 114: CDI plot for statistical area for the occurrence of positive catch JMM7 MW observer catch-per-unit-effort dataset.

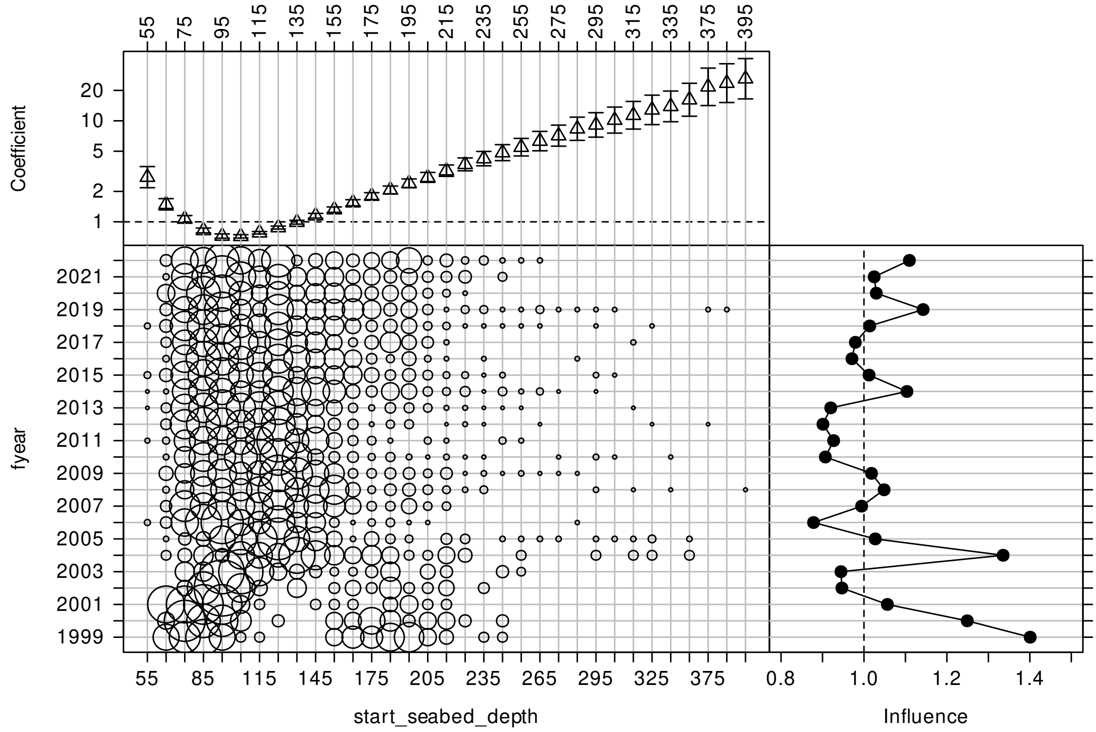

Figure 115: CDI plot for start seabed depth (m) for the occurrence of positive catch JMM7 MW observer catch-per-unit-effort dataset.

Table 22: **Summary of stepwise selection for the lognormal model. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.**

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	22	13 334	15.1	15.1	*
+ stat area	9	13 191	18.5	3.4	*
+ ns(log(fishing duration), 3)	3	13 126	20.0	1.5	*
+ month	11	13 059	21.8	1.8	*
+ ns(log(start seabed depth), 3)	3	13 042	22.2	0.5	
+ ns(log(headline height), 3)	3	13 032	22.5	0.3	
+ vessel key	9	13 026	23.0	0.5	
+ ns(log(start time), 3)	3	13 025	23.2	0.1	

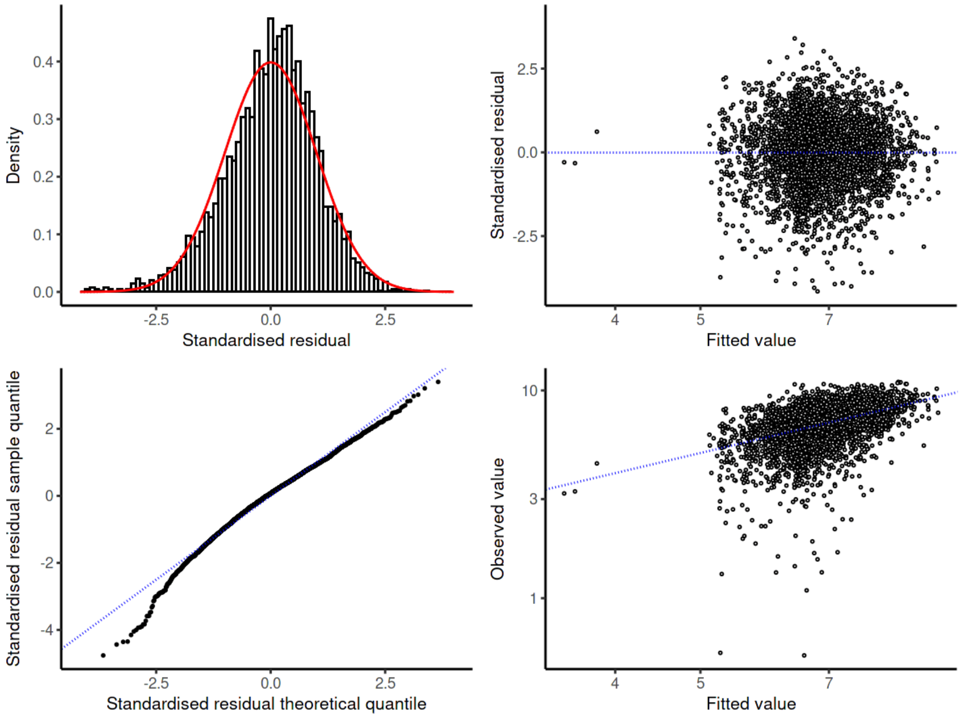

Figure 116: Diagnostic plots for the lognormal model for the JMM7 MW observer dataset.

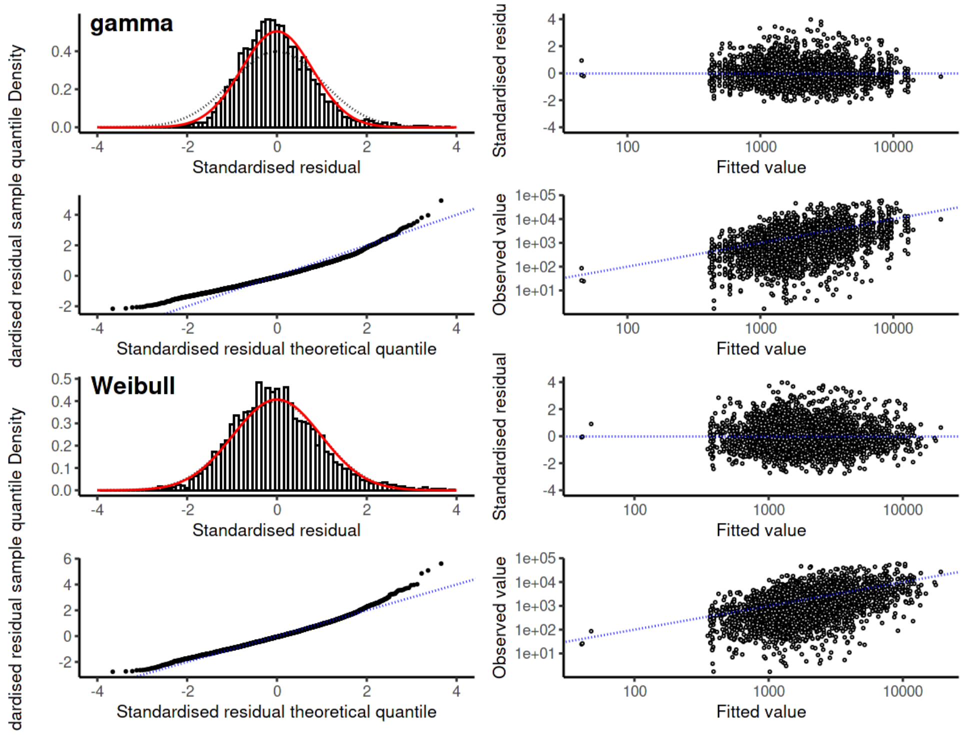

Figure 117: Diagnostic plots for the gamma and Weibull model for the JMM7 MW observer dataset.

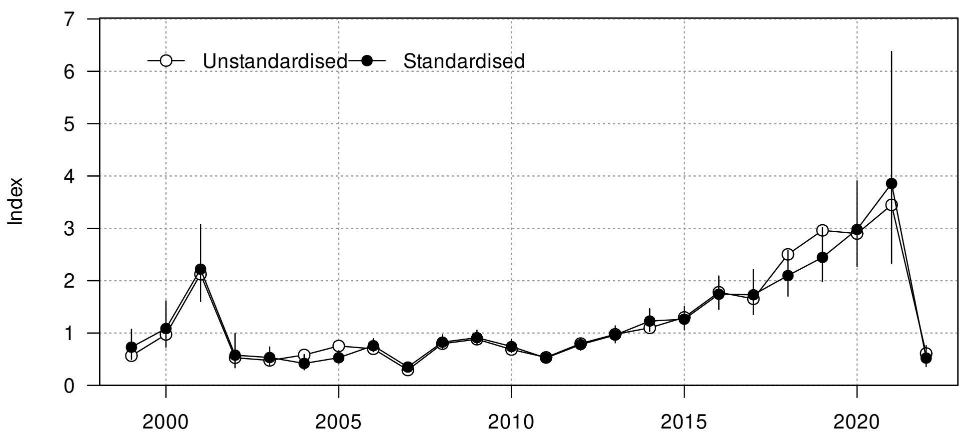

Figure 118: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch in the JMM7 MW observer dataset.

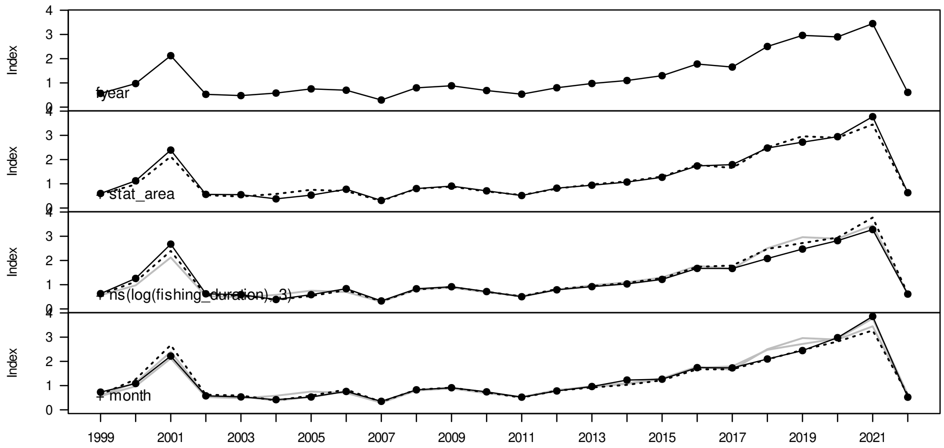

Figure 119: Changes to the JMM7 MW observer positive catch index as terms are successively entered into the model.

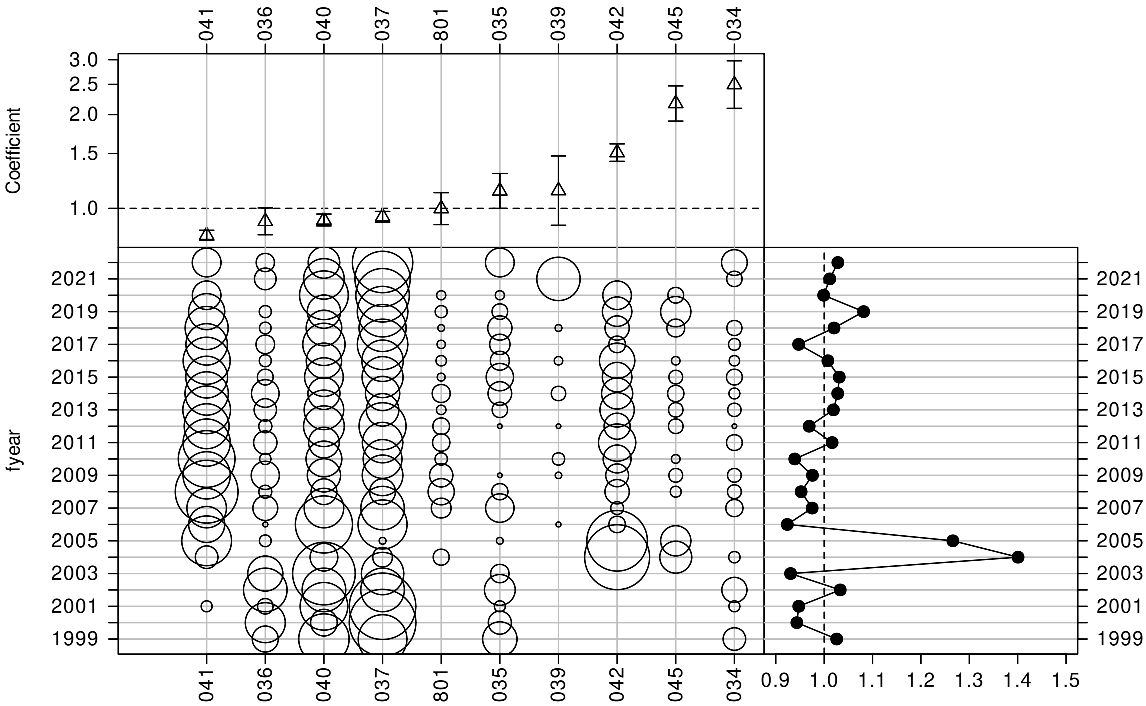

Figure 120: CDI plot for statistical area for the positive catch JMM7 MW observer catch-per-unit-effort dataset.

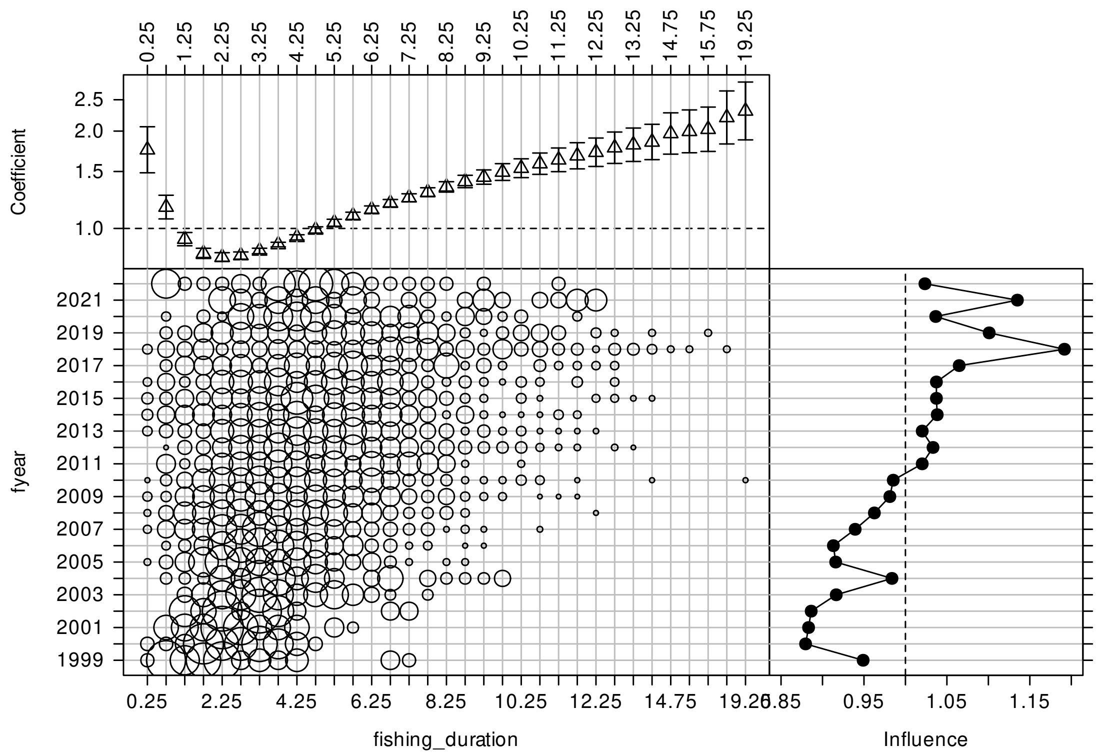

Figure 121: CDI plot for fishing duration (h) for the positive catch JMM7 MW observer catch-per-unit-effort dataset.

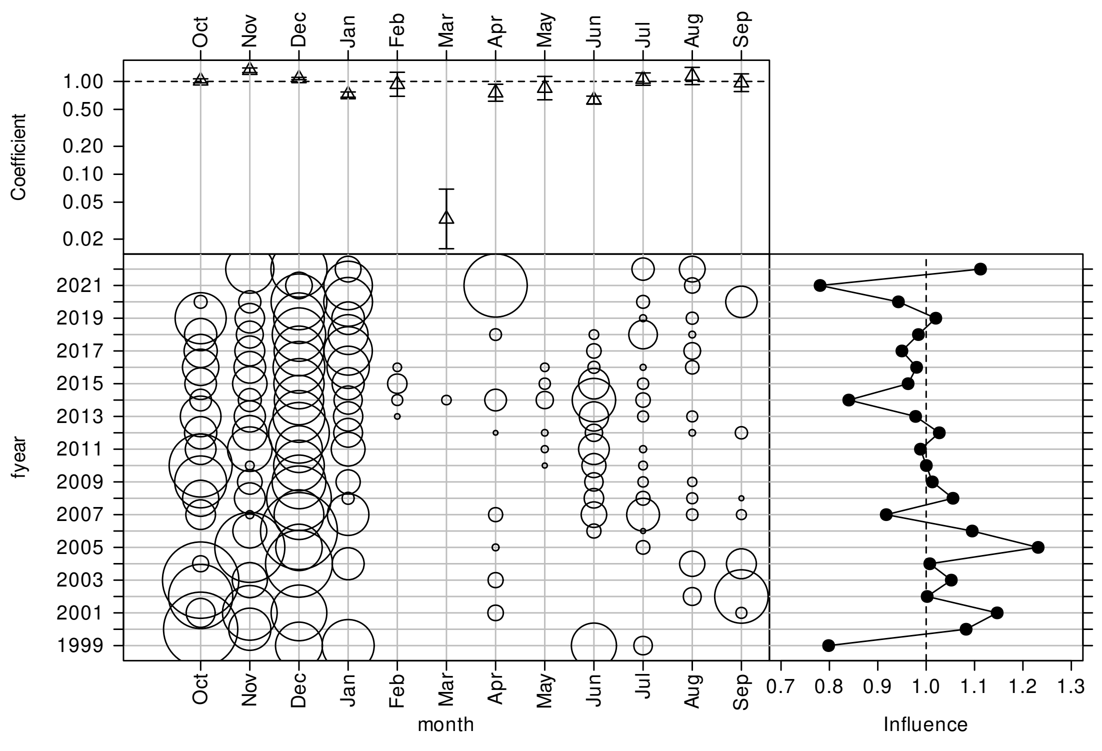

Figure 122: CDI plot for month for the positive catch JMM7 MW observer catch-per-unit-effort dataset.

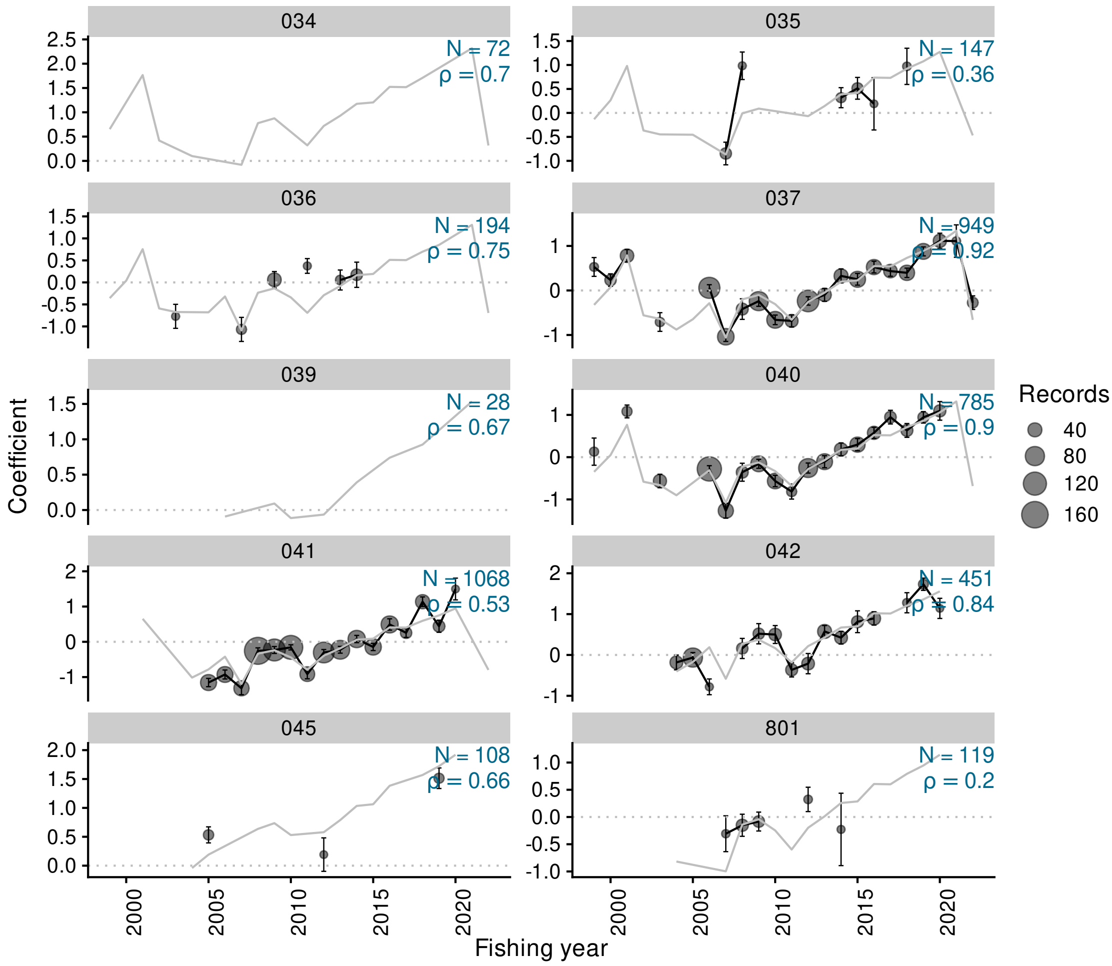

Figure 123: Residual implied coefficients for area-year in the lognormal positive catch model for the JMM7 MW observer dataset.

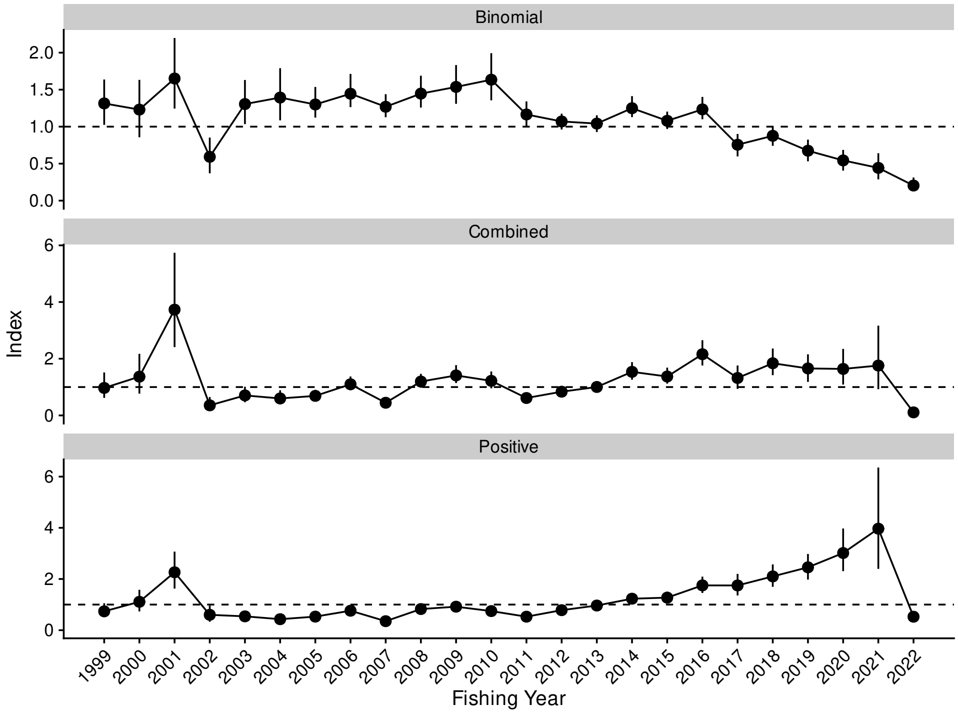

Figure 124: Standardised indices and 95% confidence intervals for the JMM7 MW observer dataset.

Figure 125: Standardised indices for the JMM7 MW observer dataset.

Table 23: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in JMM7 MW observer.

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
1999	1.314	0.156	1.025	1.637	0.969	0.229	0.618	1.516	0.736	0.138	0.511	1.053
2000	1.231	0.198	0.857	1.632	1.367	0.358	0.767	2.172	1.109	0.215	0.733	1.578
2001	1.651	0.243	1.244	2.198	3.731	0.849	2.410	5.738	2.262	0.369	1.624	3.069
2002	0.592	0.123	0.370	0.853	0.355	0.124	0.161	0.647	0.600	0.161	0.328	0.959
2003	1.305	0.152	1.035	1.631	0.705	0.139	0.465	1.011	0.541	0.084	0.387	0.714
2004	1.393	0.180	1.086	1.790	0.599	0.126	0.394	0.887	0.430	0.077	0.304	0.605
2005	1.300	0.106	1.122	1.537	0.689	0.097	0.523	0.903	0.530	0.059	0.423	0.653
2006	1.445	0.114	1.264	1.713	1.098	0.123	0.890	1.373	0.760	0.061	0.652	0.890
2007	1.269	0.079	1.128	1.439	0.446	0.048	0.360	0.549	0.352	0.030	0.294	0.412
2008	1.447	0.110	1.258	1.689	1.195	0.125	0.976	1.466	0.826	0.066	0.708	0.967
2009	1.537	0.134	1.309	1.833	1.411	0.161	1.141	1.774	0.918	0.071	0.790	1.066
2010	1.635	0.163	1.356	1.993	1.219	0.151	0.956	1.549	0.746	0.059	0.638	0.868
2011	1.165	0.086	1.003	1.342	0.614	0.076	0.476	0.776	0.527	0.053	0.433	0.641
2012	1.070	0.054	0.961	1.175	0.837	0.073	0.700	0.985	0.782	0.054	0.679	0.890
2013	1.042	0.058	0.927	1.154	1.003	0.099	0.822	1.209	0.963	0.082	0.810	1.130
2014	1.250	0.072	1.129	1.413	1.537	0.158	1.259	1.880	1.230	0.103	1.040	1.444
2015	1.079	0.060	0.968	1.204	1.372	0.144	1.122	1.685	1.271	0.111	1.073	1.508
2016	1.233	0.077	1.100	1.402	2.158	0.228	1.761	2.654	1.750	0.163	1.454	2.092
2017	0.756	0.077	0.598	0.901	1.321	0.211	0.935	1.761	1.748	0.215	1.357	2.200
2018	0.876	0.068	0.741	1.007	1.840	0.240	1.420	2.360	2.101	0.223	1.694	2.570
2019	0.675	0.075	0.532	0.825	1.657	0.248	1.183	2.156	2.456	0.255	1.977	2.978
2020	0.544	0.071	0.406	0.686	1.640	0.321	1.088	2.346	3.015	0.425	2.306	3.973
2021	0.443	0.090	0.288	0.641	1.759	0.572	0.926	3.166	3.966	1.010	2.396	6.356
2022	0.204	0.047	0.129	0.313	0.107	0.031	0.060	0.183	0.526	0.096	0.358	0.736

7.4 CPUE comparisons and sensitivities

A range of sensitivities and comparative CPUE analyses were undertaken, and detailed diagnostics for the additional series are included in Appendix C.

7.4.1 Tow duration

A steady increase in the reported duration of tows from 1999 to 2011 was apparent in the datasets for the observer event-level CPUE analyses (see Figures 87, 105, and 121). This feature was one of the few aspects of the operation of the midwater fishery that showed much change after current fishing patterns became established in the mid-2000s. To verify that the change was real, rather than an artefact of a change in data recording by observers, the commercial catch and effort data were examined.

The duration of tows reported in the commercial data was investigated using the dataset prepared for the JMA7 MW event CPUE series (detailed in Appendix C.1). The fisher reported data showed a similar trend, with tow durations increasing from 1999 to 2011, remaining stable until 2020, and then showing a slight decrease to 2022 (Figure 126a). As a result of the increased durations of individual tows, there is a corresponding slight decrease in the average number of tows undertaken in each day of fishing (Figure 126b). The seven vessels that operated in the JMA 7 fishery for at least ten years all show similar trends in reported tow durations (Figure 127). There was evidence, however, that the increased durations were predominantly from the Taranaki Bight areas of the fishery (Figure 128), with flatter trends in the southern parts of the fishery (Statistical Areas 034 and 035).

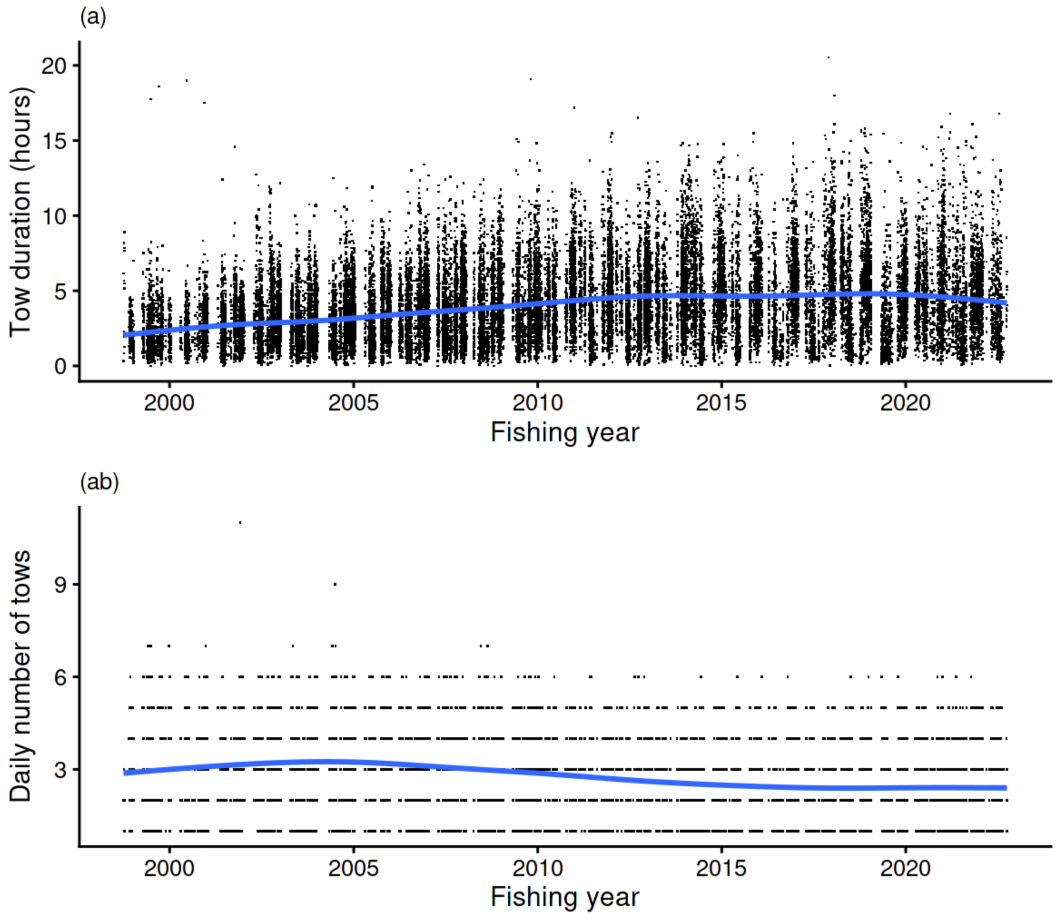

Figure 126: Tow durations reported in the fisher-reported (commercial) effort data from the JMA 7 fishery, using the JMA7 MW event CPUE dataset (see Appendix C.1).

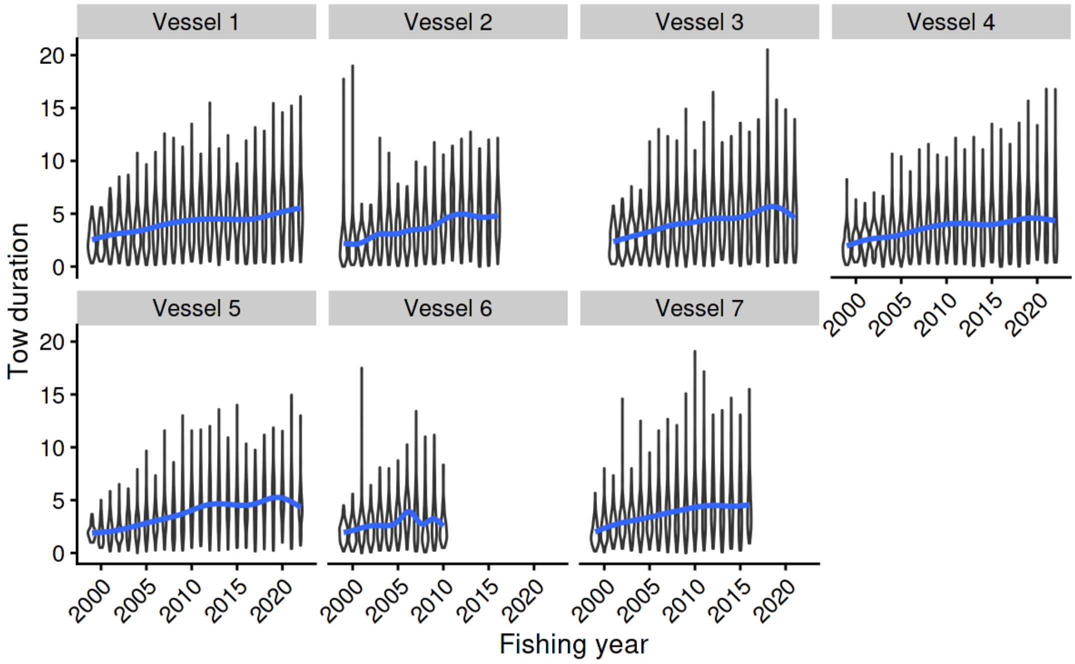

Figure 127: Tow durations reported in the fisher-reported (commercial) effort data for individual vessels that operated in the JMA 7 fishery for at least ten years.

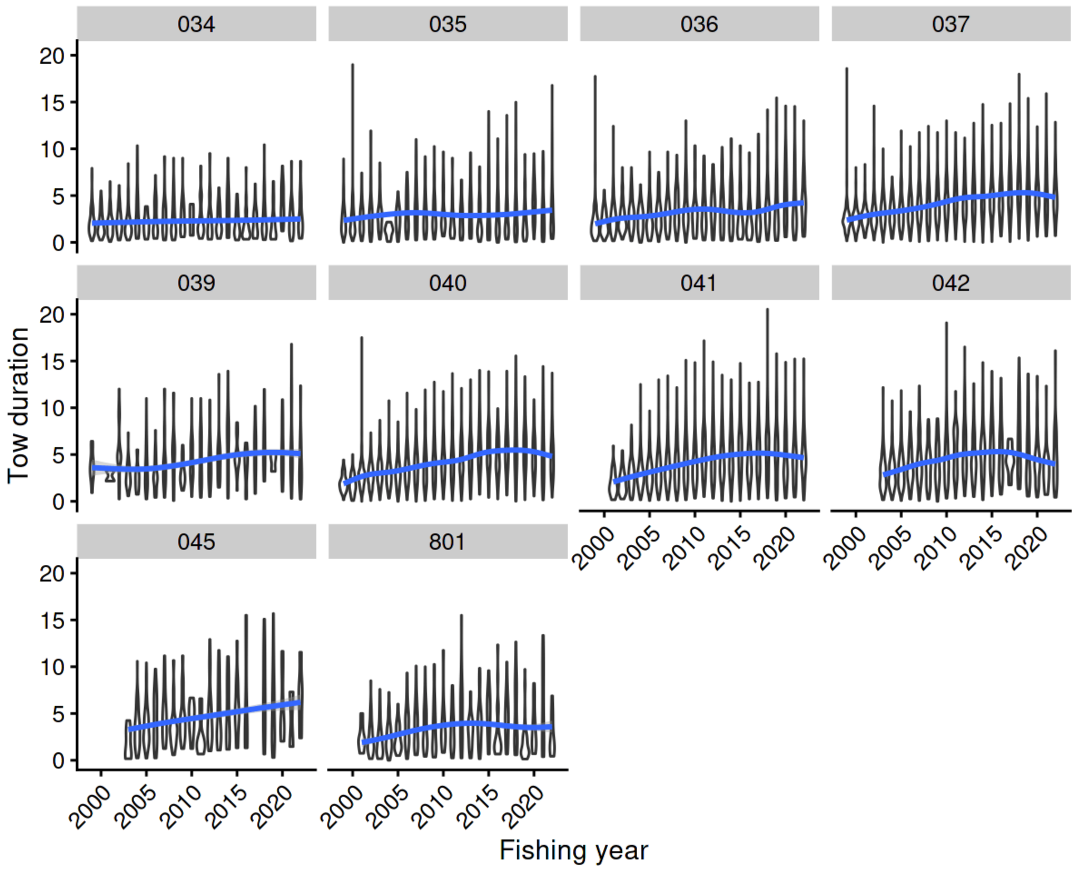

Figure 128: Tow durations reported in the fisher-reported (commercial) effort data for different statistical areas, from 1999 to 2022.

7.4.2 Observer sampling bias?

A key concern discussed by the Deepwater Working Group was whether the use of an observer dataset that only included tows where length-frequency sampling had been carried out could potentially introduce bias into the indices. It is axiomatic that jack mackerels must have been caught in order for a length-frequency sample to have been taken. As a result, zero catches may be less prevalent than would otherwise be the case although, as the fishery is a target fishery for jack mackerels, zero catches are expected to be rare. Furthermore, because the overall jack mackerel catch is decomposed into estimated catches of the individual species, it is still possible for zero catches of an individual species to occur from tows with a catch of jack mackerels and a length-frequency sample.

Most length-frequency samples of jack mackerels were from tows where at least one tonne of jack mackerels were caught (Figure 129), and unsampled tows occurred across the range of catch quantities. When jack mackerels were targeted there was no indication that smaller sample sizes were particularly taken from lower volume tows, although smaller samples occurred in this situation when jack mackerels were not targeted.

Annual density distributions for the jack mackerel catch in observed tows, with and without a jack mackerel length-frequency sample, are illustrated in Figure 130. A lack of sampling from the tows with the smallest catch quantities was apparent; however sampling was undertaken over the majority of catch sizes. The annual median catch size was lower in unsampled tows but showed a similar trend over time to that in sampled tows.

It was possible to assess whether the subset of tows with length-frequency samples result in differing CPUE trends from the complete set of tows, but only where the aggregate catch of jack mackerels (i.e., not separated by species) was modelled. Additional CPUE series were constructed for:

- the total catch of jack mackerels using the comprehensive fisher-reported data (JMA7 MW event; Appendix C.1)
- the total catch of jack mackerels in the subset of tows recorded by Fisheries New Zealand observers, using observer data (JMA7 MW observer; Appendix C.2); and
- the total catch of jack mackerels in observed tows with length-frequency samples (JMA7 MW observer LF; Appendix C.3)

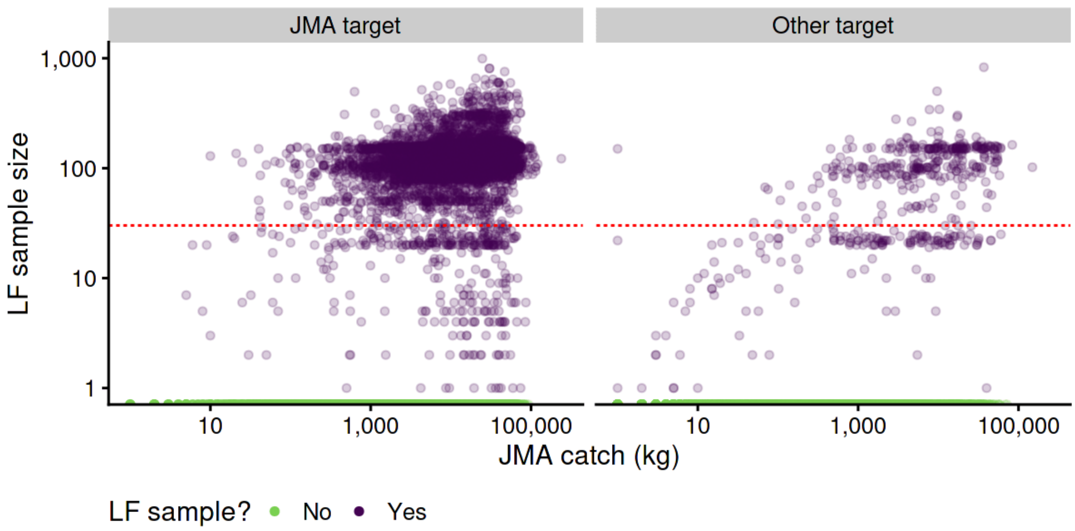

Figure 129: Length-frequency sample sizes (number of fish sampled) in relation to the total jack mackerel catch from a tow, for jack mackerel target tows, and other target species.

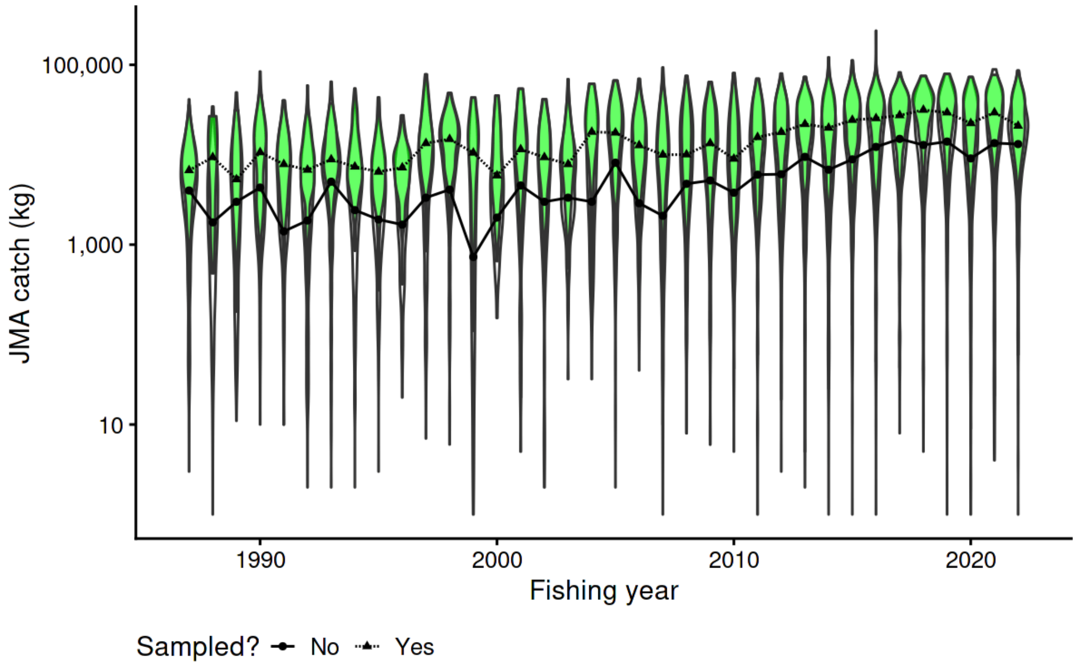

Figure 130: Density distribution of catch quantities of sampled (green filled violin plots) and unsampled (unfilled plots) tows where jack mackerels were caught. The median annual catch in sampled and unsampled tows is also indicated by the points and lines.

All these series used target jack mackerel effort by the midwater trawl fleet, modelled at the event-level (i.e., using tow-by-tow data).

The index using observed tows with length-frequency samples is necessarily a positive catch only index. For the wider observer dataset a positive catch index was also produced because some years had jack mackerel catch in all tows, and there was little indication of a trend in occurrence. The positive indices for the three series are compared in Figure 131. While some annual indices (e.g., 2003 and 2005) showed more marked differences, the two series using observer data were generally very similar, especially with respect to overall trend. The CPUE series using the fisher-reported data also showed a similar overall trend but was less variable in the period from 1999 to 2011, potentially reflecting the lower observer coverage in the earlier part of the period.

A comparison of the positive catch observer index with the combined index from the series constructed with fisher-reported data showed little difference in trend over the series (Figure 132), but the combined indices in 2021 and 2022 were slightly elevated by an increase in the binomial index (Figure C.28).

The Deepwater Working Group, with the endorsement of the Stock Assessment Plenary meeting, concluded that significant bias in the individual CPUE indices was unlikely, given the distribution of sampling and the fact that combined jack mackerel catch indices showed little difference in trend for the full fishery and observer data subsets. In future, a model-based approach for species composition could be used to estimate species composition in unsampled tows.

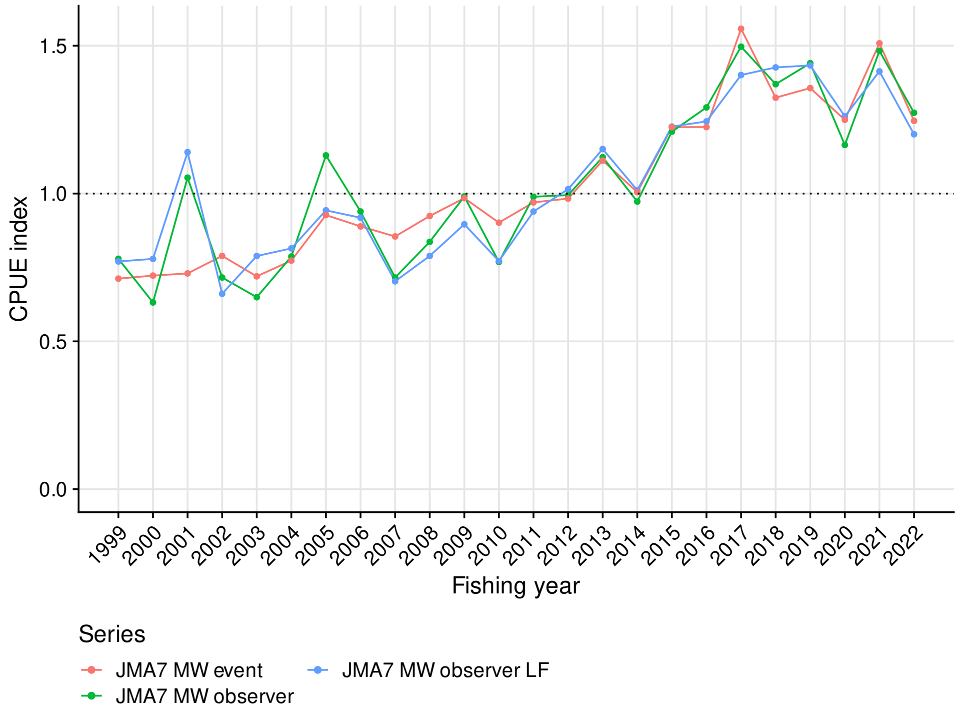

Figure 131: Comparison of the positive indices for the JMA7 MW event, JMA7 MW observer, and JMA7 MW observer LF series.

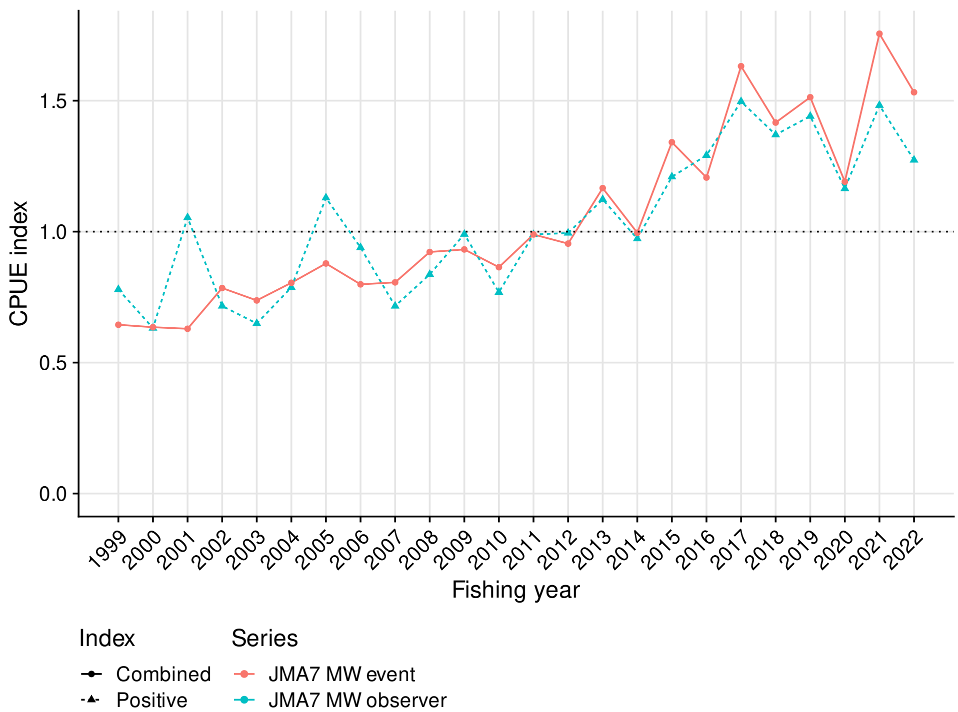

Figure 132: Comparison of the positive index for the JMA7 MW observer series with the combined index from the JMA7 MW event series.

7.4.3 Sampling data quality

As discussed in the Introduction, an initial concern was that misidentification of the different jack mackerels—evident in some observer data—may impact on the CPUE indices. The investigations in Section 5 tended to suggest that misidentified fish, while present in much of the observer data, were sufficiently infrequent to be considered a second-order effect in some analyses. While misidentified fish were probably influential on growth curve estimation, they did not appear to have substantial influence on the key features of annual length-frequency distributions.

A range of sensitivity CPUE analyses were carried out with filtered datasets, to establish whether there were any significant changes in the key trends from the analyses. The sensitivities focussed on the CPUE series for the two native species:

- omitting tows with small (< 30 fish) length-frequency samples (JMD7 MW observer no small samples, Appendix C.4; and JMN7 MW observer no small samples; Appendix C.5)
- omitting data from trips where misidentified fish were indicated by the mixture modelling (JMD7 MW observer no trip misID; Appendix C.6; and JMN7 MW observer no trip misID, Appendix C.7); and
- including data only from trips with age-length data, and where the mixture modelling did not indicate misidentified fish (JMD7 MW observer zero misID, Appendix C.8; and JMN7 MW observer zero misID, Appendix C.9)

All these sensitivities involve reducing the dataset available for CPUE modelling. The omission of data from trips with misidentified fish only affects trips where aged otoliths are available. Because otolith sampling was limited prior to 2005 (Figure 54), the early part of the CPUE dataset is unaffected by this filter. Similarly, at the time this sensitivity was carried out, ageing data were only available to 2020. A more demanding sensitivity was to include only those trips where age-length data were available *and* where the mixture modelling did not indicate any misidentified fish; however, the resulting dataset is limited to the 2007 to 2020 periods.

Results for both *T. declivis* (Figure 133) and *T. novaezelandiae* (Figure 134) demonstrated that the application of these data quality filters had little impact on the key trends in the annual indices. The omission of small length-frequency samples had a negligible impact on the indices. The omission of data from trips with misidentified fish resulted in more substantial changes in some annual indices, although the main effect was an increase in the interannual variation in the indices rather than any change in overall trend. Both of these latter sensitivities represented a reasonably stringent approach to data quality, dropping complete trips if any misidentified fish were indicated (or retaining only trips with no misidentified fish). A less stringent filtering of the data would clearly be possible (e.g., only omitting tows with misidentified fish); however, the fact that the more stringent approach resulted in no significant change in trend suggested this need not be pursued further.

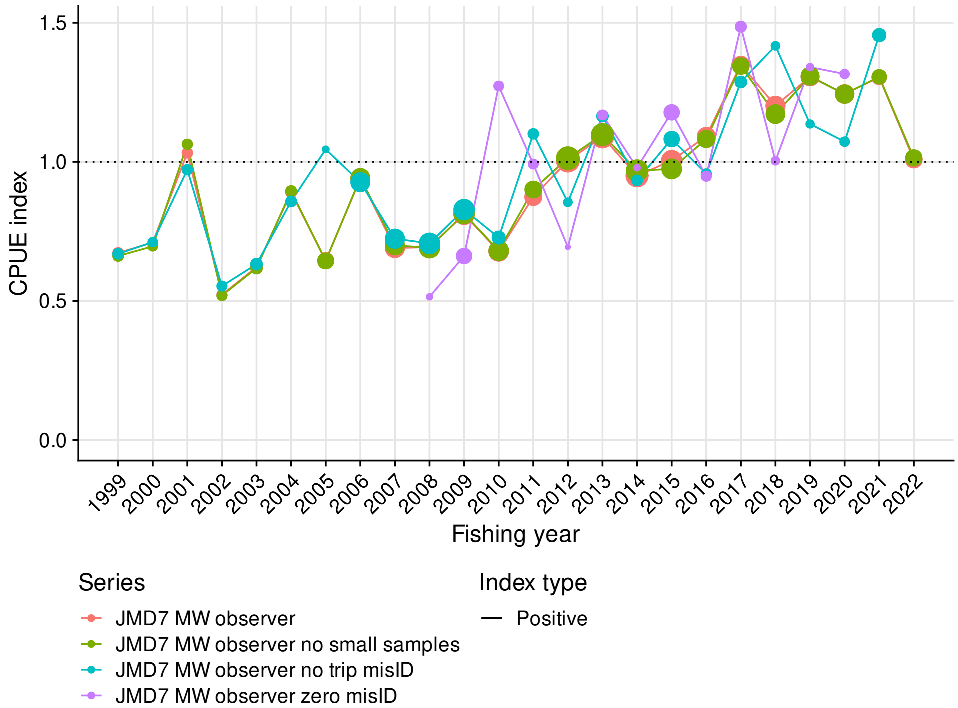

Figure 133: Positive catch CPUE indices for *T. declivis* with different data-quality filters applied to the dataset (see text), in comparison to the primary JMD7 MW observer series. The size of the plotted points is scaled proportionally to the number of data records, and the series are standardised to have a geometric mean of one for the years in common.

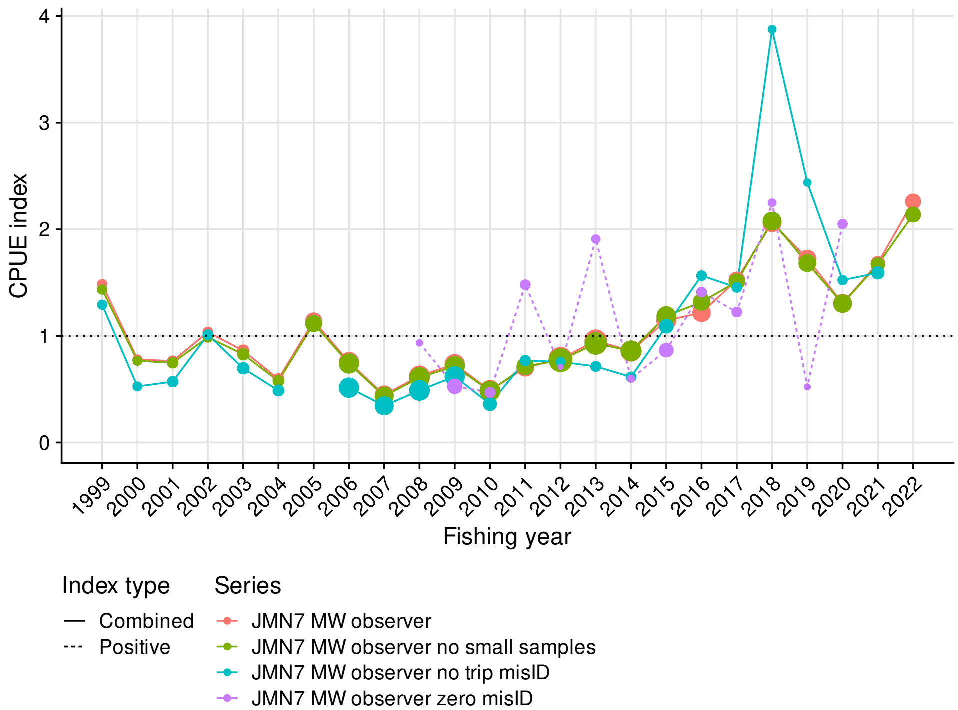

Figure 134: Positive catch CPUE indices for *T. novaezelandiae* with different data-quality filters applied to the dataset (see text), in comparison to the primary JMN7 MW observer series. The size of the plotted points is scaled proportionally to the number of data records, and the series are standardised to have a geometric mean of one for the years in common.

7.4.4 Effort creep

Further sensitivities addressed the hypothesis of 'effort creep', the possibility that vessels in the fishery tended to become more efficient over time. The primary CPUE analyses estimated vessel effects that were constant over time. In the case of the three primary analyses for jack mackerel taken by the midwater fishery, vessel effects were not retained by the stepwise selection process. This is relatively unusual for CPUE analyses of New Zealand fisheries and presumably reflects the fact that the west coast midwater fleet comprises generally similar vessels (most are near identical or in fact true sister-ships), that also have similar crewing arrangements.

Investigating the possibility that vessel effects had changed over time was implemented by artificially dividing the data from a vessel into multiple pseudo-vessels; vessels were split when they had been in the fishery for seven years. Sensitivity CPUE analyses are reported here for *T. declivis* (JMD7 MW observer split vessels; Appendix C.10) and *T. novaezelandiae* (JMN7 MW observer split vessels; Appendix C.11) using data to the 2021 fishing year. The sensitivity CPUE analyses resulted in annual indices that had similar overall trends to the primary analyses (Figure 135, Figure 136) although the sensitivity indices, particularly for *T. novaezelandiae*, tended to have a somewhat flatter trend.

After stepwise selection of covariates, vessel was included in the sensitivity CPUE series: for the positive index for *T. declivis* (Table C.52), and for both the binomial and positive catch indices for *T. novaezelandiae* (Table C.57, Table C.58). However, the estimated coefficients did not consistently suggest an increase in vessel efficiency. In some cases vessel coefficients did increase over time (for example, the pseudo-vessels 2410, 2411, and 2412 in Figure C.167) but others showed decreases (for example, the pseudo-vessels 3650, 3651, and 3652 in Figure C.167) or increases then decreases (or vice versa).

As a result, it was concluded that there was no evidence that vessels in the JMA 7 midwater fleet had become more efficient over time. The flattening of the CPUE series in the split vessel sensitivities is attributable to the fact that the additional vessel coefficients are able to absorb some of the year to year variation in catch rates, but the models with fixed vessel coefficients over time were preferred in the absence of a signal that there were consistent changes in efficiency.

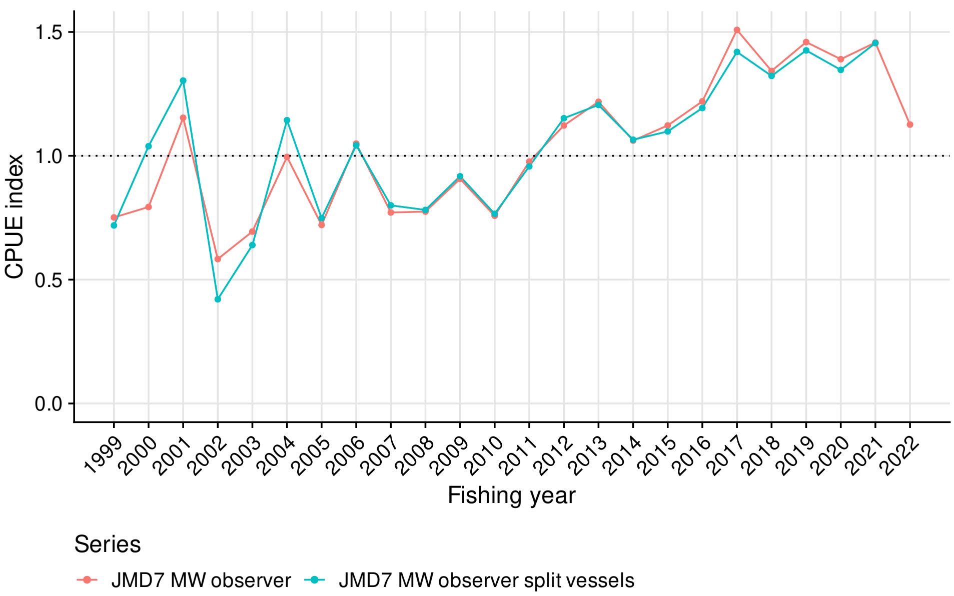

Figure 135: Annual positive catch indices from the primary CPUE analysis for *T. declivis* (JMD7 MW observer) and a sensitivity analysis (JMD7 MW observer split vessels) where data from a vessel were assigned to a new pseudo-vessel after participating in the fishery for seven years.

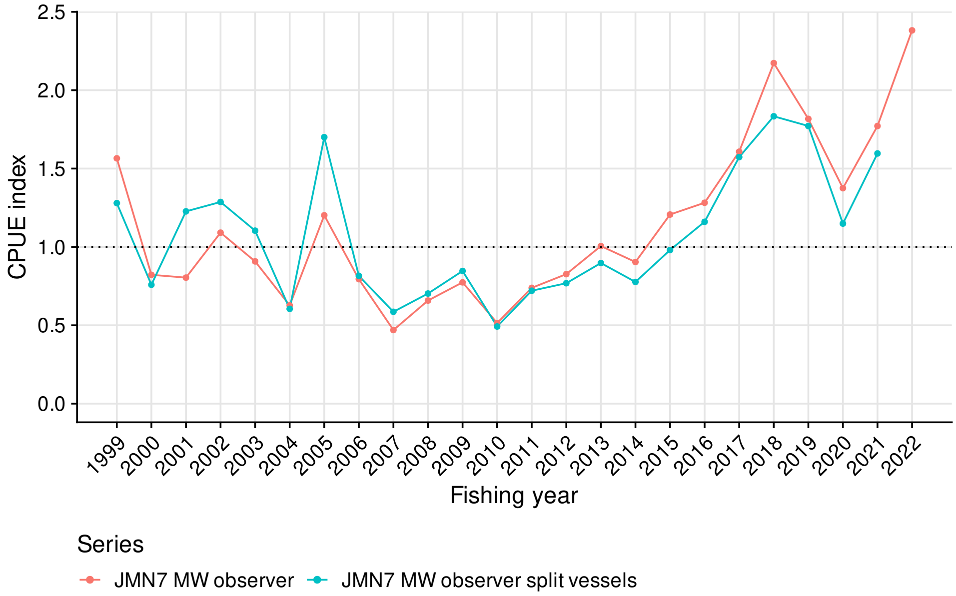

Figure 136: Annual combined (binomial and positive catch) indices from the primary CPUE analysis for *T. novaezelandiae* (JMN7 MW observer) and a sensitivity analysis (JMN7 MW observer split vessels) where data from a vessel were assigned to a new pseudo-vessel after participating in the fishery for seven years.

7.4.5 Inclusion of observed bottom trawling

The final set of CPUE sensitivities was for models that sought to extend the period of the CPUE analyses by including observer data from bottom trawling effort, in addition to that from the midwater fleet. Comparisons were produced for *T. declivis* (JMD7 TR observer; Appendix C.12), *T. novaezelandiae* (JMN7 TR observer; Appendix C.13), and *T. murphyi* (JMM7 TR observer; Appendix C.14).

For the years in common, there was little variation between the primary, midwater trawl only, indices and the extended indices with bottom trawl data added (Figures 137, 138, and 139). The addition of bottom trawl data allowed CPUE series to be calculated from 1991 to 2022 rather than starting in 1999. For *T. murphyi* this resulted in a dramatic series which suggested that abundance increased around sixty-fold from 1991 to 1993, then decreased by a similar amount by 1999. Although a substantial increase and decrease in the abundance of *T. murphyi* is generally plausible, because of the understanding that *T. murphyi* arrived in New Zealand waters as an ‘invasion’ from the wider Pacific stock (Taylor 2002), the scale of the estimated change is likely implausible.

Although method was offered as a covariate to these sensitivity models, it was not accepted in the stepwise model selection process. This is not unexpected, as there is very limited overlap between the bottom trawl fleet, that was active in the 1990s, and the midwater fleet operating from around 1999 (see, for example, Figure C.193); in consequence, the effect of trawl gear type is confounded with vessel and year effects, and there is no real hope that the model can correctly estimate year effects for the two periods.

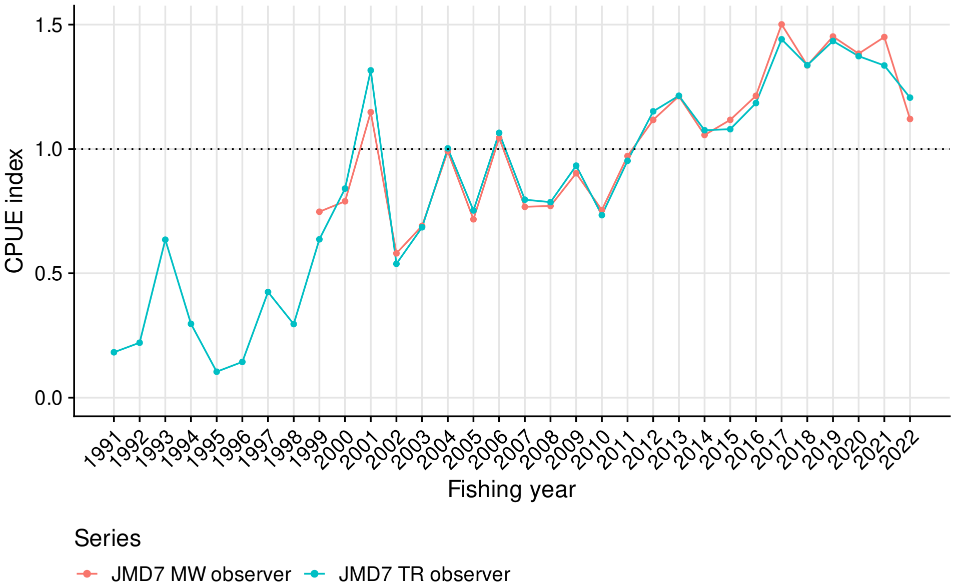

Figure 137: Comparison of the primary midwater trawl CPUE index for *T. declivis* (JMD7 MW observer) with a sensitivity that included observer data from both bottom and midwater trawling (JMD7 TR observer).

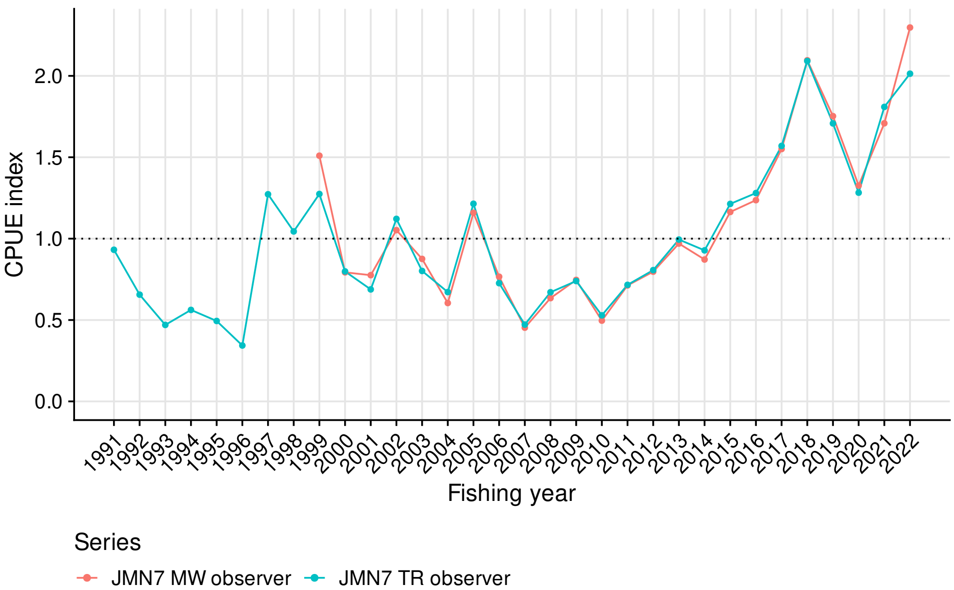

Figure 138: Comparison of the primary midwater trawl CPUE index for *T. novaezelandiae* (JMN7 MW observer) with a sensitivity that included observer data from both bottom and midwater trawling (JMD7 TR observer).

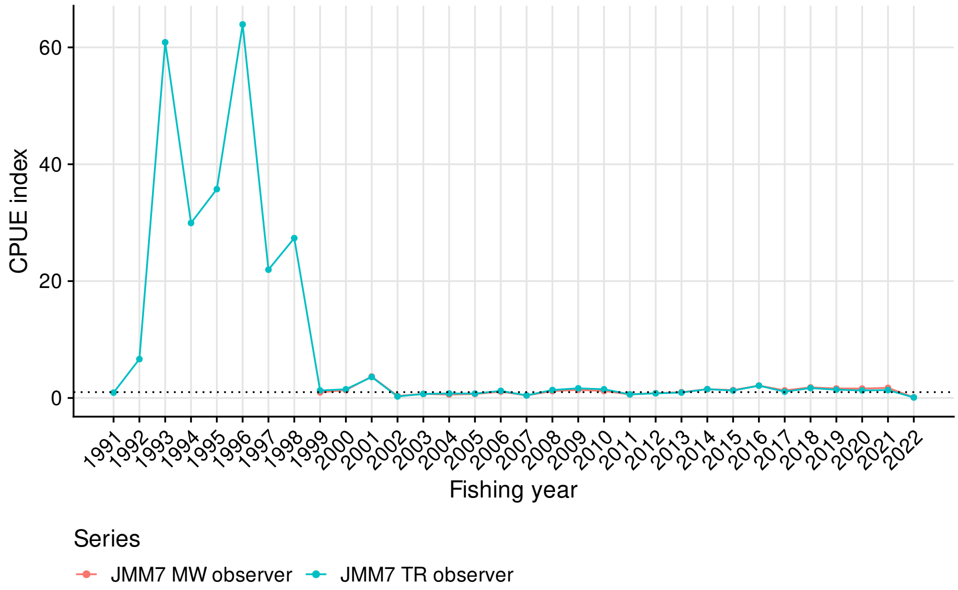

Figure 139: Comparison of the primary midwater trawl CPUE index for *T. murphyi* (JMM7 MW observer) with a sensitivity that included observer data from both bottom and midwater trawling (JMD7 TR observer).

8. DISCUSSION

Previous analyses of CPUE for the west coast jack mackerel fishery have been subsequently rejected, because of the approach taken to separation of the catch by species, or limited to estimating the trends in abundance for the three jack mackerel species combined (Webber & Starr 2022). Standardised catch per unit effort is, however, the only available approach for providing abundance indices of jack mackerels in JMA 7. The inshore trawl surveys conducted off the west coasts of the North and South islands are generally unsuited to sampling jack mackerels due to low trawl speeds, and they typically only encounter small fish (MacGibbon et al. 2022, Jones et al. 2023). An acoustic survey of jack mackerels was attempted but the species could not be discriminated acoustically and conducting targeted mark identification trawling was considered infeasible (O'Driscoll et al. 2013). As a result, developing new CPUE indices for JMA 7 is an important first step in providing stock assessments for these species.

A key concern about potential bias in observer sampling for jack mackerels was addressed in a previous study (Middleton 2022), but concern remained about the impacts of misidentification of the species in some observer data. Misidentified fish 'stand out' in age-length data, but only for older fish when the growth curves diverge. A new mixture modelling approach (Neubauer & Middleton in prep.) was able to predict the misidentification of species, including for younger fish. Although misidentified fish occur frequently in the observer data, a relatively small proportion of fish (< 10%) are affected. Impacts on scaled length-frequency distributions were minor. Likewise, a range of sensitivities suggested that the current level of misidentified fish did not appear to significantly alter trends in CPUE indices for jack mackerel species.

A range of other sensitivities were carried out, in particular: investigation of possible bias from use of a subset of observer data (tows with length-frequency samples) and potential effects of changes in vessel efficiency. After reviewing these results, the CPUE indices for *T. declivis* and *T. novaezelandiae* using observer data from the midwater trawl fleet from 1999 to 2022 were accepted as indices of abundance. The index for *T. murphyi* was not considered sufficiently reliable, due to the lack of a satisfactory explanation for the contradictory trends in the binomial and positive catch indices, and the fact that the resulting combined index simply averaged these conflicting trends. Longer indices using observed bottom trawl data from the 1990s were also not accepted, because of the likelihood that the models were unable to adequately estimate abundance over the transition from a primarily bottom trawl fishery in the 1990s to a midwater trawl fishery from 1999 onwards.

The indices for *T. declivis* and *T. novaezelandiae* are overlaid in Figure 140. Both show a general increase in abundance over the period from 1999 to 2022, but the series differ in detail. Abundance of *T. declivis* fluctuated without trend from 1999 to 2010, then increased to 2017, and has remained at a higher level (approximately 1.5 times the abundance in the 2000s) to 2022. In contrast, *T. novaezelandiae* showed a gradual decrease in abundance from 1999 to 2007, but increased three- to four-fold over the period from 2010 to 2017, remaining at the higher level to 2022.

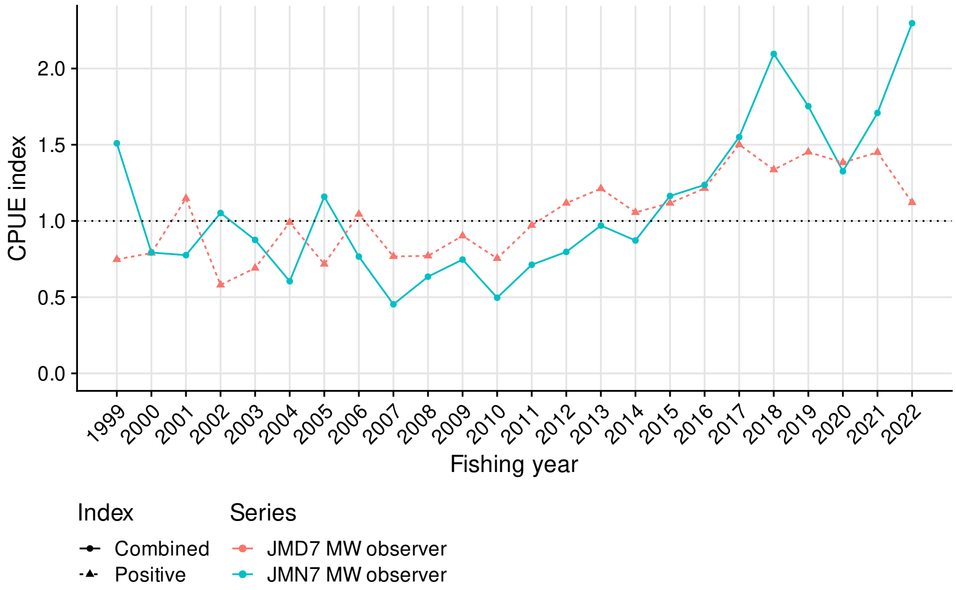

Figure 140: Final CPUE indices for *T. declivis* (JMD7 MW observer, positive catches model only) and *T. novaezelandiae* (JMN7 MW observer, combined binomial/positive catch model) in JMA 7.

8.1 Partial quantitative assessment

The Deepwater Working Group (DWWG) considered that there was little information available to allow abundance in a particular period to be equated with a specific stock status for either of the two native jack mackerel species. Commercial fisheries became established in JMA 7 in the 1970s, but catches were lower than in recent decades, and there was no indication that the stocks were depleted when jack mackerels entered the QMS in 1987. The DWWG noted that the Harvest Strategy Standard Operational Guidelines propose that, in cases where the relationship between CPUE and abundance can be assumed to be more or less proportional, it was reasonable to select an appropriate historical period when both CPUE and catches were relatively high and stable and to use this CPUE level as a target (conceptual B_{MSY}; Ministry of Fisheries 2011).

Catches in JMA 7 were considered to have been stable since the early-mid 2000s, with the establishment of the midwater trawl fleet. Periods of stable abundance were identified as 2004–2011 for *T. declivis* and 2006–2012 for *T. novaezealandiae*. Noting that both species had subsequently increased in abundance while combined species catches remained stable, the Plenary meeting adopted the geometric mean CPUE in each of these periods as the target reference level for the appropriate species (equated to 35% B_0 for these medium-productivity species). The soft limit (20% B_0) was set at 4/7 of the mean value for each period and the hard limit (10% B_0) was set at 2/7 of the mean value by period.

For *T. declivis*, the stock was estimated to be Likely (> 60%) to be at or above the target in 2022 (Figure 141), while *T. novaezealandiae* was considered to be Very Likely (> 90%) to be at or above the target (Figure 142).

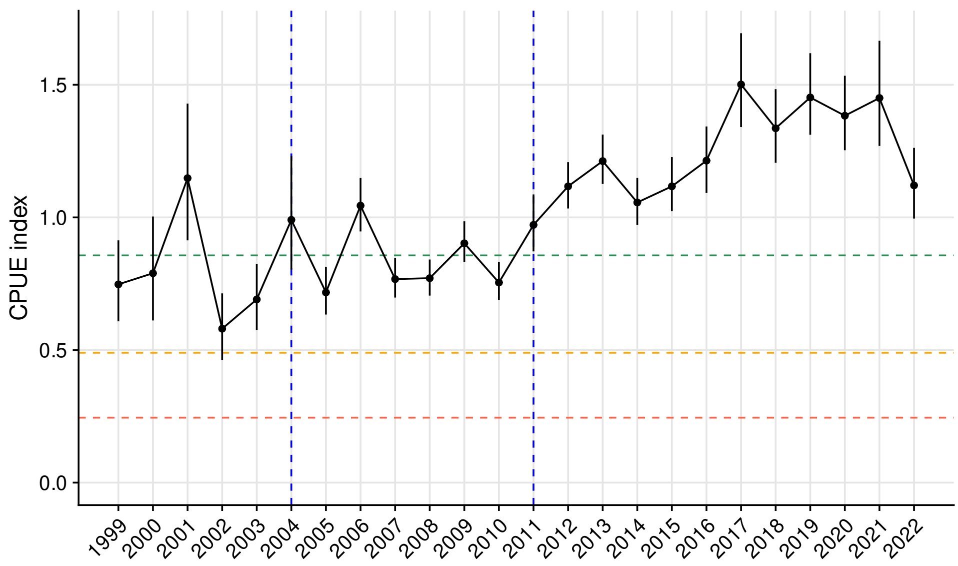

Figure 141: Stock status of *T. declivis* (JMD) relative to the reference period (2004–2011, indicated by dashed vertical lines), with geometric mean CPUE in this period considered to represent the target and indicated by the horizontal green dashed line. The hard and soft limits are represented by horizontal dashed red and orange lines, respectively.

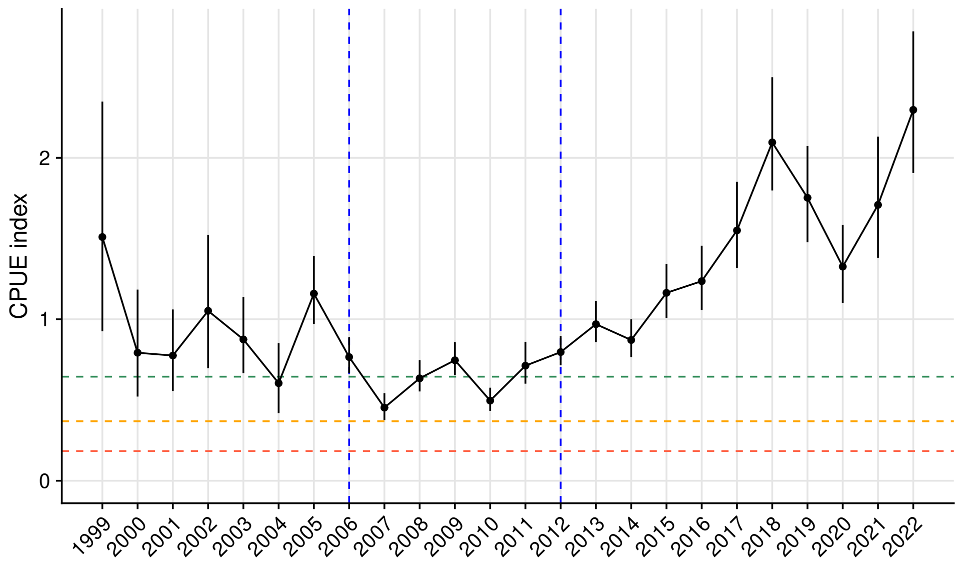

Figure 142: Stock status of *T. novaezelandiae* (JMN) relative to the reference period (2006–2012, indicated by dashed vertical lines), with geometric mean CPUE in this period considered to represent the target and indicated by the horizontal green dashed line. The hard and soft limits are represented by horizontal dashed red and orange lines, respectively.

In addition to facilitating partial quantitative assessments for *T. declivis* and *T. novaezelandiae* in JMA 7, the establishment of CPUE-based abundance series offers the possibility for developing fully quantitative assessments in the future. However, a number of other steps would be necessary in support of a full assessment. The mixture-modelling (Neubauer & Middleton in prep.) has provided new estimates of growth for all three jack mackerel species in JMA 7, but it is necessary to extend this modelling to allow evaluation of whether significant sex- or area-specific differences in growth are present for any species.

A review of the methodology used to create annual age frequency distributions, including the stratification used, is also necessary. The annual length-frequency distributions (Figure 74, Figure 76) often showed evidence of recruiting year classes, but these are not always apparent in estimated age distributions (for example, Saunders et al. 2022); reasons for this are currently unclear.

Appoaches for developing time series of catch by species should be reviewed. In the JMA 1 fishery a stratified bootstrapping approach is currently used (Langley et al. 2016), but a model-based approach could also be considered. The latter would also potentially assist in allowing unsampled tows to be included in the CPUE analysis.

9. ACKNOWLEDGEMENTS

This work was funded by Fisheries New Zealand, under project JMA2021-01. The project was managed by Gretchen Skea and benefited from review by the Deepwater Working Group and Stock Assessment Plenary meeting. Fisheries New Zealand’s independent reviewer, Sophie Mormede, noted the possibility of potential bias due to the use of the subset of trawls with sampling data, which led to the sensitivity analyses included here. Adam Langley provided additional helpful input on data quality metrics. Analyses were carried out using the Kahawai Collective’s reproducible research platform, with data provided by Fisheries New Zealand.

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APPENDIX A: 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).

A.1 Landings

Table A.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

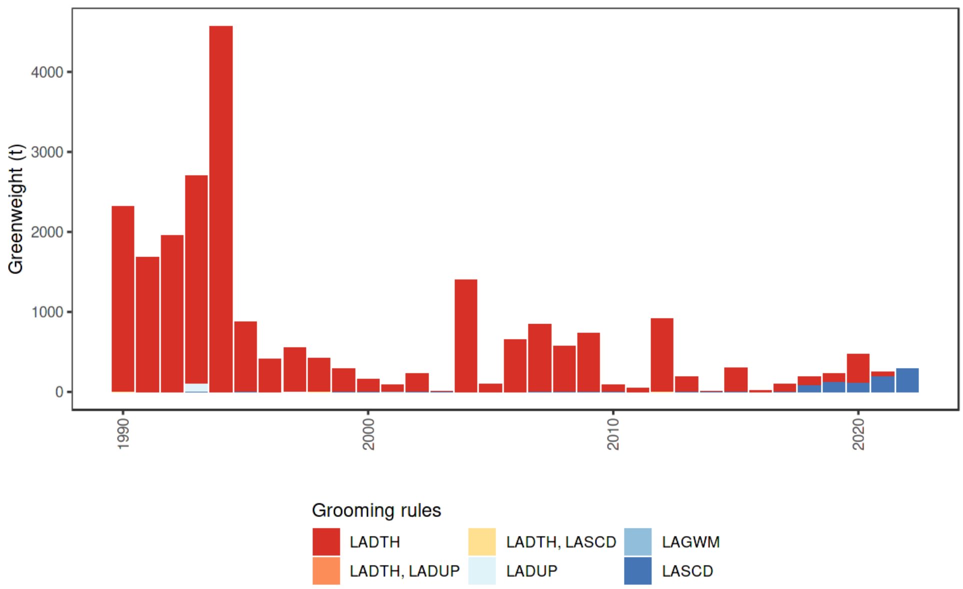

Figure A.1: The quantity of landings dropped, with the relevant grooming rules indicated.

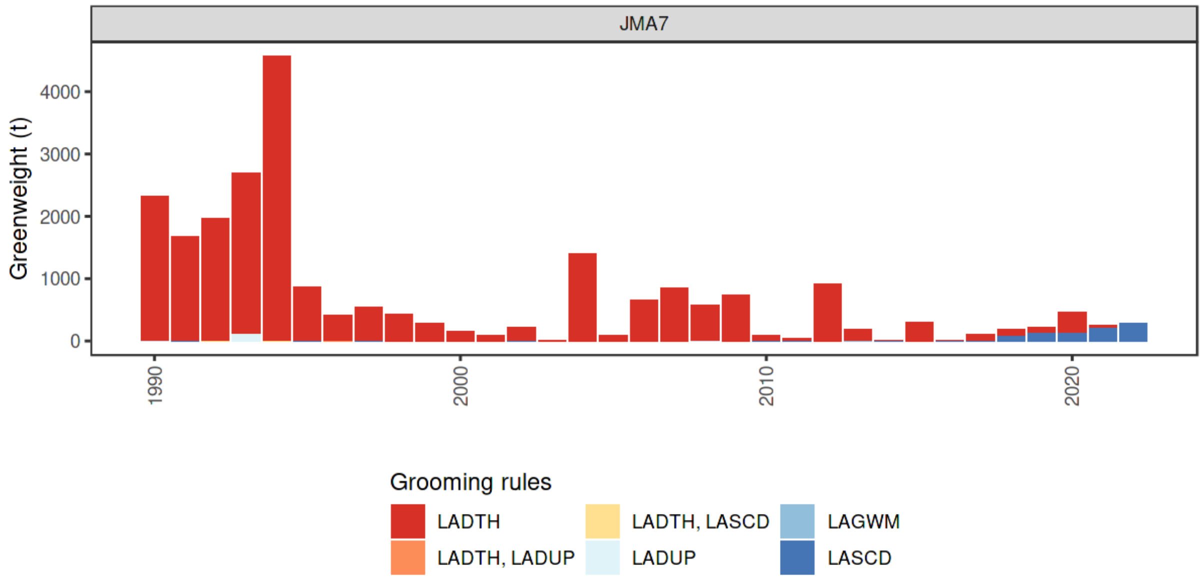

Figure A.2: The quantity of landings dropped, with the relevant grooming rules indicated, by QMA.

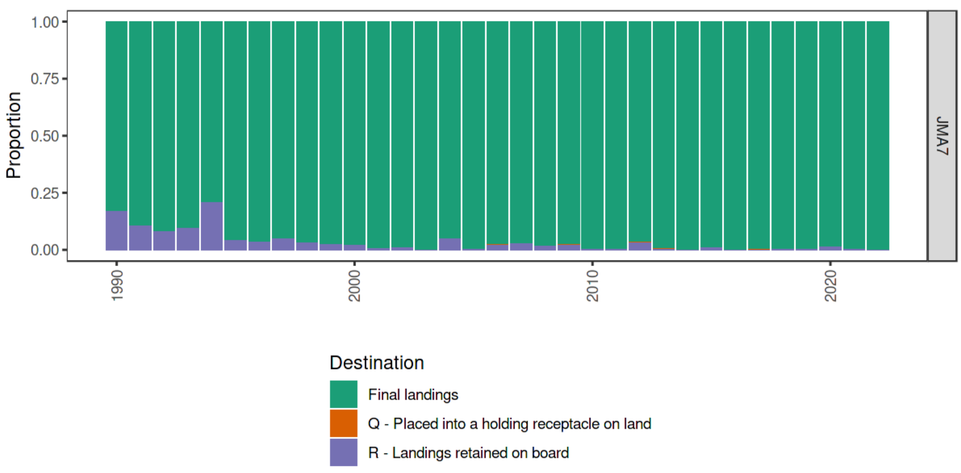

Figure A.3: The proportion of total (final and non-final) landings that are initially to non-final destinations, by stock and fishing year.

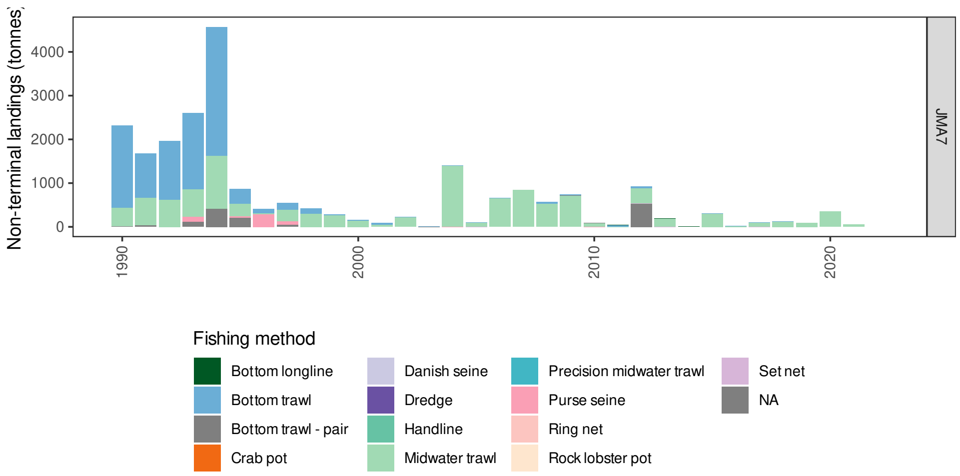

Figure A.4: The quantity of non-final landings, by stock, fishing year, and the modal fishing method used on the trip.

Table A.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
JMA7	1991	1	941 314	941.314
JMA7	1992	3	5 622 753	2 577.441
JMA7	1994	3	2 164 790	2 164.790
JMA7	1995	1	219 247	219.247
JMA7	2004	2	137	1.370
JMA7	2007	1	56	0.560
JMA7	2008	1	142	1.420
JMA7	2011	1	76	0.760
JMA7	2012	1	52	0.520
JMA7	2013	1	44	0.440
JMA7	2015	2	1 192	11.920
JMA7	2019	1	94 819	94.819
JMA7	2020	1	37	0.370

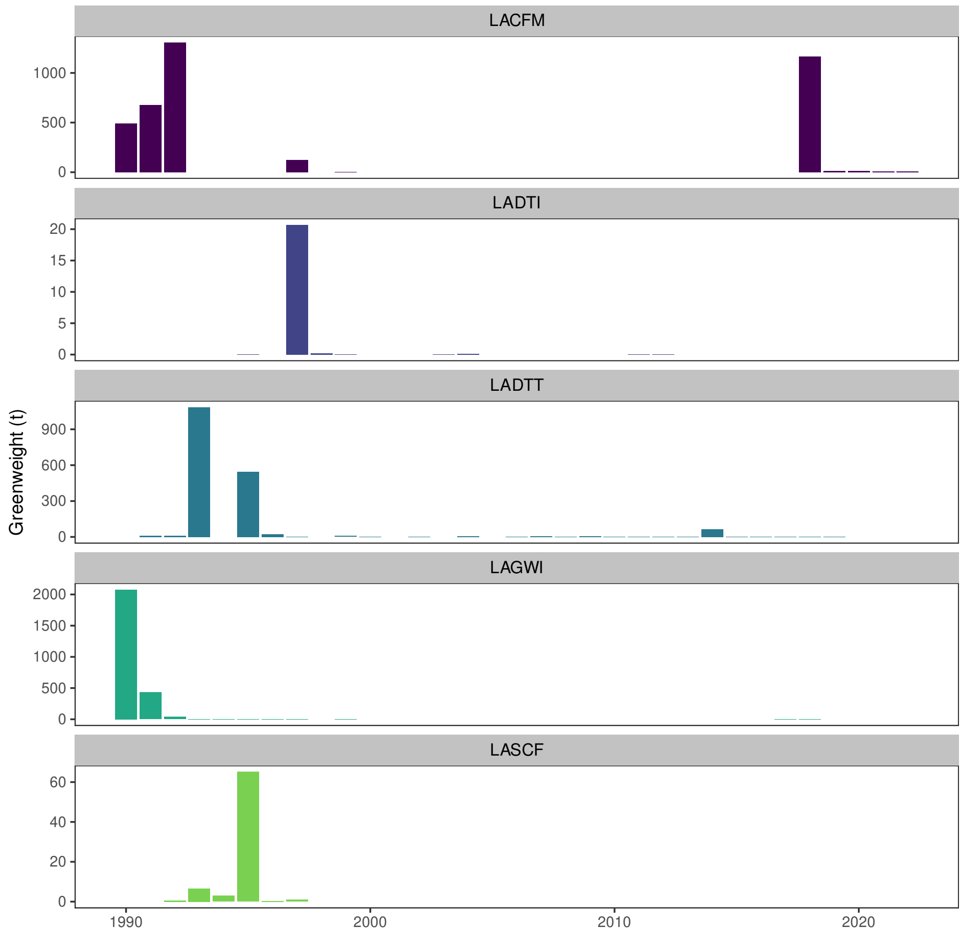

Figure A.5: The quantity of landings flagged by the grooming rules, or where fixes were applied to fields other than the landed greenweight. Note that some landing events may be affected by multiple rules.

A.2 Effort

Table A.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 A.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

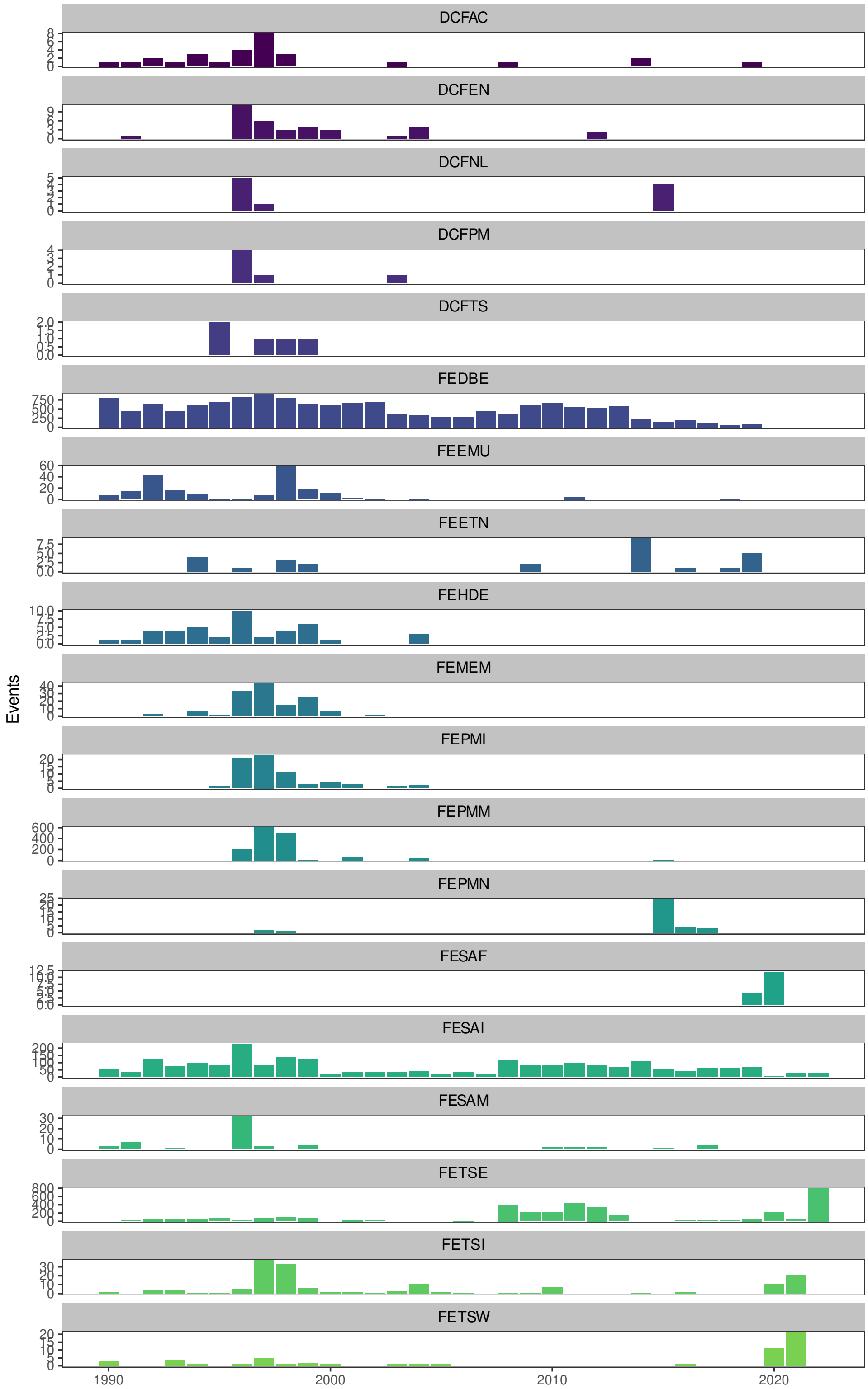

Figure A.6: The number of fishing events flagged or fixed by the grooming rules. Note that some events may be affected by multiple rules.

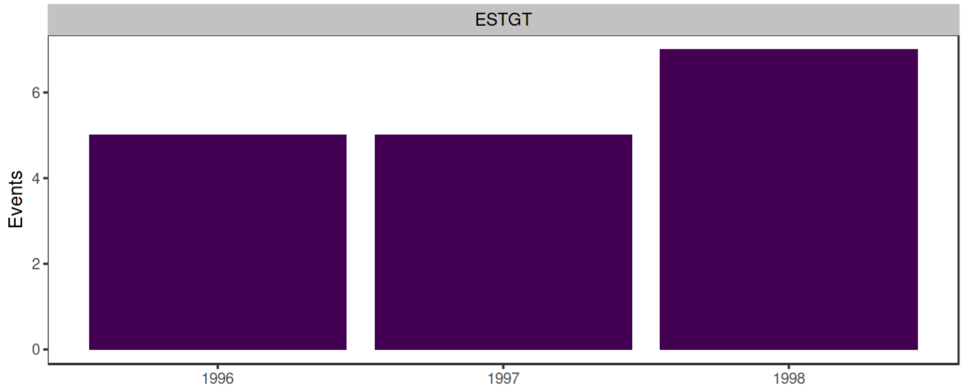

Figure A.7: The number of fishing events where the estimated catch of jack mackerels was flagged or fixed by the grooming rules. Note that some events may be affected by multiple rules.

APPENDIX B: TABULATED FISHERIES CHARACTERISATION DATA

Table B.1: Annual Total Allowable Commercial Catch (TACC; t) and Monthly Harvest Return/Quota Management Report totals (t) for JMA 7 from 1990 to 2022.

Fishing year	JMA7	
	TACC	MHR/QMR
1990	17 020.30	21 776.12
1991	23 468.06	17 786.20
1992	24 310.93	25 879.74
1993	26 362.65	24 659.42
1994	29 563.07	22 376.76
1995	32 536.50	18 912.49
1996	32 536.50	12 270.39
1997	32 536.50	12 055.94
1998	32 536.50	14 292.76
1999	32 536.50	13 628.56
2000	32 536.50	7 889.42
2001	32 536.50	15 702.87
2002	32 536.76	22 337.91
2003	32 536.76	26 083.78
2004	32 536.76	28 888.33
2005	32 536.76	36 507.32
2006	32 536.76	27 781.80
2007	32 536.76	32 039.47
2008	32 536.76	34 059.24
2009	32 536.76	28 827.76
2010	32 536.76	31 152.31
2011	32 536.76	28 176.51
2012	32 536.76	28 266.15
2013	32 536.76	31 776.15
2014	32 536.76	35 174.91
2015	32 536.76	33 969.77
2016	32 536.76	30 875.41
2017	32 536.76	33 801.51
2018	32 536.76	34 189.99
2019	32 536.76	31 751.74
2020	32 536.76	31 450.72
2021	32 536.76	31 809.55
2022	32 536.76	27 782.46

Table B.2: Annual JMA 7 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 A) landings/discards data summed by stock (see Table 2 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 jack mackerels was targeted. – : no observations.

Fishing year	QMR/MHR (t)	Catches (t)	Allocated catches				Target catches	
			Total (t)	MW-PRM (%)	BT-PRB (%)	PS (%)	tonnes	%
1990	21 776.12	11 486.62	12 057.72	12.85	71.96	15.06	9 838.45	81.59
1991	17 786.20	14 462.22	14 375.22	26.71	53.22	19.84	11 466.35	79.76
1992	25 879.74	22 982.05	24 819.38	44.69	46.80	8.46	22 774.59	91.76
1993	24 659.42	25 121.97	24 987.83	22.91	57.52	19.50	22 926.22	91.75
1994	22 376.76	17 586.13	16 906.04	45.39	36.89	17.65	14 119.59	83.52
1995	18 912.49	19 670.13	19 757.40	70.71	19.15	10.03	15 509.36	78.50
1996	12 270.39	11 871.07	11 826.54	49.82	34.67	15.04	9 088.26	76.85
1997	12 055.94	11 027.32	11 124.90	61.34	34.13	4.48	8 918.71	80.17
1998	14 292.76	13 932.97	14 646.80	34.74	62.29	2.92	13 631.94	93.07
1999	13 628.56	12 596.33	12 530.42	72.71	23.17	4.00	11 395.86	90.95
2000	7 889.42	8 241.74	8 286.91	89.69	6.70	3.40	7 495.89	90.45
2001	15 702.87	14 179.63	14 189.24	88.14	10.75	1.03	13 566.24	95.61
2002	22 337.91	21 612.91	21 719.69	90.03	8.67	1.28	21 038.90	96.87
2003	26 083.78	26 503.71	26 531.05	96.50	2.64	0.85	25 768.13	97.12
2004	28 888.33	27 671.94	28 078.25	97.17	1.41	1.42	27 280.79	97.16
2005	36 507.32	37 613.37	37 721.77	98.46	1.20	0.30	35 592.13	94.35
2006	27 781.80	27 515.20	27 556.99	99.20	0.59	0.16	27 073.99	98.25
2007	32 039.47	29 781.47	31 241.78	97.79	1.72	0.49	30 424.66	97.38
2008	34 059.24	34 726.19	34 731.23	96.64	2.99	0.35	34 175.37	98.40
2009	28 827.76	28 532.86	28 560.45	98.65	1.25	0.07	28 041.06	98.18
2010	31 152.31	31 833.16	31 957.13	99.21	0.67	0.08	31 492.51	98.55
2011	28 176.51	28 113.61	28 194.05	99.24	0.68	0.04	27 964.81	99.19
2012	28 266.15	27 359.59	27 373.19	99.02	0.95	0.02	27 015.58	98.69
2013	31 776.15	32 751.82	32 818.40	99.18	0.60	0.20	32 085.36	97.77
2014	35 174.91	35 142.88	35 242.02	99.32	0.44	0.23	33 471.82	94.98
2015	33 969.77	33 954.82	34 089.81	99.30	0.69	0.00	30 531.28	89.56
2016	30 875.41	30 876.68	30 945.12	96.07	0.68	3.23	29 319.65	94.75
2017	33 801.51	33 701.23	33 811.51	99.56	0.44	0.00	33 127.46	97.98
2018	34 189.99	34 265.51	34 454.50	99.57	0.42	0.00	32 109.86	93.19
2019	31 751.74	31 680.42	31 701.40	99.28	0.72	0.00	30 708.31	96.87
2020	31 450.72	30 363.20	30 474.90	99.49	0.50	0.00	27 613.18	90.61
2021	31 809.55	32 896.73	33 002.62	99.51	0.49	0.00	32 408.51	98.20
2022	27 782.46	27 554.98	27 580.61	99.49	0.40	0.11	26 634.37	96.57

Table B.3: Annual jack mackerels catches (t) by destination code for the JMA 7 Quota Management Area. L = Landings to an LFR, T = Transhipments. A complete list of destination codes is provided in Table 2. – : no observations.

Fishing year	L	T	Other	Total
1990	3 328.85	7 842.90	314.87	11 486.62
1991	5 175.09	8 622.11	665.03	14 462.22
1992	8 933.61	13 914.83	133.61	22 982.05
1993	8 494.22	15 454.73	1 173.02	25 121.97
1994	10 184.12	7 379.98	22.04	17 586.13
1995	13 488.52	5 547.46	634.15	19 670.13
1996	9 357.64	2 384.01	129.42	11 871.07
1997	9 139.21	1 770.04	118.07	11 027.32
1998	12 939.45	642.29	351.23	13 932.97
1999	12 266.02	7.45	322.86	12 596.33
2000	8 239.90	0.81	1.04	8 241.74
2001	14 169.86	0.29	9.48	14 179.63
2002	21 603.62	-	9.29	21 612.91
2003	26 499.20	-	4.51	26 503.71
2004	27 667.17	-	4.77	27 671.94
2005	37 598.10	-	15.26	37 613.37
2006	27 507.29	-	7.91	27 515.20
2007	29 773.38	-	8.09	29 781.47
2008	34 718.96	-	7.24	34 726.19
2009	28 524.57	0.01	8.29	28 532.86
2010	31 818.28	-	14.88	31 833.16
2011	28 103.20	-	10.41	28 113.61
2012	27 338.85	-	20.75	27 359.59
2013	32 727.76	-	24.07	32 751.82
2014	35 109.33	-	33.55	35 142.88
2015	33 940.80	-	14.02	33 954.82
2016	30 858.15	-	18.54	30 876.68
2017	33 685.57	-	15.66	33 701.23
2018	34 128.04	-	137.47	34 265.51
2019	31 642.73	-	37.69	31 680.42
2020	29 999.51	-	363.69	30 363.20
2021	32 888.47	-	8.26	32 896.73
2022	27 545.35	-	9.63	27 554.98

Table B.4: Annual catches by landed state of jack mackerels from the JMA 7 Quota Management Area. DRE = Dressed, FIL = Fillets: skin-on, GRE = Green (or whole), HGT = Headed, gutted, and tailed, HGU = Headed and gutted, MEA = Fish meal, SUR = Surimi. A complete list of state codes is provided in Table D.1. – : no observations. Records where the landed state was missing were excluded.

Fishing year	DRE	GRE	MEA	HGU	FIL	HGT	SUR	Other	Total
1990	-	6 082.98	155.28	4 892.46	-	336.38	19.44	0.09	11 486.62
1991	6 307.55	6 831.05	119.16	1 073.08	1.16	120.85	9.37	-	14 462.22
1992	15 422.70	6 959.24	141.06	445.01	13.77	-	0.17	0.09	22 982.05
1993	13 564.41	8 283.76	116.61	1 176.42	1 980.55	-	-	0.23	25 121.97
1994	11 158.08	4 622.58	505.53	1 151.59	148.09	-	-	0.27	17 586.13
1995	15 422.16	3 542.49	679.52	0.69	6.38	-	13.51	5.39	19 670.13
1996	7 672.30	3 750.00	447.82	0.41	-	-	-	0.53	11 871.05
1997	7 648.02	2 682.13	690.21	1.27	-	-	5.33	0.01	11 026.97
1998	11 429.15	1 314.28	1 187.92	1.10	0.03	-	-	0.45	13 932.92
1999	7 784.35	4 462.21	348.67	0.17	0.04	-	-	0.89	12 596.33
2000	5 959.16	1 821.08	460.66	0.01	0.04	-	-	0.80	8 241.74
2001	11 448.28	1 796.62	934.20	0.53	-	-	-	0.01	14 179.63
2002	16 632.82	3 442.07	1 532.37	0.01	-	-	-	5.64	21 612.91
2003	21 785.09	2 731.48	1 987.15	-	-	-	-	-	26 503.71
2004	20 980.38	4 687.71	2 003.77	-	0.07	-	-	0.02	27 671.94
2005	26 853.43	7 136.36	3 622.64	-	0.88	-	-	0.06	37 613.37
2006	22 132.55	3 935.31	1 447.20	0.00	-	-	-	0.13	27 515.20
2007	25 846.13	2 784.34	1 150.93	0.03	0.01	-	-	0.03	29 781.47
2008	26 363.36	6 772.87	1 589.71	-	-	-	-	0.25	34 726.19
2009	24 222.97	3 463.84	845.88	-	-	-	-	0.17	28 532.86
2010	26 316.31	4 291.37	1 223.23	0.11	-	-	-	2.14	31 833.16
2011	19 184.00	7 774.05	1 155.16	0.38	-	-	-	0.01	28 113.61
2012	17 664.85	7 845.78	1 676.21	0.01	172.72	-	-	0.03	27 359.59
2013	17 909.40	12 736.21	2 105.95	0.03	0.00	-	-	0.05	32 751.65
2014	16 942.64	16 831.30	1 351.68	-	17.18	-	-	0.08	35 142.88
2015	14 794.87	18 045.92	1 113.64	-	-	-	-	0.40	33 954.82
2016	16 491.33	13 322.62	1 006.62	0.00	54.56	-	-	1.55	30 876.68
2017	20 764.65	11 594.38	1 307.31	0.07	34.82	-	-	0.01	33 701.23
2018	14 364.07	18 541.31	1 315.64	0.08	44.12	-	-	0.29	34 265.51
2019	15 227.62	15 037.58	1 382.28	-	32.64	-	-	0.29	31 680.41
2020	10 362.99	18 877.95	1 122.26	-	-	-	-	-	30 363.20
2021	11 731.50	19 308.45	1 801.94	-	54.80	-	-	0.04	32 896.73
2022	9 065.46	17 259.28	1 224.12	-	5.00	-	-	1.11	27 554.98

Table B.5: Annual modal conversion factor reported for product state codes of jack mackerels from the JMA 7 Quota Management Areas. DRE = Dressed, FIL = Fillets: skin-on, GRE = Green (or whole), GUT = Gutted, HGT = Headed, gutted, and tailed, HGU = Headed and gutted, MEA = Fish meal, SKF = Fillets: skin-off, SUR = Surimi. – : no observations.

Fishing year	GRE	GUT	HGT	HGU	MEA	SUR	DRE	FIL	SKF
1990	1.00	1.10	1.60	1.50	5.56	4.30	-	-	-
1991	1.00	-	1.60	1.50	5.60	4.30	1.60	2.50	-
1992	1.00	1.10	-	1.50	5.60	-	1.60	2.50	-
1993	1.00	1.10	-	1.50	5.60	-	1.60	2.50	-
1994	1.00	1.10	-	1.50	5.60	-	1.60	2.50	-
1995	1.00	1.10	-	1.50	5.60	4.30	1.60	2.50	-
1996	1.00	1.10	-	1.50	5.60	-	1.60	-	-
1997	1.00	1.10	-	1.50	5.60	4.30	1.60	-	-
1998	1.00	1.10	-	1.50	5.60	-	1.60	2.50	-
1999	1.00	1.10	-	1.50	5.60	-	1.60	2.50	-
2000	1.00	1.10	-	1.50	5.60	-	1.60	2.50	-
2001	1.00	1.10	-	1.50	5.60	-	1.60	-	-
2002	1.00	1.10	-	1.50	5.60	-	1.60	-	-
2003	1.00	-	-	-	5.60	-	1.60	-	-
2004	1.00	-	-	-	5.60	-	1.60	2.50	3.10
2005	1.00	1.10	-	-	5.60	-	1.60	2.50	-
2006	1.00	1.10	-	1.50	5.60	-	1.60	-	-
2007	1.00	1.10	-	1.50	5.60	-	1.60	2.50	-
2008	1.00	1.10	-	-	5.60	-	1.60	-	-
2009	1.00	1.10	-	-	5.60	-	1.60	-	-
2010	1.00	1.10	-	1.50	5.60	-	1.60	-	-
2011	1.00	1.10	-	1.50	5.60	-	1.60	-	-
2012	1.00	1.10	-	1.50	5.60	-	1.60	2.50	-
2013	1.00	1.10	-	1.50	5.60	-	1.60	2.50	-
2014	1.00	1.10	-	-	5.60	-	1.60	2.50	-
2015	1.00	1.10	-	-	5.60	-	1.60	-	-
2016	1.00	1.10	-	1.50	5.60	-	1.60	2.50	-
2017	1.00	1.10	-	1.50	5.60	-	1.60	2.50	-
2018	1.00	1.10	-	1.50	5.60	-	1.60	2.50	-
2019	1.00	1.10	-	-	5.60	-	1.60	2.50	-
2020	1.00	-	-	-	-	-	1.60	-	-
2021	1.00	1.10	-	-	-	-	1.60	2.50	-
2022	1.00	1.10	-	-	-	-	1.60	2.50	-

Table B.6: Reporting forms used for effort on trips landing jack mackerels from the JMA 7 Quota Management Area in terms of data records and their allocated catches. A complete list of form type codes is provided in Table D.2. – : no observations.

	Records (N)						Allocated catches (t)					
Fishing year	TCP	CEL	Other	TCE	ERS - Trawl	Total	TCP	CEL	Other	TCE	ERS - Trawl	Total
1990	8358	1676	-	-	-	10034	10168.40	1889.32	-	-	-	12057.72
1991	8492	2394	-	-	-	10886	11359.84	3015.38	-	-	-	14375.22
1992	8349	2429	-	-	-	10778	22584.87	2234.51	-	-	-	24819.38
1993	8747	3080	-	-	-	11827	19951.07	5036.76	-	-	-	24987.83
1994	10932	2874	2	-	-	13808	13790.57	3115.47	0.00	-	-	16906.04
1995	13372	3061	-	-	-	16433	17612.77	2144.63	-	-	-	19757.40
1996	12366	2492	-	-	-	14858	9914.69	1911.85	-	-	-	11826.54
1997	13268	2872	-	-	-	16140	10421.28	703.62	-	-	-	11124.90
1998	13340	2166	-	-	-	15506	14118.39	528.41	-	-	-	14646.80
1999	12758	2952	-	-	-	15710	11794.05	736.37	-	-	-	12530.42
2000	11180	2825	-	-	-	14005	7824.06	462.85	-	-	-	8286.91
2001	11361	3025	-	-	-	14386	13869.35	319.89	-	-	-	14189.24
2002	11120	2937	3	-	-	14060	21238.57	481.10	0.02	-	-	21719.69
2003	11677	2895	4	-	-	14576	26089.30	441.75	0.00	-	-	26531.05
2004	11921	2737	-	-	-	14658	27519.57	558.68	-	-	-	28078.25
2005	11079	2562	-	-	-	13641	37461.13	260.63	-	-	-	37721.77
2006	7999	1467	-	-	-	9466	27478.01	78.98	-	-	-	27556.99
2007	8764	2116	143	-	-	11023	31039.77	201.38	0.63	-	-	31241.78
2008	7197	174	134	7957	-	15462	34536.79	123.39	1.11	69.94	-	34731.23
2009	5699	324	362	9067	-	15452	28424.02	25.24	1.18	110.00	-	28560.45
2010	5410	253	269	10399	-	16331	31801.00	26.79	1.34	128.01	-	31957.13
2011	4949	291	316	10562	-	16118	28048.71	12.22	2.06	131.06	-	28194.05
2012	5750	415	317	9952	-	16434	27254.09	4.51	3.80	110.79	-	27373.19
2013	5641	278	385	9836	-	16140	32599.10	67.30	3.58	148.41	-	32818.40
2014	6607	336	413	8621	-	15977	35031.74	79.83	4.30	126.16	-	35242.02
2015	7212	253	366	8667	-	16498	33956.77	0.36	2.62	130.06	-	34089.81
2016	6469	261	243	8201	-	15174	29789.08	1000.11	4.80	151.12	-	30945.12
2017	6694	209	223	8590	-	15716	33701.65	0.27	1.76	107.83	-	33811.51
2018	415	227	261	8698	6411	16012	3907.24	0.59	1.46	97.62	30447.60	34454.50
2019	-	249	283	6178	7617	14327	-	0.27	0.76	78.18	31622.20	31701.40
2020	-	11	709	-	12823	13543	-	0.01	1.86	-	30473.04	30474.90
2021	-	-	676	-	12008	12684	-	-	1.26	-	33001.36	33002.62
2022	-	-	528	-	11676	12204	-	-	32.07	-	27548.54	27580.61

Table B.7: Allocated catches (t) of jack mackerels in JMA 7 by method of capture and fishing year. A complete list of fishing method codes is provided in Table D.3. – : no observations.

Fishing year	BT	MW	PS	Other	Total
1990	8676.51	1549.90	1815.95	15.36	12057.72
1991	7650.80	3839.13	2851.56	33.72	14375.22
1992	11614.24	11091.04	2100.84	13.26	24819.38
1993	14373.31	5725.70	4873.29	15.53	24987.83
1994	6236.09	7673.88	2984.51	11.57	16906.04
1995	3784.03	13971.14	1982.12	20.12	19757.40
1996	4100.43	5891.85	1779.04	55.22	11826.54
1997	3797.32	6823.75	498.90	4.92	11124.90
1998	9123.53	5088.31	428.39	6.57	14646.80
1999	2903.52	9111.23	501.77	13.90	12530.42
2000	554.87	7432.29	282.00	17.76	8286.91
2001	1525.71	12506.03	146.12	11.37	14189.24
2002	1884.07	19555.13	278.16	2.34	21719.69
2003	700.05	25601.47	224.55	4.98	26531.05
2004	395.17	27282.63	397.65	2.81	28078.25
2005	453.85	37141.57	114.59	11.76	37721.77
2006	163.19	27336.43	44.58	12.79	27556.99
2007	537.18	30550.35	153.46	0.79	31241.78
2008	1038.42	33563.76	122.38	6.67	34731.23
2009	356.97	28175.97	20.98	6.53	28560.45
2010	214.07	31704.24	26.41	12.41	31957.13
2011	192.40	27980.50	12.00	9.15	28194.05
2012	260.93	27103.95	4.13	4.18	27373.19
2013	196.64	32550.87	66.85	4.03	32818.40
2014	155.55	35002.34	79.62	4.51	35242.02
2015	233.81	33851.80	0.11	4.09	34089.81
2016	205.16	29728.43	999.90	11.63	30945.12
2017	141.81	33655.70	0.05	13.95	33811.51
2018	128.36	34306.57	0.39	19.19	34454.50
2019	221.43	31472.66	0.01	7.30	31701.40
2020	152.00	30319.25	0.05	3.59	30474.90
2021	158.83	32840.24	0.69	2.86	33002.62
2022	100.26	27439.42	31.60	9.33	27580.61

APPENDIX C: ADDITIONAL CPUE SERIES

C.1 JMA7 MW event

Table C.1: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the JMA7 MW event CPUE series.

Series	JMA7 MW event
QMS stock	JMA7
Reporting forms	TCE, TCP, ERS - Trawl
Fishing methods	MW
Target species	JMA, JMD, JMM, JMN
Statistical Areas	034, 035, 036, 037, 039, 040, 041, 042, 045, 801
Period	1998-10-01, 2022-09-30
Resolution	Fishing event
Core fleet years	4
Core fleet trips	1
Default model	allockg_top5 ~ fyear + vessel_key + month + stat_area + ns(log(fishing_duration), 3) + ns(log(start_time), 3) + ns(log(bottom_depth), 3) + ns(log(effort_height), 3) + ns(effort_speed, 3)
Stepwise selection	No
Positive catch distribution	Weibull

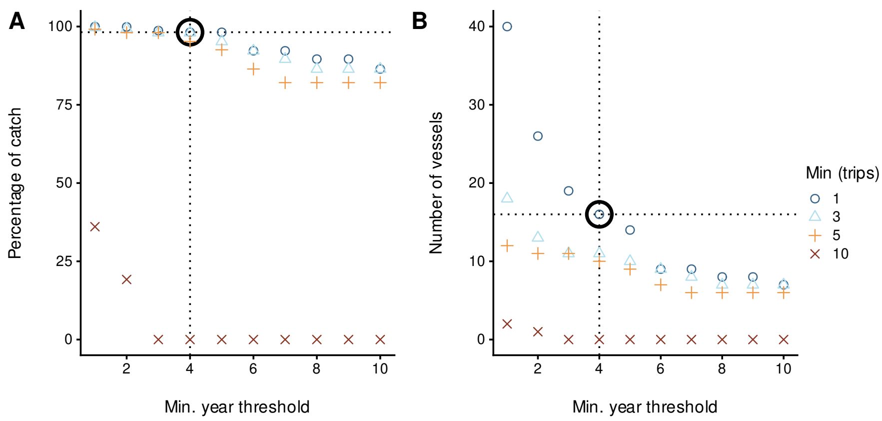

Figure C.1: Percentage of catch and number of vessels for different core vessel selection criteria for the JMA7 MW event CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

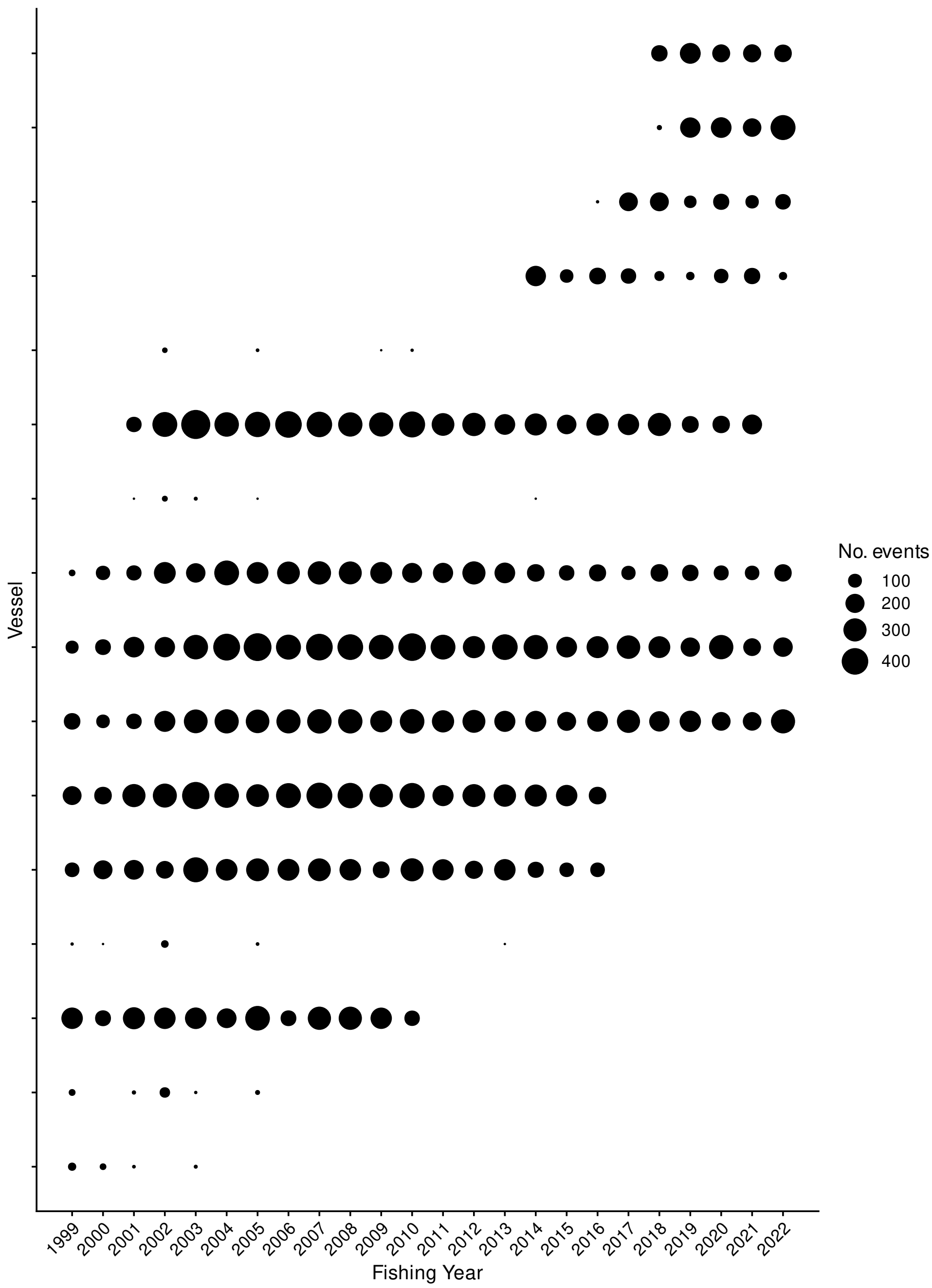

Figure C.2: Number of events by fishing year for core vessels. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table C.2: Summary of the JMA7 MW event 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	1999	2000	2001	2002	2003	2004	2005	2006	2007
Ungroomed data	8555 (100%) n: 1282	6991 (100%) n: 937	12429 (100%) n: 1482	19640 (100%) n: 2106	25215 (100%) n: 2603	28039 (100%) n: 2297	34261 (100%) n: 2398	27217 (100%) n: 2227	31163 (100%) n: 2500
Fishing speed not null	8555 (100%) n: 1281	6991 (100%) n: 937	12429 (100%) n: 1482	19640 (100%) n: 2106	25215 (100%) n: 2603	28039 (100%) n: 2297	34261 (100%) n: 2398	27217 (100%) n: 2227	31163 (100%) n: 2500
Start date not null	8555 (100%) n: 1281	6991 (100%) n: 937	12429 (100%) n: 1482	19640 (100%) n: 2106	25215 (100%) n: 2603	28039 (100%) n: 2297	34261 (100%) n: 2398	27217 (100%) n: 2227	31163 (100%) n: 2500
End date not null	8555 (100%) n: 1281	6991 (100%) n: 937	12429 (100%) n: 1482	19640 (100%) n: 2106	25215 (100%) n: 2603	28039 (100%) n: 2297	34261 (100%) n: 2398	27217 (100%) n: 2227	31163 (100%) n: 2500
Start depth not null	7664 (90%) n: 1118	6883 (100%) n: 920	12320 (100%) n: 1459	19336 (100%) n: 2047	24778 (100%) n: 2517	28039 (100%) n: 2297	34261 (100%) n: 2398	27217 (100%) n: 2227	31130 (100%) n: 2498
Headline height not null	7664 (90%) n: 1118	6883 (100%) n: 920	12320 (100%) n: 1459	19336 (100%) n: 2047	24778 (100%) n: 2517	28039 (100%) n: 2297	34261 (100%) n: 2398	27217 (100%) n: 2227	31130 (100%) n: 2498
Fishing speed >3.5kn	7664 (90%) n: 1117	6883 (100%) n: 920	12307 (100%) n: 1454	19334 (100%) n: 2045	24739 (100%) n: 2516	28006 (100%) n: 2294	34261 (100%) n: 2397	27195 (100%) n: 2226	31123 (100%) n: 2497
Headline height >15m	7626 (89%) n: 1112	6809 (100%) n: 907	12299 (100%) n: 1448	19293 (100%) n: 2039	24575 (100%) n: 2507	27856 (100%) n: 2283	34242 (100%) n: 2393	27115 (100%) n: 2219	31045 (100%) n: 2490
Headline height <90m	7623 (89%) n: 1111	6809 (100%) n: 907	12299 (100%) n: 1448	19234 (100%) n: 2036	24550 (100%) n: 2503	27856 (100%) n: 2281	34240 (100%) n: 2392	27115 (100%) n: 2219	31043 (100%) n: 2489
Fishing duration >15mins	7458 (87%) n: 1095	6620 (95%) n: 895	12227 (100%) n: 1435	19225 (100%) n: 2022	24128 (100%) n: 2481	27850 (100%) n: 2271	33931 (100%) n: 2374	26864 (100%) n: 2205	30945 (100%) n: 2480
Seabed depth >50m	7458 (87%) n: 1095	6620 (95%) n: 895	12227 (100%) n: 1435	19225 (100%) n: 2022	24128 (100%) n: 2481	27850 (100%) n: 2271	33931 (100%) n: 2374	26864 (100%) n: 2205	30900 (100%) n: 2479
Seabed depth <400m	7383 (86%) n: 1081	6611 (95%) n: 893	12213 (100%) n: 1433	19189 (100%) n: 2014	24076 (100%) n: 2463	27823 (100%) n: 2265	33410 (100%) n: 2343	26826 (100%) n: 2203	30874 (100%) n: 2478
Start time >0	7189 (84%) n: 1060	6402 (92%) n: 874	12043 (100%) n: 1411	18841 (100%) n: 1979	23543 (93%) n: 2418	27456 (100%) n: 2237	33055 (100%) n: 2317	26066 (100%) n: 2170	30229 (100%) n: 2434
Core fleet selection	6699 (78%) n: 871	6375 (91%) n: 853	12037 (100%) n: 1405	18620 (95%) n: 1944	23403 (93%) n: 2392	27456 (100%) n: 2237	33055 (100%) n: 2317	25759 (95%) n: 2115	30099 (100%) n: 2382

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	32330 (100%) n: 2320	28231 (100%) n: 1966	30940 (100%) n: 2243	27858 (100%) n: 1670	27480 (100%) n: 1686	31540 (100%) n: 1815	33401 (100%) n: 1982	30515 (100%) n: 1460	28266 (100%) n: 1392
Fishing speed not null	32330 (100%) n: 2320	28231 (100%) n: 1966	30940 (100%) n: 2243	27858 (100%) n: 1670	27480 (100%) n: 1686	31540 (100%) n: 1815	33401 (100%) n: 1982	30515 (100%) n: 1460	28266 (100%) n: 1392
Start date not null	32330 (100%) n: 2320	28231 (100%) n: 1966	30940 (100%) n: 2243	27858 (100%) n: 1670	27480 (100%) n: 1686	31540 (100%) n: 1815	33401 (100%) n: 1982	30515 (100%) n: 1460	28266 (100%) n: 1392
End date not null	32330 (100%) n: 2320	28231 (100%) n: 1966	30940 (100%) n: 2243	27858 (100%) n: 1670	27480 (100%) n: 1686	31540 (100%) n: 1815	33401 (100%) n: 1982	30515 (100%) n: 1460	28266 (100%) n: 1392
Start depth not null	32313 (100%) n: 2319	28231 (100%) n: 1966	30940 (100%) n: 2243	27822 (100%) n: 1669	27480 (100%) n: 1686	31540 (100%) n: 1815	33401 (100%) n: 1982	30515 (100%) n: 1460	28266 (100%) n: 1392
Headline height not null	32313 (100%) n: 2319	28231 (100%) n: 1966	30940 (100%) n: 2243	27822 (100%) n: 1669	27480 (100%) n: 1686	31540 (100%) n: 1815	33401 (100%) n: 1982	30515 (100%) n: 1460	28266 (100%) n: 1392
Fishing speed >3.5kn	32266 (100%) n: 2318	28231 (100%) n: 1966	30940 (100%) n: 2240	27789 (100%) n: 1668	27480 (100%) n: 1686	31540 (100%) n: 1815	33401 (100%) n: 1982	30515 (100%) n: 1459	28266 (100%) n: 1392
Headline height >15m	32211 (100%) n: 2312	28129 (100%) n: 1963	30902 (100%) n: 2238	27745 (100%) n: 1664	27400 (100%) n: 1681	31527 (100%) n: 1812	33390 (100%) n: 1977	30515 (100%) n: 1459	28266 (100%) n: 1392
Headline height <90m	32211 (100%) n: 2312	28113 (100%) n: 1962	30902 (100%) n: 2238	27745 (100%) n: 1664	27400 (100%) n: 1681	31527 (100%) n: 1812	33276 (100%) n: 1976	30469 (100%) n: 1458	28261 (100%) n: 1391
Fishing duration >15mins	32182 (100%) n: 2301	27996 (100%) n: 1954	30902 (100%) n: 2236	27691 (100%) n: 1661	27251 (100%) n: 1674	31432 (100%) n: 1802	33089 (100%) n: 1967	30469 (100%) n: 1454	28203 (100%) n: 1384
Seabed depth >50m	32182 (100%) n: 2301	27996 (100%) n: 1954	30902 (100%) n: 2236	27691 (100%) n: 1661	27251 (100%) n: 1674	31432 (100%) n: 1802	33089 (100%) n: 1967	30469 (100%) n: 1454	28203 (100%) n: 1384
Seabed depth <400m	32133 (100%) n: 2295	27919 (100%) n: 1949	30843 (100%) n: 2231	27621 (100%) n: 1659	27099 (100%) n: 1663	31316 (100%) n: 1797	33063 (100%) n: 1961	30369 (100%) n: 1447	28203 (100%) n: 1383
Start time >0	31528 (100%) n: 2258	27584 (100%) n: 1932	30476 (100%) n: 2213	27269 (100%) n: 1639	26795 (100%) n: 1646	30975 (100%) n: 1783	32733 (100%) n: 1944	30035 (100%) n: 1437	27993 (100%) n: 1374
Core fleet selection	31522 (100%) n: 2256	27559 (100%) n: 1921	30081 (100%) n: 2161	27268 (100%) n: 1632	26787 (100%) n: 1641	29977 (100%) n: 1627	28766 (86%) n: 1662	25305 (83%) n: 1230	27993 (100%) n: 1374

Filter	2017	2018	2019	2020	2021	2022
Ungroomed data	33145 (100%) n: 1302	32022 (100%) n: 1369	30646 (100%) n: 1354	28692 (100%) n: 1478	31321 (100%) n: 1310	26836 (100%) n: 1384
Fishing speed not null	33145 (100%) n: 1302	32022 (100%) n: 1369	30646 (100%) n: 1354	28692 (100%) n: 1478	31321 (100%) n: 1310	26836 (100%) n: 1384
Start date not null	33145 (100%) n: 1302	32022 (100%) n: 1369	30646 (100%) n: 1354	28692 (100%) n: 1478	31321 (100%) n: 1310	26836 (100%) n: 1384
End date not null	33145 (100%) n: 1302	32022 (100%) n: 1369	30646 (100%) n: 1354	28692 (100%) n: 1478	31321 (100%) n: 1310	26836 (100%) n: 1384
Start depth not null	33145 (100%) n: 1302	32022 (100%) n: 1369	30646 (100%) n: 1354	28692 (100%) n: 1478	31321 (100%) n: 1310	26836 (100%) n: 1384
Headline height not null	33145 (100%) n: 1302	32022 (100%) n: 1369	30646 (100%) n: 1354	28692 (100%) n: 1478	31321 (100%) n: 1310	26836 (100%) n: 1384
Fishing speed >3.5kn	33145 (100%) n: 1302	32022 (100%) n: 1369	30646 (100%) n: 1354	28692 (100%) n: 1478	31321 (100%) n: 1310	26836 (100%) n: 1384
Headline height >15m	33101 (100%) n: 1300	32022 (100%) n: 1369	30646 (100%) n: 1354	28692 (100%) n: 1478	31321 (100%) n: 1310	26836 (100%) n: 1384
Headline height <90m	33101 (100%) n: 1300	32022 (100%) n: 1369	30646 (100%) n: 1354	28692 (100%) n: 1478	31321 (100%) n: 1310	26836 (100%) n: 1384
Fishing duration >15mins	33050 (100%) n: 1294	32018 (100%) n: 1366	30591 (100%) n: 1345	28692 (100%) n: 1478	31256 (100%) n: 1305	26836 (100%) n: 1382
Seabed depth >50m	33050 (100%) n: 1294	32018 (100%) n: 1366	30591 (100%) n: 1345	28682 (100%) n: 1477	31256 (100%) n: 1305	26836 (100%) n: 1382
Seabed depth <400m	32997 (100%) n: 1293	31940 (100%) n: 1361	30452 (100%) n: 1343	28635 (100%) n: 1473	31256 (100%) n: 1304	26762 (100%) n: 1379
Start time >0	32825 (100%) n: 1285	31882 (100%) n: 1358	30327 (100%) n: 1337	28529 (100%) n: 1468	31013 (100%) n: 1297	26681 (100%) n: 1376
Core fleet selection	32825 (100%) n: 1285	31882 (100%) n: 1358	30327 (100%) n: 1337	28529 (100%) n: 1468	31012 (100%) n: 1289	26681 (100%) n: 1376

Table C.3: Summary of the JMA7 MW event dataset after core fleet selection. 'Records' indicates the number of rows (events) in the dataset, and 'Records caught' indicates the percentage of events with catches of jack mackerels.

Fishing year	Vessels	Trips	Records	Hrs	Catch (t)	Records caught
1999	9	36	871	1 872.37	6 698.78	84.27
2000	8	27	853	1 886.60	6 375.39	86.05
2001	10	40	1 405	3 613.05	12 037.03	88.61
2002	11	45	1 944	5 557.35	18 620.00	94.08
2003	10	54	2 392	7 117.32	23 402.86	95.57
2004	7	45	2 237	6 657.17	27 456.29	96.83
2005	11	42	2 317	7 281.90	33 055.06	95.51
2006	7	38	2 115	7 279.73	25 759.20	94.47
2007	7	52	2 382	8 868.00	30 098.96	94.46
2008	7	48	2 256	8 452.30	31 521.84	95.79
2009	8	39	1 921	7 492.38	27 559.47	94.74
2010	8	42	2 161	8 650.70	30 080.88	97.36
2011	6	34	1 632	7 537.25	27 267.64	97.67
2012	6	44	1 641	7 450.63	26 786.65	97.26
2013	7	45	1 627	7 298.10	29 976.54	98.16
2014	8	44	1 662	7 457.35	28 765.88	96.15
2015	7	40	1 230	5 571.93	25 305.12	98.13
2016	8	43	1 374	5 711.17	27 992.85	96.58
2017	6	46	1 285	6 009.25	32 824.63	97.59
2018	8	44	1 358	7 230.28	31 881.94	97.86
2019	8	48	1 337	6 242.73	30 327.25	97.76
2020	8	50	1 468	6 806.93	28 529.36	96.19
2021	8	48	1 289	5 981.35	31 012.29	98.68
2022	7	46	1 376	6 135.70	26 681.10	99.20

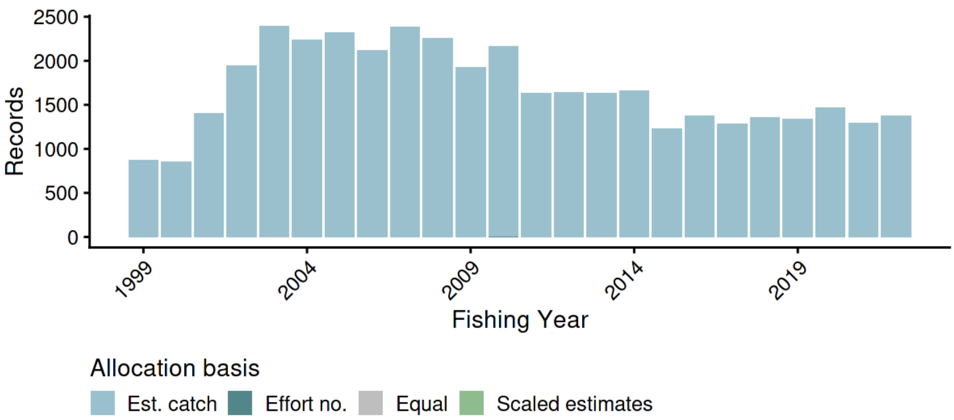

Figure C.3: Allocation basis for attributing landings to records in the JMA7 MW event catch-per-unit-effort dataset. Allocation basis is in terms of estimated catch, effort number, and/or equal.

Table C.4: Summary of stepwise selection for occurrence of positive catch. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	72.00	10 994	24.10	24.10	*

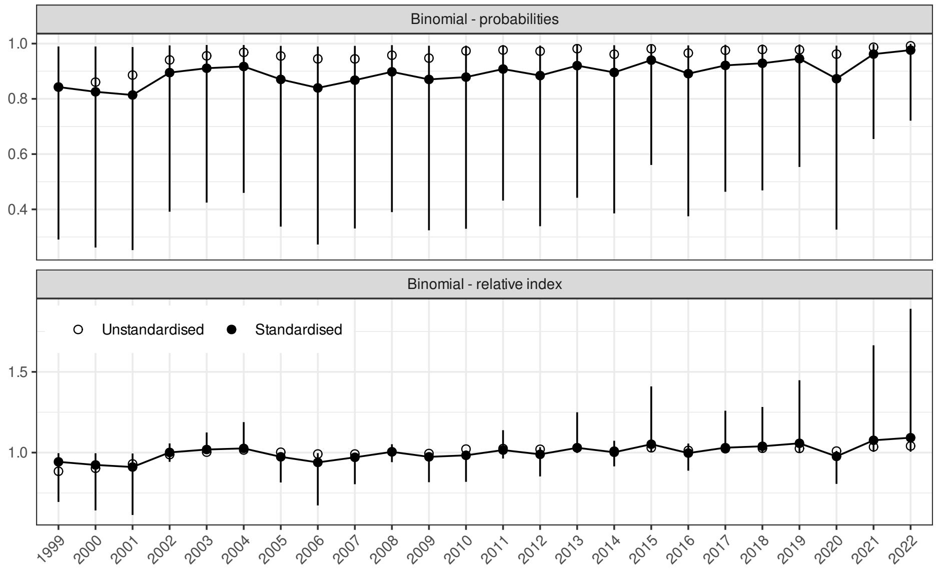

Figure C.4: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the JMA7 MW event dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

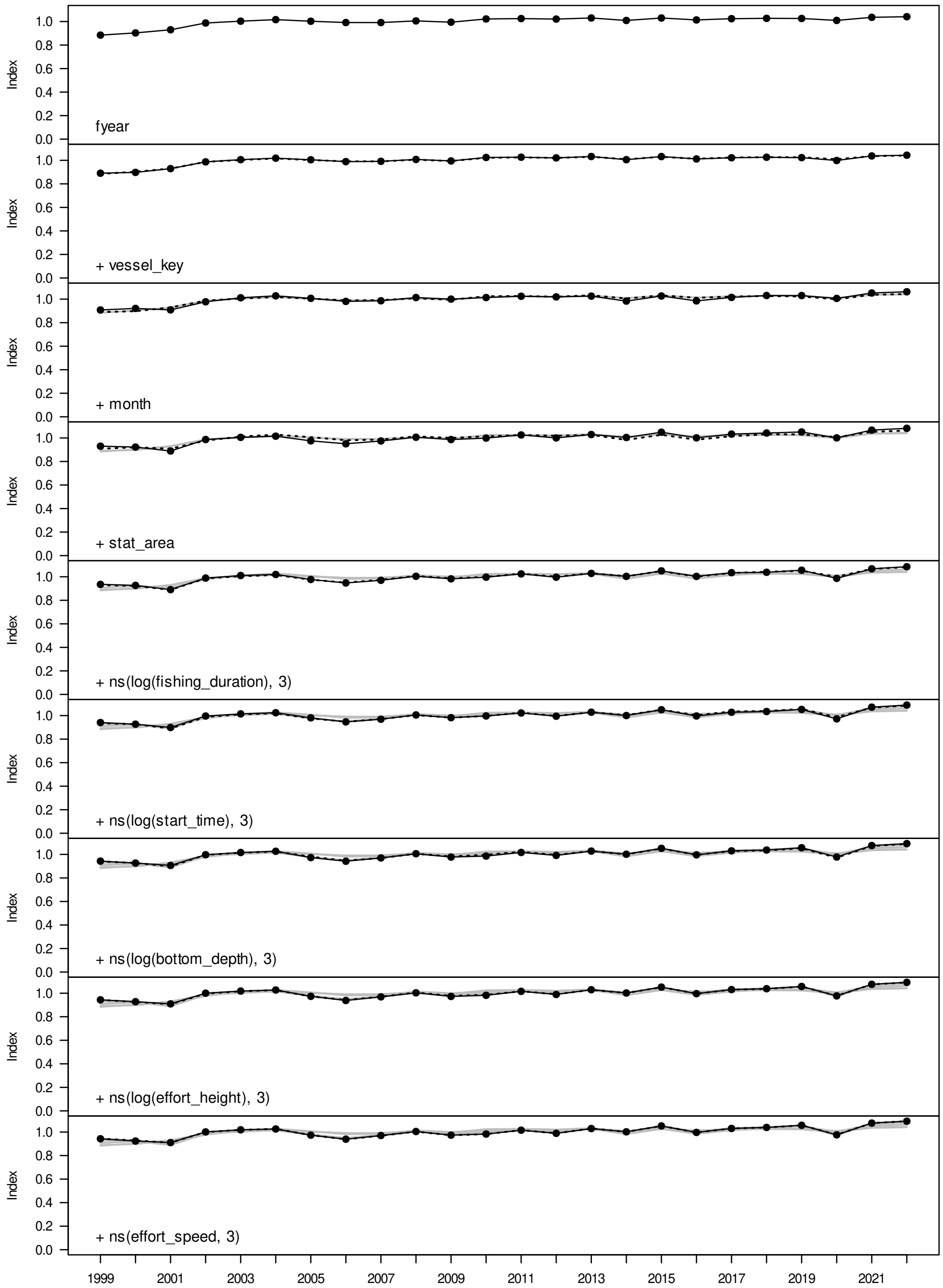

Figure C.5: Step plot for occurrence of catch in the JMA7 MW event dataset.

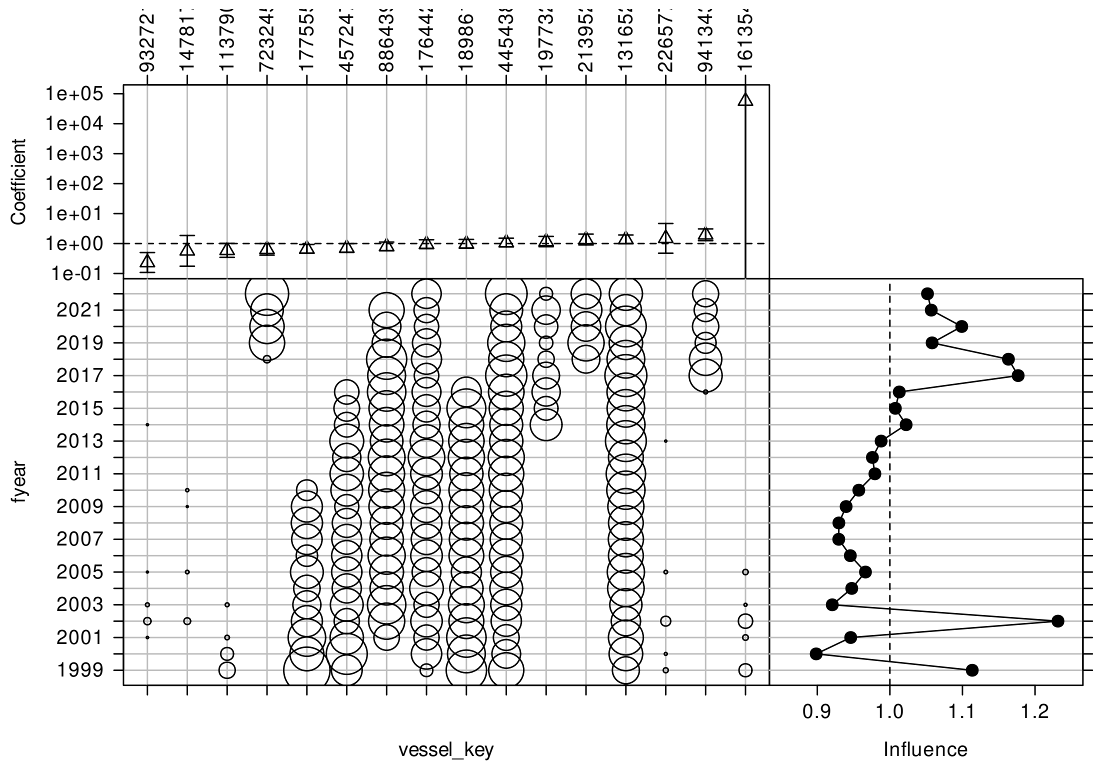

Figure C.6: CDI plot for vessel key for the occurrence of positive catch JMA7 MW event catch-per-unit-effort dataset.

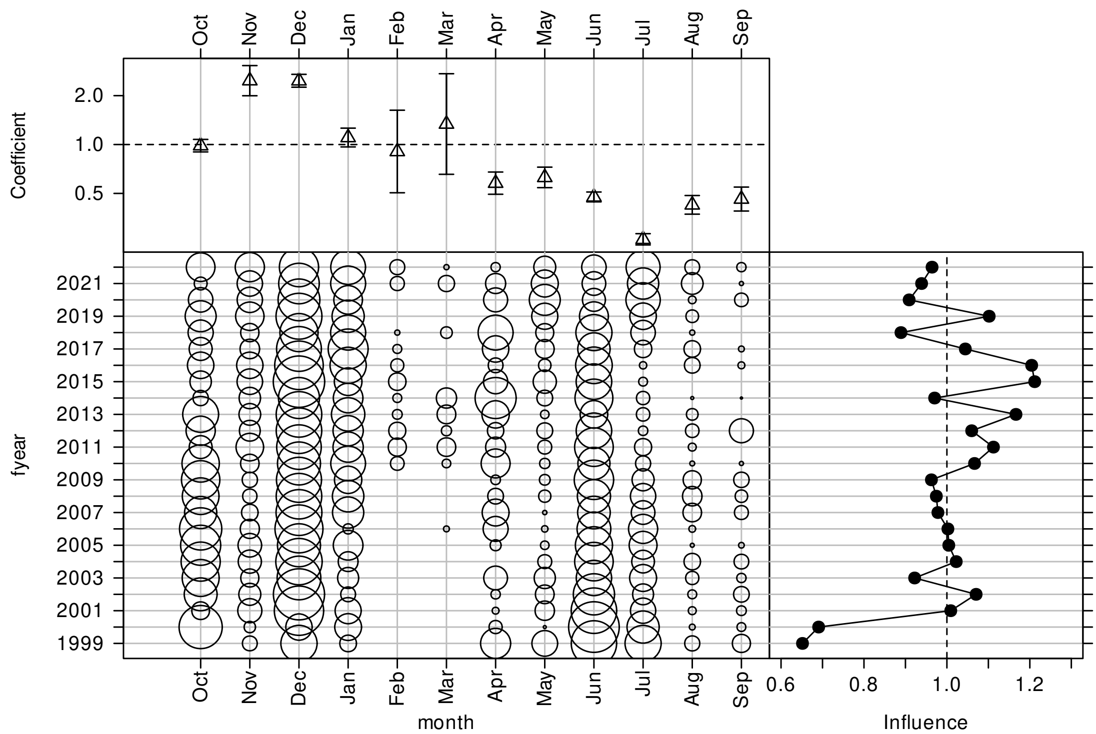

Figure C.7: CDI plot for month for the occurrence of positive catch JMA7 MW event catch-per-unit-effort dataset.

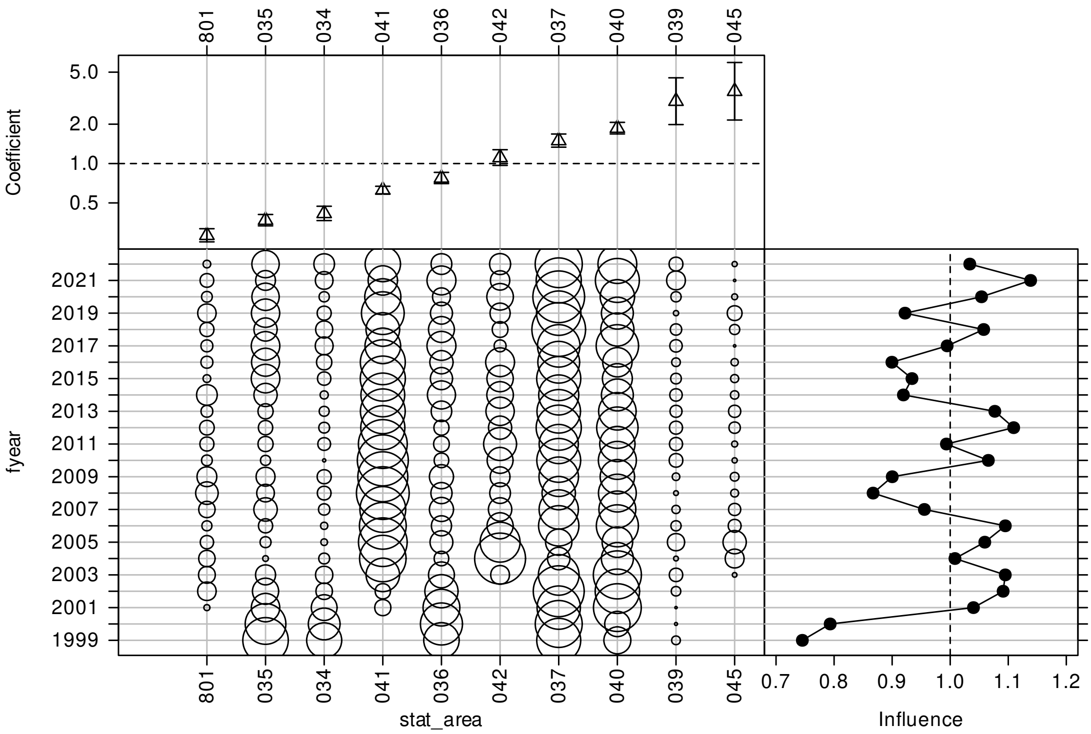

Figure C.8: CDI plot for statistical area for the occurrence of positive catch JMA7 MW event catch-per-unit-effort dataset.

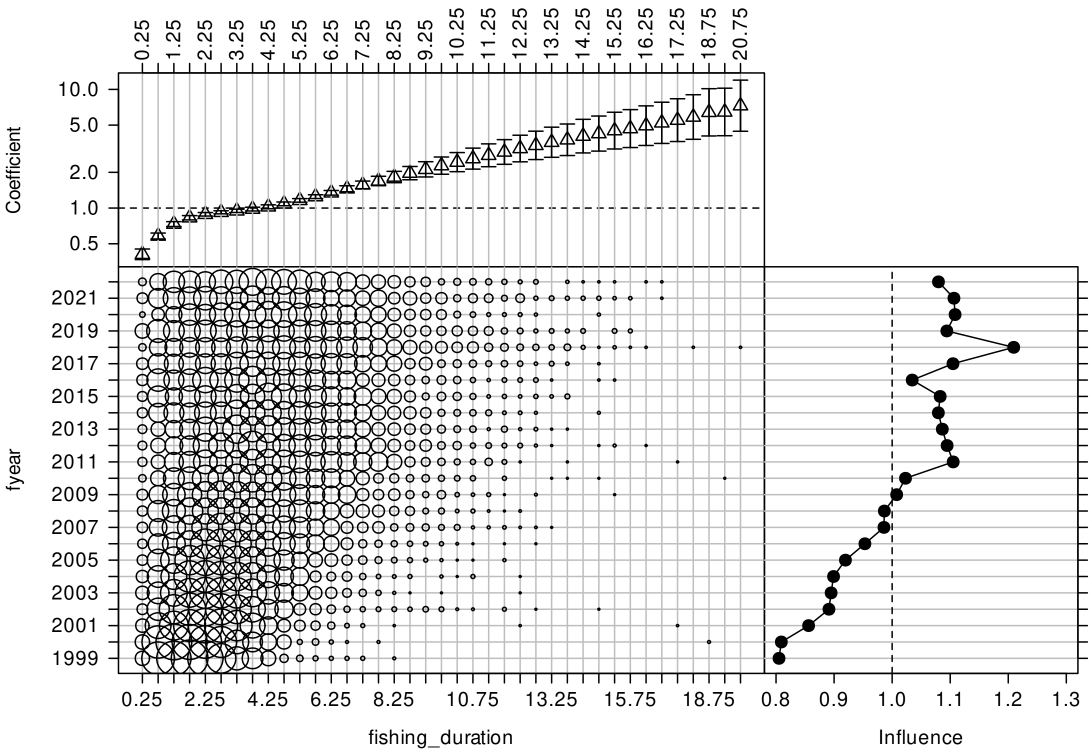

Figure C.9: CDI plot for fishing duration (h) for the occurrence of positive catch JMA7 MW event catch-per-unit-effort dataset.

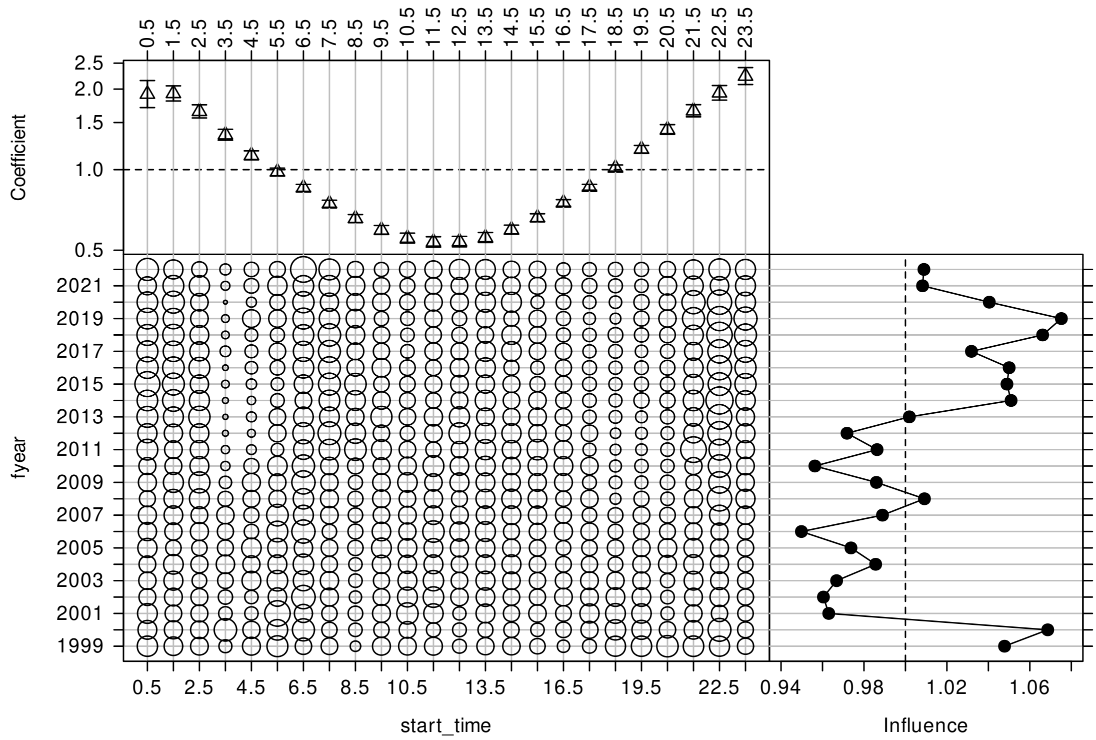

Figure C.10: CDI plot for start time for the occurrence of positive catch JMA7 MW event catch-per-unit-effort dataset.

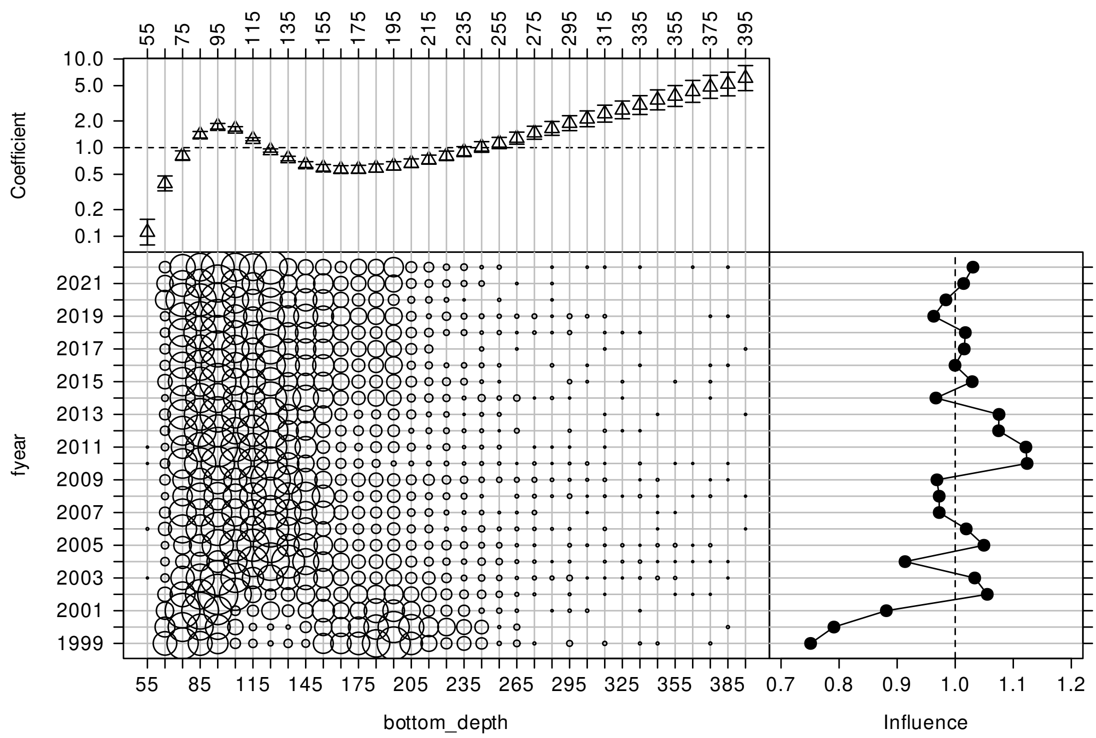

Figure C.11: CDI plot for bottom depth (m) for the occurrence of positive catch JMA7 MW event catch-per-unit-effort dataset.

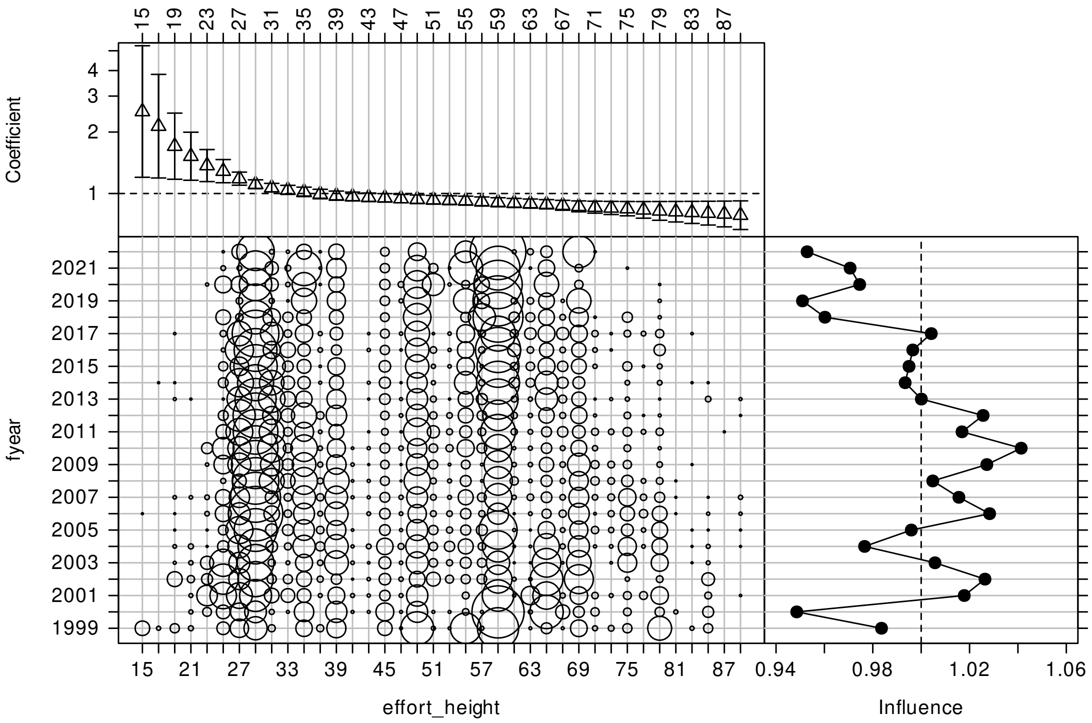

Figure C.12: CDI plot for effort height (m) for the occurrence of positive catch JMA7 MW event catch-per-unit-effort dataset.

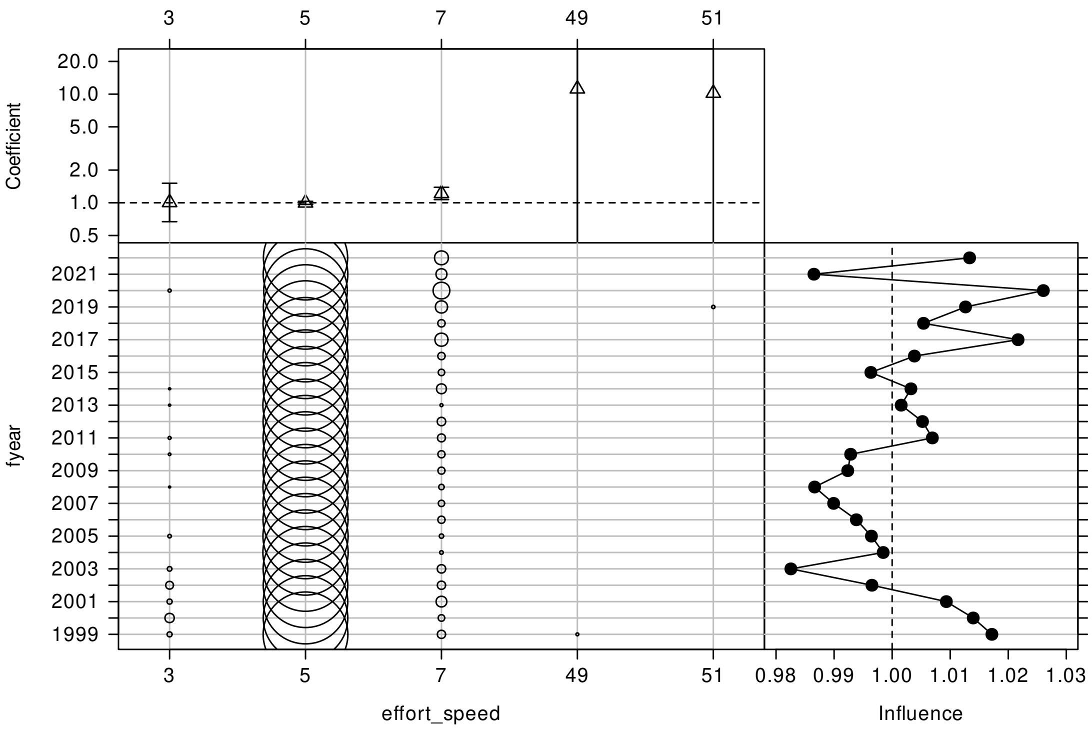

Figure C.13: CDI plot for effort speed for the occurrence of positive catch JMA7 MW event catch-per-unit-effort dataset.

Table C.5: Summary table for the Weibull 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	820 870.9	0	0	*
fyear	23	817 711.6	-	-	*
vessel key	15	817 366.4	-	-	*
month	11	817 181.1	-	-	*
stat area	9	816 540.9	-	-	*
ns(log(fishing duration), 3)	3	815 711.7	-	-	*
ns(log(start time), 3)	3	815 206.5	-	-	*
ns(log(bottom depth), 3)	3	815 186.9	-	-	*
ns(log(effort height), 3)	3	815 089.3	-	-	*
ns(effort speed, 3)	3	815 039.9	-	-	*

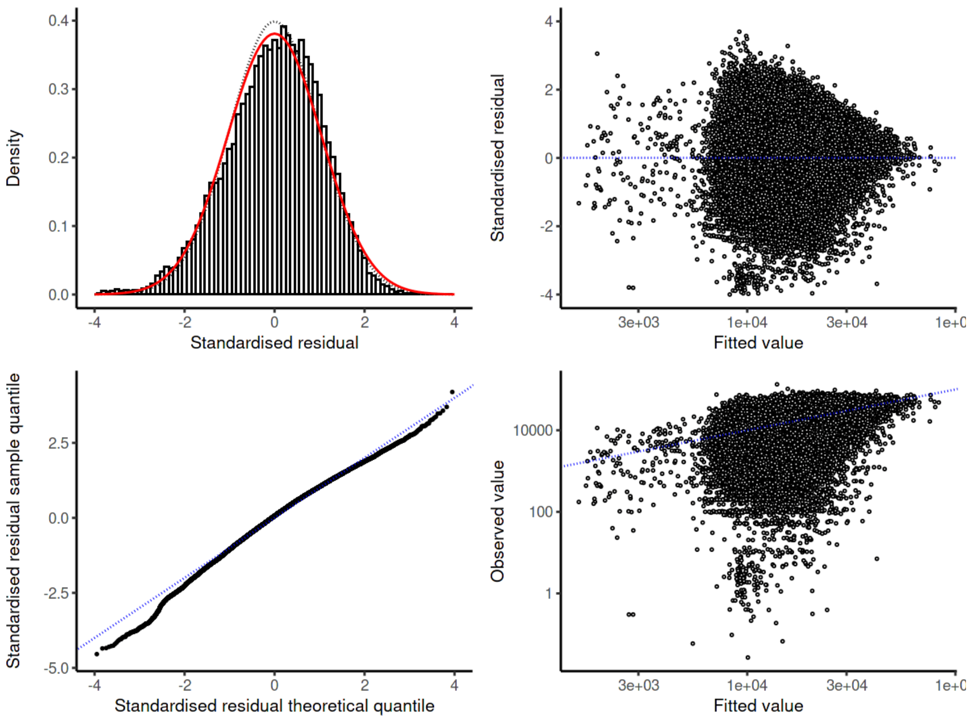

Figure C.14: Diagnostic plots for the Weibull model for the JMA7 MW event dataset.

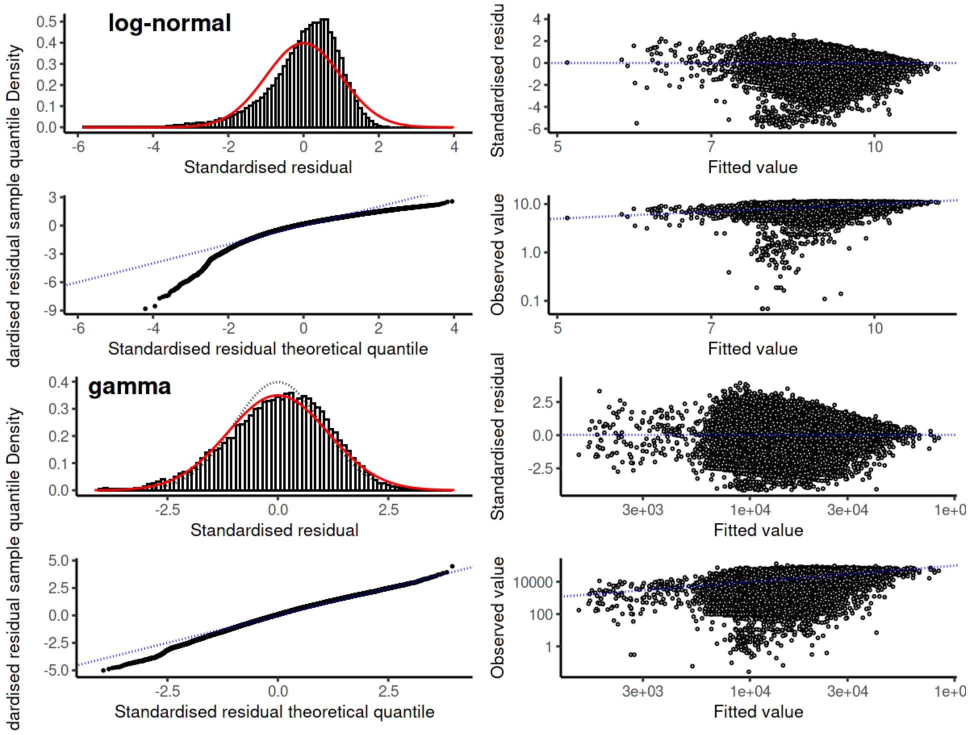

Figure C.15: Diagnostic plots for the log-normal and gamma model for the JMA7 MW event dataset.

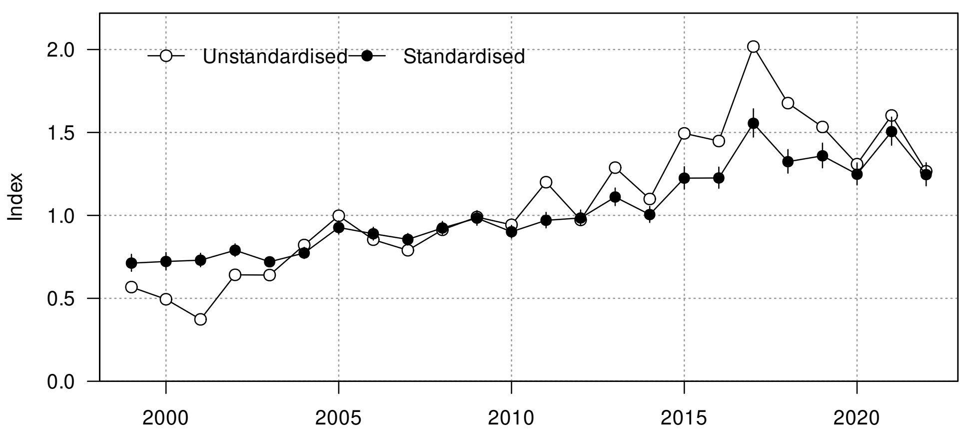

Figure C.16: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch in the JMA7 MW event dataset.

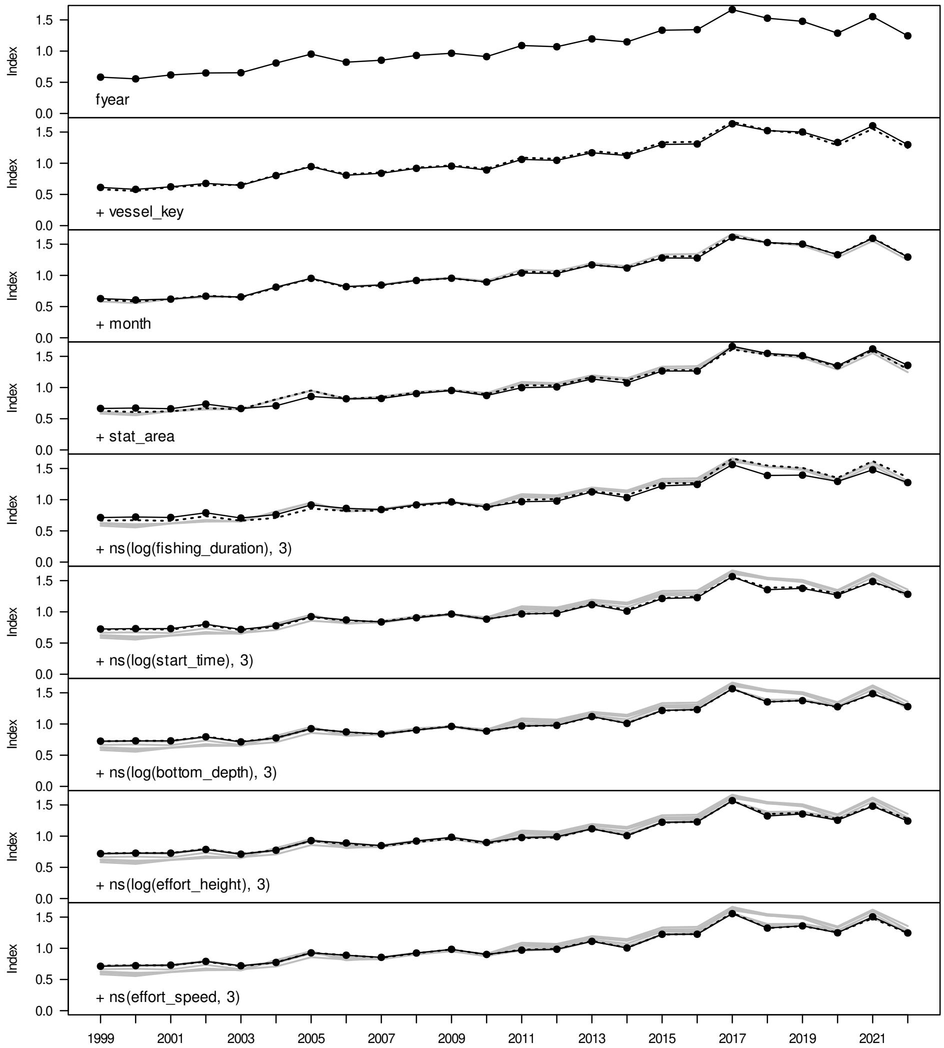

Figure C.17: Changes to the JMA7 MW event positive catch index as terms are successively entered into the model.

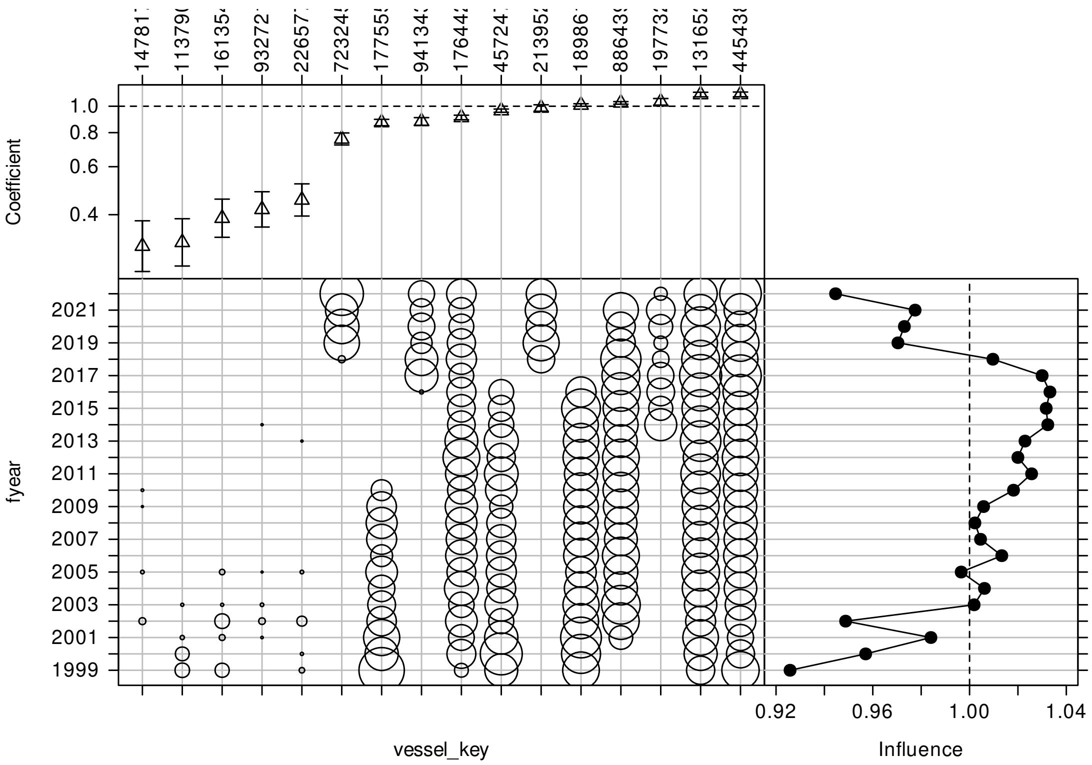

Figure C.18: CDI plot for vessel key for the positive catch JMA7 MW event catch-per-unit-effort dataset.

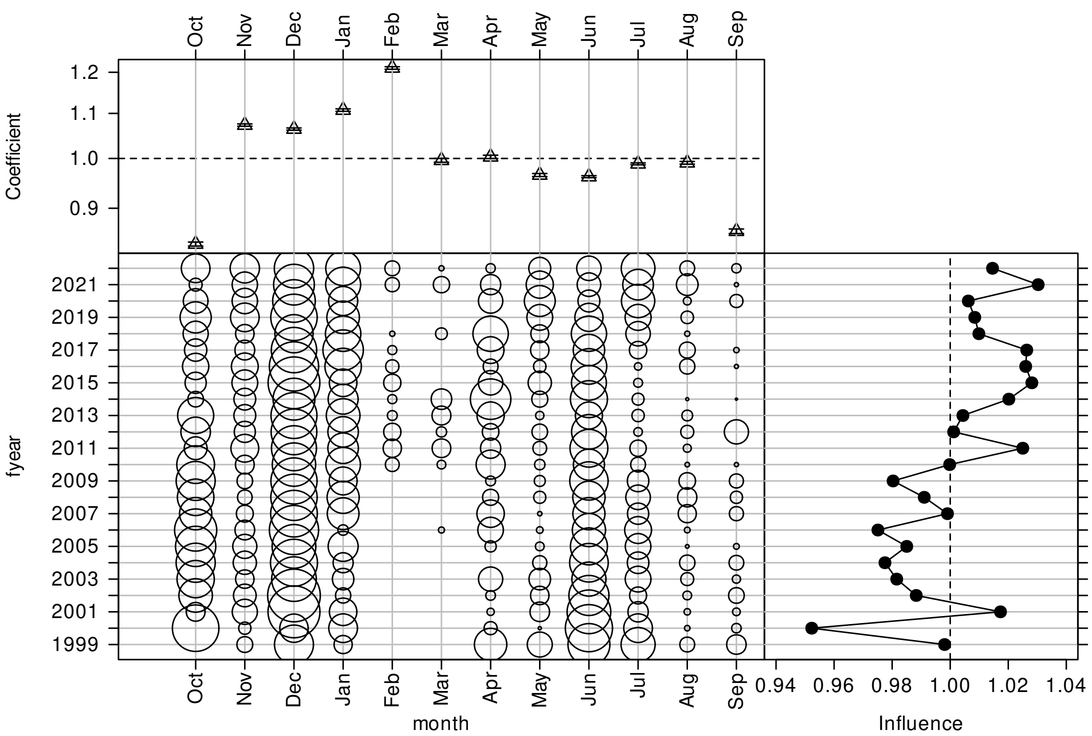

Figure C.19: CDI plot for month for the positive catch JMA7 MW event catch-per-unit-effort dataset.

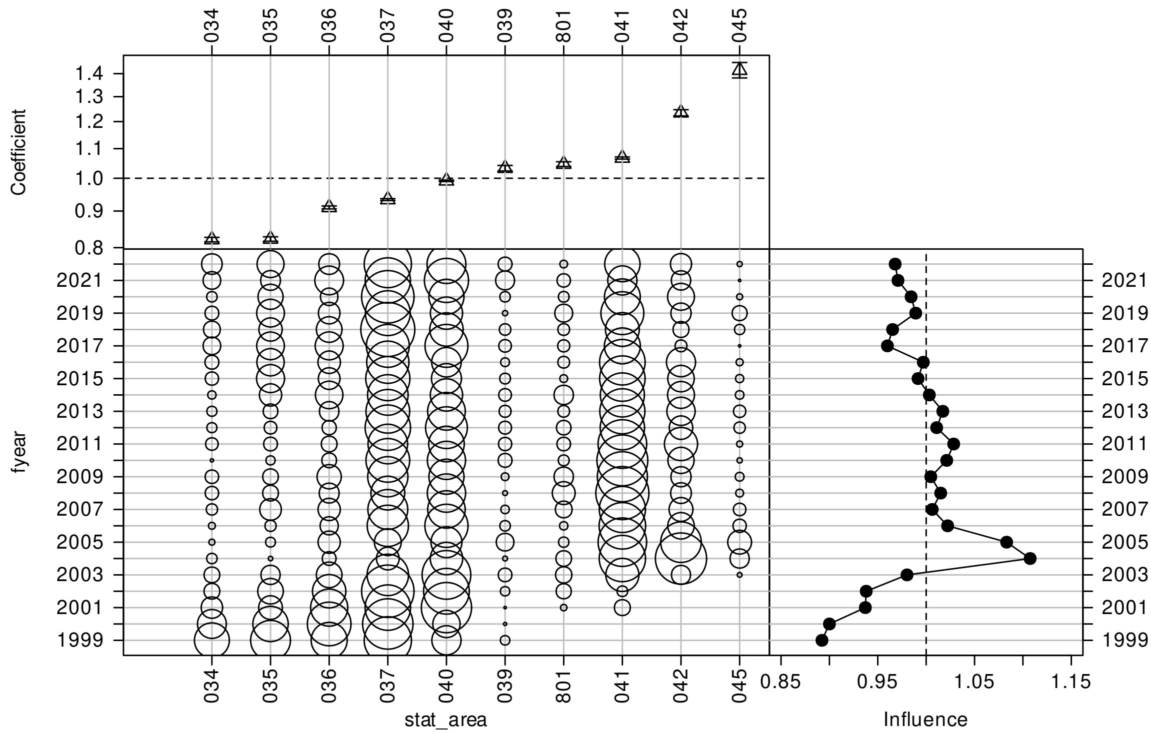

Figure C.20: CDI plot for statistical area for the positive catch JMA7 MW event catch-per-unit-effort dataset.

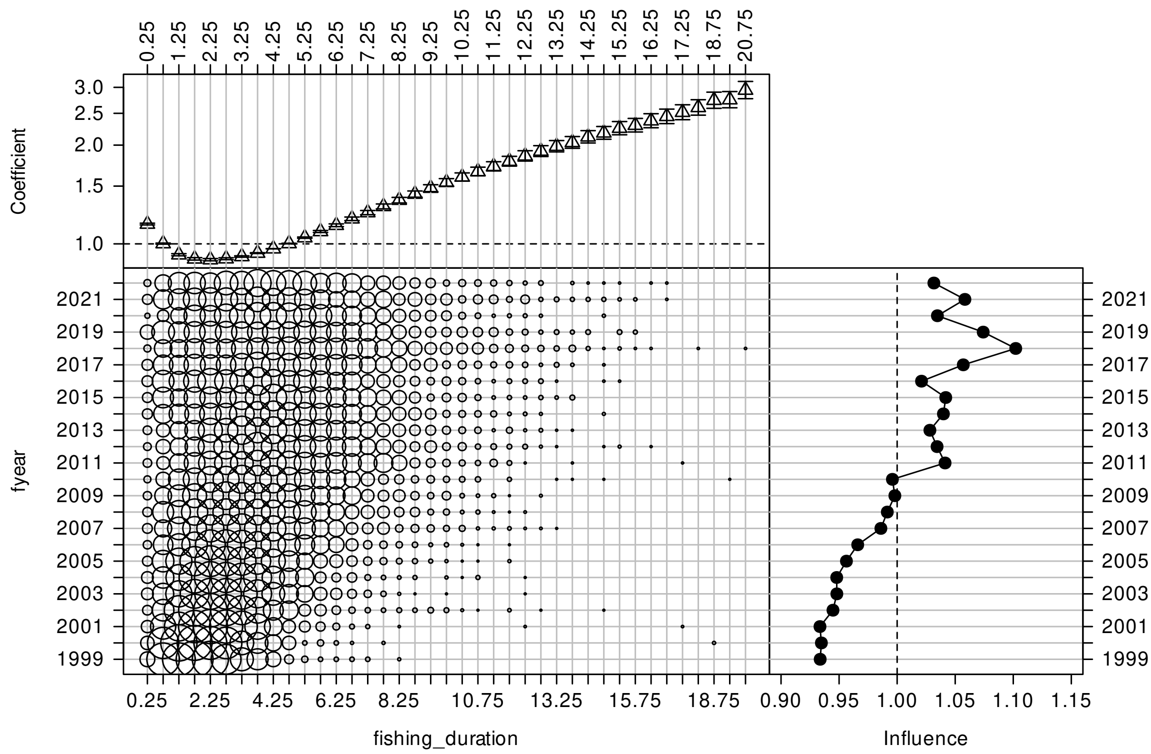

Figure C.21: CDI plot for fishing duration (h) for the positive catch JMA7 MW event catch-per-unit-effort dataset.

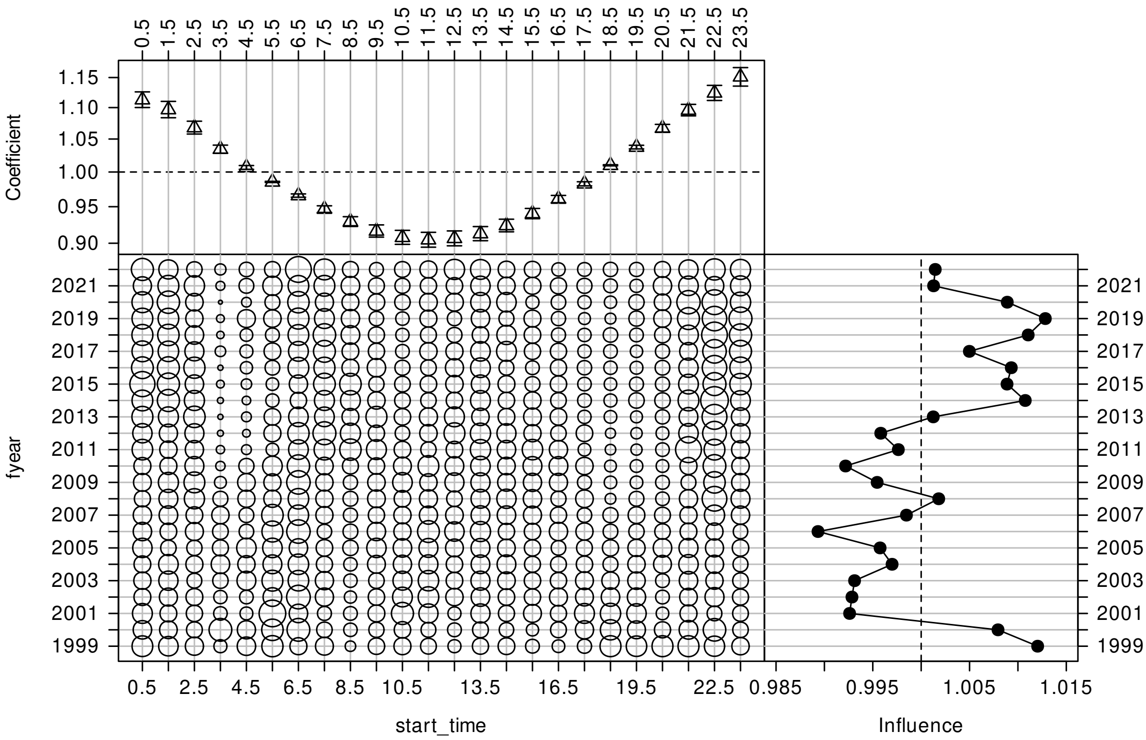

Figure C.22: CDI plot for start time for the positive catch JMA7 MW event catch-per-unit-effort dataset.

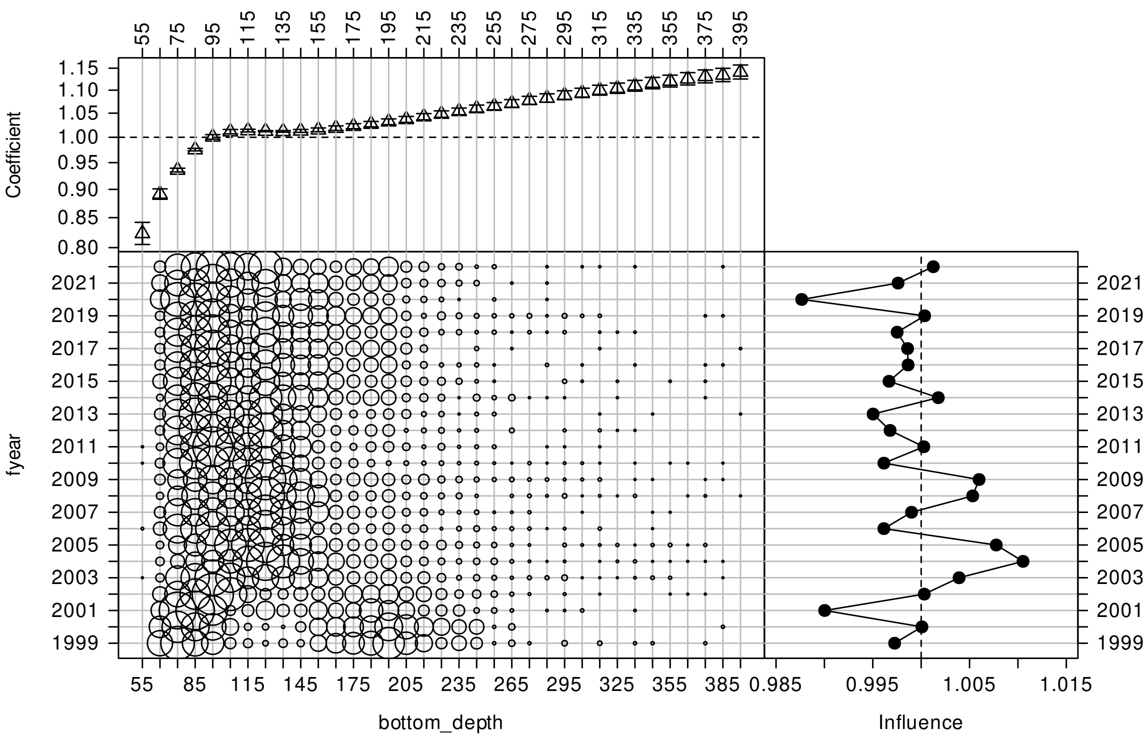

Figure C.23: CDI plot for bottom depth (m) for the positive catch JMA7 MW event catch-per-unit-effort dataset.

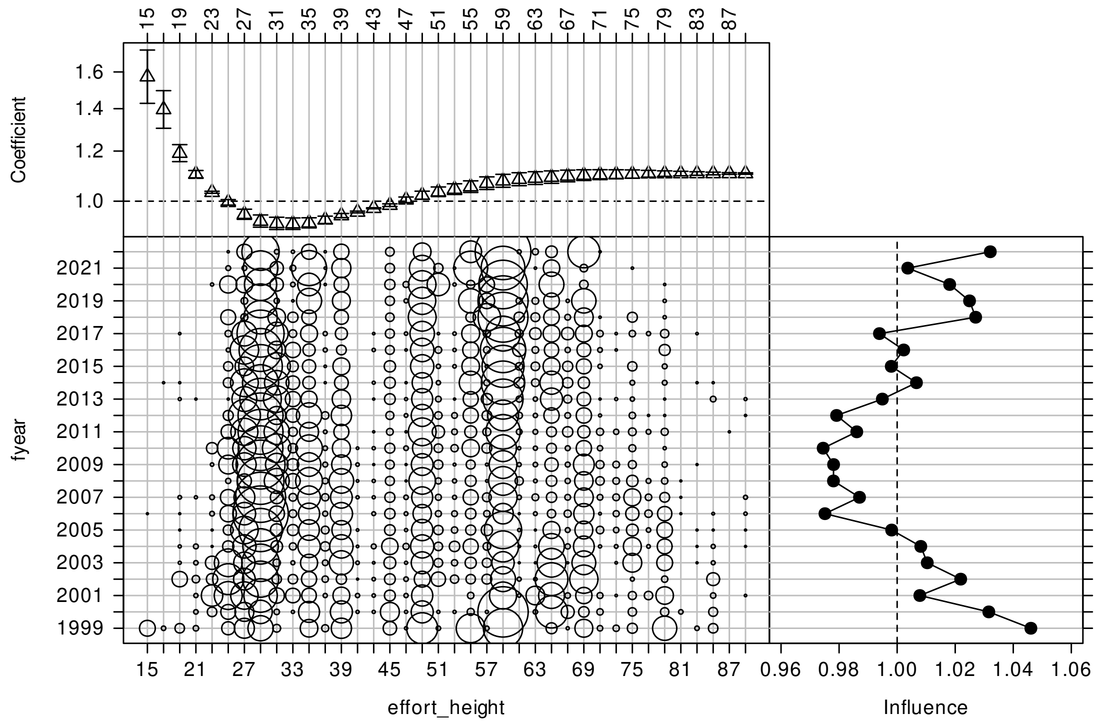

Figure C.24: CDI plot for effort height (m) for the positive catch JMA7 MW event catch-per-unit-effort dataset.

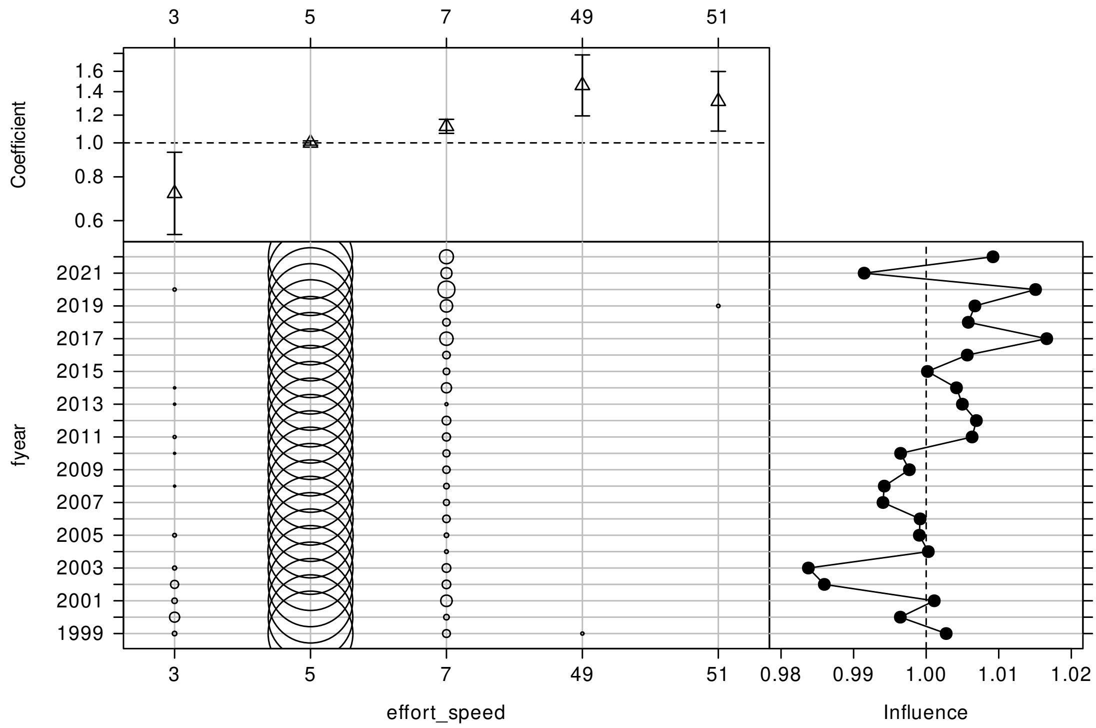

Figure C.25: CDI plot for effort speed for the positive catch JMA7 MW event catch-per-unit-effort dataset.

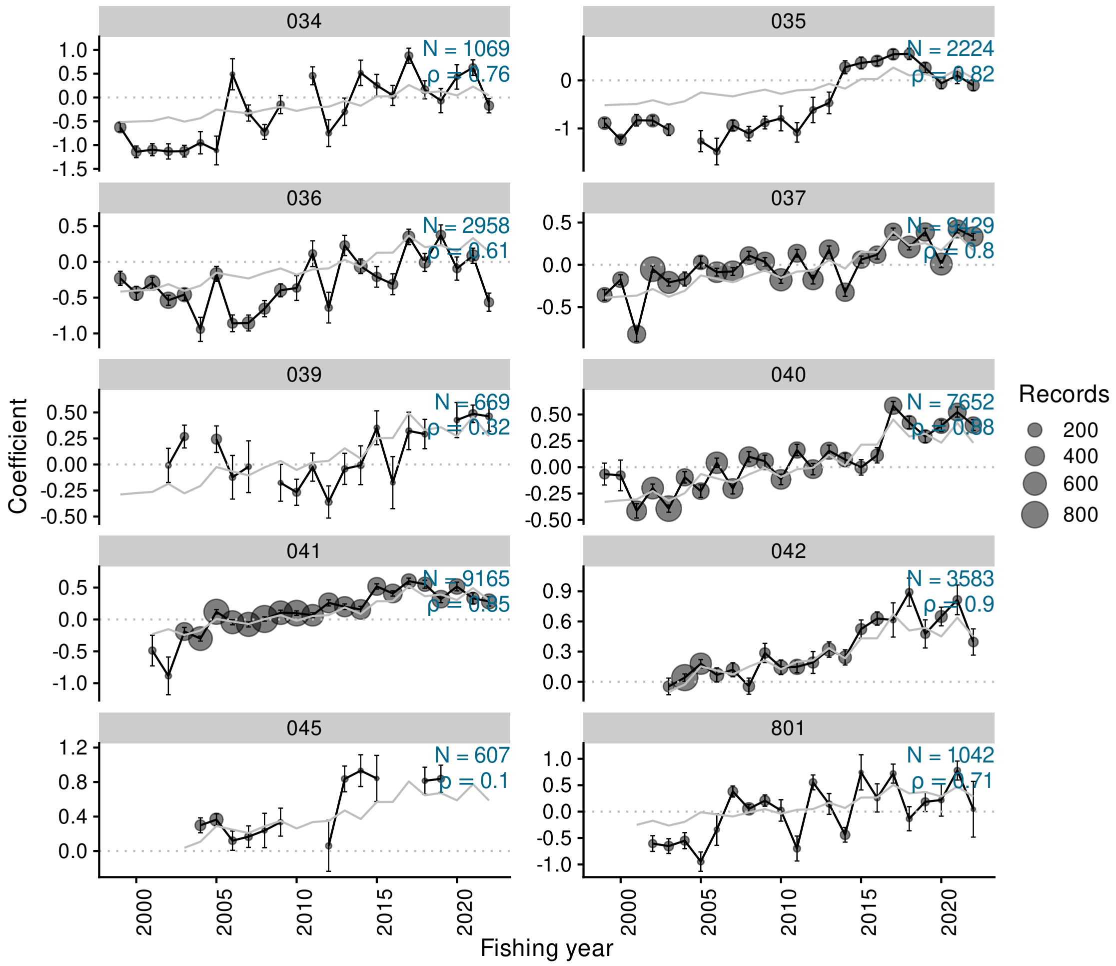

Figure C.26: Residual implied coefficients for area-year in the Weibull positive catch model for the JMA7 MW event dataset.

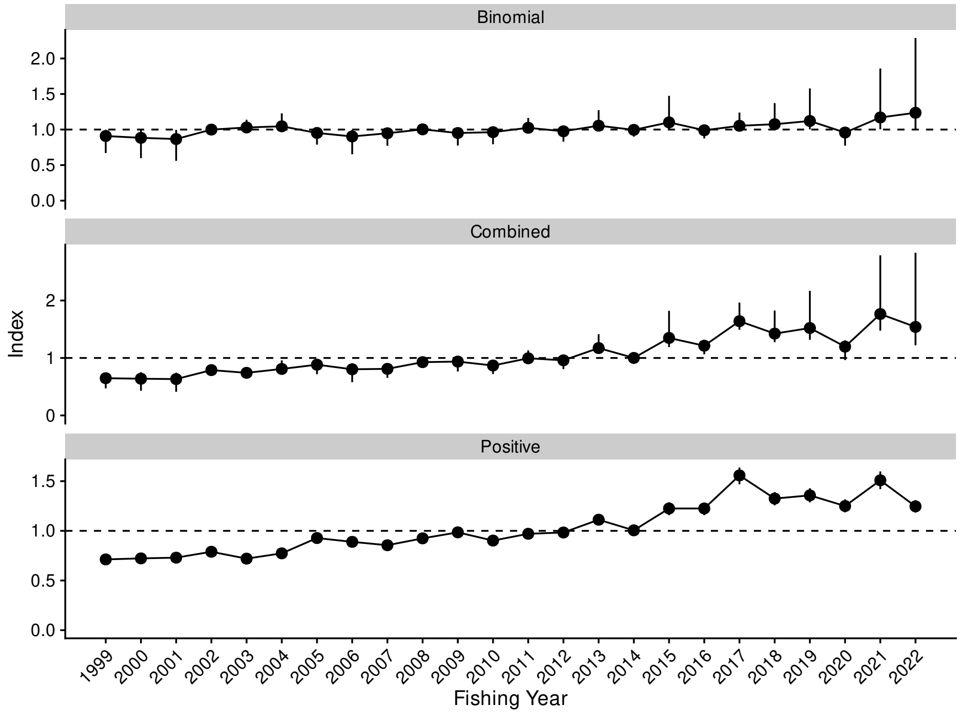

Figure C.27: Standardised indices and 95% confidence intervals for the JMA7 MW event dataset.

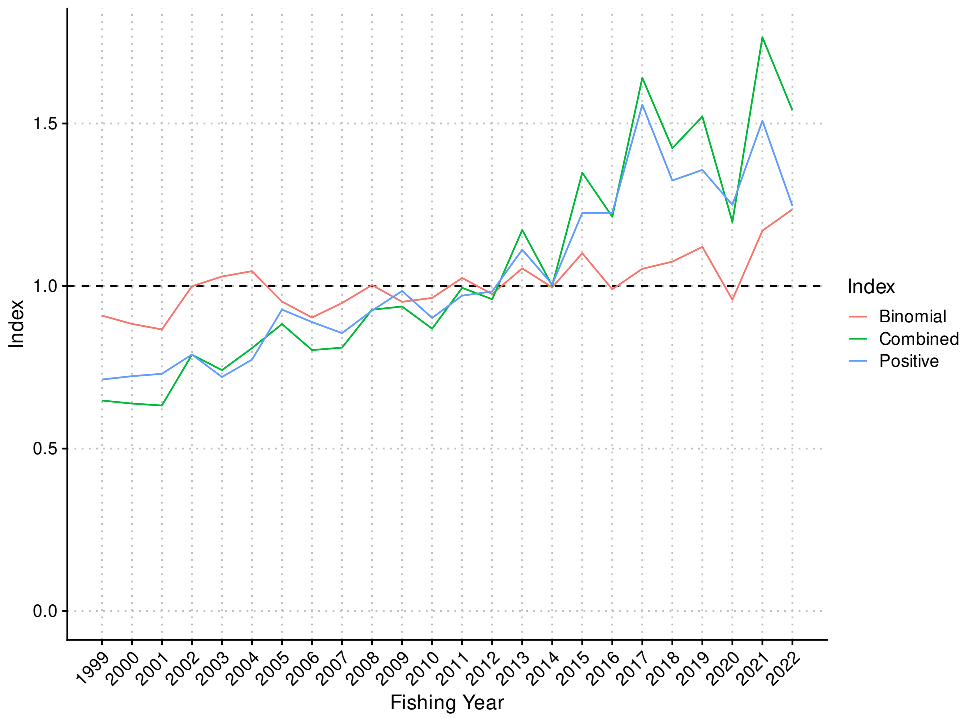

Figure C.28: Standardised indices for the JMA7 MW event dataset.

Table C.6: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in JMA7 MW event.

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
1999	0.909	0.083	0.670	0.997	0.648	0.068	0.471	0.739	0.712	0.026	0.664	0.765
2000	0.884	0.101	0.598	0.995	0.638	0.082	0.429	0.752	0.723	0.027	0.671	0.779
2001	0.867	0.111	0.560	0.995	0.632	0.085	0.411	0.743	0.730	0.021	0.690	0.771
2002	0.999	0.035	0.928	1.066	0.789	0.031	0.730	0.851	0.789	0.018	0.756	0.827
2003	1.029	0.036	0.996	1.138	0.741	0.033	0.697	0.825	0.720	0.014	0.693	0.749
2004	1.046	0.058	1.000	1.228	0.809	0.053	0.752	0.959	0.774	0.017	0.741	0.808
2005	0.952	0.054	0.788	1.000	0.883	0.059	0.717	0.950	0.927	0.019	0.892	0.966
2006	0.903	0.088	0.652	0.996	0.803	0.084	0.578	0.907	0.889	0.019	0.853	0.927
2007	0.948	0.058	0.772	0.999	0.811	0.057	0.655	0.879	0.855	0.018	0.822	0.891
2008	1.003	0.031	0.940	1.063	0.927	0.035	0.855	0.994	0.924	0.020	0.886	0.963
2009	0.951	0.057	0.775	1.000	0.937	0.063	0.764	1.012	0.985	0.022	0.943	1.030
2010	0.963	0.056	0.793	1.012	0.869	0.055	0.720	0.936	0.902	0.019	0.864	0.939
2011	1.025	0.055	0.946	1.163	0.995	0.057	0.907	1.132	0.970	0.023	0.926	1.018
2012	0.976	0.053	0.830	1.036	0.959	0.059	0.806	1.038	0.983	0.023	0.939	1.029
2013	1.054	0.070	0.998	1.273	1.172	0.086	1.076	1.414	1.112	0.028	1.057	1.166
2014	0.996	0.039	0.900	1.055	1.001	0.045	0.900	1.076	1.005	0.024	0.959	1.052
2015	1.101	0.120	1.002	1.474	1.349	0.161	1.190	1.821	1.225	0.033	1.158	1.288
2016	0.990	0.045	0.876	1.053	1.213	0.064	1.064	1.314	1.225	0.032	1.158	1.283
2017	1.053	0.062	0.996	1.239	1.640	0.121	1.491	1.964	1.558	0.043	1.469	1.637
2018	1.075	0.095	1.001	1.372	1.424	0.141	1.274	1.826	1.325	0.034	1.257	1.390
2019	1.121	0.147	1.003	1.579	1.521	0.218	1.316	2.169	1.357	0.036	1.286	1.429
2020	0.958	0.062	0.773	1.014	1.197	0.088	0.964	1.308	1.250	0.033	1.186	1.317
2021	1.170	0.218	1.004	1.859	1.765	0.335	1.475	2.787	1.509	0.045	1.420	1.598
2022	1.236	0.327	1.006	2.288	1.540	0.411	1.221	2.832	1.246	0.032	1.183	1.309

C.2 JMA7 MW observer

Table C.7: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the JMA7 MW observer CPUE series.

Series	JMA7 MW observer
QMS stock	JMA7
Reporting forms	
Fishing methods	MW
Target species	JMA, JMD, JMM, JMN
Statistical Areas	034, 035, 036, 037, 039, 040, 041, 042, 045, 801
Period	1998-10-01, 2022-09-30
Resolution	Observed event
Core fleet years	4
Core fleet trips	1
Default model	obskg ~ fyear + vessel_key + month + stat_area + ns(log(fishing_duration), 3) + ns(log(start_time), 3) + ns(log(start_seabed_depth), 3) + ns(log(headline_height), 3) + ns(fishing_speed, 3)
Stepwise selection	Yes
Positive catch distribution	Weibull

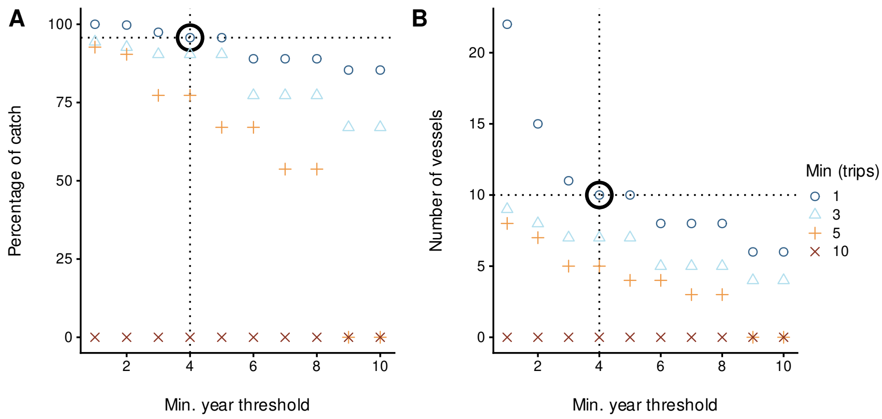

Figure C.29: Percentage of catch and number of vessels for different core vessel selection criteria for the JMA7 MW observer CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel was observed in the fishery and the number of observed trips per year.

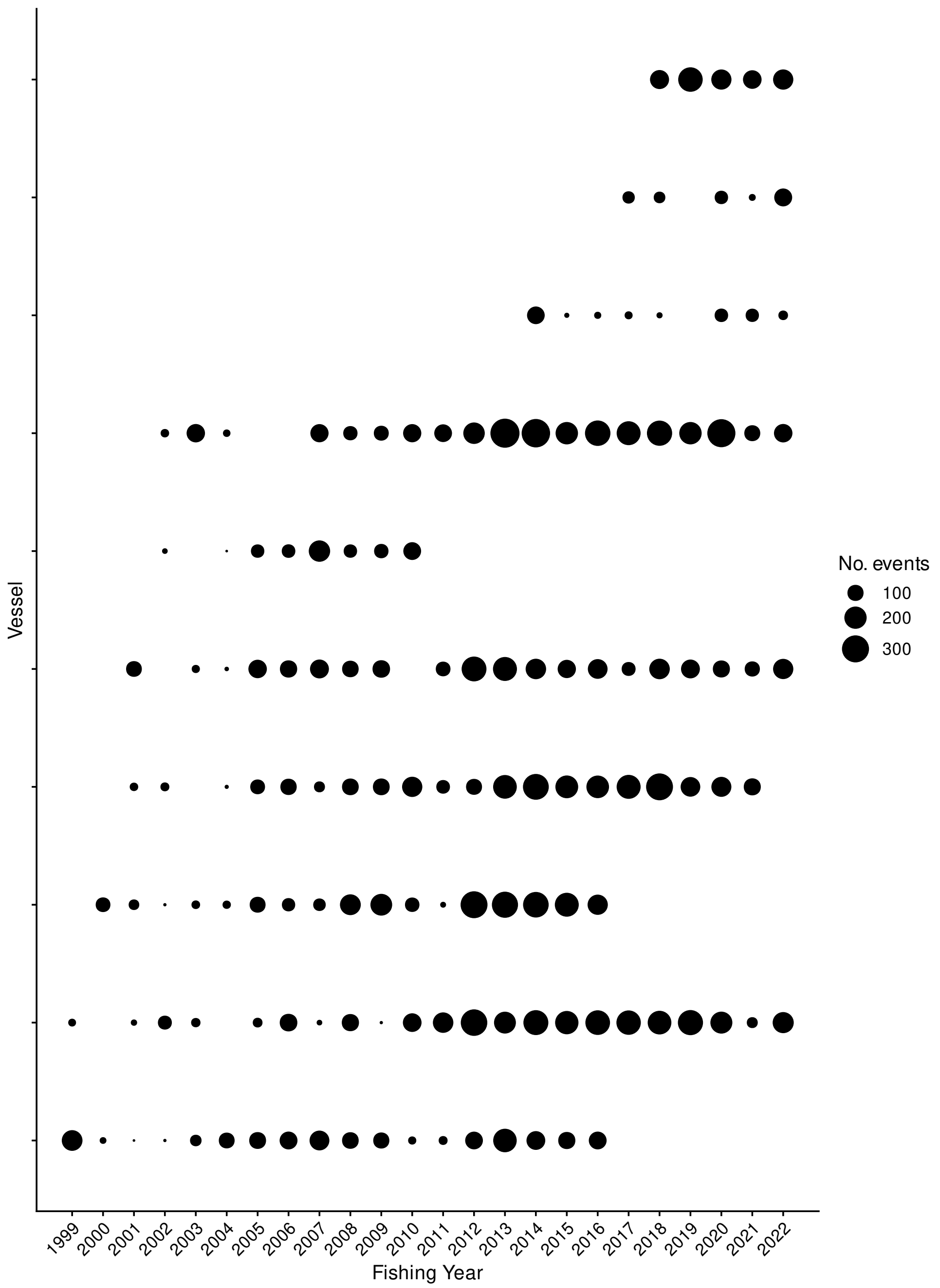

Figure C.30: Number of events by fishing year for core vessels. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table C.8: Summary of the JMA7 MW observer 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	1999	2000	2001	2002	2003	2004	2005	2006	2007
Ungroomed data	2231 (100%) n: 353	789 (100%) n: 102	2024 (100%) n: 186	1258 (100%) n: 148	2071 (100%) n: 265	2109 (100%) n: 152	8921 (100%) n: 542	7741 (100%) n: 611	7662 (100%) n: 751
Fishing speed not null	2164 (100%) n: 344	789 (100%) n: 102	2010 (100%) n: 183	1258 (100%) n: 148	2071 (100%) n: 265	2103 (100%) n: 151	8886 (100%) n: 540	7741 (100%) n: 611	7657 (100%) n: 749
Start date not null	2164 (100%) n: 344	789 (100%) n: 102	2010 (100%) n: 183	1258 (100%) n: 148	2071 (100%) n: 265	2103 (100%) n: 151	8886 (100%) n: 540	7741 (100%) n: 611	7657 (100%) n: 749
End date not null	2164 (100%) n: 344	789 (100%) n: 102	2010 (100%) n: 183	1258 (100%) n: 148	2071 (100%) n: 265	2103 (100%) n: 151	8886 (100%) n: 540	7741 (100%) n: 611	7657 (100%) n: 749
Start depth not null	2164 (100%) n: 344	789 (100%) n: 102	2010 (100%) n: 183	1258 (100%) n: 148	2071 (100%) n: 265	2103 (100%) n: 151	8886 (100%) n: 540	7741 (100%) n: 611	7616 (100%) n: 747
Headline height not null	2144 (100%) n: 343	789 (100%) n: 102	2010 (100%) n: 183	1258 (100%) n: 148	2063 (100%) n: 264	2103 (100%) n: 151	8886 (100%) n: 540	7741 (100%) n: 611	7584 (100%) n: 744
Fishing speed >3.5kn	2144 (100%) n: 343	789 (100%) n: 102	2010 (100%) n: 183	1258 (100%) n: 148	2063 (100%) n: 264	2103 (100%) n: 151	8886 (100%) n: 540	7741 (100%) n: 611	7583 (100%) n: 743
Headline height >15m	2144 (100%) n: 342	789 (100%) n: 102	2010 (100%) n: 183	1258 (100%) n: 148	2056 (100%) n: 263	2103 (100%) n: 151	8883 (100%) n: 538	7730 (100%) n: 610	7525 (100%) n: 739
Headline height <90m	2144 (100%) n: 342	789 (100%) n: 102	2010 (100%) n: 183	1258 (100%) n: 148	2053 (100%) n: 262	2103 (100%) n: 151	8881 (100%) n: 537	7730 (100%) n: 610	7524 (100%) n: 738
Fishing duration >15mins	2075 (93%) n: 332	748 (95%) n: 100	2009 (100%) n: 182	1258 (100%) n: 146	2053 (100%) n: 261	2103 (100%) n: 150	8775 (100%) n: 533	7659 (100%) n: 607	7469 (100%) n: 734
Seabed depth >50m	2075 (93%) n: 332	748 (95%) n: 100	2009 (100%) n: 182	1258 (100%) n: 146	2053 (100%) n: 261	2103 (100%) n: 150	8775 (100%) n: 533	7659 (100%) n: 607	7469 (100%) n: 734
Seabed depth <400m	2060 (92%) n: 329	702 (89%) n: 98	2009 (100%) n: 182	1240 (100%) n: 142	2053 (100%) n: 260	2050 (100%) n: 148	8728 (100%) n: 530	7659 (100%) n: 607	7469 (100%) n: 734
Start time >0	2053 (92%) n: 326	698 (88%) n: 97	2009 (100%) n: 182	1169 (93%) n: 137	2048 (100%) n: 258	2025 (100%) n: 147	8616 (100%) n: 524	7613 (100%) n: 600	7323 (100%) n: 725
Core fleet selection	1675 (75%) n: 191	697 (88%) n: 96	1996 (100%) n: 172	1169 (93%) n: 137	2048 (100%) n: 258	2025 (100%) n: 147	8616 (100%) n: 524	7613 (100%) n: 600	7322 (100%) n: 720

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	10290 (100%) n: 777	10460 (100%) n: 729	8826 (100%) n: 735	7581 (100%) n: 502	21523 (100%) n: 1355	27050 (100%) n: 1580	27806 (100%) n: 1752	25709 (100%) n: 1297	23339 (100%) n: 1201
Fishing speed not null	10226 (100%) n: 776	10455 (100%) n: 728	8792 (100%) n: 732	7581 (100%) n: 502	21520 (100%) n: 1354	26974 (100%) n: 1576	27776 (100%) n: 1750	25709 (100%) n: 1297	23324 (100%) n: 1200
Start date not null	10226 (100%) n: 776	10455 (100%) n: 728	8792 (100%) n: 732	7581 (100%) n: 502	21520 (100%) n: 1354	26974 (100%) n: 1576	27776 (100%) n: 1750	25709 (100%) n: 1297	23324 (100%) n: 1200
End date not null	10226 (100%) n: 776	10455 (100%) n: 728	8792 (100%) n: 732	7581 (100%) n: 502	21520 (100%) n: 1354	26974 (100%) n: 1576	27776 (100%) n: 1750	25709 (100%) n: 1297	23324 (100%) n: 1200
Start depth not null	10207 (100%) n: 773	10047 (100%) n: 701	8703 (100%) n: 727	7452 (100%) n: 496	20146 (94%) n: 1280	26318 (100%) n: 1547	27701 (100%) n: 1745	25139 (100%) n: 1263	23251 (100%) n: 1194
Headline height not null	10205 (100%) n: 772	10000 (100%) n: 696	8554 (100%) n: 718	7407 (100%) n: 495	19965 (93%) n: 1268	26002 (100%) n: 1532	27589 (100%) n: 1741	25078 (100%) n: 1259	23217 (100%) n: 1191
Fishing speed >3.5kn	10194 (100%) n: 771	10000 (100%) n: 696	8554 (100%) n: 718	7407 (100%) n: 495	19962 (93%) n: 1267	26002 (100%) n: 1532	27589 (100%) n: 1740	25077 (100%) n: 1257	23190 (100%) n: 1190
Headline height >15m	10194 (100%) n: 771	9936 (95%) n: 694	8500 (100%) n: 716	7407 (100%) n: 495	19897 (92%) n: 1266	25899 (100%) n: 1524	27588 (100%) n: 1739	24981 (100%) n: 1253	23190 (100%) n: 1190
Headline height <90m	10192 (100%) n: 770	9936 (95%) n: 694	8500 (100%) n: 716	7375 (100%) n: 494	19884 (92%) n: 1265	25899 (100%) n: 1524	27570 (100%) n: 1738	24937 (100%) n: 1247	23190 (100%) n: 1190
Fishing duration >15mins	10189 (100%) n: 767	9936 (95%) n: 693	8500 (100%) n: 715	7269 (100%) n: 491	19863 (92%) n: 1263	25849 (100%) n: 1514	27516 (100%) n: 1732	24936 (100%) n: 1241	23187 (100%) n: 1184
Seabed depth >50m	10189 (100%) n: 767	9921 (95%) n: 691	8462 (100%) n: 714	7269 (100%) n: 491	19849 (92%) n: 1261	25829 (100%) n: 1513	27516 (100%) n: 1732	24869 (100%) n: 1238	23177 (100%) n: 1183
Seabed depth <400m	10161 (100%) n: 764	9921 (95%) n: 689	8451 (100%) n: 712	7269 (100%) n: 491	19695 (92%) n: 1251	25802 (100%) n: 1511	27488 (100%) n: 1725	24748 (100%) n: 1229	23164 (100%) n: 1181
Start time >0	9936 (100%) n: 753	9894 (95%) n: 685	8362 (95%) n: 707	7208 (100%) n: 486	19488 (91%) n: 1242	25652 (95%) n: 1505	27177 (100%) n: 1710	24635 (100%) n: 1225	22978 (100%) n: 1174
Core fleet selection	9936 (100%) n: 753	9894 (95%) n: 684	7962 (90%) n: 655	7178 (95%) n: 479	19488 (91%) n: 1242	25652 (95%) n: 1504	23912 (86%) n: 1553	20869 (81%) n: 1115	22978 (100%) n: 1174

Filter	2017	2018	2019	2020	2021	2022
Ungroomed data	20073 (100%) n: 885	26176 (100%) n: 1174	23368 (100%) n: 1049	19378 (100%) n: 1115	16257 (100%) n: 733	18094 (100%) n: 958
Fishing speed not null	19953 (100%) n: 882	26166 (100%) n: 1173	23318 (100%) n: 1045	19219 (100%) n: 1109	16037 (100%) n: 728	18066 (100%) n: 957
Start date not null	19953 (100%) n: 882	26166 (100%) n: 1173	23318 (100%) n: 1045	19219 (100%) n: 1109	16037 (100%) n: 728	18066 (100%) n: 957
End date not null	19953 (100%) n: 882	26166 (100%) n: 1173	23318 (100%) n: 1045	19219 (100%) n: 1109	16037 (100%) n: 728	18066 (100%) n: 957
Start depth not null	19759 (100%) n: 873	26140 (100%) n: 1172	23318 (100%) n: 1045	19117 (100%) n: 1097	15694 (100%) n: 704	15534 (86%) n: 865
Headline height not null	19611 (100%) n: 868	26090 (100%) n: 1169	23289 (100%) n: 1043	19085 (100%) n: 1094	15694 (100%) n: 704	15508 (86%) n: 864
Fishing speed >3.5kn	19611 (100%) n: 868	26090 (100%) n: 1169	23289 (100%) n: 1043	19085 (100%) n: 1094	15656 (100%) n: 703	15508 (86%) n: 864
Headline height >15m	19562 (100%) n: 866	26067 (100%) n: 1168	23289 (100%) n: 1043	19056 (100%) n: 1092	15567 (100%) n: 702	15493 (86%) n: 863
Headline height <90m	19562 (100%) n: 866	26019 (100%) n: 1164	23289 (100%) n: 1043	19056 (100%) n: 1092	15567 (100%) n: 702	15477 (86%) n: 861
Fishing duration >15mins	19521 (100%) n: 862	26013 (100%) n: 1160	23214 (100%) n: 1038	19056 (100%) n: 1092	15500 (100%) n: 696	15477 (86%) n: 860
Seabed depth >50m	19521 (100%) n: 862	25934 (100%) n: 1158	23214 (100%) n: 1038	19056 (100%) n: 1092	15500 (100%) n: 696	15448 (85%) n: 859
Seabed depth <400m	19521 (100%) n: 862	25879 (100%) n: 1156	23087 (100%) n: 1031	19056 (100%) n: 1092	15500 (100%) n: 694	15394 (85%) n: 856
Start time >0	19395 (100%) n: 857	25814 (100%) n: 1153	22969 (100%) n: 1024	18950 (100%) n: 1087	15306 (94%) n: 690	15394 (85%) n: 856
Core fleet selection	19395 (100%) n: 857	25814 (100%) n: 1153	22352 (100%) n: 996	18950 (100%) n: 1087	12048 (74%) n: 559	13984 (77%) n: 796

Table C.9: Summary of the JMA7 MW observer dataset after core fleet selection. 'Records' indicates the number of rows (events) in the dataset, and 'Records caught' indicates the percentage of events with catches of jack mackerels.

Fishing year	Vessels	Trips	Records	Hrs	Catch (t)	Records caught
1999	2	3	191	407.75	1 675.13	92.67
2000	2	2	96	237.93	696.85	100.00
2001	5	8	172	469.02	1 996.09	95.35
2002	6	6	137	412.48	1 169.37	96.35
2003	5	7	258	796.65	2 047.99	99.22
2004	6	6	147	553.28	2 024.58	97.96
2005	6	10	524	1 637.50	8 615.57	98.09
2006	6	9	600	2 083.05	7 612.83	99.67
2007	7	16	720	2 560.73	7 321.65	96.94
2008	7	18	753	2 925.52	9 935.74	99.07
2009	7	15	684	2 650.68	9 893.56	97.95
2010	6	11	655	2 644.47	7 961.57	97.86
2011	6	8	479	2 041.12	7 177.96	98.54
2012	6	24	1 242	5 746.87	19 488.04	98.15
2013	6	36	1 504	6 746.40	25 651.80	99.20
2014	7	36	1 553	6 963.82	23 912.31	99.16
2015	7	33	1 115	5 070.68	20 869.17	99.01
2016	7	36	1 174	4 886.68	22 978.12	98.47
2017	6	29	857	4 180.98	19 394.71	99.53
2018	7	31	1 153	6 195.93	25 814.48	98.61
2019	5	25	996	4 665.45	22 351.76	98.19
2020	7	32	1 087	5 285.05	18 949.68	98.44
2021	7	19	559	2 638.33	12 047.59	95.17
2022	6	21	796	3 538.52	13 984.19	97.86

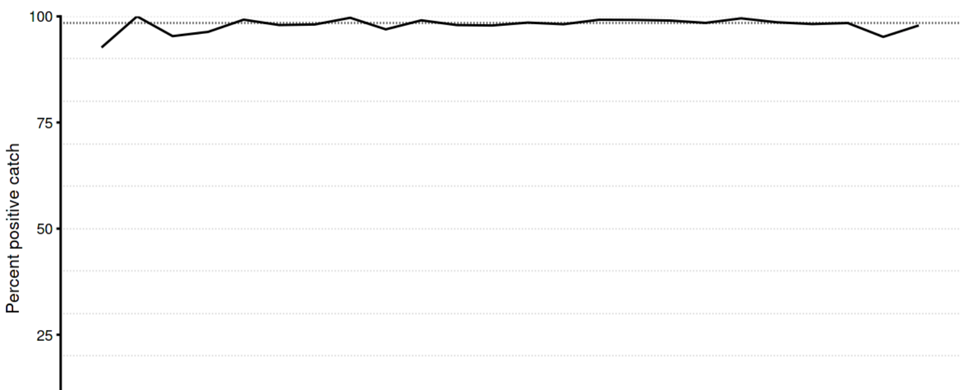

Figure C.31: Percentage of positive catch records in the JMA7 MW observer catch-per-unit-effort dataset.

Table C.10: Summary of stepwise selection for the Weibull model. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	25	367 968	4.0	4.0	*
+ ns(log(fishing duration), 3)	3	367 385	6.7	2.7	*
+ ns(log(start time), 3)	3	367 055	8.3	1.5	*
+ stat area	9	366 838	9.4	1.1	*
+ month	11	366 732	10.0	0.6	
+ vessel key	9	366 649	10.4	0.5	
+ ns(log(headline height), 3)	3	366 585	10.7	0.3	
+ ns(fishing speed, 3)	3	366 555	10.9	0.2	
+ ns(log(start seabed depth), 3)	3	366 535	11.0	0.1	

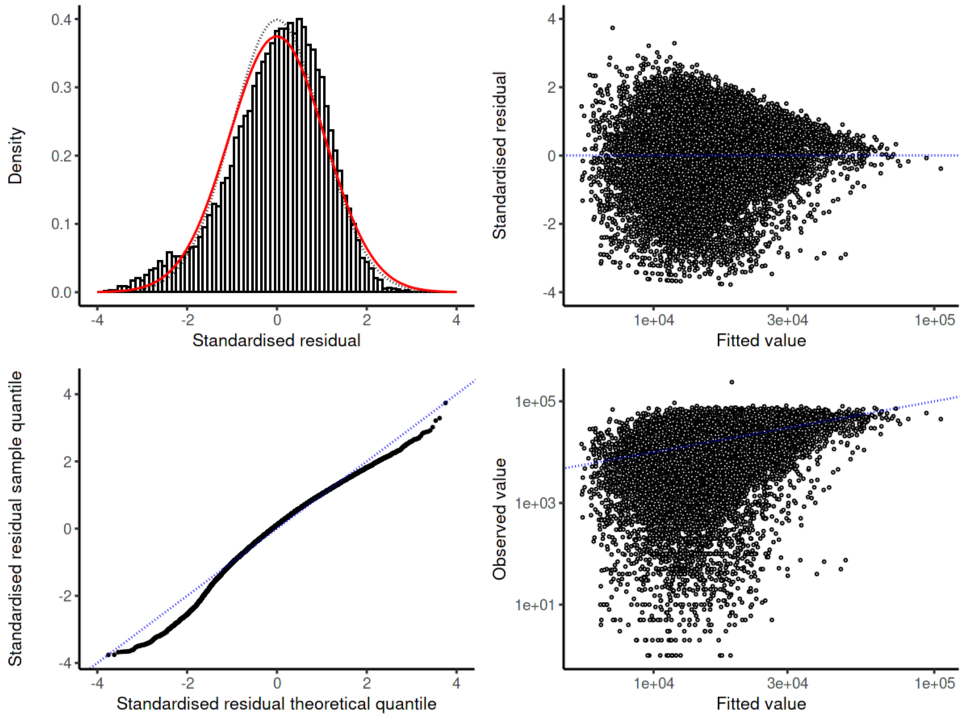

Figure C.32: Diagnostic plots for the Weibull model for the JMA7 MW observer dataset.

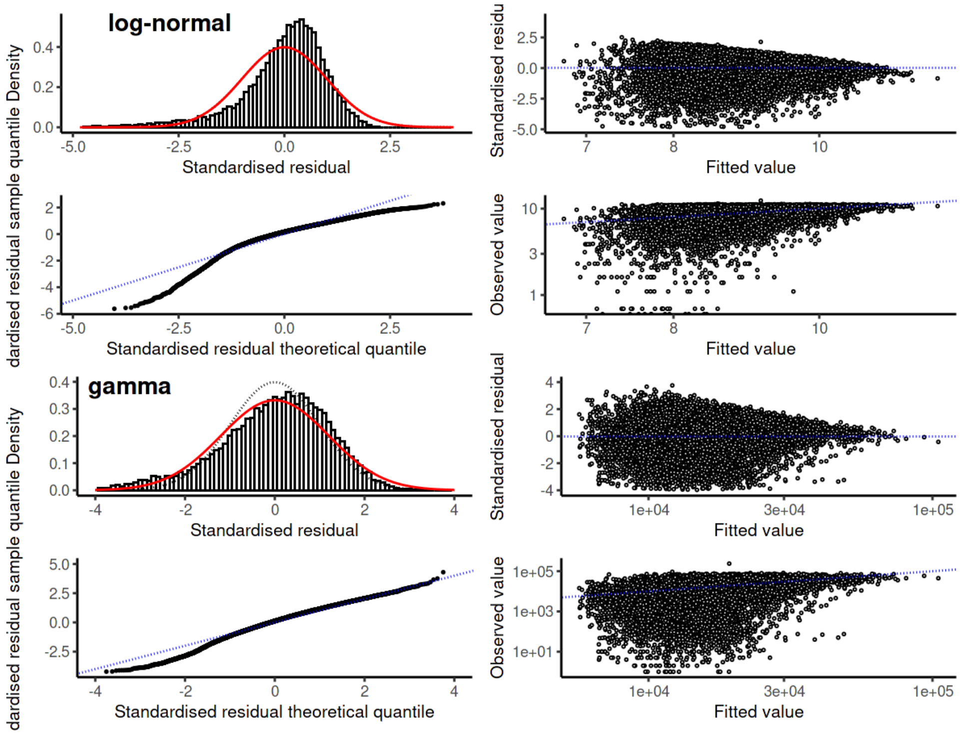

Figure C.33: Diagnostic plots for the log-normal and gamma model for the JMA7 MW observer dataset.

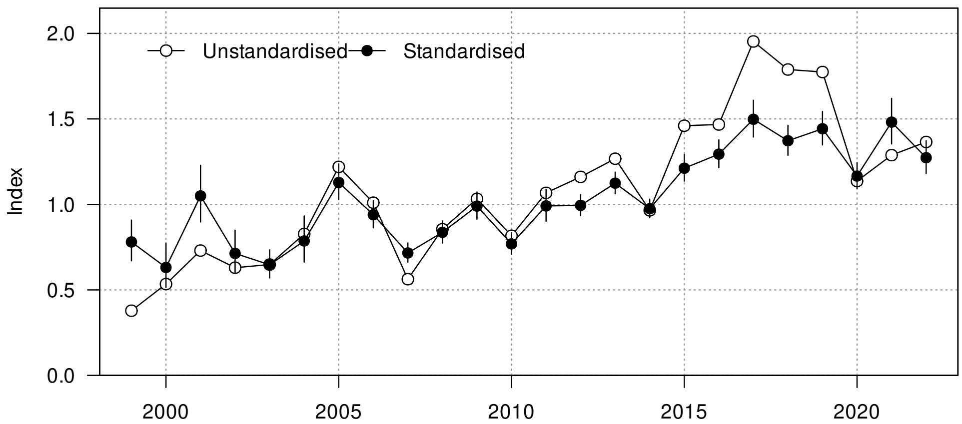

Figure C.34: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch in the JMA7 MW observer dataset.

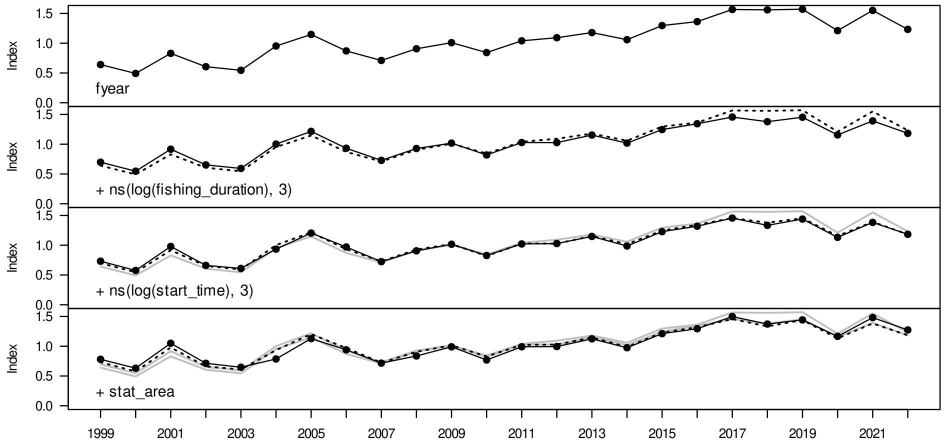

Figure C.35: Changes to the JMA7 MW observer positive catch index as terms are successively entered into the model.

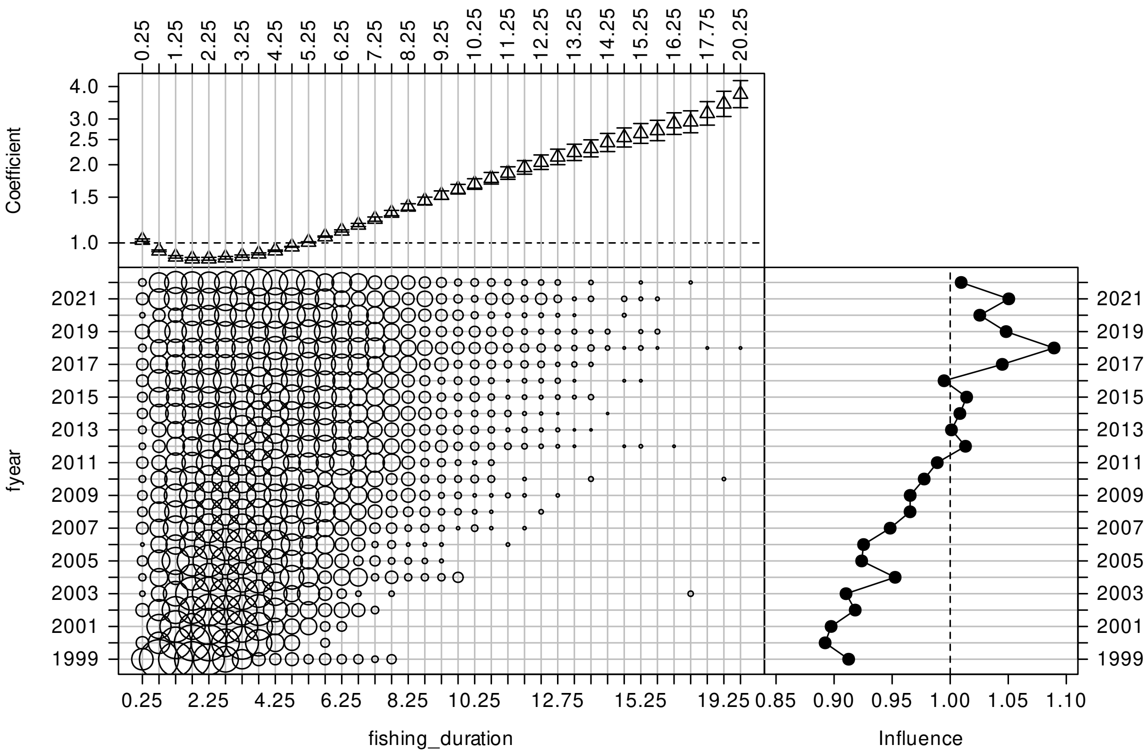

Figure C.36: CDI plot for fishing duration (h) for the positive catch JMA7 MW observer catch-per-unit-effort dataset.

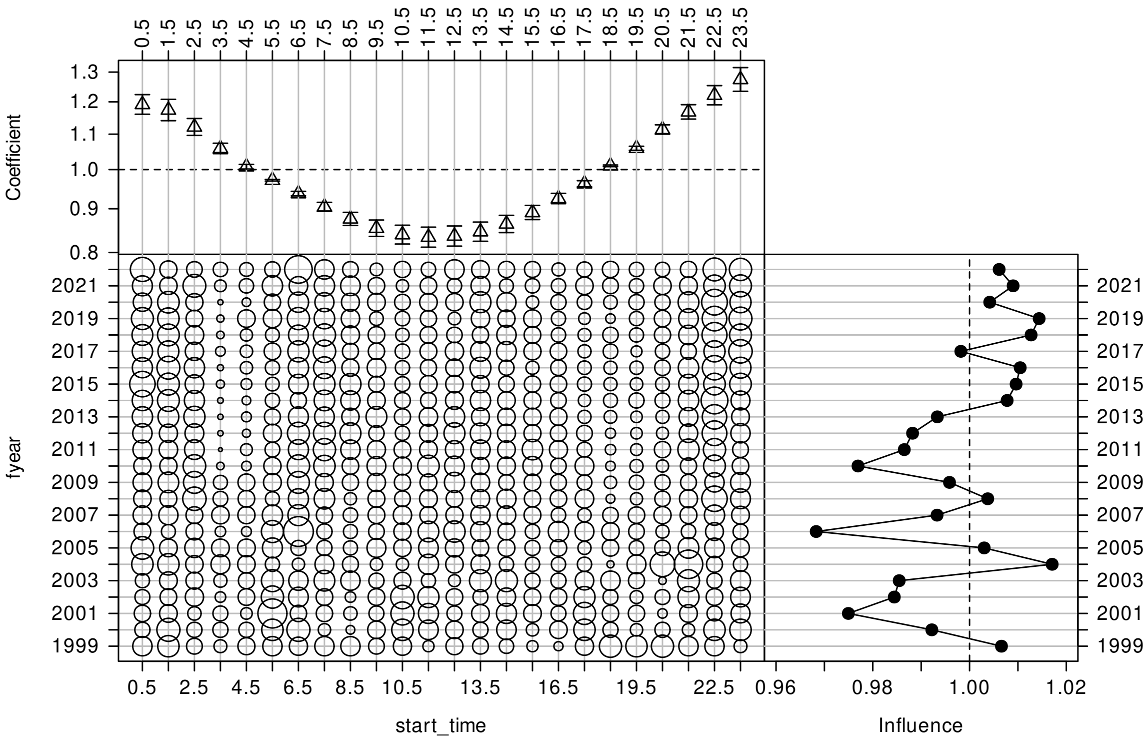

Figure C.37: CDI plot for start time for the positive catch JMA7 MW observer catch-per-unit-effort dataset.

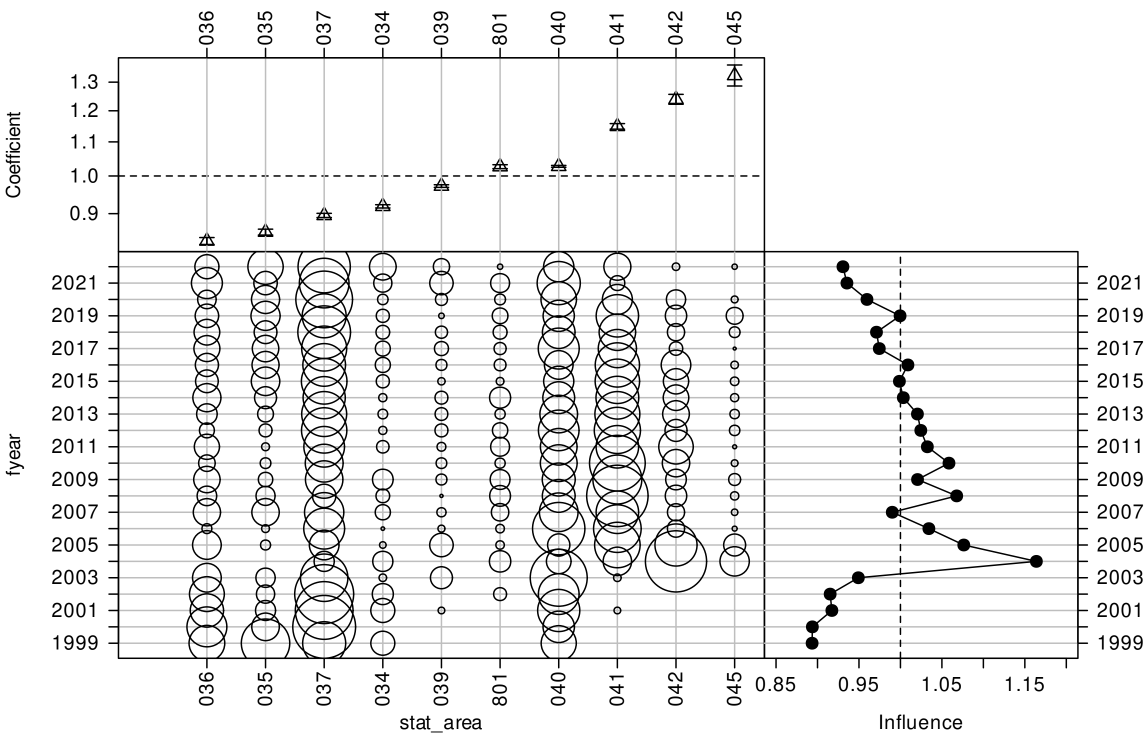

Figure C.38: CDI plot for statistical area for the positive catch JMA7 MW observer catch-per-unit-effort dataset.

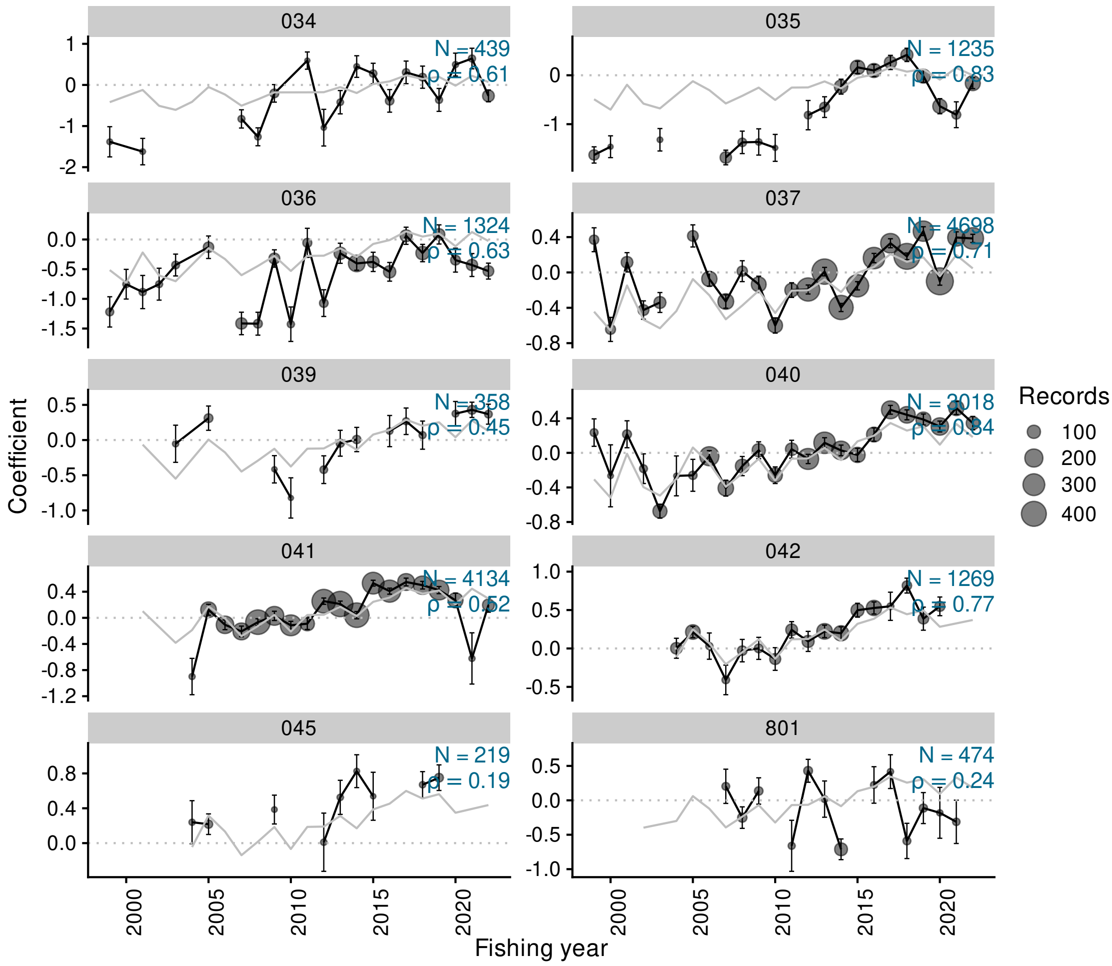

Figure C.39: Residual implied coefficients for area-year in the Weibull positive catch model for the JMA7 MW observer dataset.

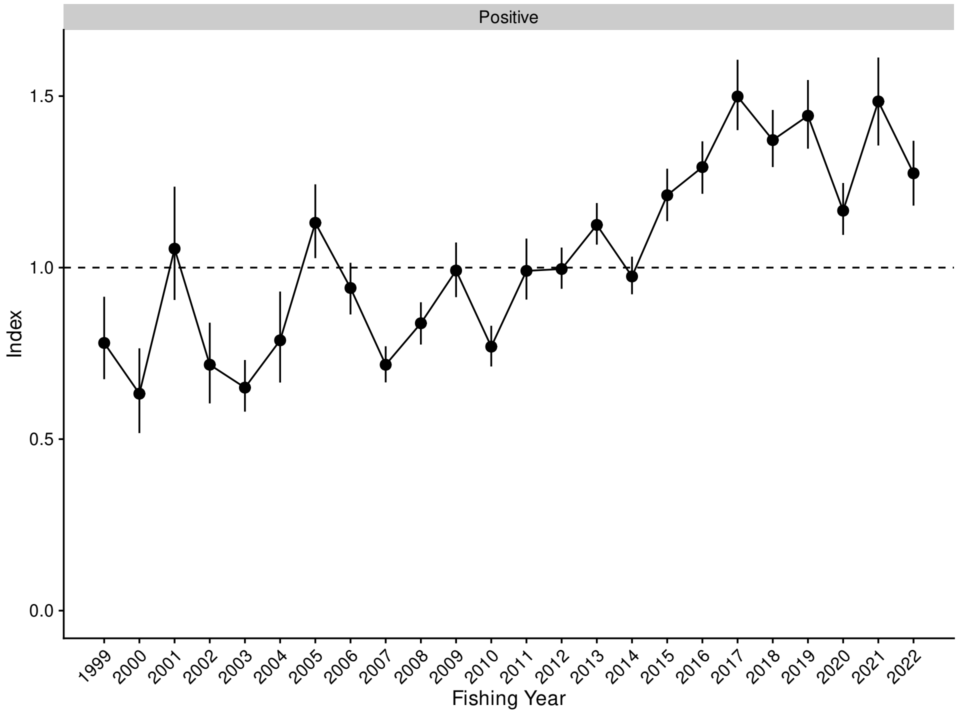

Figure C.40: Standardised indices and 95% confidence intervals for the JMA7 MW observer dataset.

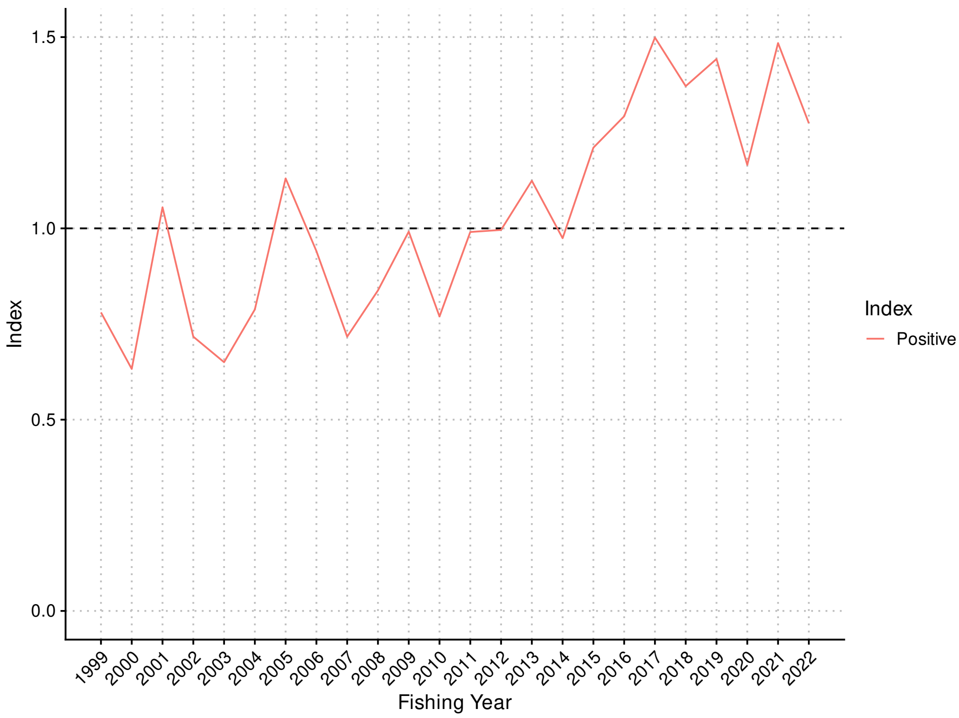

Figure C.41: Standardised indices for the JMA7 MW observer dataset.

Table C.11: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in JMA7 MW observer.

	Positive			
Fishing year	index	SE	LCI	UCI
1999	0.780	0.061	0.675	0.915
2000	0.633	0.063	0.518	0.765
2001	1.055	0.084	0.906	1.236
2002	0.717	0.060	0.604	0.839
2003	0.650	0.038	0.580	0.731
2004	0.788	0.068	0.665	0.930
2005	1.131	0.055	1.028	1.243
2006	0.941	0.038	0.863	1.014
2007	0.717	0.027	0.665	0.771
2008	0.838	0.031	0.776	0.899
2009	0.992	0.041	0.914	1.073
2010	0.770	0.030	0.712	0.831
2011	0.991	0.045	0.907	1.085
2012	0.996	0.031	0.938	1.058
2013	1.125	0.031	1.067	1.188
2014	0.974	0.028	0.922	1.032
2015	1.211	0.039	1.135	1.288
2016	1.293	0.039	1.215	1.368
2017	1.499	0.052	1.401	1.606
2018	1.372	0.042	1.293	1.460
2019	1.443	0.051	1.347	1.547
2020	1.166	0.039	1.095	1.247
2021	1.484	0.065	1.356	1.612
2022	1.275	0.048	1.181	1.370

C.3 JMA7 MW observer LF

Table C.12: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the JMA7 MW observer LF CPUE series.

Series	JMA7 MW observer LF
QMS stock	JMA7
Reporting forms	
Fishing methods	MW
Target species	JMA, JMD, JMM, JMN
Statistical Areas	034, 035, 036, 037, 039, 040, 041, 042, 045, 801
Period	1998-10-01, 2022-09-30
Resolution	Observed event
Core fleet years	4
Core fleet trips	1
Default model	obskg ~ fyear + vessel_key + month + stat_area + ns(log(fishing_duration), 3) + ns(log(start_time), 3) + ns(log(start_seabed_depth), 3) + ns(log(headline_height), 3) + ns(fishing_speed, 3)
Stepwise selection	Yes
Positive catch distribution	Weibull

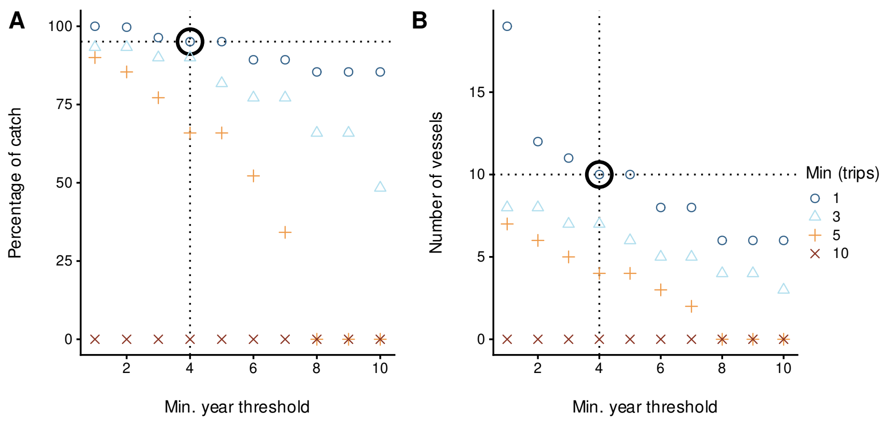

Figure C.42: Percentage of catch and number of vessels for different core vessel selection criteria for the JMA7 MW observer LF CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel was observed in the fishery and the number of observed trips per year.

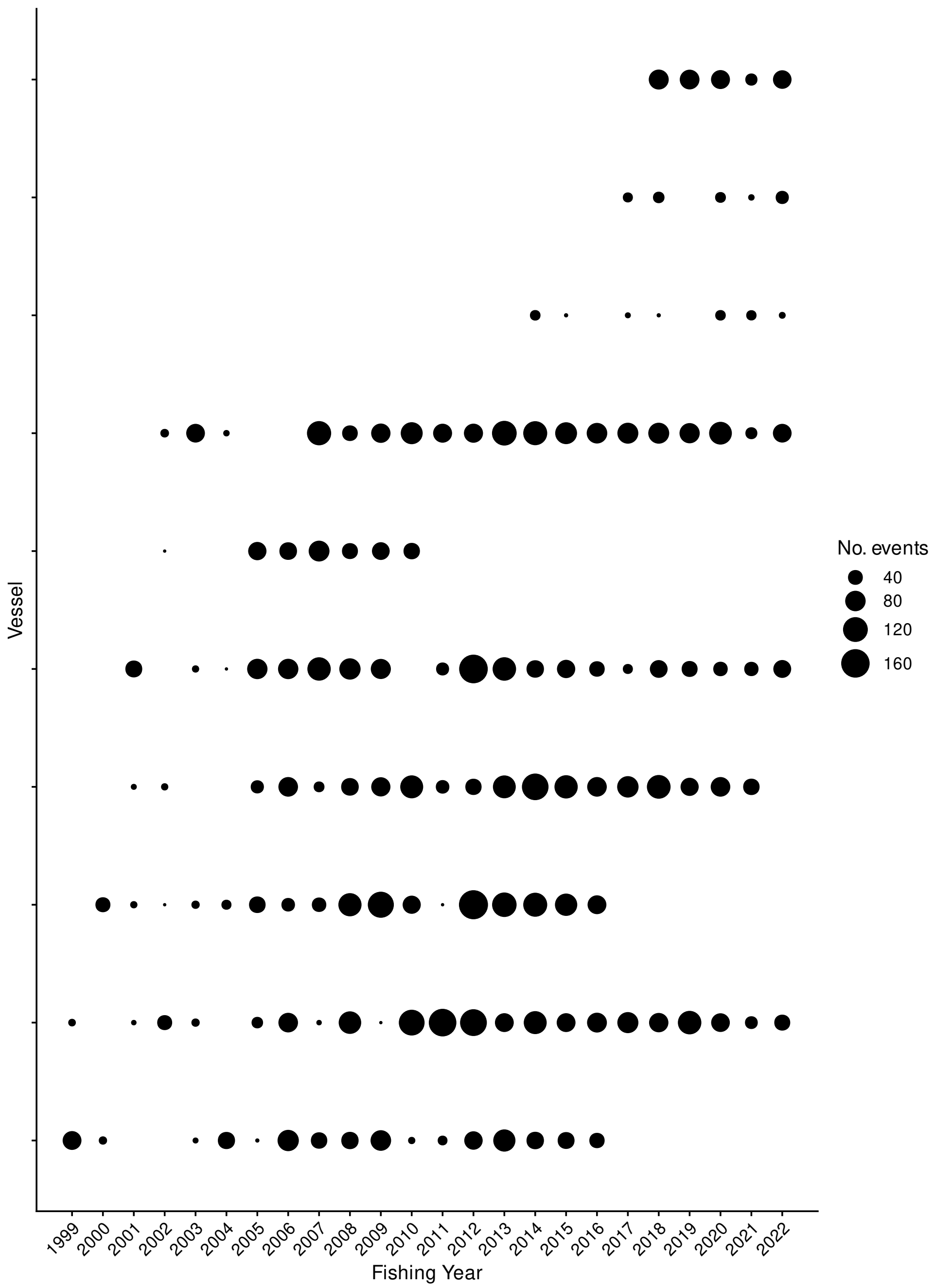

Figure C.43: Number of events by fishing year for core vessels. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table C.13: Summary of the JMA7 MW observer LF 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	1999	2000	2001	2002	2003	2004	2005	2006	2007
Ungroomed data	2231 (100%) n: 353	789 (100%) n: 102	2024 (100%) n: 186	1258 (100%) n: 148	2071 (100%) n: 265	2109 (100%) n: 152	8921 (100%) n: 542	7741 (100%) n: 611	7662 (100%) n: 751
Fishing speed not null	2164 (100%) n: 344	789 (100%) n: 102	2010 (100%) n: 183	1258 (100%) n: 148	2071 (100%) n: 265	2103 (100%) n: 151	8886 (100%) n: 540	7741 (100%) n: 611	7657 (100%) n: 749
Start date not null	2164 (100%) n: 344	789 (100%) n: 102	2010 (100%) n: 183	1258 (100%) n: 148	2071 (100%) n: 265	2103 (100%) n: 151	8886 (100%) n: 540	7741 (100%) n: 611	7657 (100%) n: 749
End date not null	2164 (100%) n: 344	789 (100%) n: 102	2010 (100%) n: 183	1258 (100%) n: 148	2071 (100%) n: 265	2103 (100%) n: 151	8886 (100%) n: 540	7741 (100%) n: 611	7657 (100%) n: 749
Start depth not null	2164 (100%) n: 344	789 (100%) n: 102	2010 (100%) n: 183	1258 (100%) n: 148	2071 (100%) n: 265	2103 (100%) n: 151	8886 (100%) n: 540	7741 (100%) n: 611	7616 (100%) n: 747
Headline height not null	2144 (100%) n: 343	789 (100%) n: 102	2010 (100%) n: 183	1258 (100%) n: 148	2063 (100%) n: 264	2103 (100%) n: 151	8886 (100%) n: 540	7741 (100%) n: 611	7584 (100%) n: 744
Fishing speed >3.5kn	2144 (100%) n: 343	789 (100%) n: 102	2010 (100%) n: 183	1258 (100%) n: 148	2063 (100%) n: 264	2103 (100%) n: 151	8886 (100%) n: 540	7741 (100%) n: 611	7583 (100%) n: 743
Headline height >15m	2144 (100%) n: 342	789 (100%) n: 102	2010 (100%) n: 183	1258 (100%) n: 148	2056 (100%) n: 263	2103 (100%) n: 151	8883 (100%) n: 538	7730 (100%) n: 610	7525 (100%) n: 739
Headline height <90m	2144 (100%) n: 342	789 (100%) n: 102	2010 (100%) n: 183	1258 (100%) n: 148	2053 (100%) n: 262	2103 (100%) n: 151	8881 (100%) n: 537	7730 (100%) n: 610	7524 (100%) n: 738
Fishing duration >15mins	2075 (93%) n: 332	748 (95%) n: 100	2009 (100%) n: 182	1258 (100%) n: 146	2053 (100%) n: 261	2103 (100%) n: 150	8775 (100%) n: 533	7659 (100%) n: 607	7469 (100%) n: 734
Seabed depth >50m	2075 (93%) n: 332	748 (95%) n: 100	2009 (100%) n: 182	1258 (100%) n: 146	2053 (100%) n: 261	2103 (100%) n: 150	8775 (100%) n: 533	7659 (100%) n: 607	7469 (100%) n: 734
Seabed depth <400m	2060 (92%) n: 329	702 (89%) n: 98	2009 (100%) n: 182	1240 (100%) n: 142	2053 (100%) n: 260	2050 (100%) n: 148	8728 (100%) n: 530	7659 (100%) n: 607	7469 (100%) n: 734
Start time >0	2053 (92%) n: 326	698 (88%) n: 97	2009 (100%) n: 182	1169 (93%) n: 137	2048 (100%) n: 258	2025 (100%) n: 147	8616 (100%) n: 524	7613 (100%) n: 600	7323 (100%) n: 725
Has LF	1306 (59%) n: 107	554 (70%) n: 52	1226 (61%) n: 75	703 (56%) n: 63	1117 (54%) n: 101	1644 (78%) n: 79	5195 (58%) n: 249	6495 (84%) n: 403	5502 (72%) n: 415
Core fleet selection	1044 (47%) n: 76	554 (70%) n: 52	1215 (60%) n: 70	703 (56%) n: 63	1117 (54%) n: 101	1644 (78%) n: 79	5195 (58%) n: 249	6495 (84%) n: 403	5502 (72%) n: 415

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	10290 (100%) n: 777	10460 (100%) n: 729	8826 (100%) n: 735	7581 (100%) n: 502	21523 (100%) n: 1355	27050 (100%) n: 1580	27806 (100%) n: 1752	25709 (100%) n: 1297	23339 (100%) n: 1201
Fishing speed not null	10226 (100%) n: 776	10455 (100%) n: 728	8792 (100%) n: 732	7581 (100%) n: 502	21520 (100%) n: 1354	26974 (100%) n: 1576	27776 (100%) n: 1750	25709 (100%) n: 1297	23324 (100%) n: 1200
Start date not null	10226 (100%) n: 776	10455 (100%) n: 728	8792 (100%) n: 732	7581 (100%) n: 502	21520 (100%) n: 1354	26974 (100%) n: 1576	27776 (100%) n: 1750	25709 (100%) n: 1297	23324 (100%) n: 1200
End date not null	10226 (100%) n: 776	10455 (100%) n: 728	8792 (100%) n: 732	7581 (100%) n: 502	21520 (100%) n: 1354	26974 (100%) n: 1576	27776 (100%) n: 1750	25709 (100%) n: 1297	23324 (100%) n: 1200
Start depth not null	10207 (100%) n: 773	10047 (100%) n: 701	8703 (100%) n: 727	7452 (100%) n: 496	20146 (94%) n: 1280	26318 (100%) n: 1547	27701 (100%) n: 1745	25139 (100%) n: 1263	23251 (100%) n: 1194
Headline height not null	10205 (100%) n: 772	10000 (100%) n: 696	8554 (100%) n: 718	7407 (100%) n: 495	19965 (93%) n: 1268	26002 (100%) n: 1532	27589 (100%) n: 1741	25078 (100%) n: 1259	23217 (100%) n: 1191
Fishing speed >3.5kn	10194 (100%) n: 771	10000 (100%) n: 696	8554 (100%) n: 718	7407 (100%) n: 495	19962 (93%) n: 1267	26002 (100%) n: 1532	27589 (100%) n: 1740	25077 (100%) n: 1257	23190 (100%) n: 1190
Headline height >15m	10194 (100%) n: 771	9936 (95%) n: 694	8500 (100%) n: 716	7407 (100%) n: 495	19897 (92%) n: 1266	25899 (100%) n: 1524	27588 (100%) n: 1739	24981 (100%) n: 1253	23190 (100%) n: 1190
Headline height <90m	10192 (100%) n: 770	9936 (95%) n: 694	8500 (100%) n: 716	7375 (100%) n: 494	19884 (92%) n: 1265	25899 (100%) n: 1524	27570 (100%) n: 1738	24937 (100%) n: 1247	23190 (100%) n: 1190
Fishing duration >15mins	10189 (100%) n: 767	9936 (95%) n: 693	8500 (100%) n: 715	7269 (100%) n: 491	19863 (92%) n: 1263	25849 (100%) n: 1514	27516 (100%) n: 1732	24936 (100%) n: 1241	23187 (100%) n: 1184
Seabed depth >50m	10189 (100%) n: 767	9921 (95%) n: 691	8462 (100%) n: 714	7269 (100%) n: 491	19849 (92%) n: 1261	25829 (100%) n: 1513	27516 (100%) n: 1732	24869 (100%) n: 1238	23177 (100%) n: 1183
Seabed depth <400m	10161 (100%) n: 764	9921 (95%) n: 689	8451 (100%) n: 712	7269 (100%) n: 491	19695 (92%) n: 1251	25802 (100%) n: 1511	27488 (100%) n: 1725	24748 (100%) n: 1229	23164 (100%) n: 1181
Start time >0	9936 (100%) n: 753	9894 (95%) n: 685	8362 (95%) n: 707	7208 (100%) n: 486	19488 (91%) n: 1242	25652 (95%) n: 1505	27177 (100%) n: 1710	24635 (100%) n: 1225	22978 (100%) n: 1174
Has LF	7609 (74%) n: 495	8171 (78%) n: 492	6693 (76%) n: 468	5570 (73%) n: 298	13492 (63%) n: 652	14386 (53%) n: 606	15558 (56%) n: 649	15968 (62%) n: 568	10313 (44%) n: 383
Core fleet selection	7609 (74%) n: 495	8171 (78%) n: 492	6425 (73%) n: 445	5570 (73%) n: 298	13492 (63%) n: 652	14386 (53%) n: 606	13148 (47%) n: 598	12396 (48%) n: 478	10313 (44%) n: 383

Filter	2017	2018	2019	2020	2021	2022
Ungroomed data	20073 (100%) n: 885	26176 (100%) n: 1174	23368 (100%) n: 1049	19378 (100%) n: 1115	16257 (100%) n: 733	18094 (100%) n: 958
Fishing speed not null	19953 (100%) n: 882	26166 (100%) n: 1173	23318 (100%) n: 1045	19219 (100%) n: 1109	16037 (100%) n: 728	18066 (100%) n: 957
Start date not null	19953 (100%) n: 882	26166 (100%) n: 1173	23318 (100%) n: 1045	19219 (100%) n: 1109	16037 (100%) n: 728	18066 (100%) n: 957
End date not null	19953 (100%) n: 882	26166 (100%) n: 1173	23318 (100%) n: 1045	19219 (100%) n: 1109	16037 (100%) n: 728	18066 (100%) n: 957
Start depth not null	19759 (100%) n: 873	26140 (100%) n: 1172	23318 (100%) n: 1045	19117 (100%) n: 1097	15694 (100%) n: 704	15534 (86%) n: 865
Headline height not null	19611 (100%) n: 868	26090 (100%) n: 1169	23289 (100%) n: 1043	19085 (100%) n: 1094	15694 (100%) n: 704	15508 (86%) n: 864
Fishing speed >3.5kn	19611 (100%) n: 868	26090 (100%) n: 1169	23289 (100%) n: 1043	19085 (100%) n: 1094	15656 (100%) n: 703	15508 (86%) n: 864
Headline height >15m	19562 (100%) n: 866	26067 (100%) n: 1168	23289 (100%) n: 1043	19056 (100%) n: 1092	15567 (100%) n: 702	15493 (86%) n: 863
Headline height <90m	19562 (100%) n: 866	26019 (100%) n: 1164	23289 (100%) n: 1043	19056 (100%) n: 1092	15567 (100%) n: 702	15477 (86%) n: 861
Fishing duration >15mins	19521 (100%) n: 862	26013 (100%) n: 1160	23214 (100%) n: 1038	19056 (100%) n: 1092	15500 (100%) n: 696	15477 (86%) n: 860
Seabed depth >50m	19521 (100%) n: 862	25934 (100%) n: 1158	23214 (100%) n: 1038	19056 (100%) n: 1092	15500 (100%) n: 696	15448 (85%) n: 859
Seabed depth <400m	19521 (100%) n: 862	25879 (100%) n: 1156	23087 (100%) n: 1031	19056 (100%) n: 1092	15500 (100%) n: 694	15394 (85%) n: 856
Start time >0	19395 (100%) n: 857	25814 (100%) n: 1153	22969 (100%) n: 1024	18950 (100%) n: 1087	15306 (94%) n: 690	15394 (85%) n: 856
Has LF	8532 (43%) n: 296	13873 (53%) n: 424	11909 (51%) n: 376	9901 (51%) n: 384	7799 (48%) n: 247	6718 (37%) n: 289
Core fleet selection	8532 (43%) n: 296	13873 (53%) n: 424	11666 (50%) n: 368	9901 (51%) n: 384	6110 (38%) n: 191	6328 (35%) n: 276

Table C.14: Summary of the JMA7 MW observer LF dataset after core fleet selection. 'Records' indicates the number of rows (events) in the dataset, and 'Records caught' indicates the percentage of events with catches of jack mackerels.

Fishing year	Vessels	Trips	Records	Hrs	Catch (t)	Records caught
1999	2	3	76	165.32	1 043.87	100.00
2000	2	2	52	137.25	553.84	100.00
2001	4	6	70	184.40	1 215.46	100.00
2002	5	5	63	221.45	703.17	100.00
2003	5	5	101	365.42	1 117.16	100.00
2004	4	4	79	333.28	1 644.28	100.00
2005	6	9	249	847.98	5 195.31	100.00
2006	6	8	403	1 479.25	6 495.19	100.00
2007	7	15	415	1 505.27	5 501.91	100.00
2008	7	16	495	1 925.52	7 609.22	100.00
2009	7	15	492	2 046.68	8 171.25	98.98
2010	6	10	445	1 957.63	6 424.63	99.78
2011	6	8	298	1 368.33	5 569.66	99.33
2012	6	20	652	3 372.07	13 491.92	99.69
2013	6	31	606	2 907.90	14 385.80	100.00
2014	7	32	598	2 795.87	13 148.00	100.00
2015	7	32	478	2 361.98	12 395.53	99.79
2016	6	33	383	1 726.57	10 313.00	99.74
2017	6	26	296	1 558.88	8 531.83	100.00
2018	7	31	424	2 527.83	13 872.67	100.00
2019	5	24	368	1 932.02	11 666.30	100.00
2020	7	30	384	1 995.42	9 901.26	99.48
2021	7	19	191	1 080.73	6 110.27	100.00
2022	6	16	276	1 301.97	6 328.47	97.83

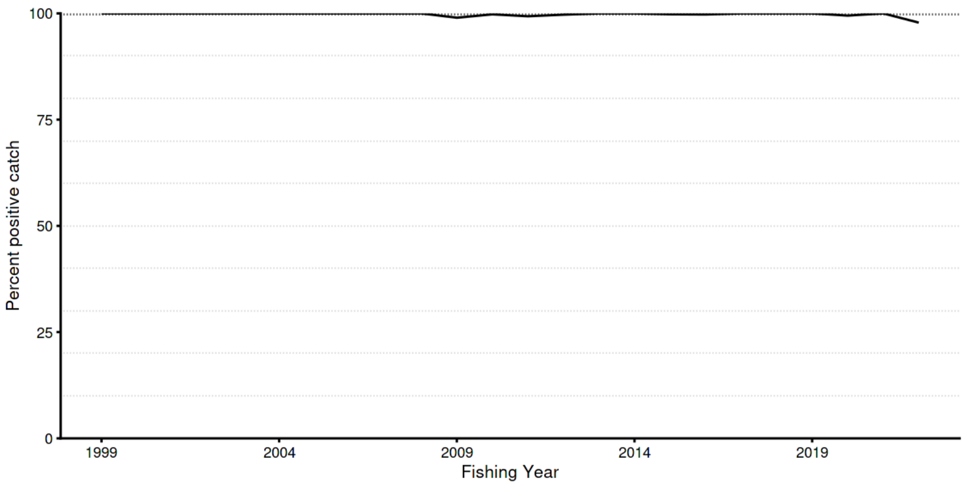

Figure C.44: Percentage of positive catch records in the JMA7 MW observer LF catch-per-unit-effort dataset.

Table C.15: Summary of stepwise selection for the Weibull model. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	25	171 797	9.0	9.0	*
+ ns(log(headline height), 3)	3	171 524	11.9	2.9	*
+ ns(log(fishing duration), 3)	3	171 328	14.0	2.1	*
+ stat area	9	171 226	15.2	1.2	*
+ month	11	171 148	16.3	1.0	*
+ vessel key	9	171 113	16.8	0.6	
+ ns(log(start time), 3)	3	171 101	17.0	0.2	
+ ns(fishing speed, 3)	3	171 100	17.1	0.1	

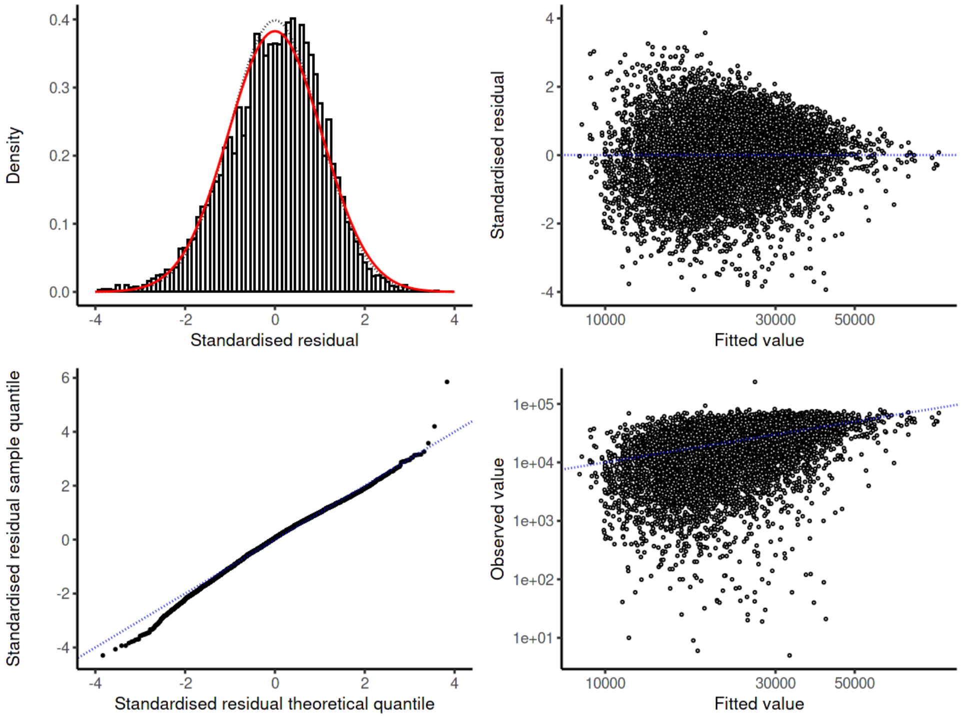

Figure C.45: Diagnostic plots for the Weibull model for the JMA7 MW observer LF dataset.

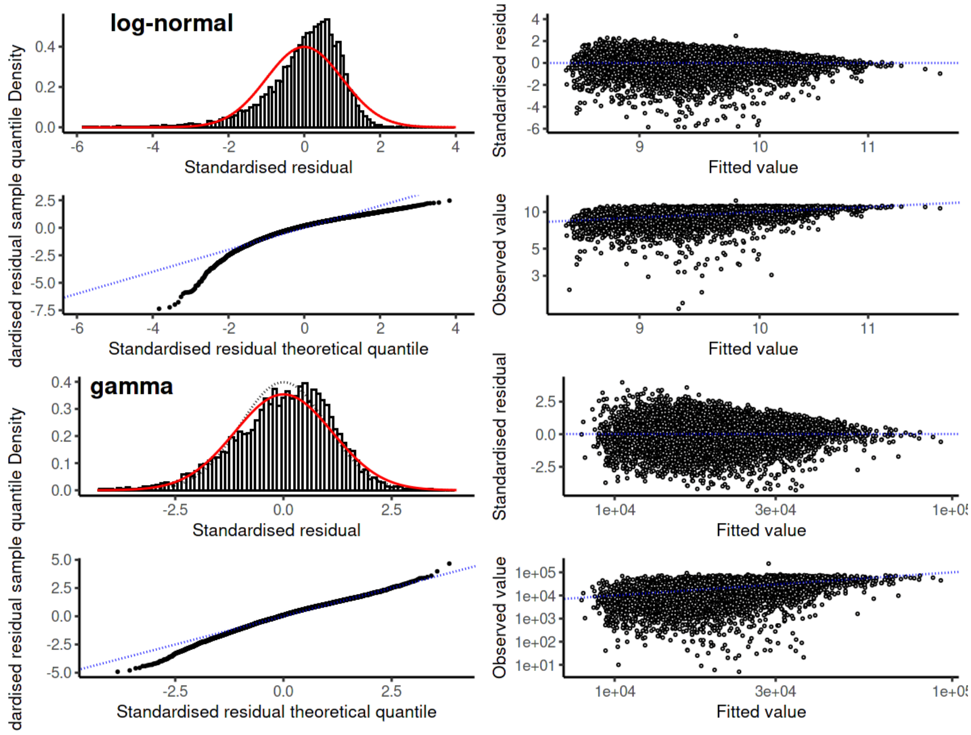

Figure C.46: Diagnostic plots for the log-normal and gamma model for the JMA7 MW observer LF dataset.

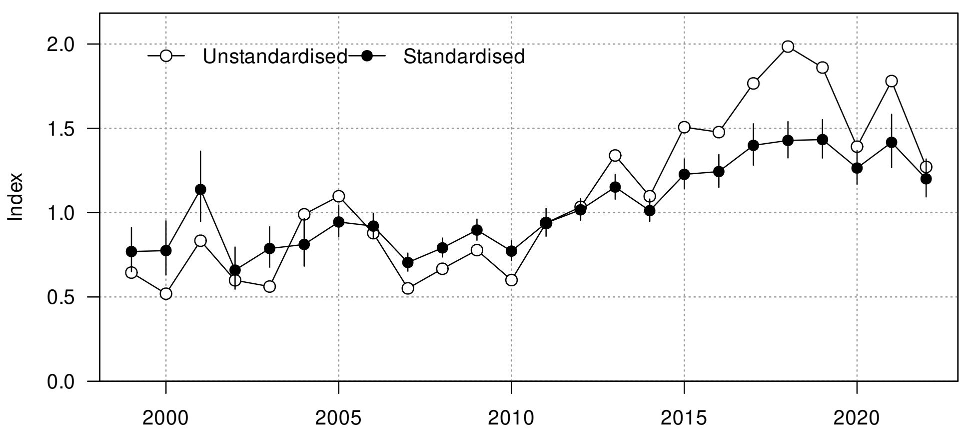

Figure C.47: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch in the JMA7 MW observer LF dataset.

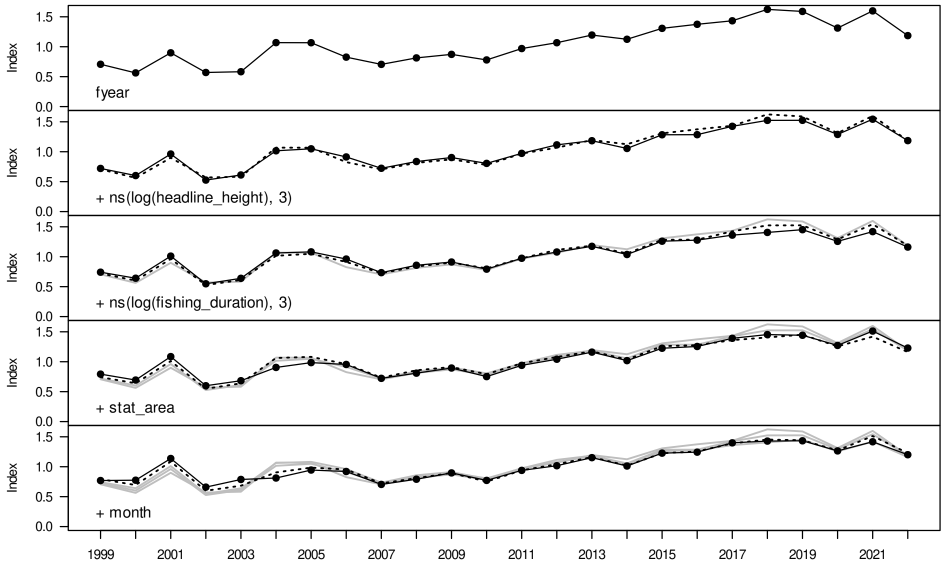

Figure C.48: Changes to the JMA7 MW observer LF positive catch index as terms are successively entered into the model.

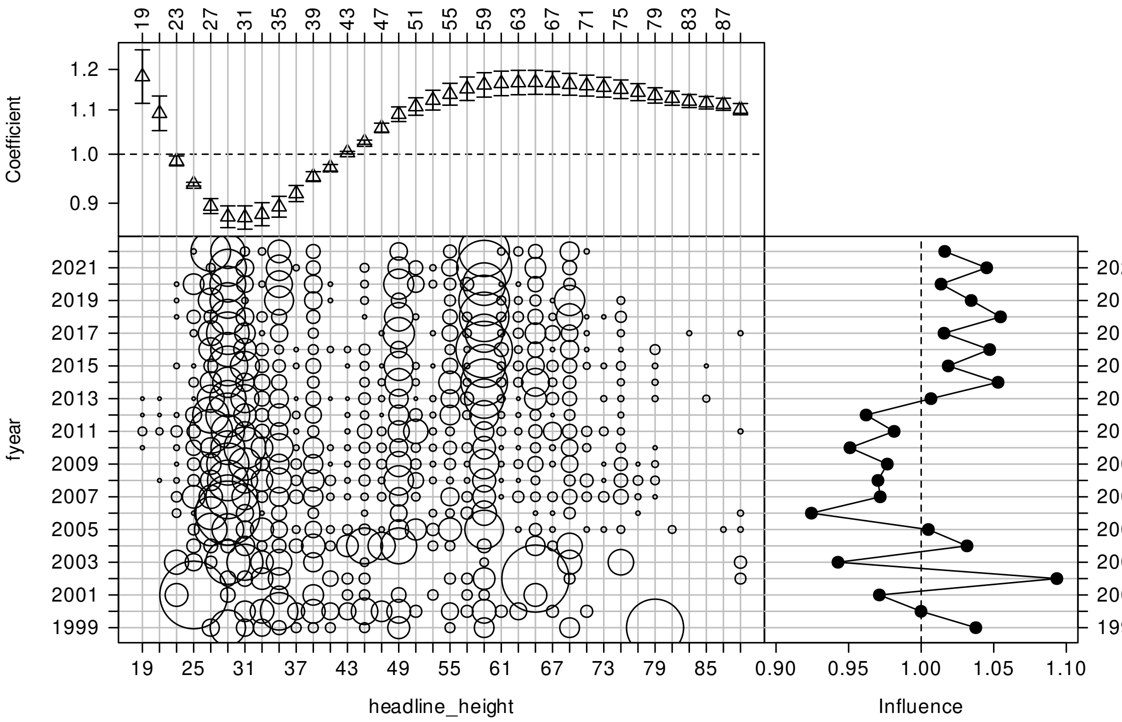

Figure C.49: CDI plot for headline height (m) for the positive catch JMA7 MW observer LF catch-per-unit-effort dataset.

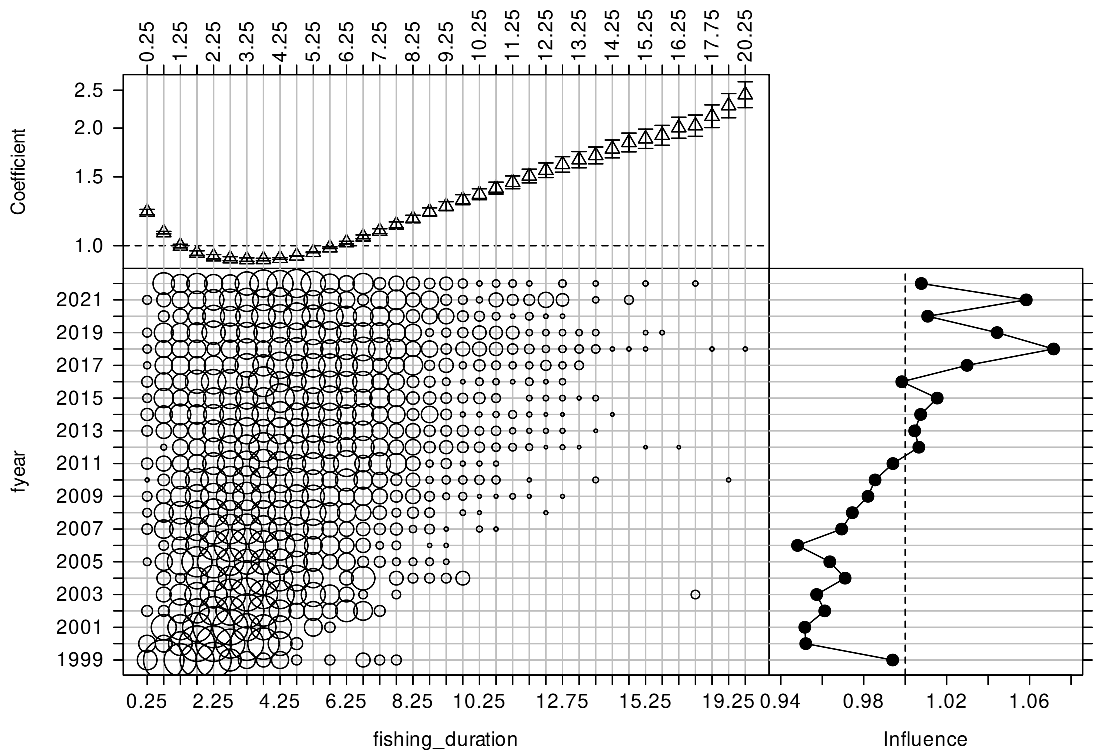

Figure C.50: CDI plot for fishing duration (h) for the positive catch JMA7 MW observer LF catch-per-unit-effort dataset.

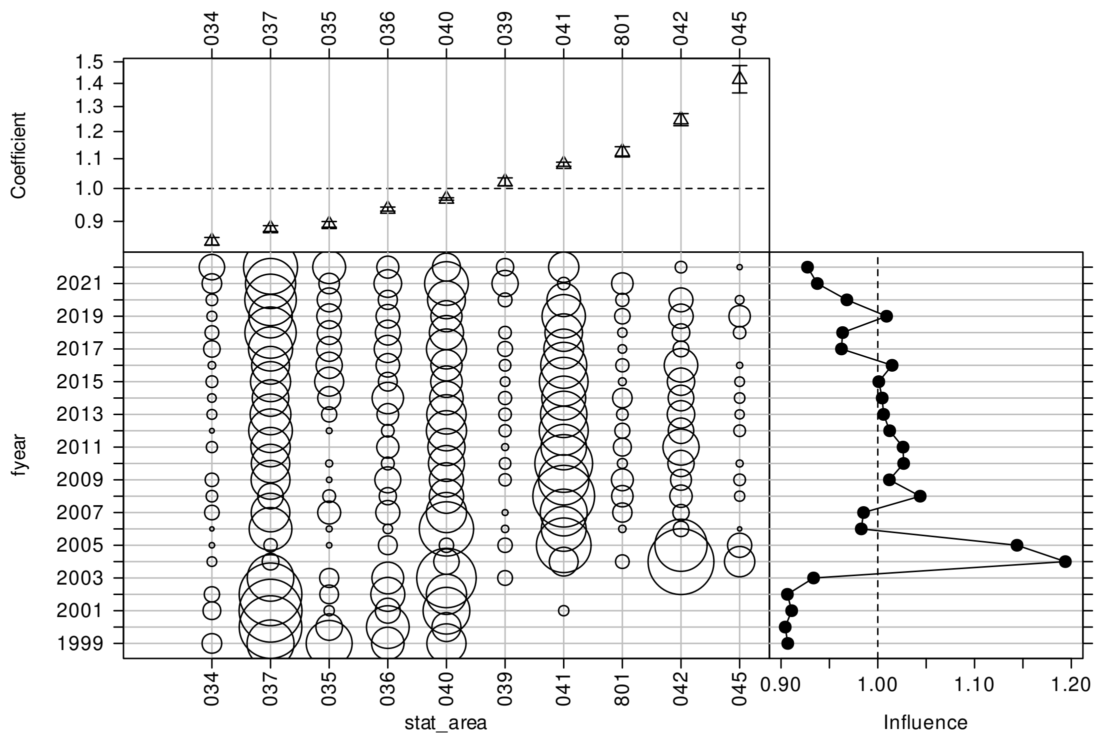

Figure C.51: CDI plot for statistical area for the positive catch JMA7 MW observer LF catch-per-unit-effort dataset.

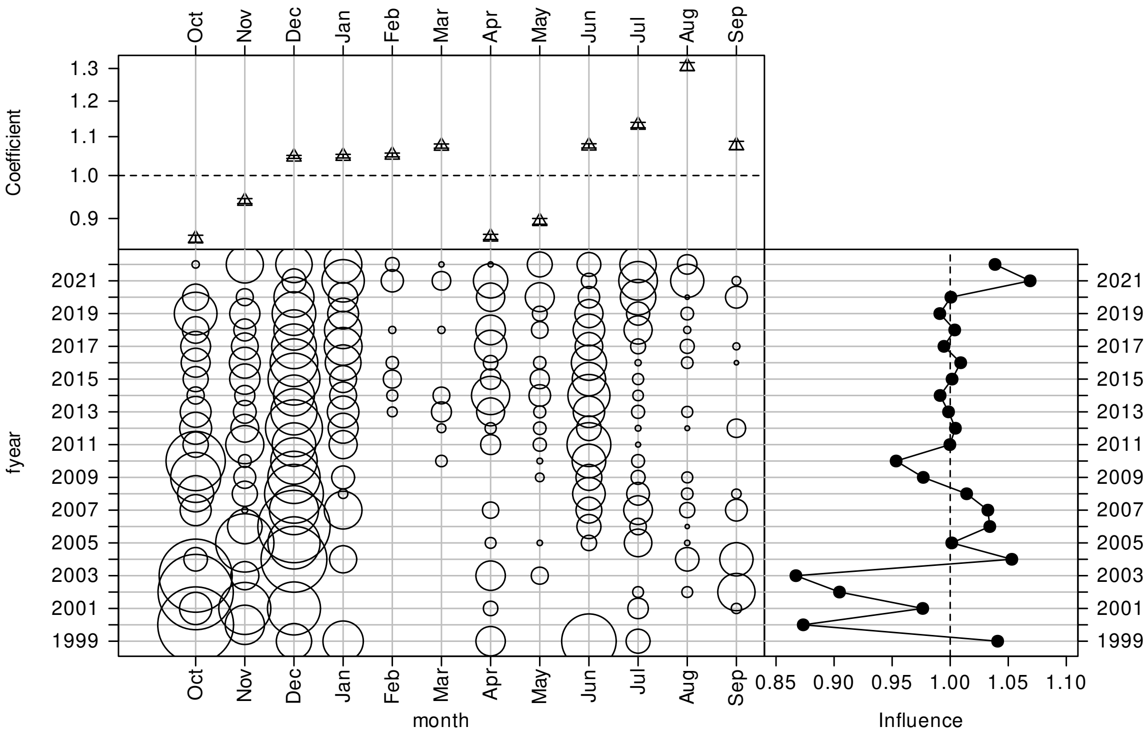

Figure C.52: CDI plot for month for the positive catch JMA7 MW observer LF catch-per-unit-effort dataset.

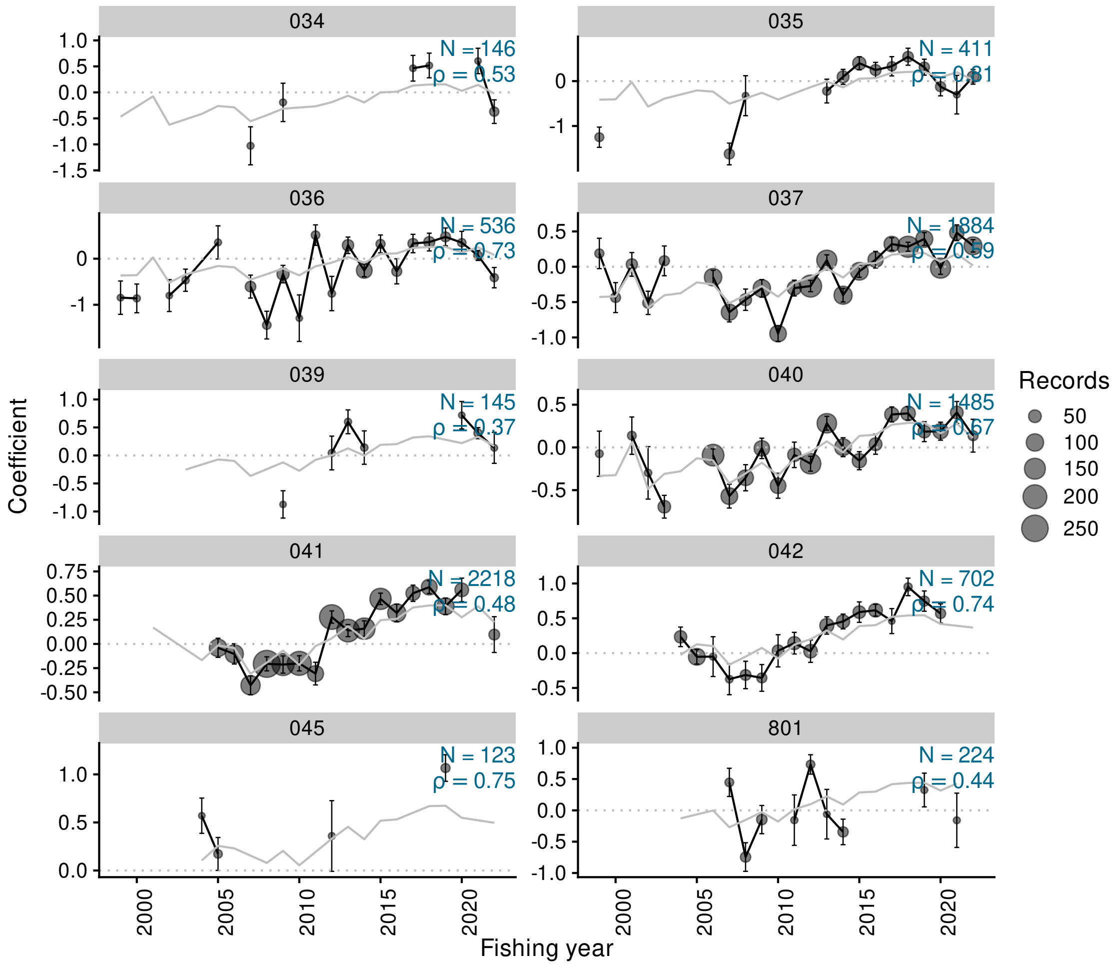

Figure C.53: Residual implied coefficients for area-year in the Weibull positive catch model for the JMA7 MW observer LF dataset.

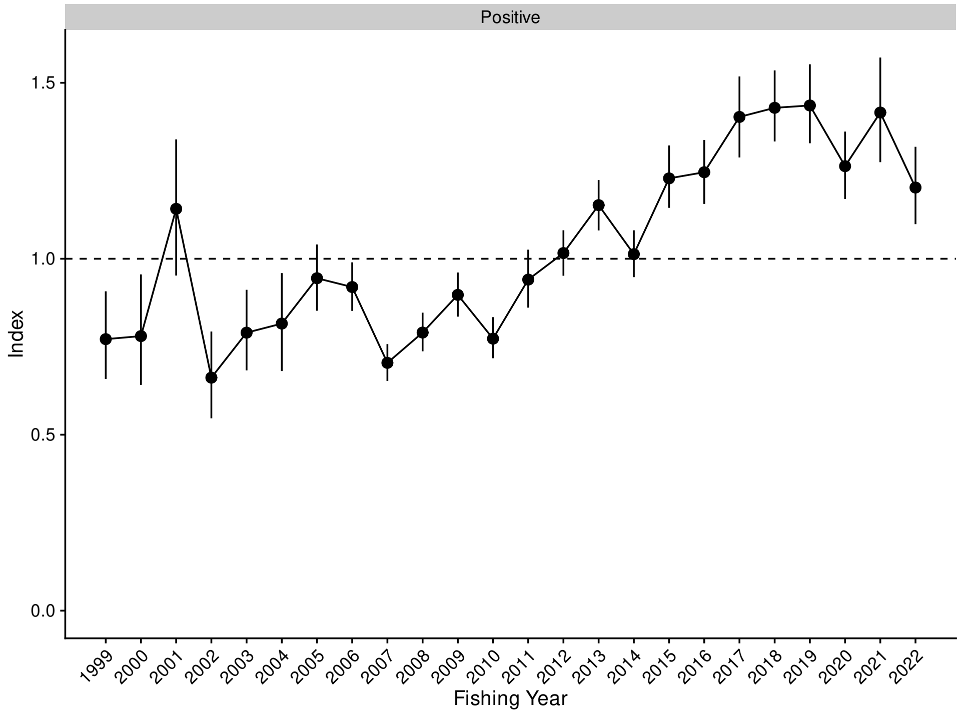

Figure C.54: Standardised indices and 95% confidence intervals for the JMA7 MW observer LF dataset.

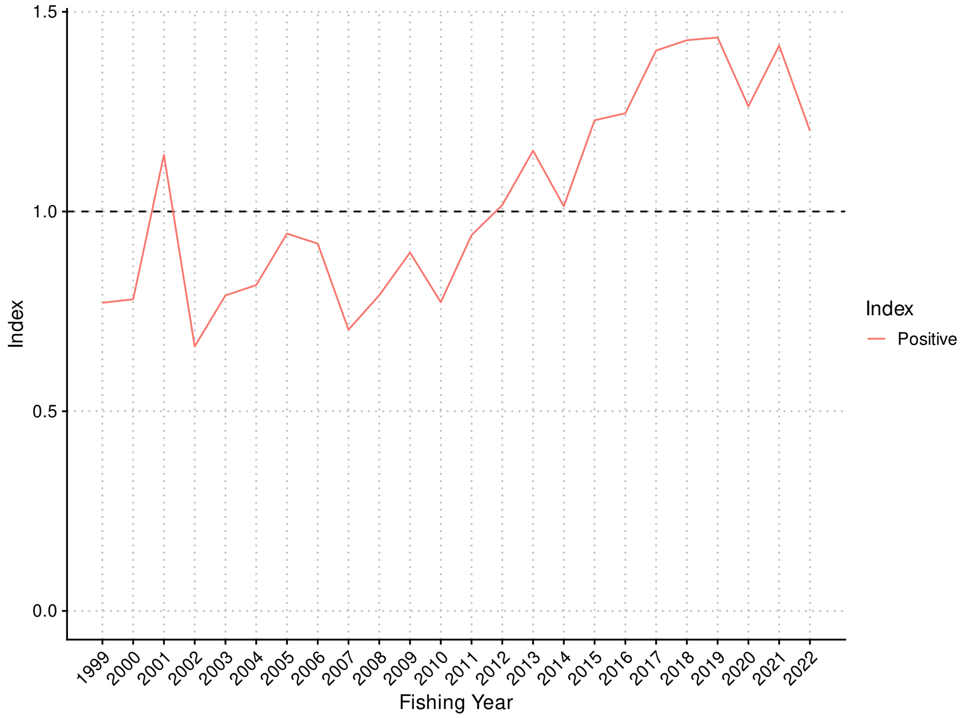

Figure C.55: Standardised indices for the JMA7 MW observer LF dataset.

Table C.16: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in JMA7 MW observer LF.

	Positive			
Fishing year	index	SE	LCI	UCI
1999	0.772	0.064	0.658	0.907
2000	0.780	0.080	0.641	0.955
2001	1.142	0.099	0.952	1.339
2002	0.662	0.063	0.547	0.793
2003	0.790	0.058	0.683	0.912
2004	0.816	0.071	0.681	0.959
2005	0.945	0.048	0.852	1.041
2006	0.920	0.035	0.852	0.990
2007	0.704	0.027	0.653	0.757
2008	0.790	0.028	0.737	0.847
2009	0.897	0.032	0.835	0.961
2010	0.773	0.030	0.717	0.834
2011	0.941	0.042	0.861	1.026
2012	1.016	0.033	0.952	1.081
2013	1.152	0.037	1.080	1.224
2014	1.013	0.034	0.948	1.081
2015	1.228	0.045	1.145	1.322
2016	1.246	0.046	1.156	1.338
2017	1.403	0.059	1.288	1.518
2018	1.429	0.052	1.333	1.535
2019	1.436	0.057	1.328	1.553
2020	1.263	0.049	1.170	1.361
2021	1.415	0.076	1.274	1.572
2022	1.202	0.056	1.098	1.318

C.4 JMD7 MW observer no small samples

Table C.17: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the JMD7 MW observer no small samples CPUE series.

Series	JMD7 MW observer no small samples
QMS stock	JMA7
Reporting forms	
Fishing methods	MW
Target species	JMA, JMD, JMM, JMN
Statistical Areas	034, 035, 036, 037, 039, 040, 041, 042, 045, 801
Period	1998-10-01, 2022-09-30
Resolution	Observed event
Core fleet years	4
Core fleet trips	1
Default model	jmdkg ~ fyear + vessel_key + month + stat_area + ns(log(fishing_duration), 3) + ns(log(start_time), 3) + ns(log(start_seabed_depth), 3) + ns(log(headline_height), 3) + ns(fishing_speed, 3)
Stepwise selection	Yes
Positive catch distribution	Weibull

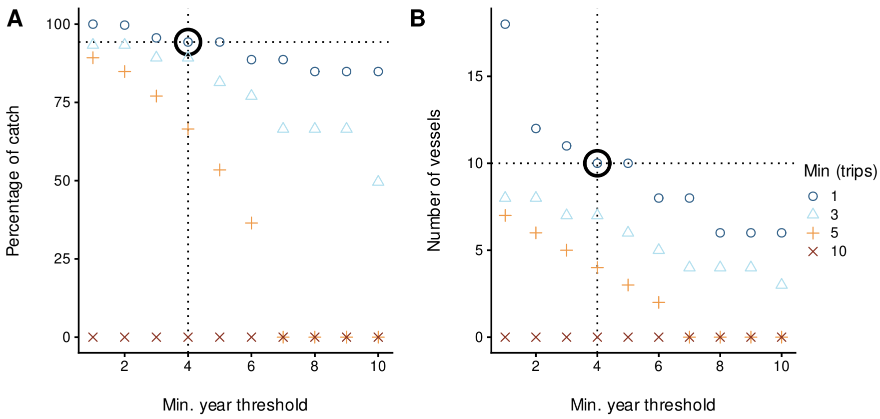

Figure C.56: Percentage of catch and number of vessels for different core vessel selection criteria for the JMD7 MW observer no small samples CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel was observed in the fishery and the number of observed trips per year.

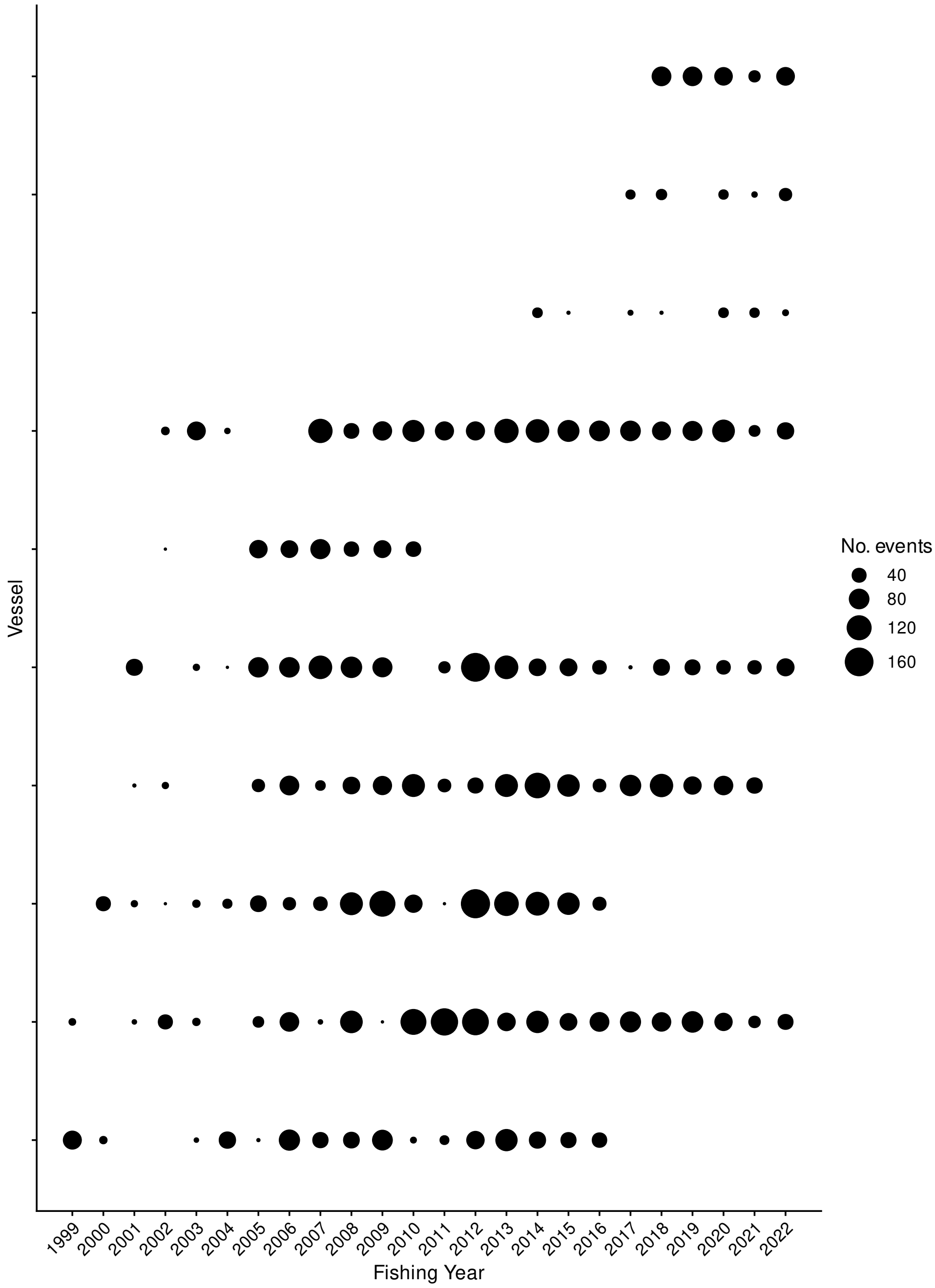

Figure C.57: Number of events by fishing year for core vessels. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table C.18: Summary of the JMD7 MW observer no small samples 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	1999	2000	2001	2002	2003	2004	2005	2006	2007
Ungroomed data	974 (100%) n: 116	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	687 (100%) n: 103	1171 (100%) n: 79	2467 (100%) n: 258	4706 (100%) n: 409	4247 (100%) n: 427
Fishing speed not null	926 (100%) n: 112	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	687 (100%) n: 103	1171 (100%) n: 79	2435 (100%) n: 256	4706 (100%) n: 409	4247 (100%) n: 427
Start date not null	926 (100%) n: 112	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	687 (100%) n: 103	1171 (100%) n: 79	2435 (100%) n: 256	4706 (100%) n: 409	4247 (100%) n: 427
End date not null	926 (100%) n: 112	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	687 (100%) n: 103	1171 (100%) n: 79	2435 (100%) n: 256	4706 (100%) n: 409	4247 (100%) n: 427
Start depth not null	926 (100%) n: 112	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	687 (100%) n: 103	1171 (100%) n: 79	2435 (100%) n: 256	4706 (100%) n: 409	4247 (100%) n: 427
Headline height not null	919 (94%) n: 111	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	679 (100%) n: 102	1171 (100%) n: 79	2435 (100%) n: 256	4706 (100%) n: 409	4247 (100%) n: 427
Fishing speed >3.5kn	919 (94%) n: 111	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	679 (100%) n: 102	1171 (100%) n: 79	2435 (100%) n: 256	4706 (100%) n: 409	4247 (100%) n: 426
Headline height >15m	919 (94%) n: 111	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	676 (100%) n: 101	1171 (100%) n: 79	2434 (100%) n: 255	4697 (100%) n: 408	4213 (100%) n: 422
Headline height <90m	919 (94%) n: 111	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	676 (100%) n: 101	1171 (100%) n: 79	2434 (100%) n: 255	4697 (100%) n: 408	4213 (100%) n: 422
Fishing duration >15mins	898 (92%) n: 109	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	676 (100%) n: 101	1171 (100%) n: 79	2433 (100%) n: 254	4628 (100%) n: 407	4159 (100%) n: 421
Seabed depth >50m	898 (92%) n: 109	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	676 (100%) n: 101	1171 (100%) n: 79	2433 (100%) n: 254	4628 (100%) n: 407	4159 (100%) n: 421
Seabed depth <400m	885 (91%) n: 108	390 (100%) n: 53	838 (100%) n: 75	474 (100%) n: 66	676 (100%) n: 101	1171 (100%) n: 79	2423 (100%) n: 252	4628 (100%) n: 407	4159 (100%) n: 421
Start time >0	883 (91%) n: 107	388 (100%) n: 52	838 (100%) n: 75	438 (92%) n: 63	676 (100%) n: 101	1171 (100%) n: 79	2399 (100%) n: 249	4613 (100%) n: 403	4073 (100%) n: 415
No small samples	883 (91%) n: 107	388 (100%) n: 52	836 (100%) n: 72	438 (92%) n: 63	672 (100%) n: 100	1171 (100%) n: 79	2399 (100%) n: 248	4613 (100%) n: 398	4056 (100%) n: 404
Core fleet selection	710 (73%) n: 76	388 (100%) n: 52	832 (100%) n: 67	438 (92%) n: 63	672 (100%) n: 100	1171 (100%) n: 79	2399 (100%) n: 248	4613 (100%) n: 398	4056 (100%) n: 404

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	4954 (100%) n: 511	5884 (100%) n: 526	4425 (100%) n: 487	4219 (100%) n: 310	9664 (100%) n: 713	9872 (100%) n: 643	11383 (100%) n: 669	9856 (100%) n: 593	6348 (100%) n: 389
Fishing speed not null	4895 (100%) n: 510	5884 (100%) n: 526	4406 (100%) n: 486	4219 (100%) n: 310	9664 (100%) n: 713	9834 (100%) n: 642	11383 (100%) n: 669	9856 (100%) n: 593	6333 (100%) n: 388
Start date not null	4895 (100%) n: 510	5884 (100%) n: 526	4406 (100%) n: 486	4219 (100%) n: 310	9664 (100%) n: 713	9834 (100%) n: 642	11383 (100%) n: 669	9856 (100%) n: 593	6333 (100%) n: 388
End date not null	4895 (100%) n: 510	5884 (100%) n: 526	4406 (100%) n: 486	4219 (100%) n: 310	9664 (100%) n: 713	9834 (100%) n: 642	11383 (100%) n: 669	9856 (100%) n: 593	6333 (100%) n: 388
Start depth not null	4884 (100%) n: 508	5628 (100%) n: 501	4358 (100%) n: 483	4146 (100%) n: 306	9122 (94%) n: 677	9346 (95%) n: 621	11338 (100%) n: 666	9786 (100%) n: 577	6333 (100%) n: 388
Headline height not null	4884 (100%) n: 508	5606 (100%) n: 499	4269 (100%) n: 475	4104 (100%) n: 305	9018 (93%) n: 670	9291 (94%) n: 617	11249 (100%) n: 663	9786 (100%) n: 576	6333 (100%) n: 388
Fishing speed >3.5kn	4884 (100%) n: 508	5606 (100%) n: 499	4269 (100%) n: 475	4104 (100%) n: 305	9018 (93%) n: 670	9291 (94%) n: 617	11249 (100%) n: 663	9786 (100%) n: 576	6331 (100%) n: 387
Headline height >15m	4884 (100%) n: 508	5586 (95%) n: 497	4233 (100%) n: 474	4104 (100%) n: 305	8954 (93%) n: 669	9216 (93%) n: 614	11249 (100%) n: 663	9786 (100%) n: 576	6331 (100%) n: 387
Headline height <90m	4884 (100%) n: 508	5586 (95%) n: 497	4233 (100%) n: 474	4094 (100%) n: 304	8943 (93%) n: 668	9216 (93%) n: 614	11231 (100%) n: 662	9771 (100%) n: 575	6331 (100%) n: 387
Fishing duration >15mins	4884 (100%) n: 507	5586 (95%) n: 497	4233 (100%) n: 474	4016 (100%) n: 301	8922 (92%) n: 667	9178 (93%) n: 612	11226 (100%) n: 660	9771 (100%) n: 575	6328 (100%) n: 386
Seabed depth >50m	4884 (100%) n: 507	5573 (95%) n: 495	4226 (100%) n: 473	4016 (100%) n: 301	8922 (92%) n: 666	9159 (93%) n: 611	11226 (100%) n: 660	9755 (100%) n: 574	6328 (100%) n: 386
Seabed depth <400m	4865 (100%) n: 504	5573 (95%) n: 495	4217 (100%) n: 472	4016 (100%) n: 301	8809 (91%) n: 659	9134 (93%) n: 609	11222 (100%) n: 659	9675 (100%) n: 571	6328 (100%) n: 386
Start time >0	4675 (94%) n: 495	5549 (94%) n: 492	4137 (93%) n: 468	4002 (95%) n: 298	8778 (91%) n: 652	9075 (92%) n: 606	11067 (100%) n: 649	9618 (100%) n: 568	6287 (100%) n: 383
No small samples	4634 (94%) n: 480	5545 (94%) n: 485	4050 (92%) n: 456	3977 (94%) n: 288	8745 (90%) n: 642	9002 (91%) n: 594	10904 (100%) n: 616	9269 (94%) n: 537	5899 (93%) n: 340
Core fleet selection	4634 (94%) n: 480	5545 (94%) n: 485	3880 (88%) n: 434	3977 (94%) n: 288	8745 (90%) n: 642	9002 (91%) n: 594	8694 (76%) n: 565	6883 (70%) n: 448	5079 (80%) n: 303

Filter	2017	2018	2019	2020	2021	2022
Ungroomed data	5899 (100%) n: 309	8658 (100%) n: 433	8557 (100%) n: 380	6557 (100%) n: 397	5650 (100%) n: 259	5498 (100%) n: 328
Fishing speed not null	5820 (100%) n: 307	8658 (100%) n: 433	8557 (100%) n: 380	6477 (100%) n: 395	5497 (100%) n: 255	5497 (100%) n: 327
Start date not null	5820 (100%) n: 307	8658 (100%) n: 433	8557 (100%) n: 380	6477 (100%) n: 395	5497 (100%) n: 255	5497 (100%) n: 327
End date not null	5820 (100%) n: 307	8658 (100%) n: 433	8557 (100%) n: 380	6477 (100%) n: 395	5497 (100%) n: 255	5497 (100%) n: 327
Start depth not null	5764 (100%) n: 304	8646 (100%) n: 432	8557 (100%) n: 380	6477 (100%) n: 389	5438 (100%) n: 249	4579 (83%) n: 289
Headline height not null	5646 (100%) n: 300	8618 (100%) n: 430	8557 (100%) n: 380	6447 (100%) n: 387	5438 (100%) n: 249	4579 (83%) n: 289
Fishing speed >3.5kn	5646 (100%) n: 300	8618 (100%) n: 430	8557 (100%) n: 380	6447 (100%) n: 387	5438 (100%) n: 249	4579 (83%) n: 289
Headline height >15m	5636 (100%) n: 299	8618 (100%) n: 430	8557 (100%) n: 380	6447 (100%) n: 387	5438 (100%) n: 249	4579 (83%) n: 289
Headline height <90m	5636 (100%) n: 299	8577 (100%) n: 428	8557 (100%) n: 380	6447 (100%) n: 387	5438 (100%) n: 249	4579 (83%) n: 289
Fishing duration >15mins	5624 (100%) n: 298	8577 (100%) n: 428	8522 (100%) n: 379	6447 (100%) n: 387	5438 (100%) n: 249	4579 (83%) n: 289
Seabed depth >50m	5624 (100%) n: 298	8532 (100%) n: 427	8522 (100%) n: 379	6447 (100%) n: 387	5438 (100%) n: 249	4579 (83%) n: 289
Seabed depth <400m	5624 (100%) n: 298	8510 (100%) n: 425	8406 (100%) n: 377	6447 (100%) n: 387	5438 (100%) n: 249	4579 (83%) n: 289
Start time >0	5546 (94%) n: 296	8505 (100%) n: 424	8366 (100%) n: 376	6401 (100%) n: 384	5374 (100%) n: 247	4579 (83%) n: 289
No small samples	5408 (92%) n: 286	8009 (93%) n: 402	8200 (100%) n: 369	6325 (100%) n: 370	5108 (90%) n: 239	4437 (81%) n: 277
Core fleet selection	5297 (90%) n: 275	7378 (85%) n: 391	7550 (88%) n: 343	6325 (100%) n: 370	4104 (73%) n: 187	4077 (74%) n: 264

Table C.19: Summary of the JMD7 MW observer no small samples dataset after core fleet selection. 'Records' indicates the number of rows (events) in the dataset, and 'Records caught' indicates the percentage of events with catches of jack mackerels.

Fishing year	Vessels	Trips	Records	Hrs	Catch (t)	Records caught
1999	2	3	76	165.32	709.60	100.00
2000	2	2	52	137.25	387.78	98.08
2001	4	6	67	177.58	831.83	100.00
2002	5	5	63	221.45	437.53	100.00
2003	5	5	100	363.17	671.68	98.00
2004	4	4	79	333.28	1 171.09	96.20
2005	6	9	248	845.90	2 399.42	99.19
2006	6	8	398	1 456.15	4 613.02	98.74
2007	7	15	404	1 474.00	4 055.97	97.28
2008	7	16	480	1 870.33	4 634.25	96.88
2009	7	15	485	2 024.73	5 544.55	96.70
2010	6	10	434	1 924.45	3 880.06	97.47
2011	6	8	288	1 339.28	3 977.14	96.88
2012	6	20	642	3 326.75	8 744.68	96.73
2013	6	31	594	2 862.97	9 001.98	95.45
2014	7	32	565	2 683.07	8 693.51	95.22
2015	7	30	448	2 209.30	6 883.12	96.88
2016	6	27	303	1 397.20	5 079.03	98.68
2017	6	25	275	1 466.42	5 297.09	96.00
2018	7	30	391	2 346.18	7 378.29	90.79
2019	5	23	343	1 823.83	7 549.61	97.96
2020	7	30	370	1 907.28	6 324.50	88.92
2021	7	19	187	1 053.53	4 104.04	96.79
2022	6	16	264	1 243.32	4 076.92	92.05

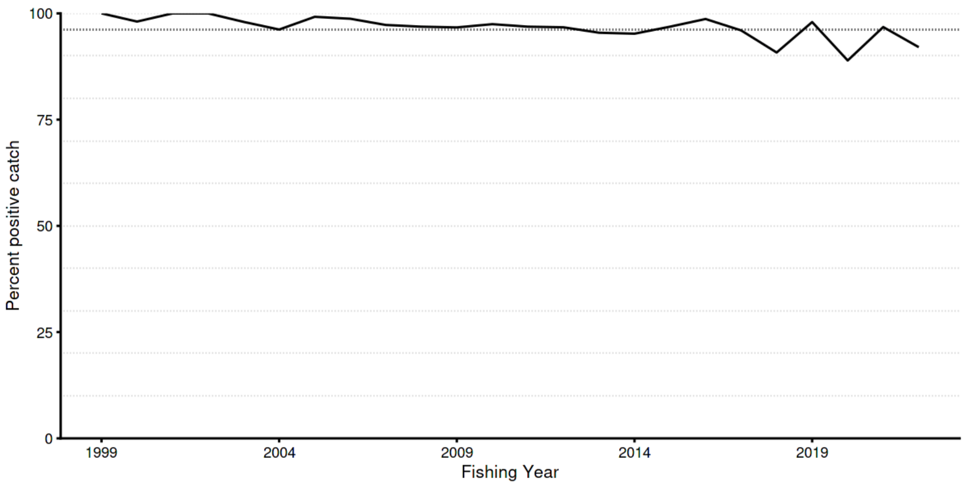

Figure C.58: Percentage of positive catch records in the JMD7 MW observer no small samples catch-per-unit-effort dataset.

Table C.20: Summary of stepwise selection for the Weibull model. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	25	153 372	7.0	7.0	*
+ ns(log(start seabed depth), 3)	3	152 826	13.5	6.5	*
+ month	11	152 636	16.0	2.5	*
+ ns(log(headline height), 3)	3	152 502	17.7	1.7	*
+ ns(log(fishing duration), 3)	3	152 398	19.0	1.3	*
+ stat area	9	152 307	20.3	1.3	*
+ vessel key	9	152 276	20.9	0.6	
+ ns(log(start time), 3)	3	152 271	21.0	0.1	

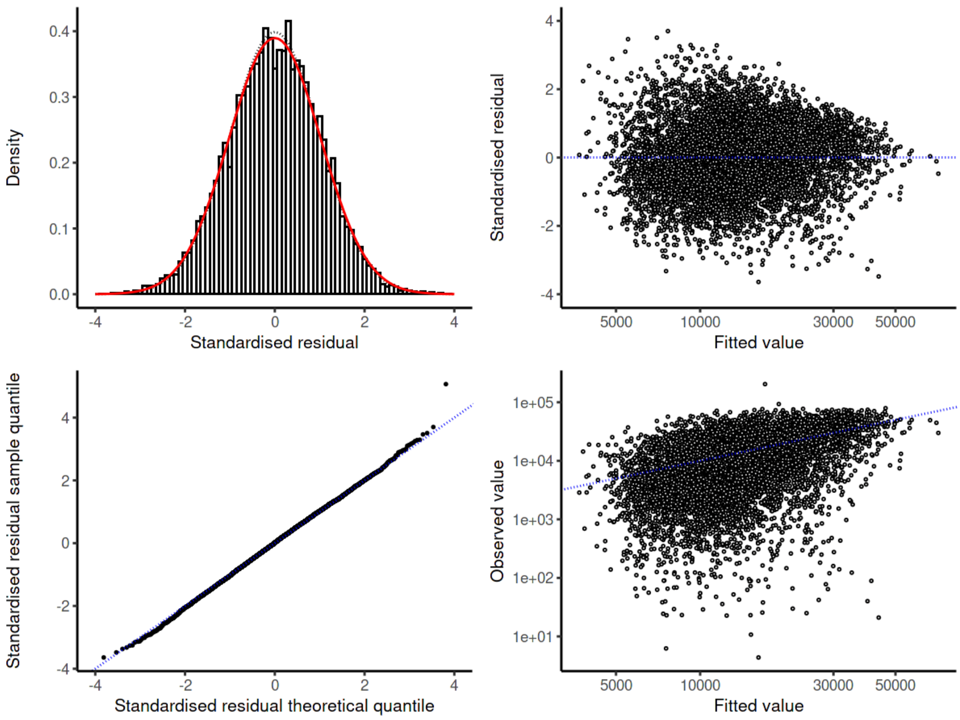

Figure C.59: Diagnostic plots for the Weibull model for the JMD7 MW observer no small samples dataset.

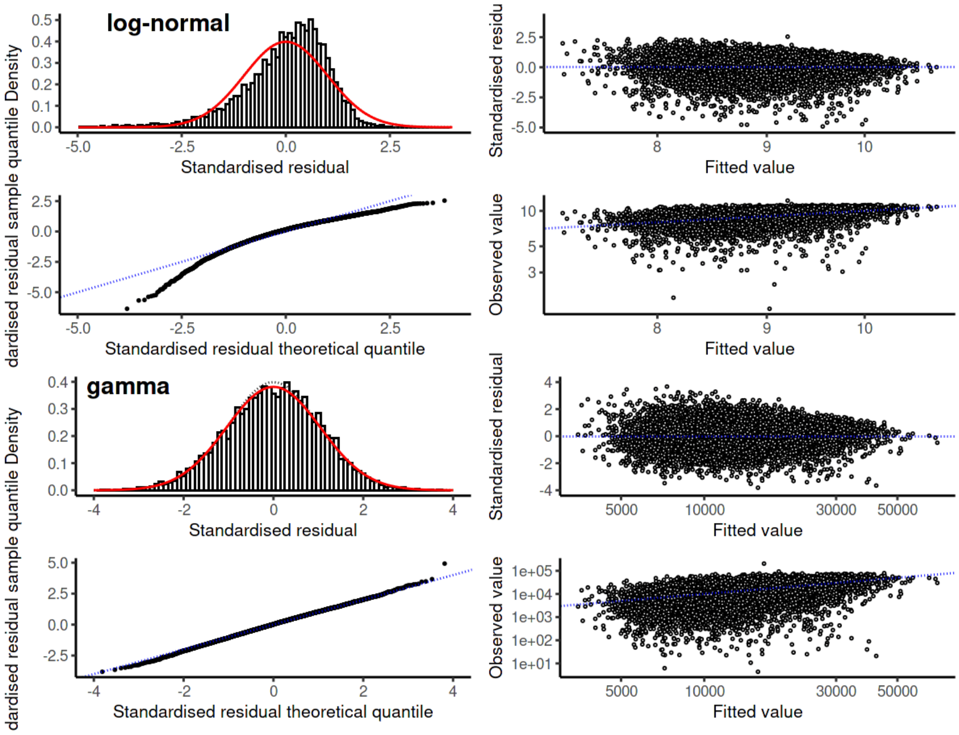

Figure C.60: Diagnostic plots for the log-normal and gamma model for the JMD7 MW observer no small samples dataset.

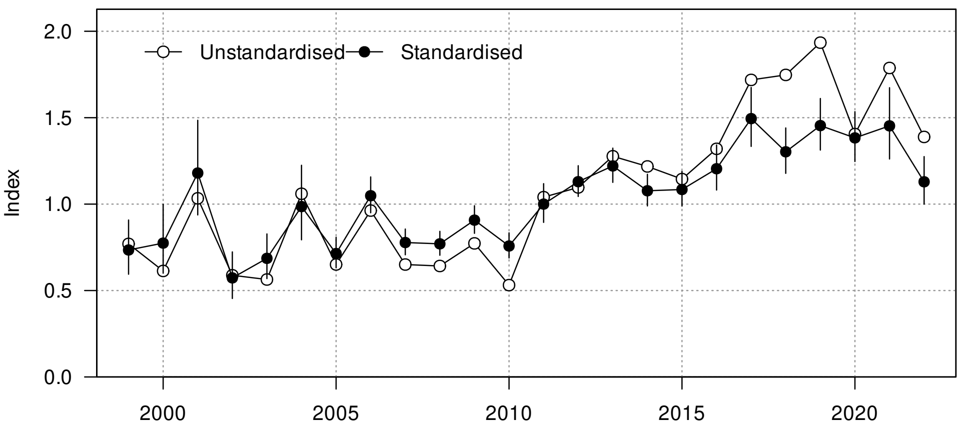

Figure C.61: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch in the JMD7 MW observer no small samples dataset.

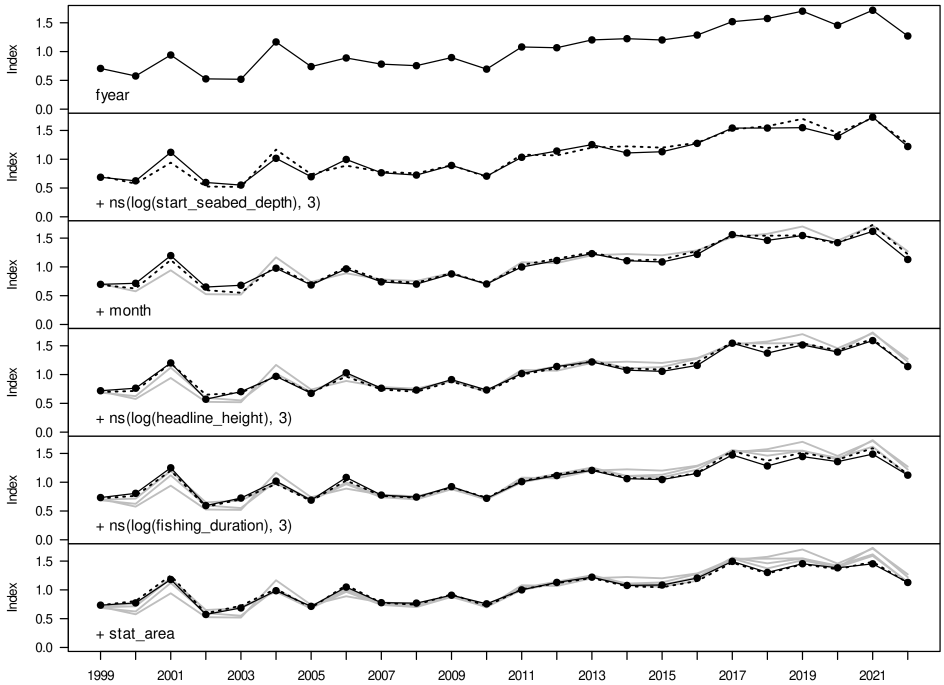

Figure C.62: Changes to the JMD7 MW observer no small samples positive catch index as terms are successively entered into the model.

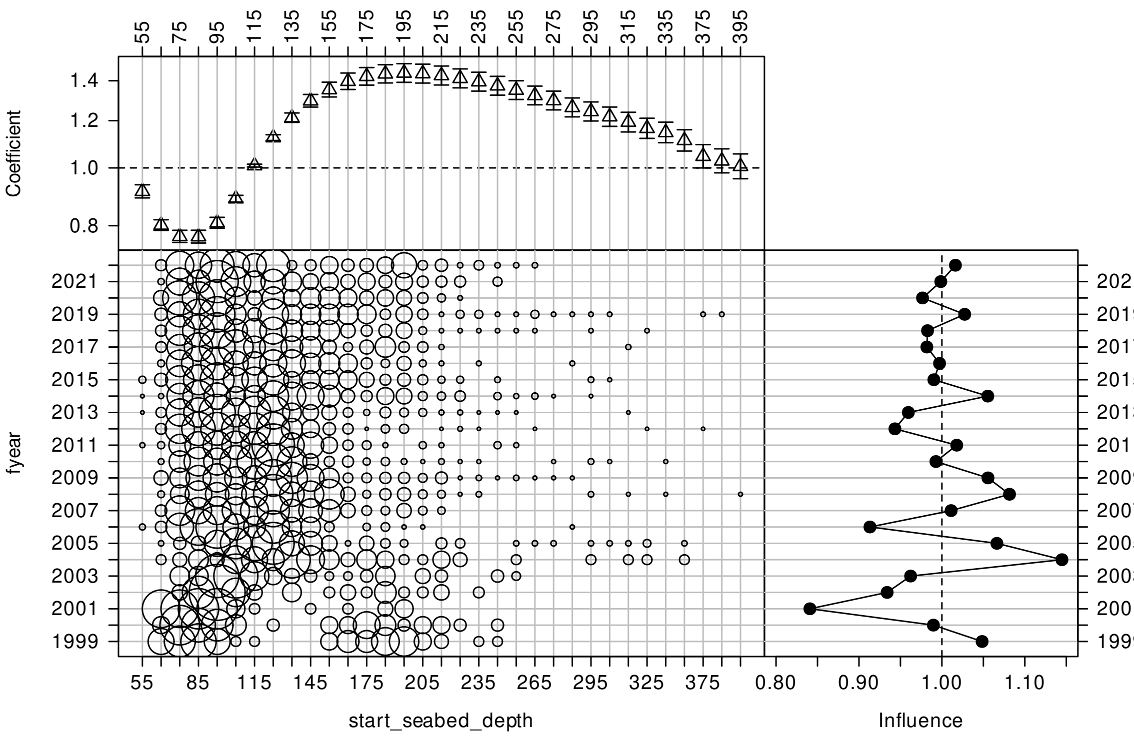

Figure C.63: CDI plot for start seabed depth (m) for the positive catch JMD7 MW observer no small samples catch-per-unit-effort dataset.

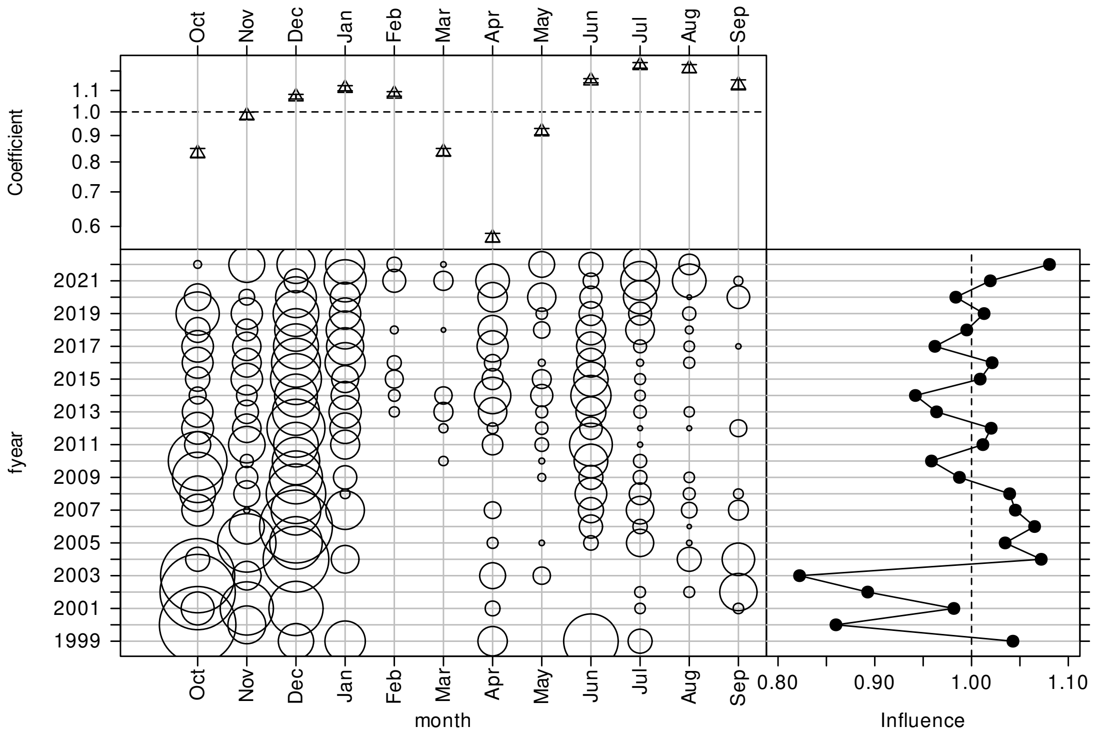

Figure C.64: CDI plot for month for the positive catch JMD7 MW observer no small samples catch-per-unit-effort dataset.

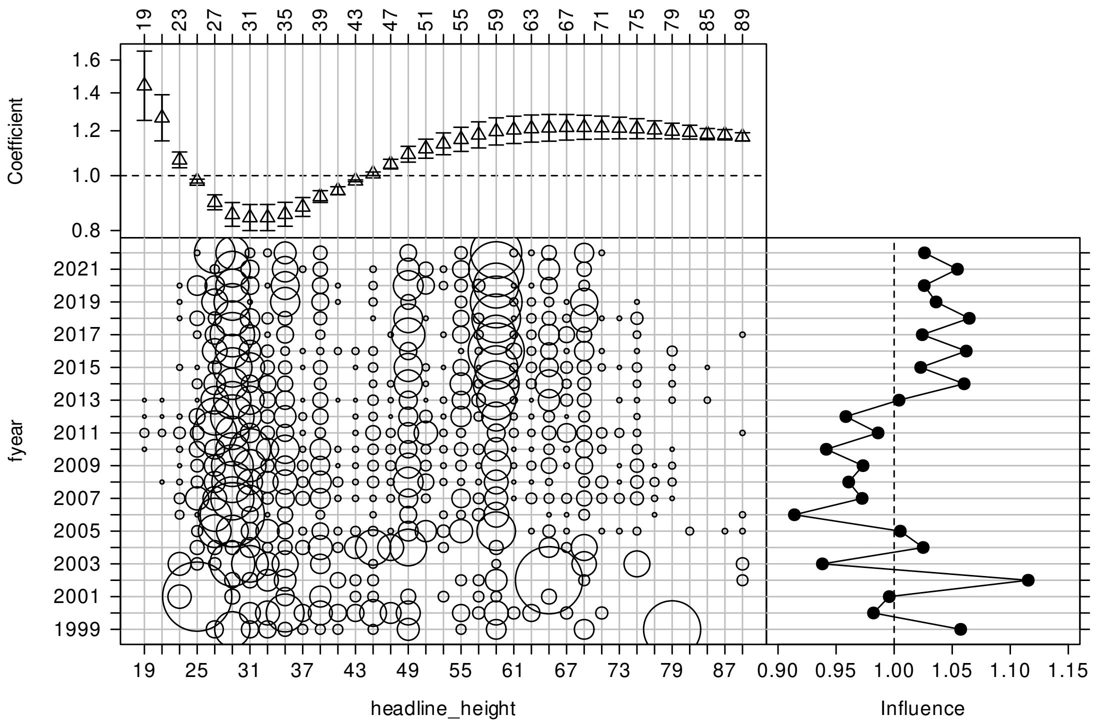

Figure C.65: CDI plot for headline height (m) for the positive catch JMD7 MW observer no small samples catch-per-unit-effort dataset.

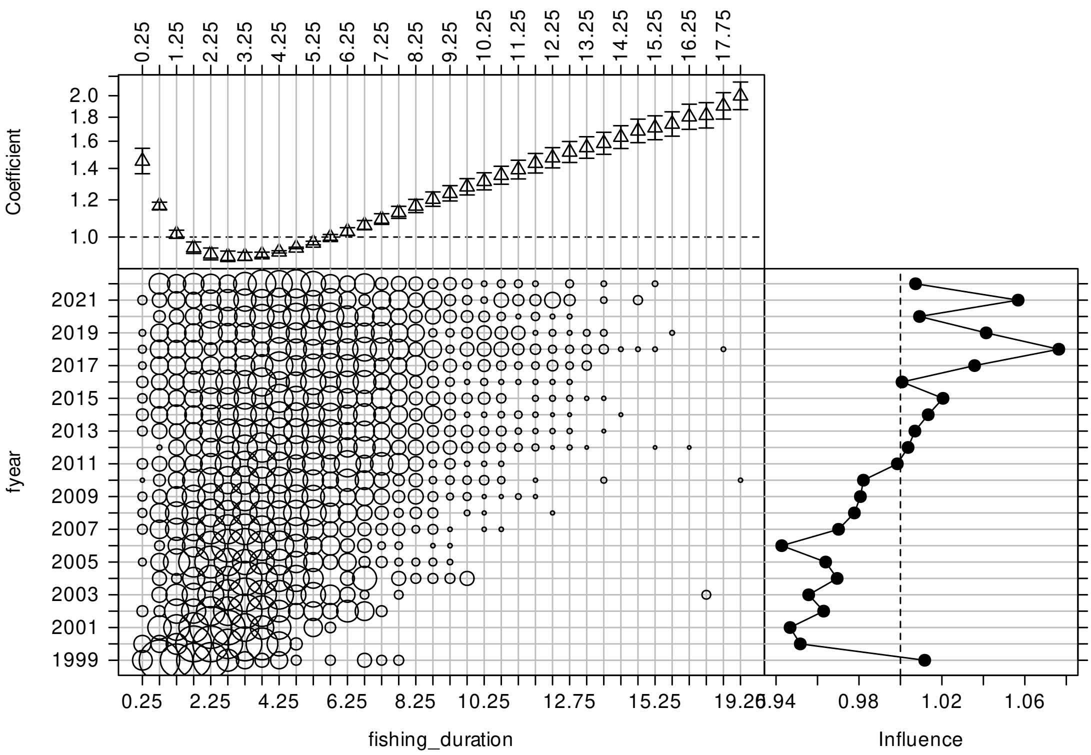

Figure C.66: CDI plot for fishing duration (h) for the positive catch JMD7 MW observer no small samples catch-per-unit-effort dataset.

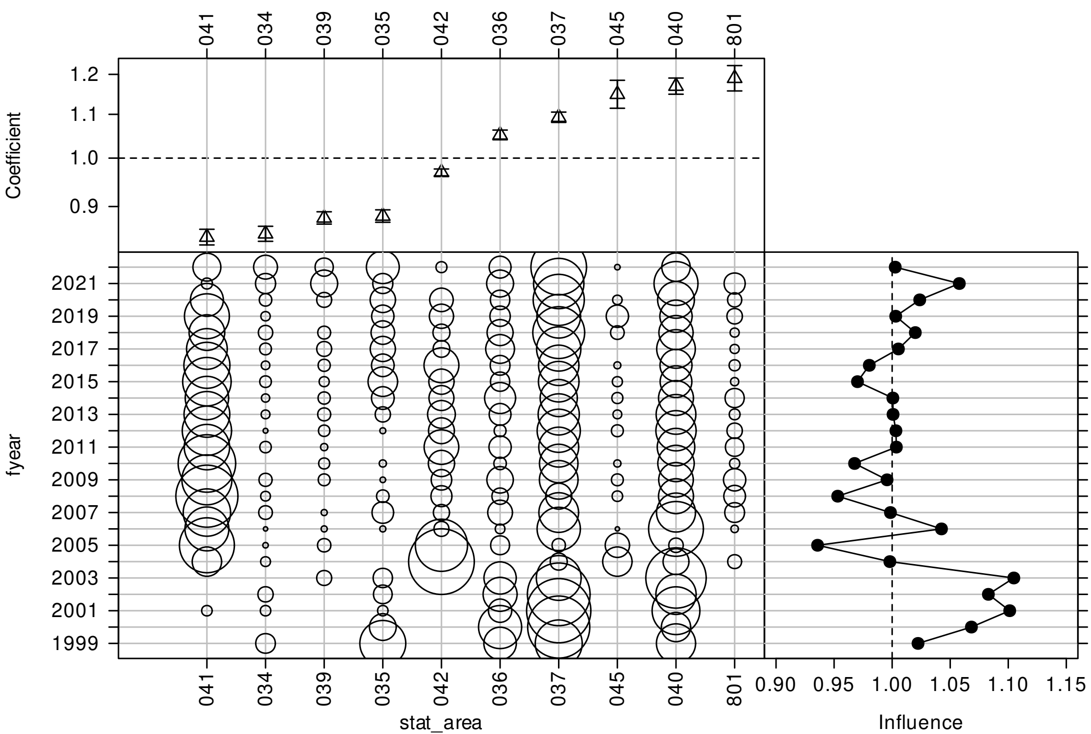

Figure C.67: CDI plot for statistical area for the positive catch JMD7 MW observer no small samples catch-per-unit-effort dataset.

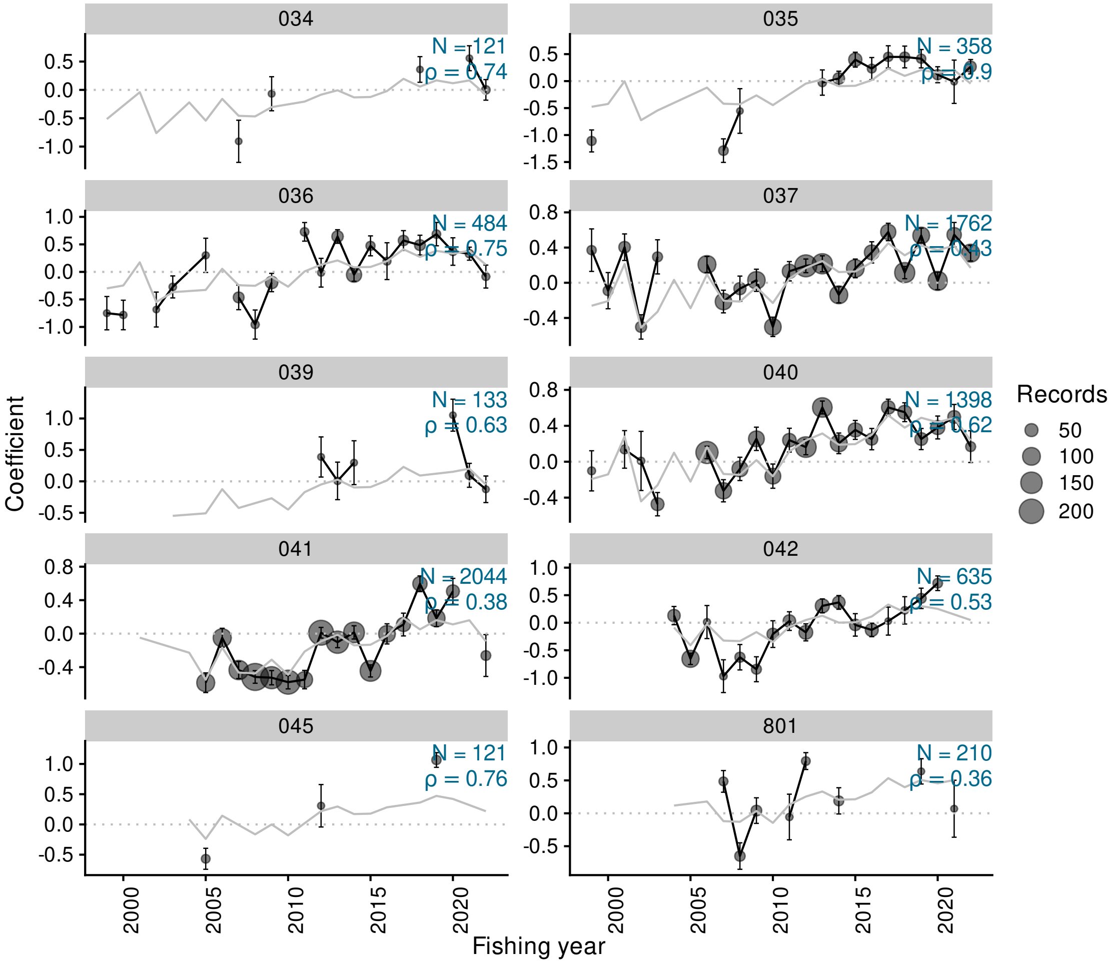

Figure C.68: Residual implied coefficients for area-year in the Weibull positive catch model for the JMD7 MW observer no small samples dataset.

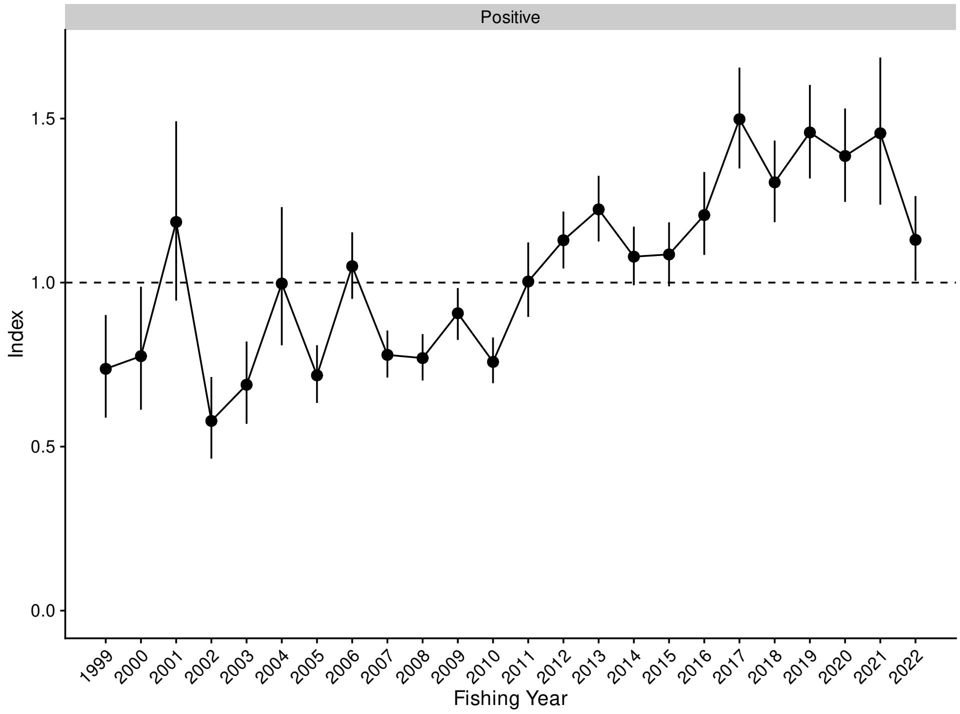

Figure C.69: Standardised indices and 95% confidence intervals for the JMD7 MW observer no small samples dataset.

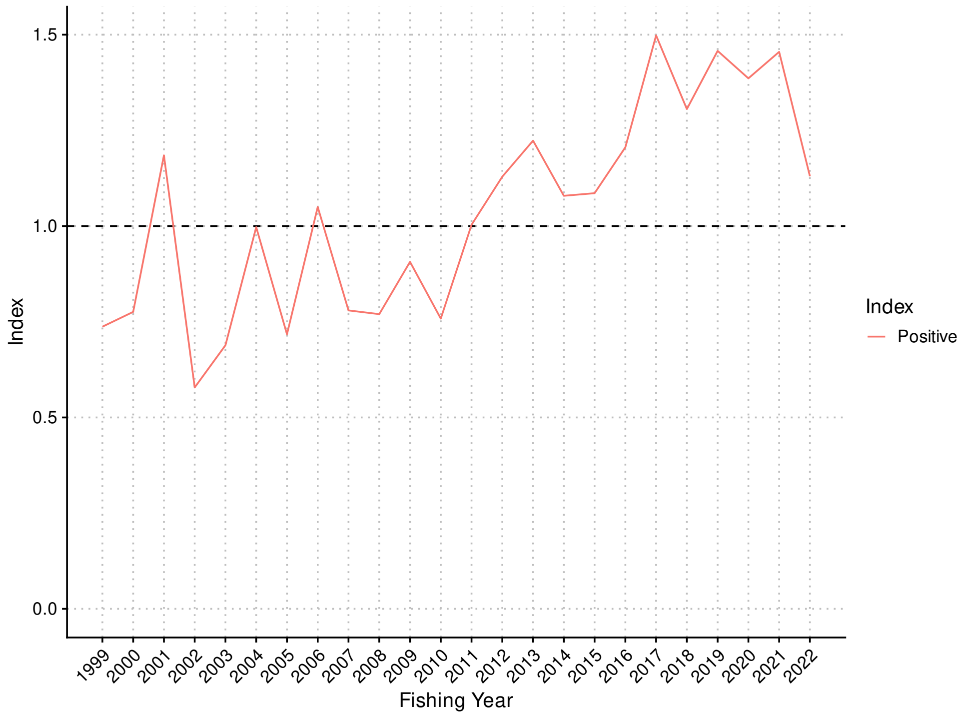

Figure C.70: Standardised indices for the JMD7 MW observer no small samples dataset.

Table C.21: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in JMD7 MW observer no small samples.

	Positive			
Fishing year	index	SE	LCI	UCI
1999	0.737	0.080	0.588	0.901
2000	0.776	0.096	0.612	0.987
2001	1.185	0.139	0.945	1.492
2002	0.578	0.063	0.463	0.712
2003	0.689	0.064	0.570	0.820
2004	0.997	0.107	0.809	1.230
2005	0.717	0.045	0.633	0.809
2006	1.050	0.052	0.950	1.153
2007	0.780	0.037	0.711	0.854
2008	0.770	0.036	0.702	0.843
2009	0.907	0.040	0.825	0.983
2010	0.758	0.036	0.693	0.833
2011	1.003	0.058	0.895	1.123
2012	1.129	0.044	1.043	1.216
2013	1.223	0.051	1.125	1.326
2014	1.079	0.046	0.992	1.171
2015	1.086	0.050	0.989	1.184
2016	1.206	0.064	1.084	1.337
2017	1.498	0.078	1.348	1.655
2018	1.306	0.063	1.184	1.433
2019	1.458	0.073	1.317	1.603
2020	1.386	0.073	1.246	1.531
2021	1.455	0.114	1.238	1.686
2022	1.130	0.066	1.006	1.264

C.5 JMN7 MW observer no small samples

Table C.22: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the JMN7 MW observer no small samples CPUE series.

Series	JMN7 MW observer no small samples
QMS stock	JMA7
Reporting forms	
Fishing methods	MW
Target species	JMA, JMD, JMM, JMN
Statistical Areas	037, 039, 040, 041, 042, 045
Period	1998-10-01, 2022-09-30
Resolution	Observed event
Core fleet years	4
Core fleet trips	1
Default model	jmnkg ~ fyear + vessel_key + month + stat_area + ns(log(fishing_duration), 3) + ns(log(start_time), 3) + ns(log(start_seabed_depth), 3) + ns(log(headline_height), 3) + ns(fishing_speed, 3)
Stepwise selection	Yes
Positive catch distribution	Weibull

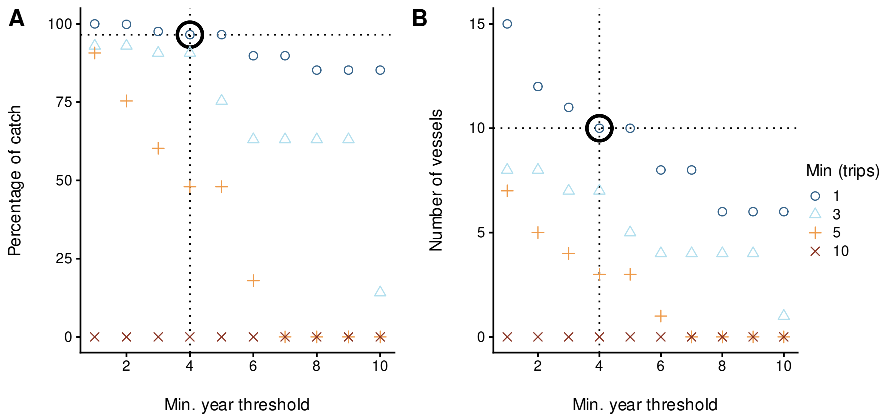

Figure C.71: Percentage of catch and number of vessels for different core vessel selection criteria for the JMN7 MW observer no small samples CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel was observed in the fishery and the number of observed trips per year.

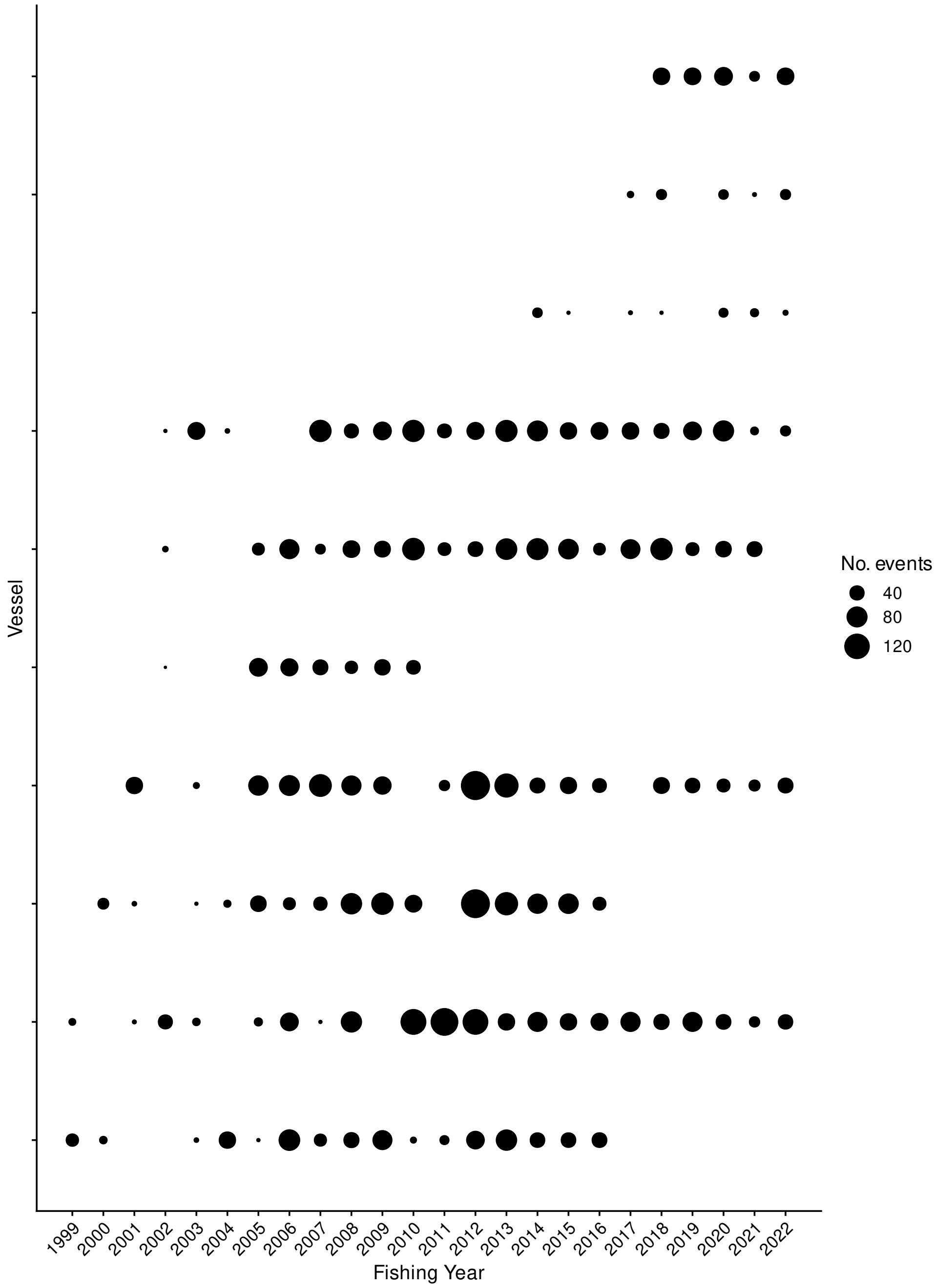

Figure C.72: Number of events by fishing year for core vessels. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table C.23: Summary of the JMN7 MW observer no small samples 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	1999	2000	2001	2002	2003	2004	2005	2006	2007
Ungroomed data	304 (100%) n: 45	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 84	403 (100%) n: 76	2571 (100%) n: 243	1541 (100%) n: 397	1331 (100%) n: 327
Fishing speed not null	304 (100%) n: 44	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 84	403 (100%) n: 76	2568 (100%) n: 241	1541 (100%) n: 397	1331 (100%) n: 327
Start date not null	304 (100%) n: 44	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 84	403 (100%) n: 76	2568 (100%) n: 241	1541 (100%) n: 397	1331 (100%) n: 327
End date not null	304 (100%) n: 44	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 84	403 (100%) n: 76	2568 (100%) n: 241	1541 (100%) n: 397	1331 (100%) n: 327
Start depth not null	304 (100%) n: 44	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 84	403 (100%) n: 76	2568 (100%) n: 241	1541 (100%) n: 397	1331 (100%) n: 327
Headline height not null	294 (100%) n: 43	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 83	403 (100%) n: 76	2568 (100%) n: 241	1541 (100%) n: 397	1331 (100%) n: 327
Fishing speed >3.5kn	294 (100%) n: 43	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 83	403 (100%) n: 76	2568 (100%) n: 241	1541 (100%) n: 397	1331 (100%) n: 326
Headline height >15m	294 (100%) n: 43	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	386 (100%) n: 82	403 (100%) n: 76	2566 (100%) n: 240	1539 (100%) n: 396	1307 (100%) n: 322
Headline height <90m	294 (100%) n: 43	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	386 (100%) n: 82	403 (100%) n: 76	2566 (100%) n: 240	1539 (100%) n: 396	1307 (100%) n: 322
Fishing duration >15mins	289 (95%) n: 42	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	386 (100%) n: 82	403 (100%) n: 76	2566 (100%) n: 239	1539 (100%) n: 396	1307 (100%) n: 322
Seabed depth >50m	289 (95%) n: 42	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	386 (100%) n: 82	403 (100%) n: 76	2566 (100%) n: 239	1539 (100%) n: 396	1307 (100%) n: 322
Seabed depth <200m	289 (95%) n: 42	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	386 (100%) n: 82	394 (100%) n: 67	2417 (94%) n: 230	1539 (100%) n: 395	1307 (100%) n: 322
Start time >0	289 (95%) n: 42	100 (100%) n: 34	178 (100%) n: 60	228 (88%) n: 48	386 (100%) n: 82	394 (100%) n: 67	2400 (93%) n: 229	1519 (100%) n: 391	1261 (95%) n: 319
No small samples	289 (95%) n: 42	100 (100%) n: 34	178 (100%) n: 60	228 (88%) n: 48	376 (100%) n: 81	394 (100%) n: 67	2400 (93%) n: 229	1511 (100%) n: 386	1260 (95%) n: 315
Core fleet selection	268 (88%) n: 39	100 (100%) n: 34	178 (100%) n: 60	228 (88%) n: 48	376 (100%) n: 81	394 (100%) n: 67	2400 (93%) n: 229	1511 (100%) n: 386	1260 (95%) n: 315

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	2365 (100%) n: 435	2171 (100%) n: 428	2177 (100%) n: 464	1501 (100%) n: 271	4646 (100%) n: 669	4978 (100%) n: 563	3725 (100%) n: 480	5772 (100%) n: 485	3096 (100%) n: 312
Fishing speed not null	2363 (100%) n: 434	2171 (100%) n: 428	2176 (100%) n: 463	1501 (100%) n: 271	4646 (100%) n: 669	4978 (100%) n: 562	3725 (100%) n: 480	5772 (100%) n: 485	3096 (100%) n: 311
Start date not null	2363 (100%) n: 434	2171 (100%) n: 428	2176 (100%) n: 463	1501 (100%) n: 271	4646 (100%) n: 669	4978 (100%) n: 562	3725 (100%) n: 480	5772 (100%) n: 485	3096 (100%) n: 311
End date not null	2363 (100%) n: 434	2171 (100%) n: 428	2176 (100%) n: 463	1501 (100%) n: 271	4646 (100%) n: 669	4978 (100%) n: 562	3725 (100%) n: 480	5772 (100%) n: 485	3096 (100%) n: 311
Start depth not null	2363 (100%) n: 433	2046 (94%) n: 405	2171 (100%) n: 460	1476 (100%) n: 267	4285 (92%) n: 634	4879 (100%) n: 542	3705 (100%) n: 478	5512 (100%) n: 469	3096 (100%) n: 311
Headline height not null	2363 (100%) n: 433	2007 (92%) n: 404	2114 (100%) n: 452	1476 (100%) n: 266	4265 (92%) n: 627	4847 (100%) n: 538	3705 (100%) n: 477	5508 (100%) n: 468	3096 (100%) n: 311
Fishing speed >3.5kn	2363 (100%) n: 433	2007 (92%) n: 404	2114 (100%) n: 452	1476 (100%) n: 266	4265 (92%) n: 627	4847 (100%) n: 538	3705 (100%) n: 477	5508 (100%) n: 468	3076 (100%) n: 310
Headline height >15m	2363 (100%) n: 433	2007 (92%) n: 403	2111 (100%) n: 451	1476 (100%) n: 266	4265 (92%) n: 627	4845 (100%) n: 535	3705 (100%) n: 477	5508 (100%) n: 468	3076 (100%) n: 310
Headline height <90m	2363 (100%) n: 433	2007 (92%) n: 403	2111 (100%) n: 451	1454 (100%) n: 265	4265 (92%) n: 626	4845 (100%) n: 535	3705 (100%) n: 477	5508 (100%) n: 468	3076 (100%) n: 310
Fishing duration >15mins	2363 (100%) n: 432	2007 (92%) n: 403	2111 (100%) n: 451	1425 (95%) n: 263	4265 (92%) n: 626	4835 (100%) n: 533	3704 (100%) n: 475	5508 (100%) n: 468	3076 (100%) n: 309
Seabed depth >50m	2363 (100%) n: 432	2005 (92%) n: 401	2086 (100%) n: 450	1425 (95%) n: 263	4264 (92%) n: 625	4835 (100%) n: 532	3704 (100%) n: 475	5504 (100%) n: 467	3076 (100%) n: 309
Seabed depth <200m	2347 (100%) n: 419	1936 (89%) n: 390	2074 (100%) n: 438	1425 (95%) n: 262	4250 (91%) n: 612	4820 (100%) n: 524	3690 (100%) n: 472	5474 (95%) n: 457	3000 (100%) n: 305
Start time >0	2332 (100%) n: 414	1936 (89%) n: 389	2074 (100%) n: 435	1416 (94%) n: 259	4160 (90%) n: 606	4801 (100%) n: 522	3630 (100%) n: 465	5427 (94%) n: 454	2931 (95%) n: 302
No small samples	2300 (100%) n: 407	1921 (88%) n: 383	2065 (95%) n: 424	1412 (94%) n: 250	4152 (89%) n: 598	4748 (100%) n: 516	3586 (100%) n: 448	5381 (93%) n: 429	2762 (89%) n: 263
Core fleet selection	2300 (100%) n: 407	1921 (88%) n: 383	2014 (93%) n: 406	1412 (94%) n: 250	4152 (89%) n: 598	4748 (100%) n: 516	3421 (92%) n: 417	4374 (76%) n: 355	2757 (89%) n: 254

Filter	2017	2018	2019	2020	2021	2022
Ungroomed data	2640 (100%) n: 238	4601 (100%) n: 346	2822 (100%) n: 302	2942 (100%) n: 329	2320 (100%) n: 205	2359 (100%) n: 241
Fishing speed not null	2638 (100%) n: 236	4601 (100%) n: 346	2822 (100%) n: 302	2942 (100%) n: 328	2299 (100%) n: 201	2359 (100%) n: 240
Start date not null	2638 (100%) n: 236	4601 (100%) n: 346	2822 (100%) n: 302	2942 (100%) n: 328	2299 (100%) n: 201	2359 (100%) n: 240
End date not null	2638 (100%) n: 236	4601 (100%) n: 346	2822 (100%) n: 302	2942 (100%) n: 328	2299 (100%) n: 201	2359 (100%) n: 240
Start depth not null	2605 (100%) n: 234	4587 (100%) n: 345	2822 (100%) n: 302	2879 (100%) n: 323	2177 (94%) n: 195	2026 (86%) n: 204
Headline height not null	2605 (100%) n: 230	4582 (100%) n: 343	2822 (100%) n: 302	2879 (100%) n: 322	2177 (94%) n: 195	2026 (86%) n: 204
Fishing speed >3.5kn	2605 (100%) n: 230	4582 (100%) n: 343	2822 (100%) n: 302	2879 (100%) n: 322	2177 (94%) n: 195	2026 (86%) n: 204
Headline height >15m	2582 (100%) n: 229	4582 (100%) n: 343	2822 (100%) n: 302	2879 (100%) n: 322	2177 (94%) n: 195	2026 (86%) n: 204
Headline height <90m	2582 (100%) n: 229	4582 (100%) n: 343	2822 (100%) n: 302	2879 (100%) n: 322	2177 (94%) n: 195	2026 (86%) n: 204
Fishing duration >15mins	2564 (100%) n: 228	4582 (100%) n: 343	2822 (100%) n: 302	2879 (100%) n: 322	2177 (94%) n: 195	2026 (86%) n: 204
Seabed depth >50m	2564 (100%) n: 228	4573 (100%) n: 342	2822 (100%) n: 302	2879 (100%) n: 322	2177 (94%) n: 195	2026 (86%) n: 204
Seabed depth <200m	2564 (100%) n: 226	4403 (100%) n: 332	2758 (100%) n: 279	2878 (100%) n: 317	2176 (94%) n: 194	2019 (86%) n: 202
Start time >0	2558 (100%) n: 225	4393 (100%) n: 331	2758 (100%) n: 279	2823 (100%) n: 314	2114 (91%) n: 193	2019 (86%) n: 202
No small samples	2515 (100%) n: 220	4311 (94%) n: 316	2739 (100%) n: 277	2810 (100%) n: 302	2066 (89%) n: 187	1971 (84%) n: 198
Core fleet selection	2428 (92%) n: 209	4311 (94%) n: 308	2654 (94%) n: 265	2810 (100%) n: 302	1630 (70%) n: 136	1941 (82%) n: 185

Table C.24: Summary of the JMN7 MW observer no small samples dataset after core fleet selection. ‘Records’ indicates the number of rows (events) in the dataset, and ‘Records caught’ indicates the percentage of events with catches of jack mackerels.

Fishing year	Vessels	Trips	Records	Hrs	Catch (t)	Records caught
1999	2	2	39	80.15	267.96	76.92
2000	2	2	34	89.50	99.83	88.24
2001	3	4	60	156.45	178.19	85.00
2002	4	4	48	181.12	228.40	79.17
2003	5	5	81	283.08	376.39	87.65
2004	3	3	67	277.55	393.81	73.13
2005	6	8	229	778.45	2 400.03	89.52
2006	6	8	386	1 407.82	1 511.18	90.16
2007	7	15	315	1 190.90	1 260.49	73.02
2008	7	15	407	1 614.38	2 300.00	70.76
2009	6	11	383	1 626.70	1 921.01	84.86
2010	6	10	406	1 817.68	2 014.44	83.50
2011	5	7	250	1 192.62	1 412.19	71.60
2012	6	18	598	3 049.38	4 152.17	82.27
2013	6	28	516	2 588.18	4 748.16	82.75
2014	7	32	417	2 147.35	3 421.30	83.69
2015	7	25	355	1 850.17	4 373.72	87.61
2016	6	22	254	1 277.77	2 756.78	86.61
2017	5	18	209	1 230.40	2 427.90	89.95
2018	7	23	308	2 024.37	4 311.32	79.22
2019	5	18	265	1 549.60	2 654.32	83.02
2020	7	29	302	1 566.28	2 810.41	72.52
2021	7	17	136	829.53	1 630.08	87.50
2022	6	14	185	972.10	1 941.42	87.57

Table C.25: Summary of stepwise selection for occurrence of positive catch. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	22.00	5 761	2.60	2.60	*
+ ns(log(start_seabed_depth), 3)	3.00	5 382	9.20	6.60	*
+ stat_area	5.00	5 096	14.20	5.10	*
+ month	11.00	5 003	16.20	2.00	*
+ vessel_key	9.00	4 969	17.10	0.90	
+ ns(log(fishing_duration), 3)	3.00	4 942	17.60	0.60	
+ ns(log(headline_height), 3)	3.00	4 927	18.00	0.40	
+ ns(fishing_speed, 3)	3.00	4 926	18.10	0.10	

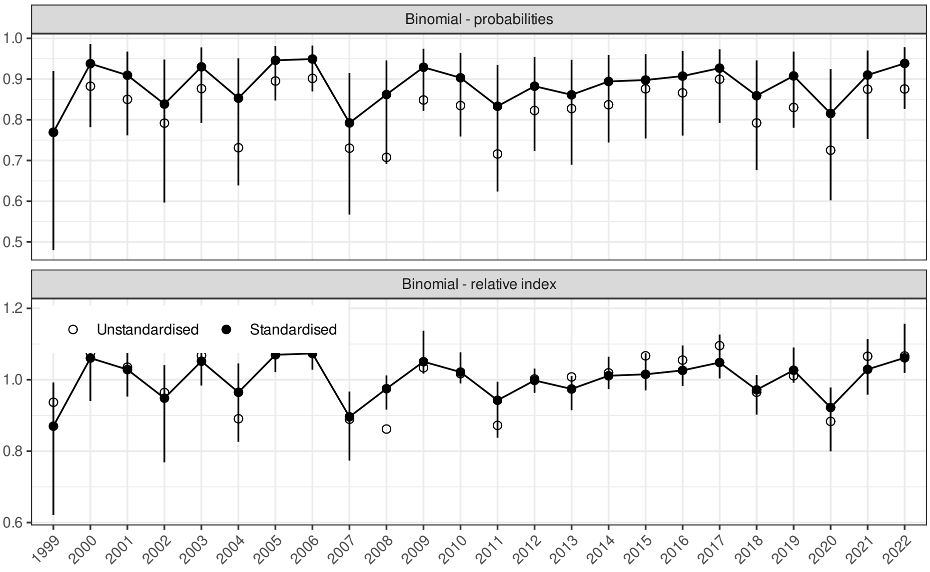

Figure C.73: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the JMN7 MW observer no small samples dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

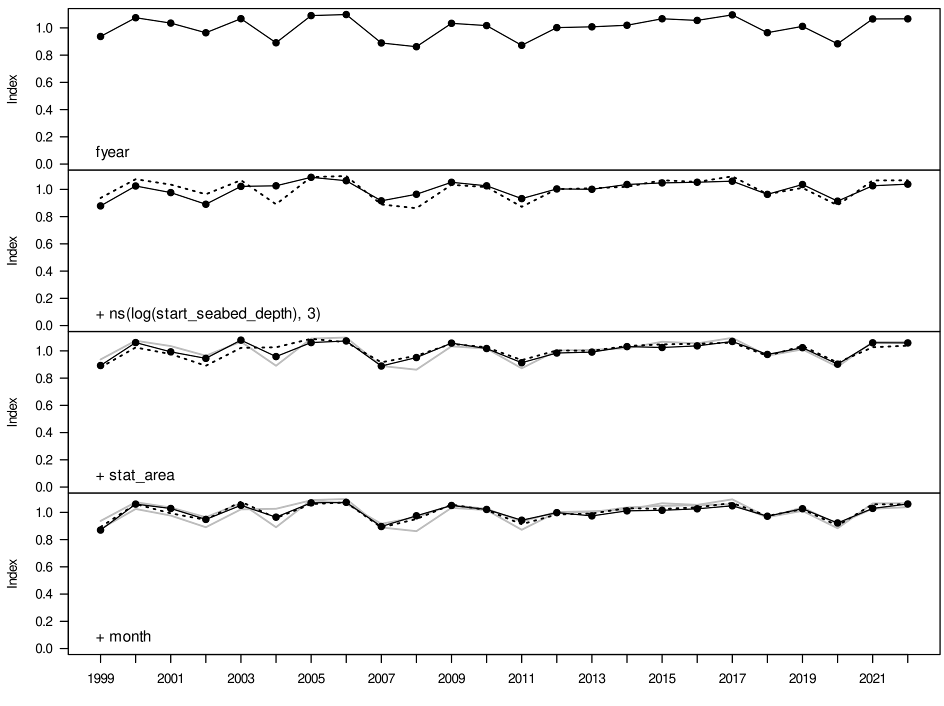

Figure C.74: Step plot for occurrence of catch in the JMN7 MW observer no small samples dataset.

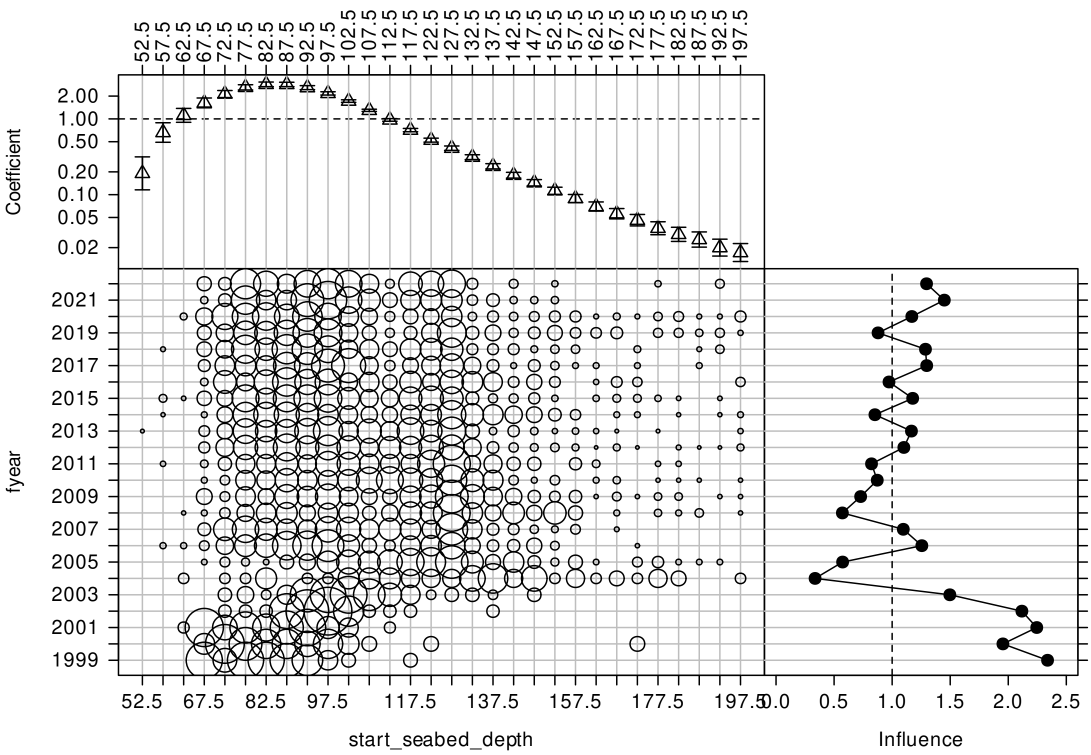

Figure C.75: CDI plot for start seabed depth (m) for the occurrence of positive catch JMN7 MW observer no small samples catch-per-unit-effort dataset.

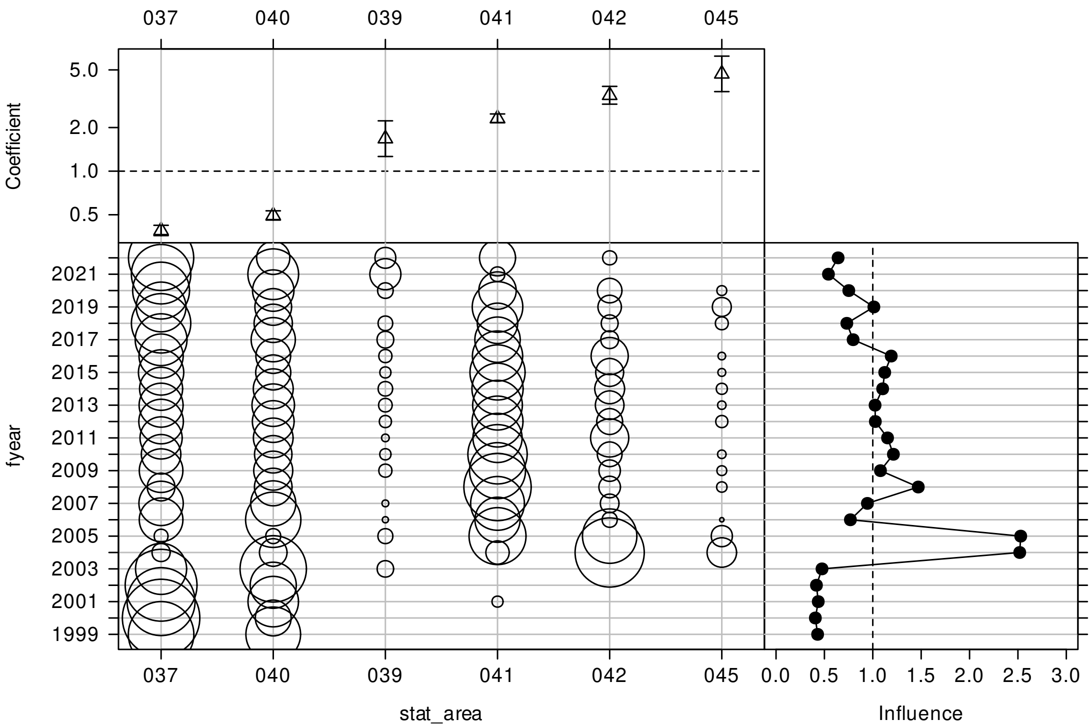

Figure C.76: CDI plot for statistical area for the occurrence of positive catch JMN7 MW observer no small samples catch-per-unit-effort dataset.

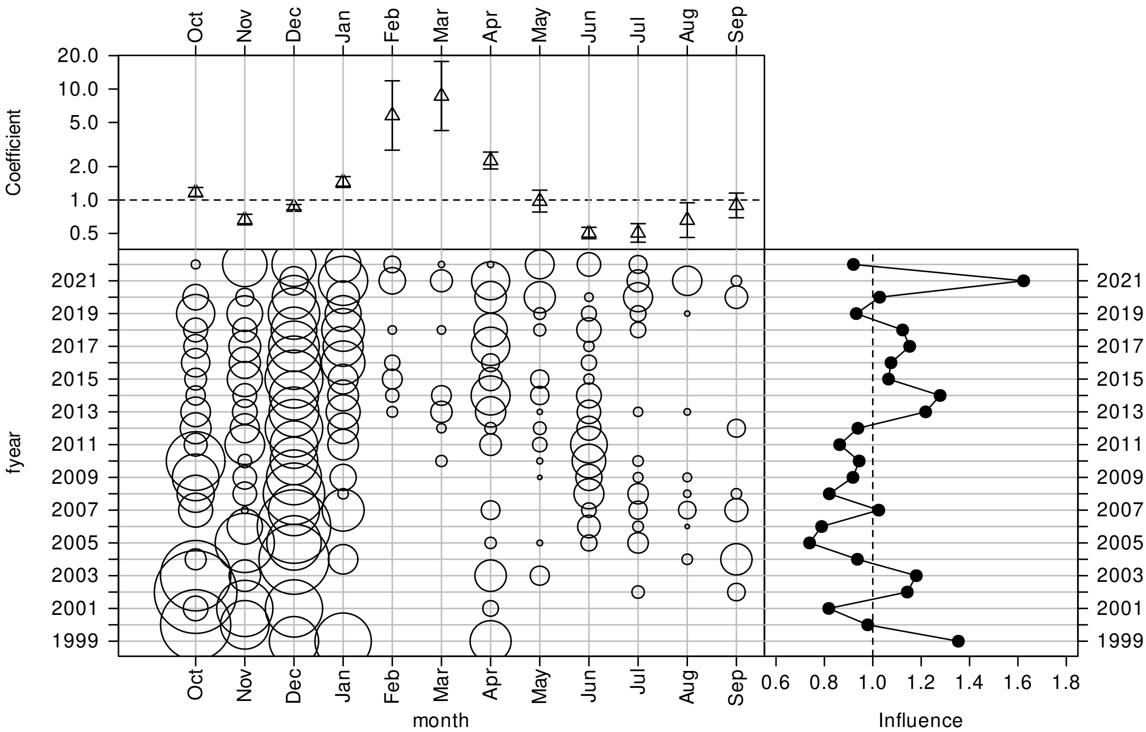

Figure C.77: CDI plot for month for the occurrence of positive catch JMN7 MW observer no small samples catch-per-unit-effort dataset.

Table C.26: Summary of stepwise selection for the Weibull model. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	25	103 460	9.3	9.3	*
+ stat area	5	103 160	14.3	5.0	*
+ month	11	102 937	18.3	4.0	*
+ ns(log(start seabed depth), 3)	3	102 837	20.0	1.7	*
+ ns(log(fishing duration), 3)	3	102 758	21.4	1.4	*
+ ns(log(headline height), 3)	3	102 686	22.6	1.3	*
+ vessel key	9	102 663	23.3	0.7	
+ ns(log(start time), 3)	3	102 657	23.5	0.2	
+ ns(fishing speed, 3)	3	102 653	23.7	0.2	

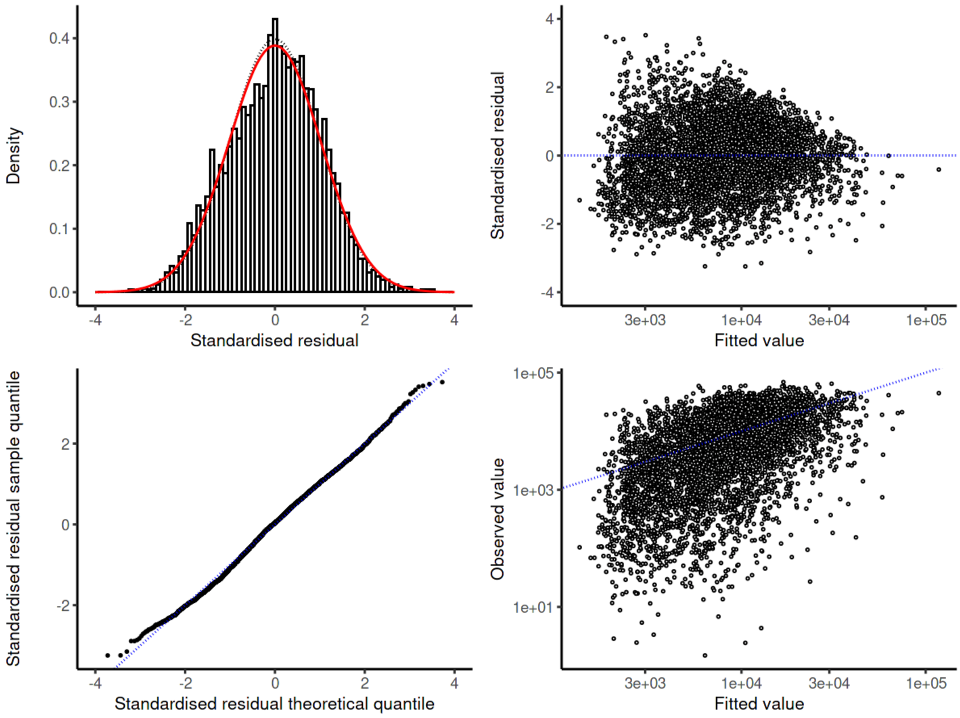

Figure C.78: Diagnostic plots for the Weibull model for the JMN7 MW observer no small samples dataset.

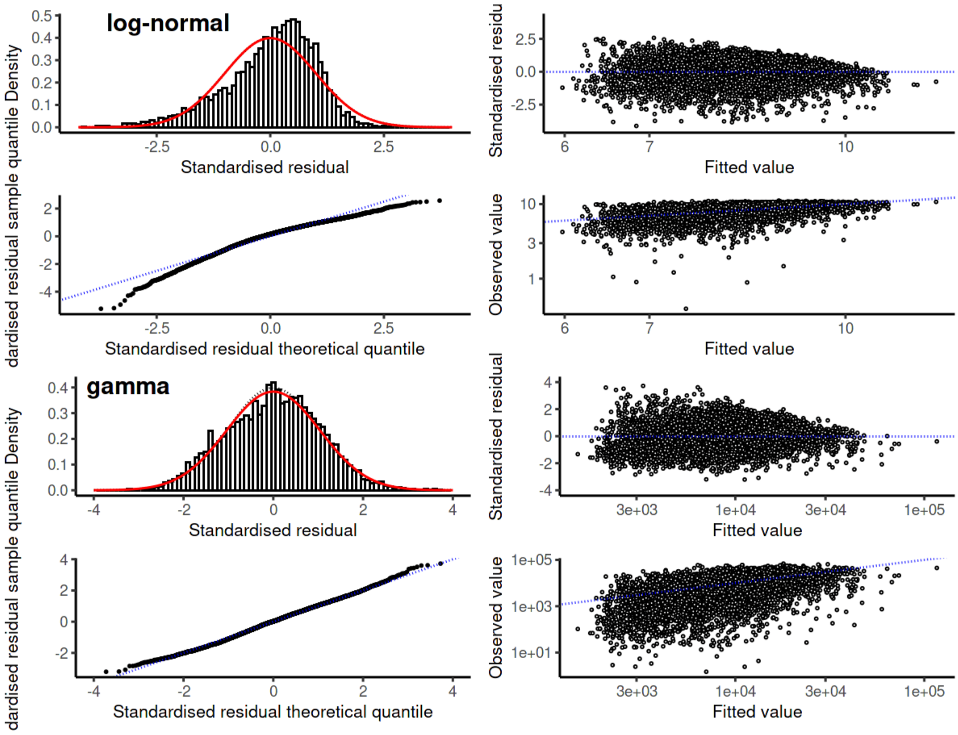

Figure C.79: Diagnostic plots for the log-normal and gamma model for the JMN7 MW observer no small samples dataset.

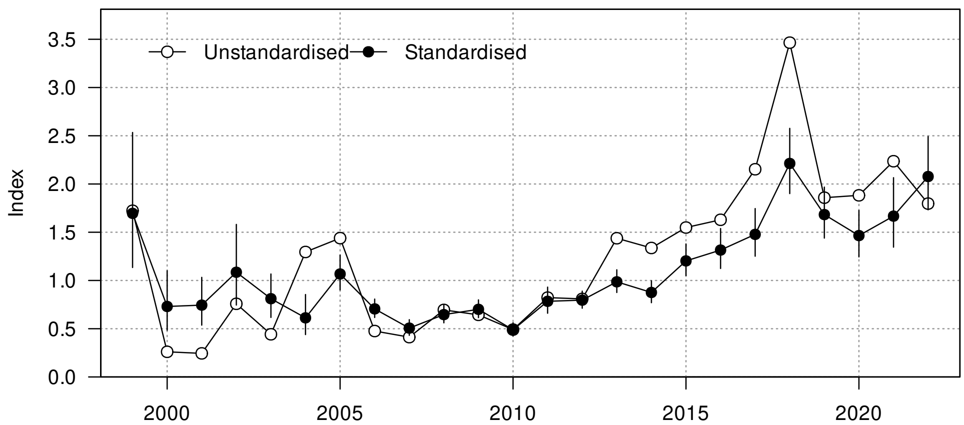

Figure C.80: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch in the JMN7 MW observer no small samples dataset.

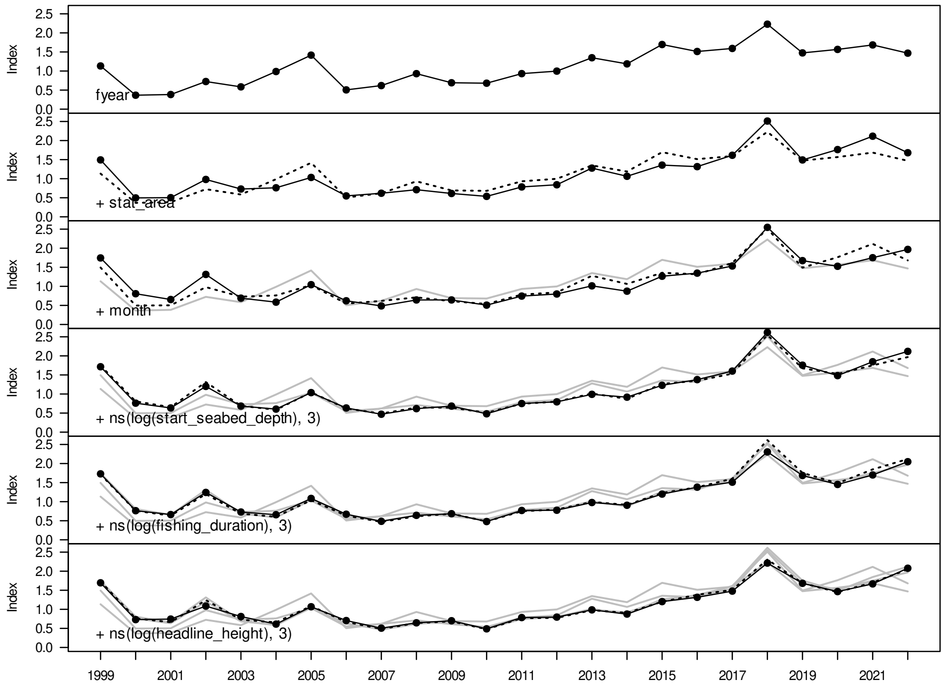

Figure C.81: Changes to the JMN7 MW observer no small samples positive catch index as terms are successively entered into the model.

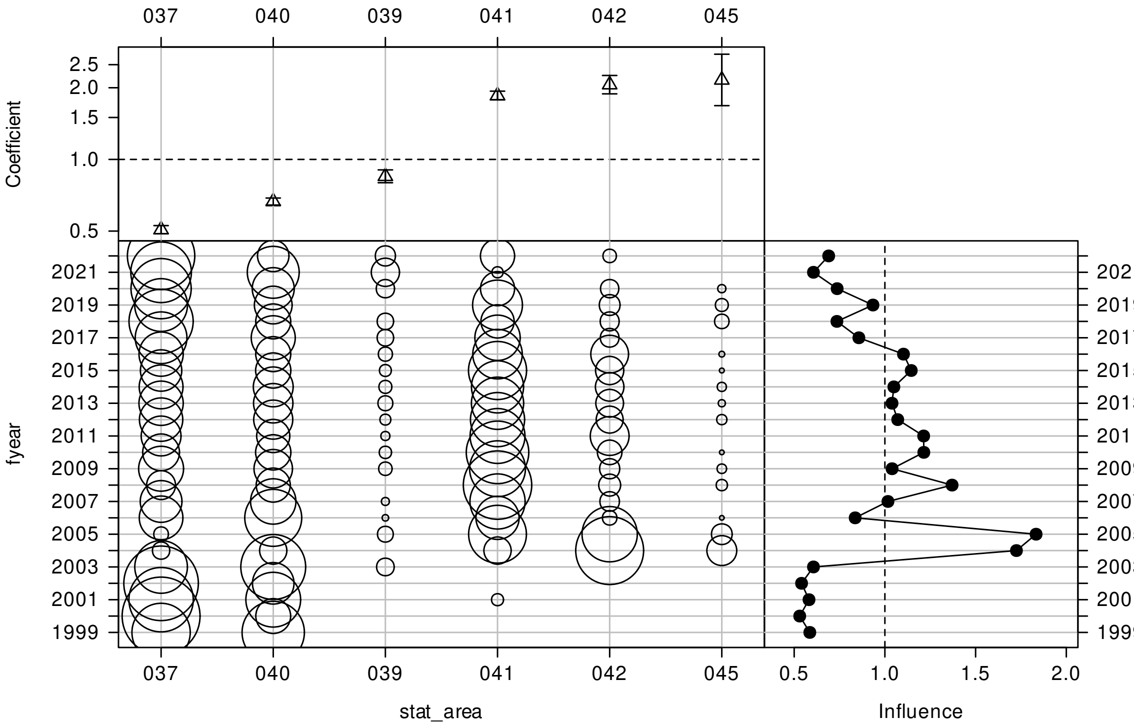

Figure C.82: CDI plot for statistical area for the positive catch JMN7 MW observer no small samples catch-per-unit-effort dataset.

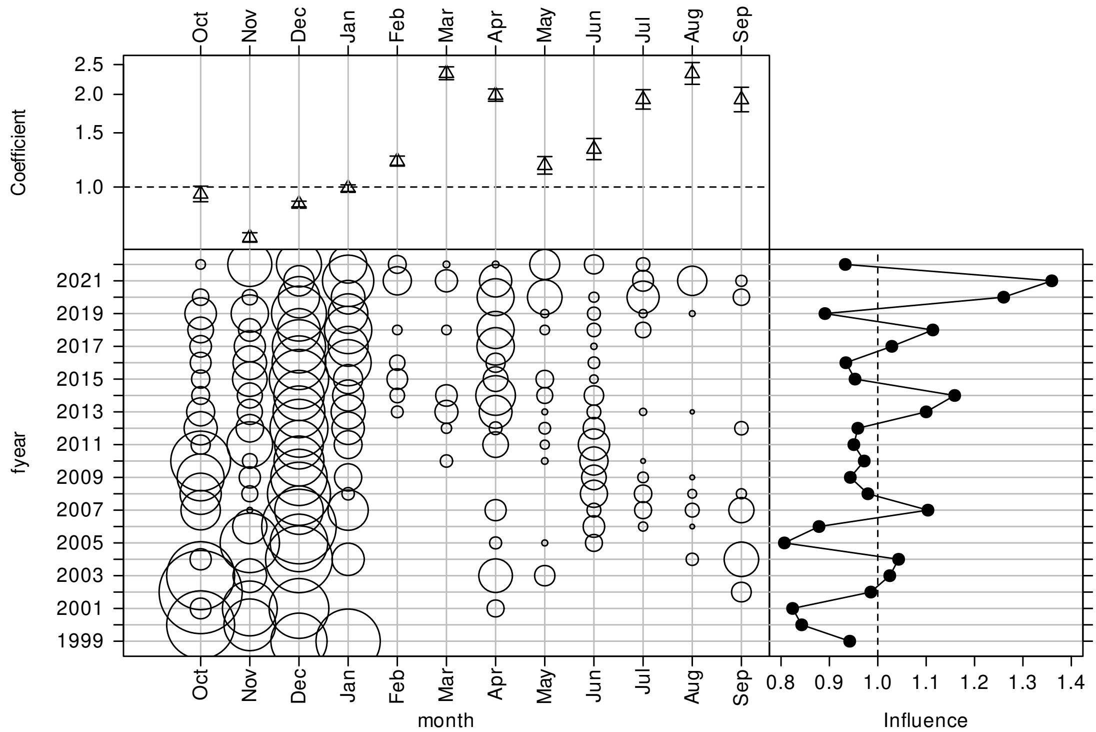

Figure C.83: CDI plot for month for the positive catch JMN7 MW observer no small samples catch-per-unit-effort dataset.

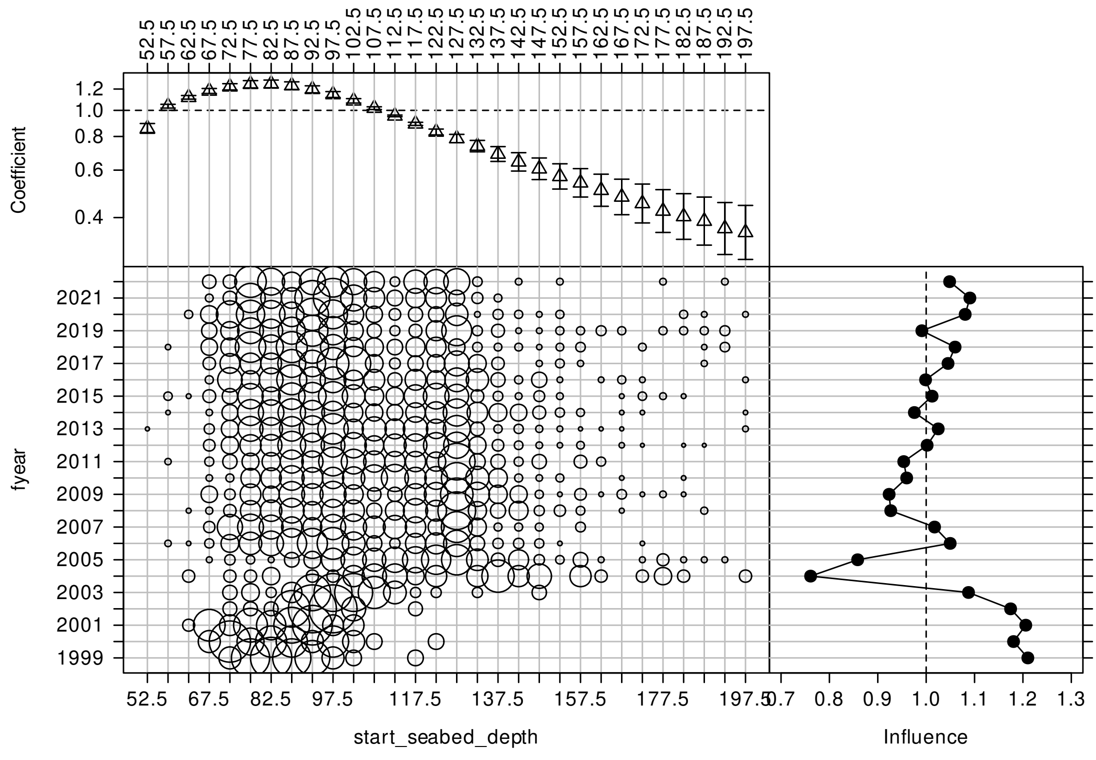

Figure C.84: CDI plot for start seabed depth (m) for the positive catch JMN7 MW observer no small samples catch-per-unit-effort dataset.

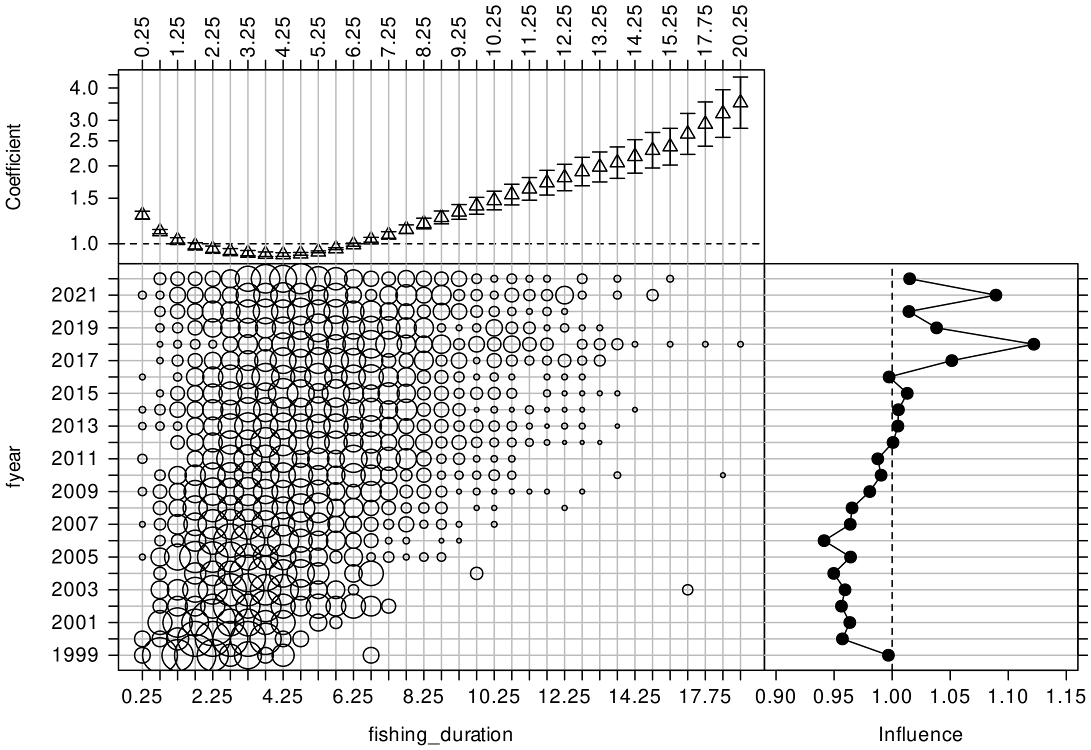

Figure C.85: CDI plot for fishing duration (h) for the positive catch JMN7 MW observer no small samples catch-per-unit-effort dataset.

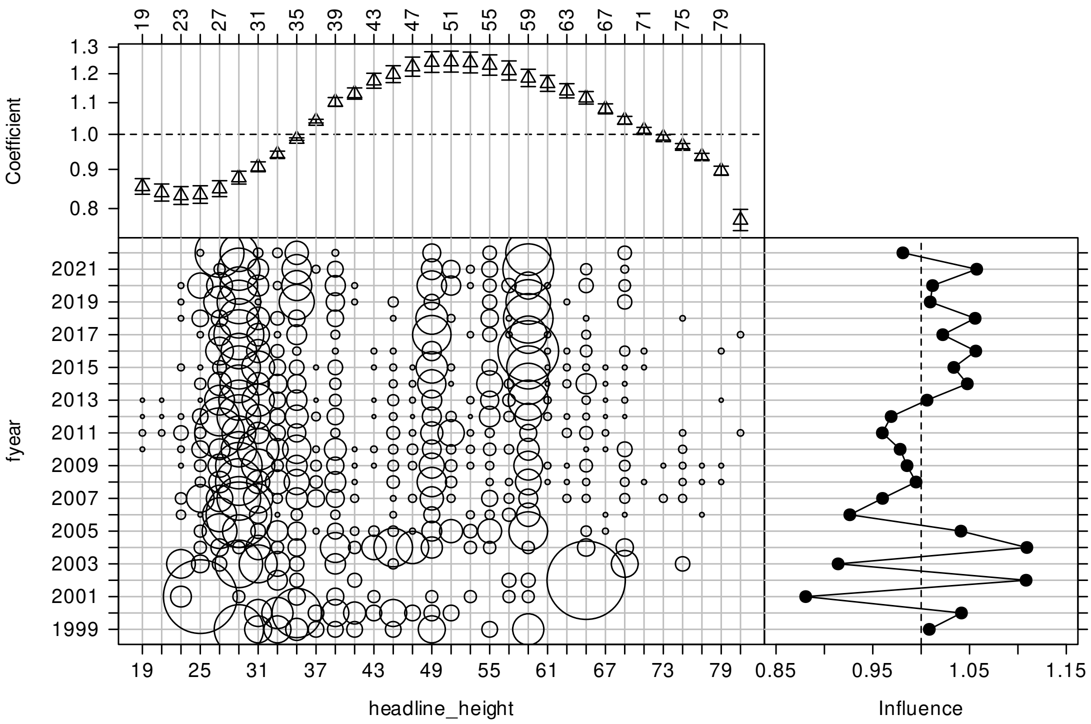

Figure C.86: CDI plot for headline height (m) for the positive catch JMN7 MW observer no small samples catch-per-unit-effort dataset.

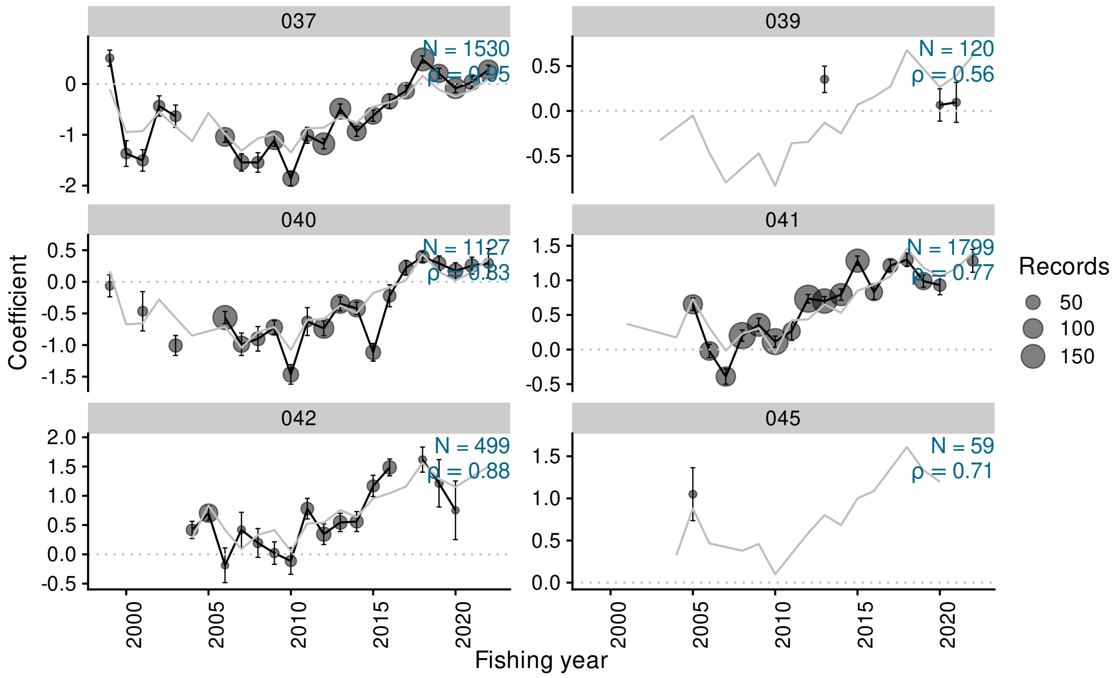

Figure C.87: Residual implied coefficients for area-year in the Weibull positive catch model for the JMN7 MW observer no small samples dataset.

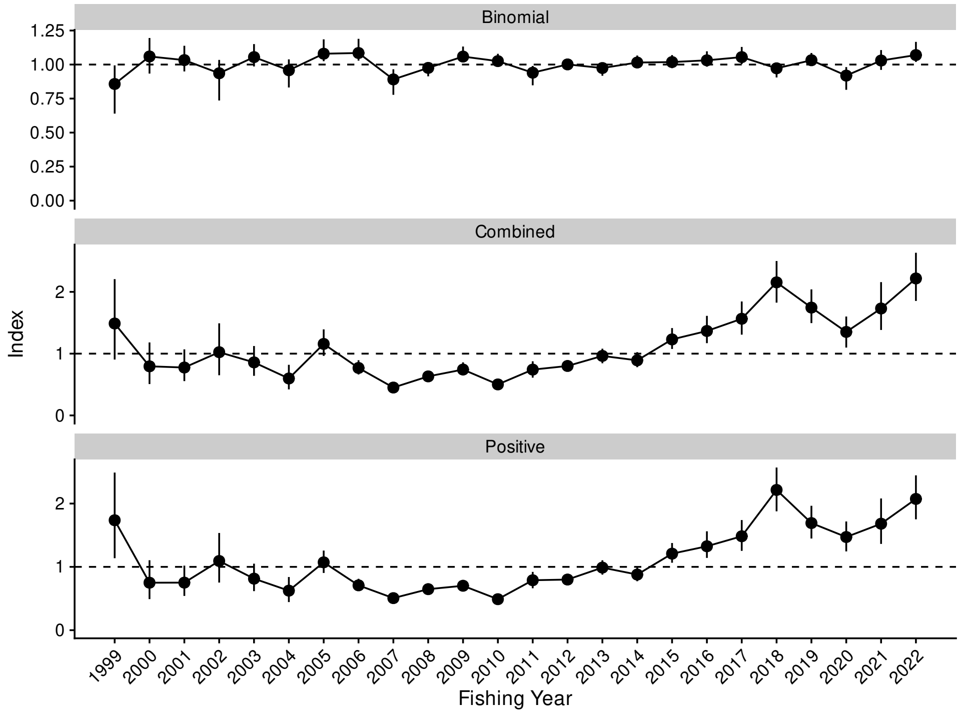

Figure C.88: Standardised indices and 95% confidence intervals for the JMN7 MW observer no small samples dataset.

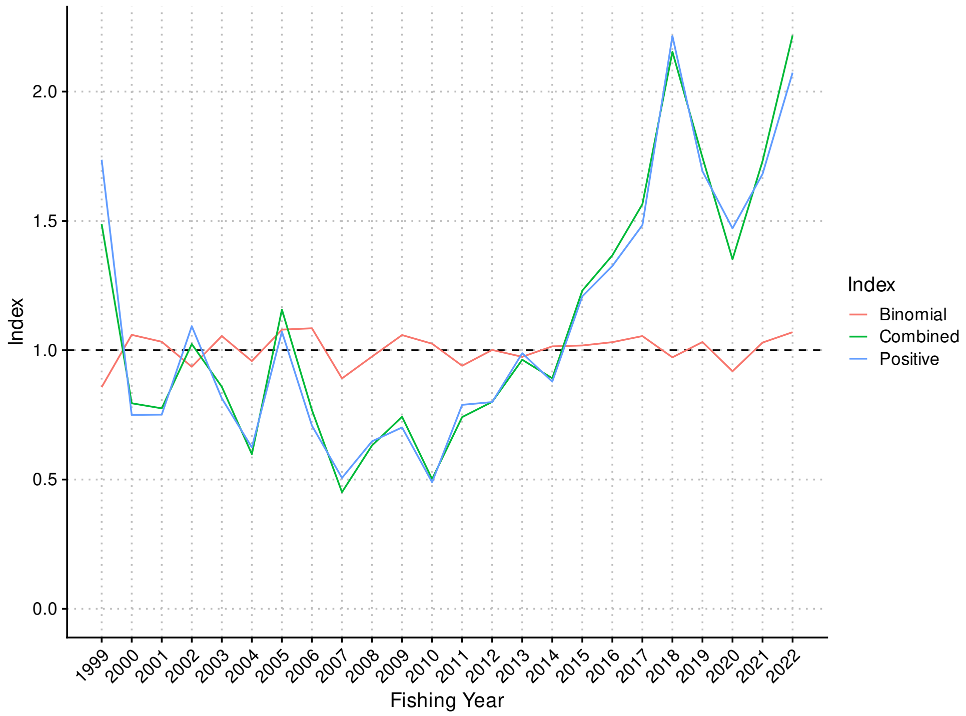

Figure C.89: Standardised indices for the JMN7 MW observer no small samples dataset.

Table C.27: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in JMN7 MW observer no small samples.

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
1999	0.857	0.090	0.639	0.994	1.488	0.332	0.904	2.206	1.737	0.345	1.137	2.490
2000	1.059	0.067	0.934	1.195	0.795	0.172	0.508	1.181	0.750	0.157	0.491	1.105
2001	1.033	0.048	0.949	1.138	0.775	0.131	0.555	1.069	0.751	0.122	0.541	1.019
2002	0.936	0.076	0.736	1.034	1.024	0.214	0.650	1.491	1.093	0.200	0.752	1.535
2003	1.055	0.042	0.986	1.150	0.859	0.123	0.641	1.123	0.814	0.111	0.617	1.050
2004	0.958	0.053	0.832	1.038	0.598	0.102	0.421	0.819	0.624	0.101	0.444	0.840
2005	1.080	0.041	1.025	1.185	1.157	0.109	0.964	1.393	1.072	0.090	0.904	1.258
2006	1.085	0.041	1.029	1.189	0.768	0.059	0.663	0.893	0.708	0.048	0.622	0.812
2007	0.891	0.048	0.778	0.965	0.451	0.043	0.372	0.540	0.506	0.039	0.435	0.589
2008	0.975	0.025	0.914	1.010	0.632	0.047	0.543	0.727	0.648	0.045	0.562	0.740
2009	1.059	0.030	1.017	1.132	0.743	0.054	0.646	0.859	0.701	0.045	0.619	0.794
2010	1.025	0.024	0.987	1.079	0.502	0.037	0.435	0.579	0.489	0.035	0.426	0.561
2011	0.940	0.036	0.848	0.990	0.741	0.068	0.611	0.876	0.789	0.066	0.662	0.921
2012	1.001	0.019	0.964	1.038	0.800	0.047	0.712	0.896	0.799	0.045	0.715	0.891
2013	0.974	0.024	0.918	1.011	0.963	0.060	0.844	1.080	0.988	0.058	0.877	1.104
2014	1.015	0.024	0.973	1.066	0.892	0.062	0.781	1.024	0.878	0.057	0.773	0.995
2015	1.018	0.025	0.973	1.070	1.231	0.086	1.076	1.414	1.208	0.079	1.065	1.377
2016	1.031	0.029	0.984	1.097	1.367	0.113	1.170	1.612	1.326	0.107	1.141	1.562
2017	1.055	0.032	1.003	1.129	1.565	0.137	1.307	1.845	1.484	0.124	1.253	1.739
2018	0.972	0.028	0.905	1.014	2.154	0.172	1.826	2.499	2.215	0.176	1.878	2.569
2019	1.032	0.023	0.996	1.085	1.745	0.139	1.494	2.040	1.692	0.132	1.448	1.965
2020	0.919	0.043	0.814	0.981	1.352	0.128	1.098	1.601	1.471	0.121	1.244	1.717
2021	1.030	0.037	0.961	1.106	1.731	0.198	1.383	2.158	1.682	0.183	1.363	2.081
2022	1.070	0.038	1.020	1.167	2.217	0.199	1.853	2.633	2.073	0.177	1.751	2.446

C.6 JMD7 MW observer no trip misID

Table C.28: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the JMD7 MW observer no trip misID CPUE series.

Series	JMD7 MW observer no trip misID
QMS stock	JMA7
Reporting forms	
Fishing methods	MW
Target species	JMA, JMD, JMM, JMN
Statistical Areas	034, 035, 036, 037, 039, 040, 041, 042, 045, 801
Period	1998-10-01, 2021-09-30
Resolution	Observed event
Core fleet years	4
Core fleet trips	1
Default model	jmdkg ~ fyear + vessel_key + month + stat_area + ns(log(fishing_duration), 3) + ns(log(start_time), 3) + ns(log(start_seabed_depth), 3) + ns(log(headline_height), 3) + ns(fishing_speed, 3)
Stepwise selection	Yes
Positive catch distribution	Weibull

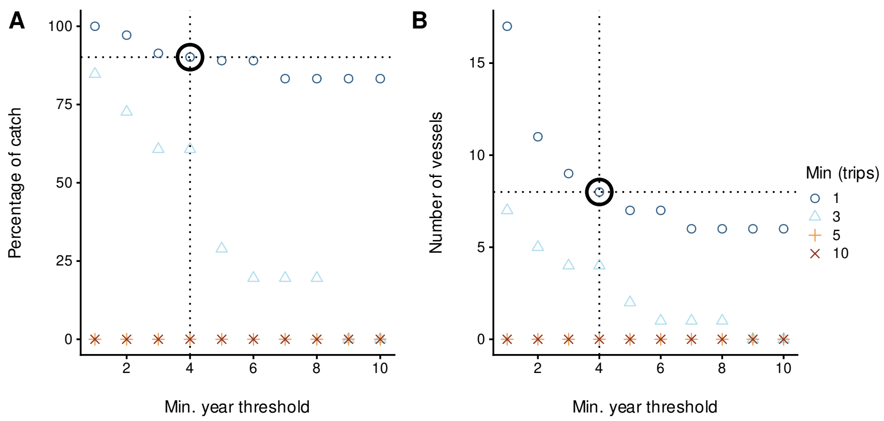

Figure C.90: Percentage of catch and number of vessels for different core vessel selection criteria for the JMD7 MW observer no trip misID CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel was observed in the fishery and the number of observed trips per year.

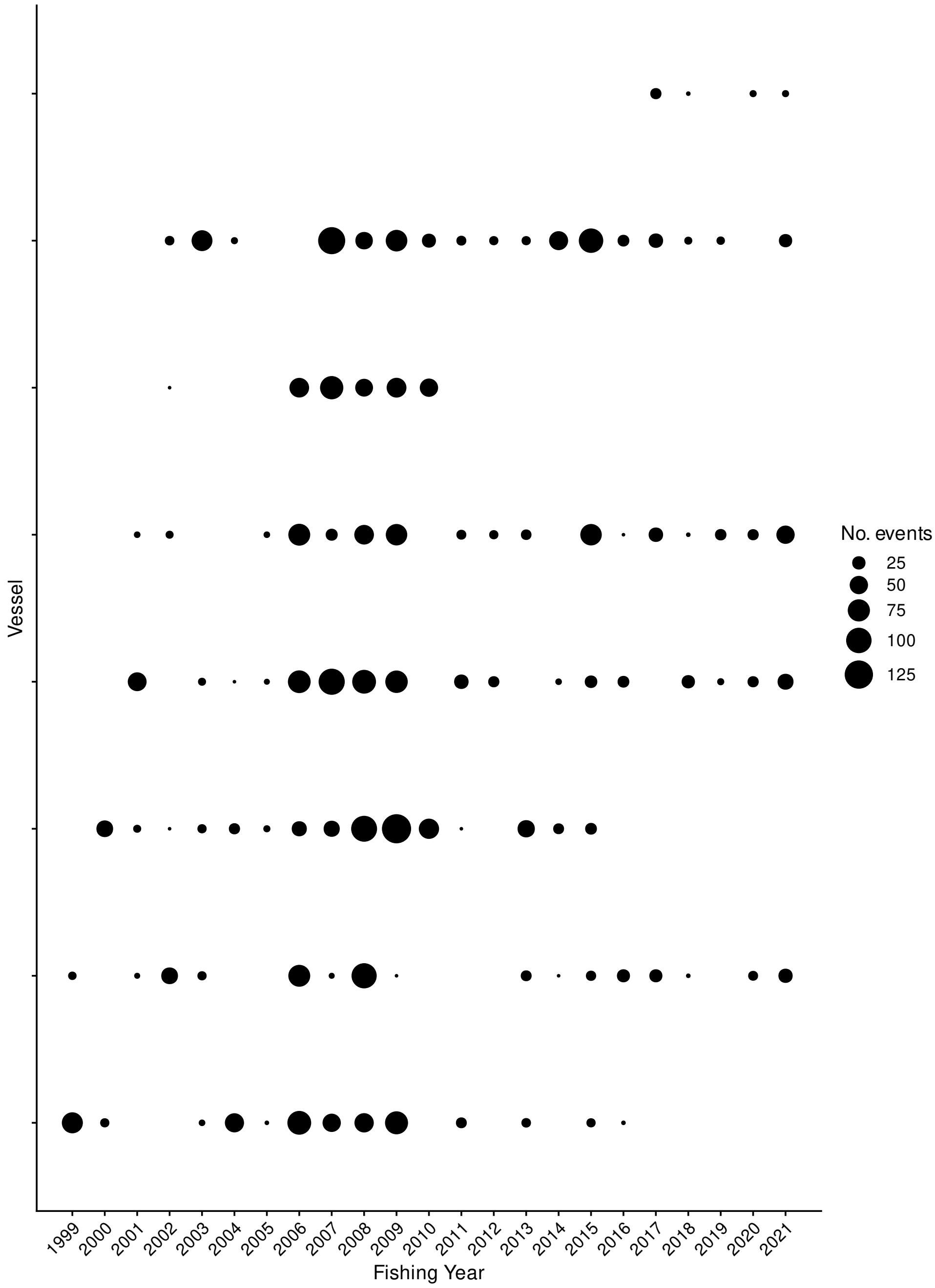

Figure C.91: Number of events by fishing year for core vessels. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table C.29: Summary of the JMD7 MW observer no trip misID 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	1999	2000	2001	2002	2003	2004	2005	2006	2007
Ungroomed data	974 (100%) n: 116	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	687 (100%) n: 103	1171 (100%) n: 79	2467 (100%) n: 258	4706 (100%) n: 409	4247 (100%) n: 427
Fishing speed not null	926 (100%) n: 112	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	687 (100%) n: 103	1171 (100%) n: 79	2435 (100%) n: 256	4706 (100%) n: 409	4247 (100%) n: 427
Start date not null	926 (100%) n: 112	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	687 (100%) n: 103	1171 (100%) n: 79	2435 (100%) n: 256	4706 (100%) n: 409	4247 (100%) n: 427
End date not null	926 (100%) n: 112	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	687 (100%) n: 103	1171 (100%) n: 79	2435 (100%) n: 256	4706 (100%) n: 409	4247 (100%) n: 427
Start depth not null	926 (100%) n: 112	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	687 (100%) n: 103	1171 (100%) n: 79	2435 (100%) n: 256	4706 (100%) n: 409	4247 (100%) n: 427
Headline height not null	919 (94%) n: 111	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	679 (100%) n: 102	1171 (100%) n: 79	2435 (100%) n: 256	4706 (100%) n: 409	4247 (100%) n: 427
Fishing speed >3.5kn	919 (94%) n: 111	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	679 (100%) n: 102	1171 (100%) n: 79	2435 (100%) n: 256	4706 (100%) n: 409	4247 (100%) n: 426
Headline height >15m	919 (94%) n: 111	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	676 (100%) n: 101	1171 (100%) n: 79	2434 (100%) n: 255	4697 (100%) n: 408	4213 (100%) n: 422
Headline height <90m	919 (94%) n: 111	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	676 (100%) n: 101	1171 (100%) n: 79	2434 (100%) n: 255	4697 (100%) n: 408	4213 (100%) n: 422
Fishing duration >15mins	898 (92%) n: 109	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	676 (100%) n: 101	1171 (100%) n: 79	2433 (100%) n: 254	4628 (100%) n: 407	4159 (100%) n: 421
Seabed depth >50m	898 (92%) n: 109	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	676 (100%) n: 101	1171 (100%) n: 79	2433 (100%) n: 254	4628 (100%) n: 407	4159 (100%) n: 421
Seabed depth <400m	885 (91%) n: 108	390 (100%) n: 53	838 (100%) n: 75	474 (100%) n: 66	676 (100%) n: 101	1171 (100%) n: 79	2423 (100%) n: 252	4628 (100%) n: 407	4159 (100%) n: 421
Start time >0	883 (91%) n: 107	388 (100%) n: 52	838 (100%) n: 75	438 (92%) n: 63	676 (100%) n: 101	1171 (100%) n: 79	2399 (100%) n: 249	4613 (100%) n: 403	4073 (100%) n: 415
No trip misID	883 (91%) n: 107	388 (100%) n: 52	838 (100%) n: 75	438 (92%) n: 63	676 (100%) n: 101	1171 (100%) n: 79	196 (8%) n: 17	4613 (100%) n: 403	4073 (100%) n: 415
Core fleet selection	710 (73%) n: 76	388 (100%) n: 52	834 (100%) n: 70	438 (92%) n: 63	676 (100%) n: 101	1171 (100%) n: 79	196 (8%) n: 17	4613 (100%) n: 403	4073 (100%) n: 415

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	4954 (100%) n: 511	5884 (100%) n: 526	4425 (100%) n: 487	4219 (100%) n: 310	9664 (100%) n: 713	9872 (100%) n: 643	11383 (100%) n: 669	9856 (100%) n: 593	6348 (100%) n: 389
Fishing speed not null	4895 (100%) n: 510	5884 (100%) n: 526	4406 (100%) n: 486	4219 (100%) n: 310	9664 (100%) n: 713	9834 (100%) n: 642	11383 (100%) n: 669	9856 (100%) n: 593	6333 (100%) n: 388
Start date not null	4895 (100%) n: 510	5884 (100%) n: 526	4406 (100%) n: 486	4219 (100%) n: 310	9664 (100%) n: 713	9834 (100%) n: 642	11383 (100%) n: 669	9856 (100%) n: 593	6333 (100%) n: 388
End date not null	4895 (100%) n: 510	5884 (100%) n: 526	4406 (100%) n: 486	4219 (100%) n: 310	9664 (100%) n: 713	9834 (100%) n: 642	11383 (100%) n: 669	9856 (100%) n: 593	6333 (100%) n: 388
Start depth not null	4884 (100%) n: 508	5628 (100%) n: 501	4358 (100%) n: 483	4146 (100%) n: 306	9122 (94%) n: 677	9346 (95%) n: 621	11338 (100%) n: 666	9786 (100%) n: 577	6333 (100%) n: 388
Headline height not null	4884 (100%) n: 508	5606 (100%) n: 499	4269 (100%) n: 475	4104 (100%) n: 305	9018 (93%) n: 670	9291 (94%) n: 617	11249 (100%) n: 663	9786 (100%) n: 576	6333 (100%) n: 388
Fishing speed >3.5kn	4884 (100%) n: 508	5606 (100%) n: 499	4269 (100%) n: 475	4104 (100%) n: 305	9018 (93%) n: 670	9291 (94%) n: 617	11249 (100%) n: 663	9786 (100%) n: 576	6331 (100%) n: 387
Headline height >15m	4884 (100%) n: 508	5586 (95%) n: 497	4233 (100%) n: 474	4104 (100%) n: 305	8954 (93%) n: 669	9216 (93%) n: 614	11249 (100%) n: 663	9786 (100%) n: 576	6331 (100%) n: 387
Headline height <90m	4884 (100%) n: 508	5586 (95%) n: 497	4233 (100%) n: 474	4094 (100%) n: 304	8943 (93%) n: 668	9216 (93%) n: 614	11231 (100%) n: 662	9771 (100%) n: 575	6331 (100%) n: 387
Fishing duration >15mins	4884 (100%) n: 507	5586 (95%) n: 497	4233 (100%) n: 474	4016 (100%) n: 301	8922 (92%) n: 667	9178 (93%) n: 612	11226 (100%) n: 660	9771 (100%) n: 575	6328 (100%) n: 386
Seabed depth >50m	4884 (100%) n: 507	5573 (95%) n: 495	4226 (100%) n: 473	4016 (100%) n: 301	8922 (92%) n: 666	9159 (93%) n: 611	11226 (100%) n: 660	9755 (100%) n: 574	6328 (100%) n: 386
Seabed depth <400m	4865 (100%) n: 504	5573 (95%) n: 495	4217 (100%) n: 472	4016 (100%) n: 301	8809 (91%) n: 659	9134 (93%) n: 609	11222 (100%) n: 659	9675 (100%) n: 571	6328 (100%) n: 386
Start time >0	4675 (94%) n: 495	5549 (94%) n: 492	4137 (93%) n: 468	4002 (95%) n: 298	8778 (91%) n: 652	9075 (92%) n: 606	11067 (100%) n: 649	9618 (100%) n: 568	6287 (100%) n: 383
No trip misID	4675 (94%) n: 495	5549 (94%) n: 492	1223 (28%) n: 142	965 (23%) n: 73	525 (5%) n: 39	2050 (21%) n: 98	2904 (26%) n: 106	4737 (48%) n: 240	1202 (19%) n: 69
Core fleet selection	4675 (94%) n: 495	5549 (94%) n: 492	1217 (27%) n: 140	965 (23%) n: 73	525 (5%) n: 39	2050 (21%) n: 98	1192 (10%) n: 76	4382 (44%) n: 228	1031 (16%) n: 65

Filter	2017	2018	2019	2020	2021
Ungroomed data	5899 (100%) n: 309	8658 (100%) n: 433	8557 (100%) n: 380	6557 (100%) n: 397	5650 (100%) n: 259
Fishing speed not null	5820 (100%) n: 307	8658 (100%) n: 433	8557 (100%) n: 380	6477 (100%) n: 395	5497 (100%) n: 255
Start date not null	5820 (100%) n: 307	8658 (100%) n: 433	8557 (100%) n: 380	6477 (100%) n: 395	5497 (100%) n: 255
End date not null	5820 (100%) n: 307	8658 (100%) n: 433	8557 (100%) n: 380	6477 (100%) n: 395	5497 (100%) n: 255
Start depth not null	5764 (100%) n: 304	8646 (100%) n: 432	8557 (100%) n: 380	6477 (100%) n: 389	5438 (100%) n: 249
Headline height not null	5646 (100%) n: 300	8618 (100%) n: 430	8557 (100%) n: 380	6447 (100%) n: 387	5438 (100%) n: 249
Fishing speed >3.5kn	5646 (100%) n: 300	8618 (100%) n: 430	8557 (100%) n: 380	6447 (100%) n: 387	5438 (100%) n: 249
Headline height >15m	5636 (100%) n: 299	8618 (100%) n: 430	8557 (100%) n: 380	6447 (100%) n: 387	5438 (100%) n: 249
Headline height <90m	5636 (100%) n: 299	8577 (100%) n: 428	8557 (100%) n: 380	6447 (100%) n: 387	5438 (100%) n: 249
Fishing duration >15mins	5624 (100%) n: 298	8577 (100%) n: 428	8522 (100%) n: 379	6447 (100%) n: 387	5438 (100%) n: 249
Seabed depth >50m	5624 (100%) n: 298	8532 (100%) n: 427	8522 (100%) n: 379	6447 (100%) n: 387	5438 (100%) n: 249
Seabed depth <400m	5624 (100%) n: 298	8510 (100%) n: 425	8406 (100%) n: 377	6447 (100%) n: 387	5438 (100%) n: 249
Start time >0	5546 (94%) n: 296	8505 (100%) n: 424	8366 (100%) n: 376	6401 (100%) n: 384	5374 (100%) n: 247
No trip misID	2307 (39%) n: 103	1879 (22%) n: 54	728 (9%) n: 33	965 (15%) n: 81	5374 (100%) n: 247
Core fleet selection	2248 (38%) n: 101	1114 (13%) n: 39	728 (9%) n: 33	682 (10%) n: 53	3290 (58%) n: 147

Table C.30: Summary of the JMD7 MW observer no trip misID dataset after core fleet selection. 'Records' indicates the number of rows (events) in the dataset, and 'Records caught' indicates the percentage of events with catches of jack mackerels.

Fishing year	Vessels	Trips	Records	Hrs	Catch (t)	Records caught
1999	2	3	76	165.32	709.60	100.00
2000	2	2	52	137.25	387.78	98.08
2001	4	6	70	184.40	833.85	100.00
2002	5	5	63	221.45	437.53	100.00
2003	5	5	101	365.42	675.58	98.02
2004	4	4	79	333.28	1 171.09	96.20
2005	4	4	17	67.00	195.99	88.24
2006	6	8	403	1 479.25	4 613.02	97.52
2007	7	15	415	1 505.27	4 072.75	96.39
2008	7	16	495	1 925.52	4 675.39	94.55
2009	7	15	492	2 046.68	5 549.46	96.14
2010	3	4	140	564.67	1 216.71	95.71
2011	5	5	73	326.40	964.91	95.89
2012	3	5	39	187.03	525.20	97.44
2013	5	12	98	376.65	2 050.10	86.73
2014	4	7	76	271.73	1 191.56	88.16
2015	6	19	228	1 080.50	4 382.38	95.18
2016	5	12	65	256.63	1 030.83	98.46
2017	4	9	101	474.30	2 248.33	100.00
2018	5	8	39	199.38	1 114.18	100.00
2019	3	7	33	132.00	728.06	93.94
2020	4	8	53	328.72	682.03	79.25
2021	5	14	147	841.62	3 289.53	97.28

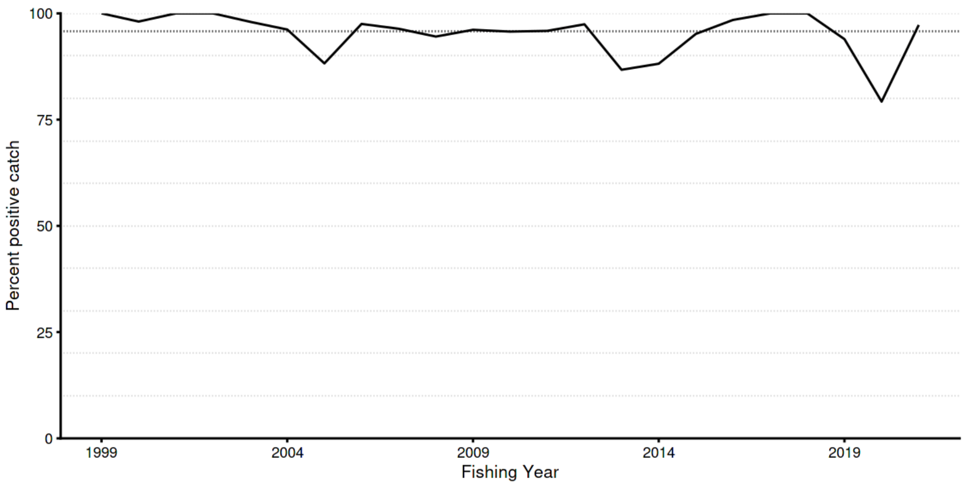

Figure C.92: Percentage of positive catch records in the JMD7 MW observer no trip misID catch-per-unit-effort dataset.

Table C.31: Summary of stepwise selection for the Weibull model. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	24	67 132	9.2	9.2	*
+ ns(log(headline height), 3)	3	66 985	13.3	4.1	*
+ month	11	66 913	15.9	2.5	*
+ ns(log(start seabed depth), 3)	3	66 878	16.9	1.1	*
+ stat area	9	66 839	18.5	1.5	*
+ ns(log(fishing duration), 3)	3	66 798	19.7	1.3	*
+ vessel key	7	66 788	20.4	0.6	
+ ns(log(start time), 3)	3	66 787	20.6	0.2	

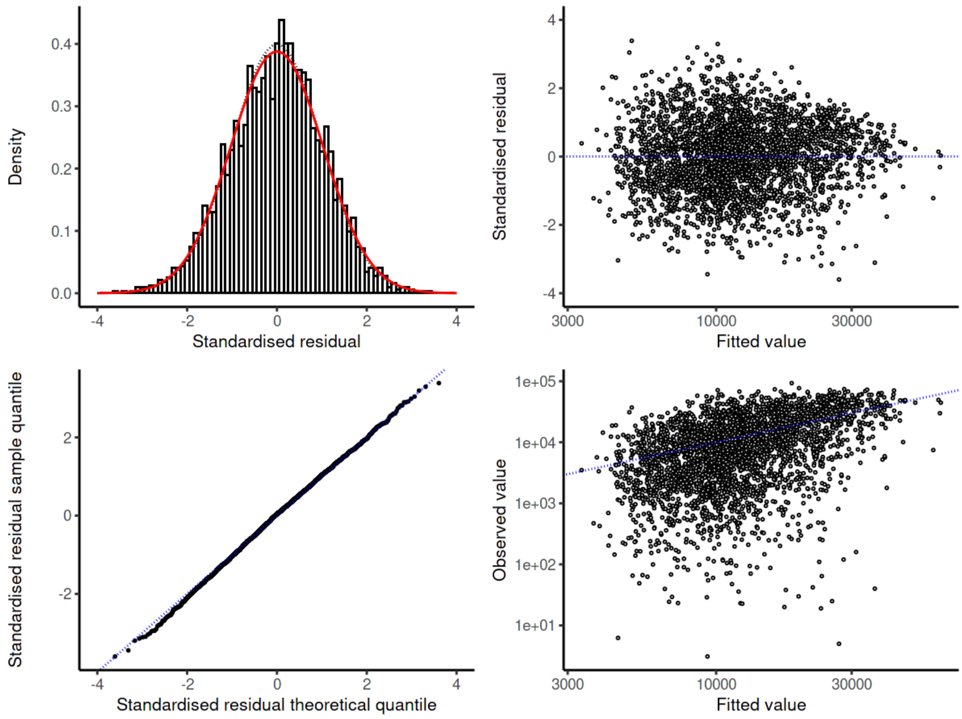

Figure C.93: Diagnostic plots for the Weibull model for the JMD7 MW observer no trip misID dataset.

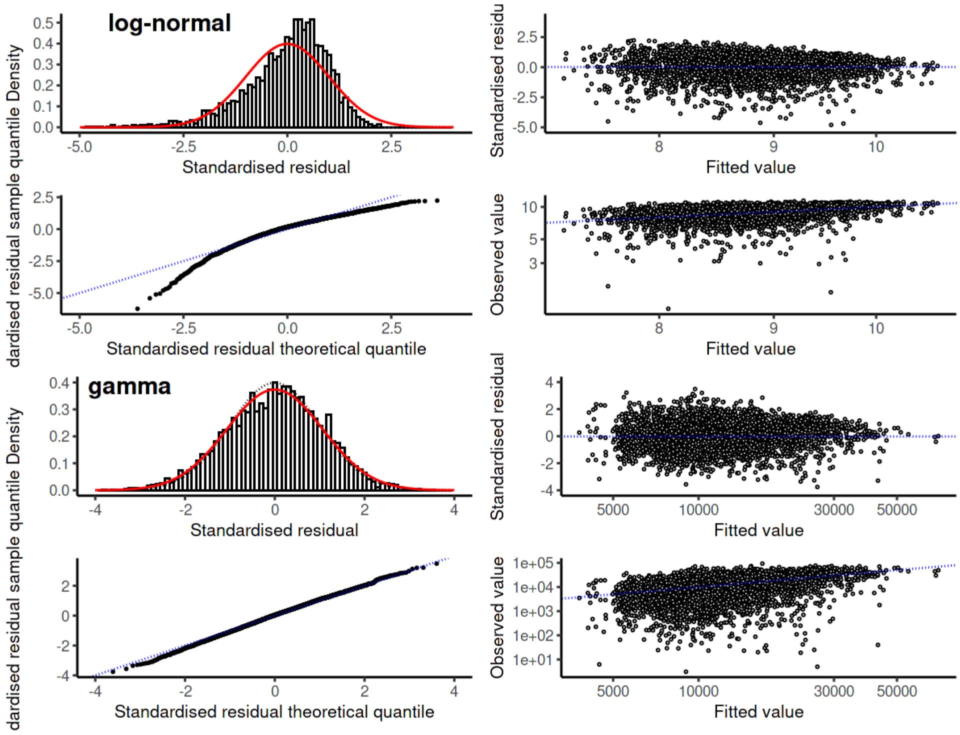

Figure C.94: Diagnostic plots for the log-normal and gamma model for the JMD7 MW observer no trip misID dataset.

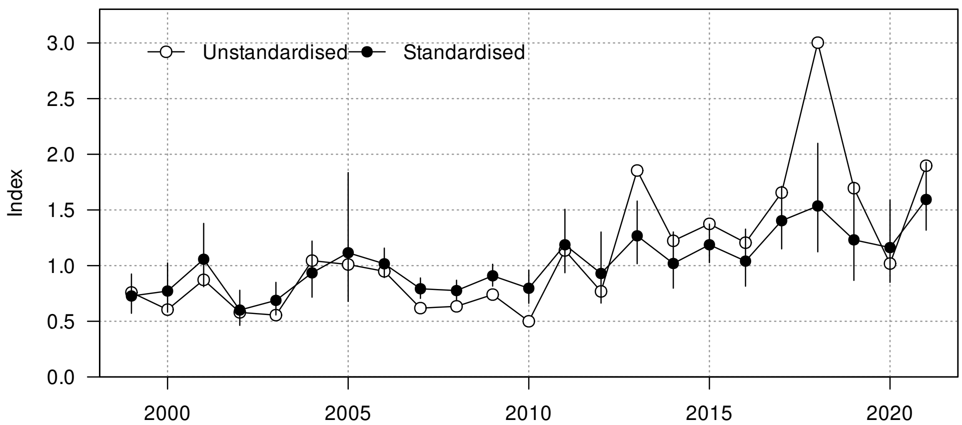

Figure C.95: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch in the JMD7 MW observer no trip misID dataset.

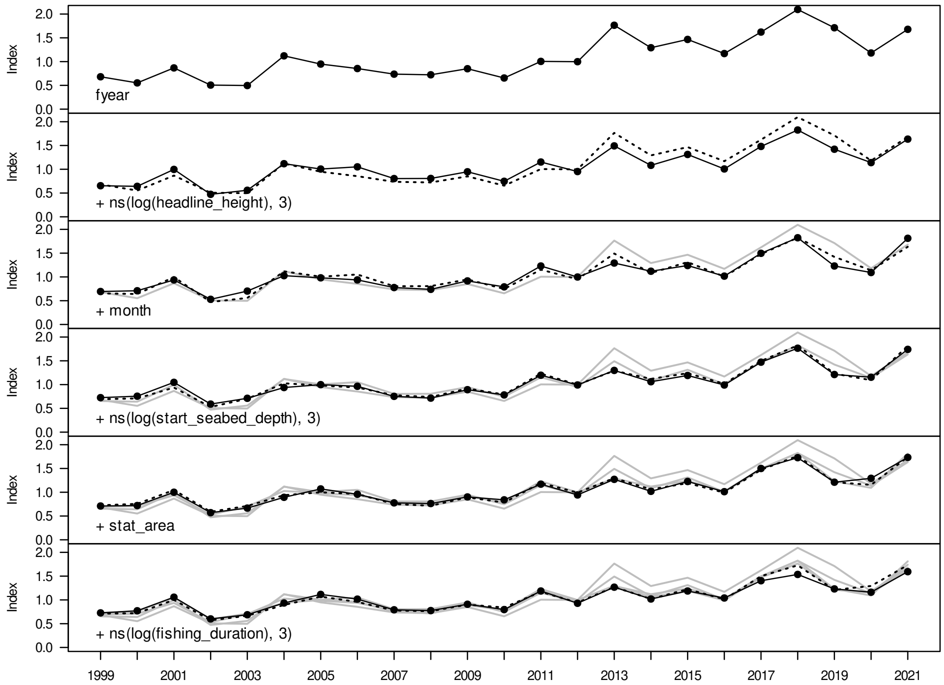

Figure C.96: Changes to the JMD7 MW observer no trip misID positive catch index as terms are successively entered into the model.

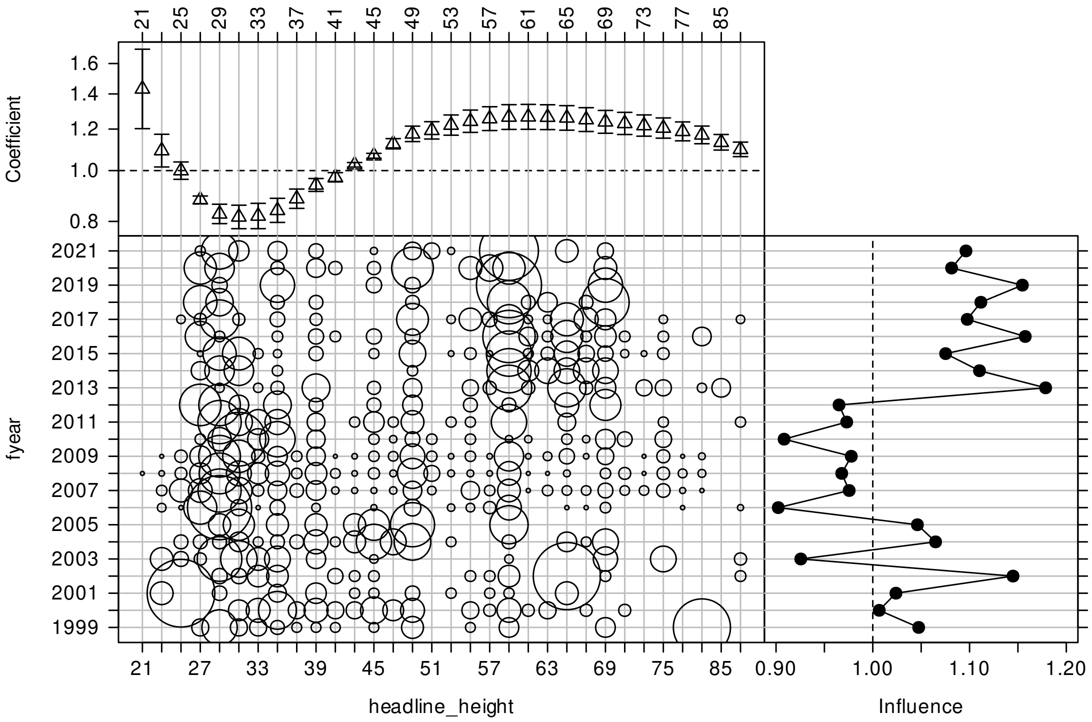

Figure C.97: CDI plot for headline height (m) for the positive catch JMD7 MW observer no trip misID catch-per-unit-effort dataset.

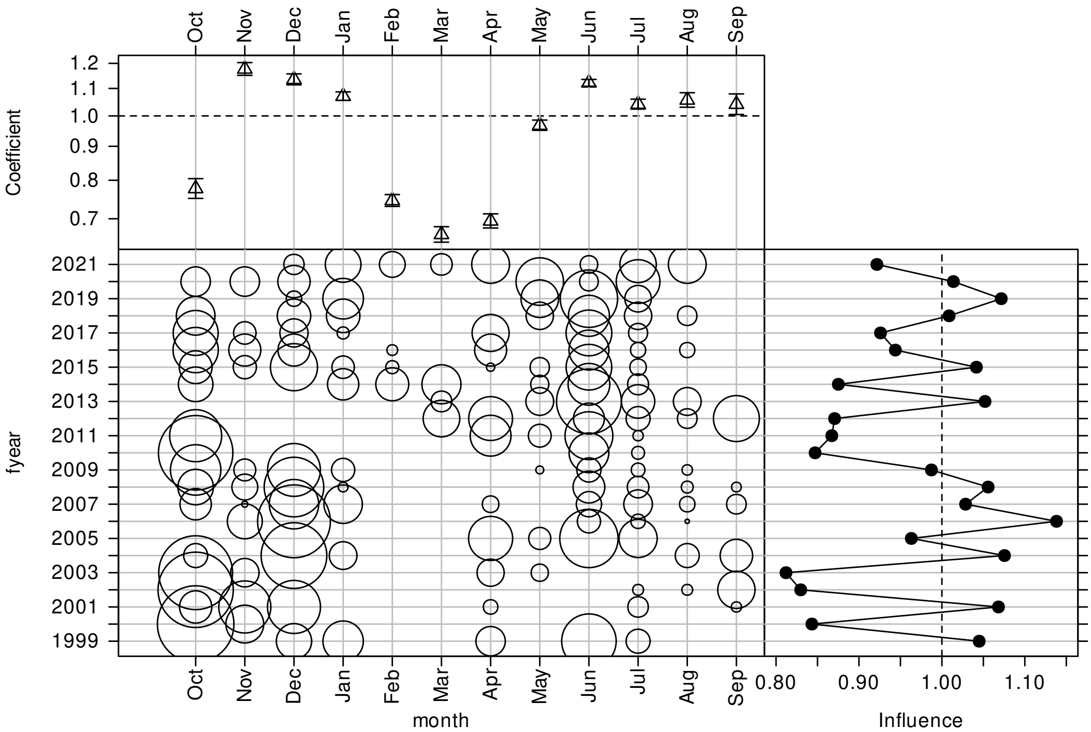

Figure C.98: CDI plot for month for the positive catch JMD7 MW observer no trip misID catch-per-unit-effort dataset.

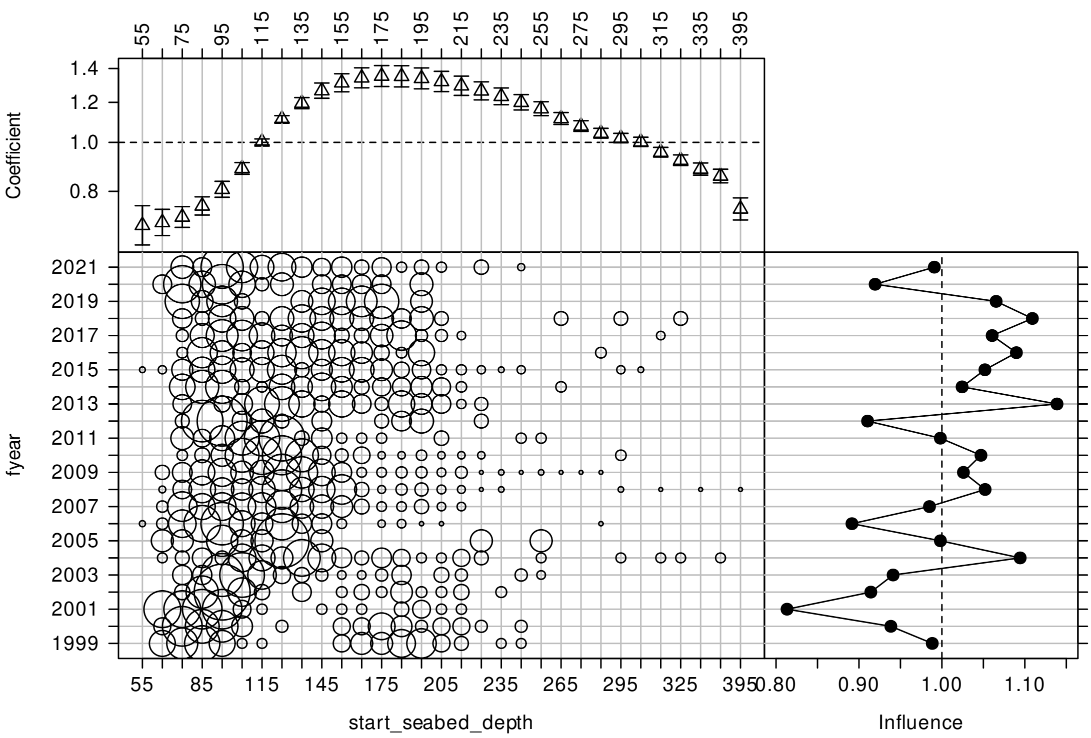

Figure C.99: CDI plot for start seabed depth (m) for the positive catch JMD7 MW observer no trip misID catch-per-unit-effort dataset.

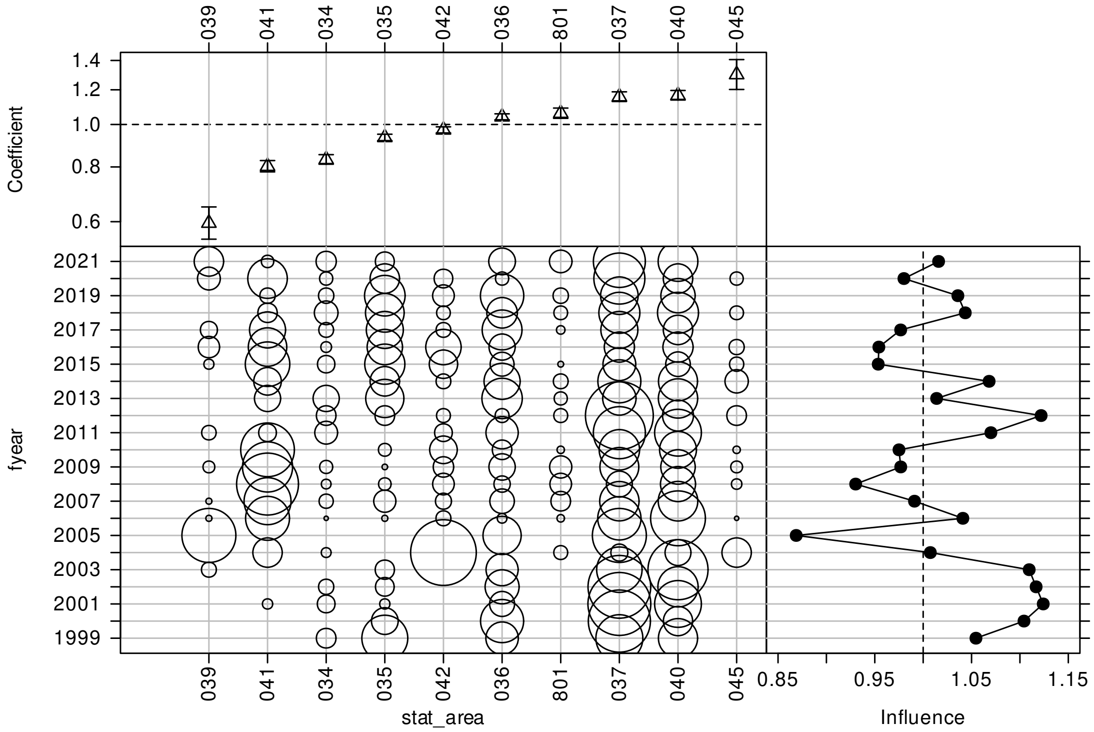

Figure C.100: CDI plot for statistical area for the positive catch JMD7 MW observer no trip misID catch-per-unit-effort dataset.

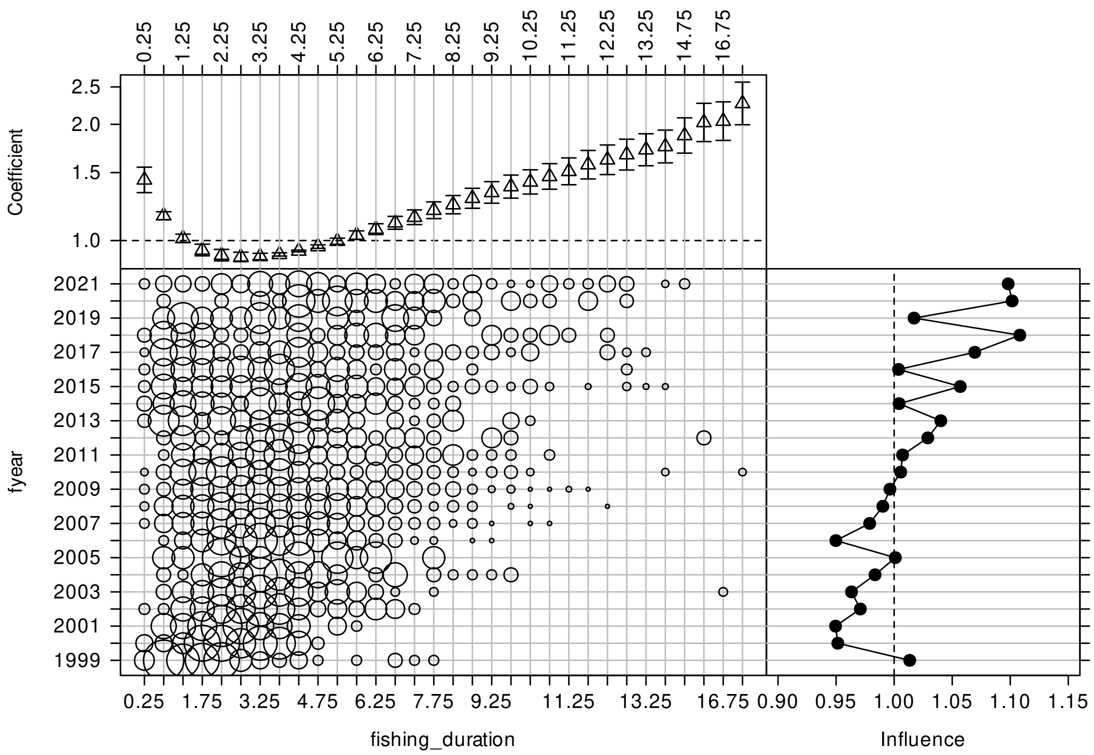

Figure C.101: CDI plot for fishing duration (h) for the positive catch JMD7 MW observer no trip misID catch-per-unit-effort dataset.

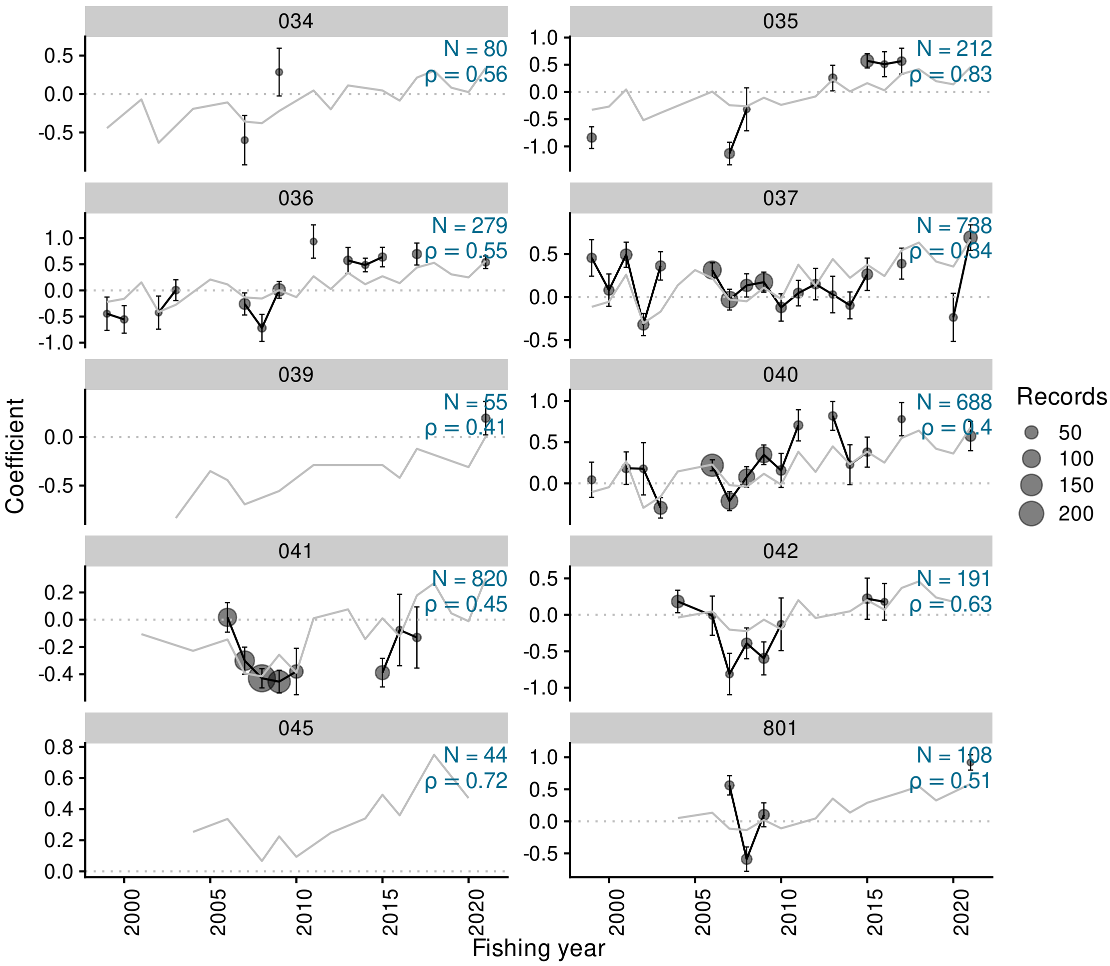

Figure C.102: Residual implied coefficients for area-year in the Weibull positive catch model for the JMD7 MW observer no trip misID dataset.

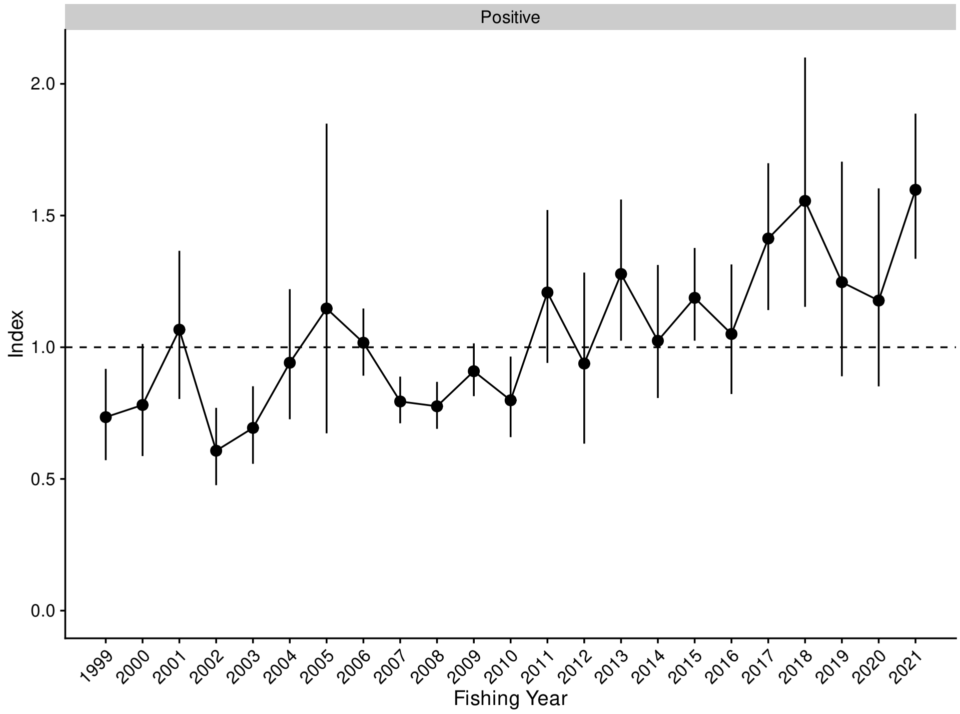

Figure C.103: Standardised indices and 95% confidence intervals for the JMD7 MW observer no trip misID dataset.

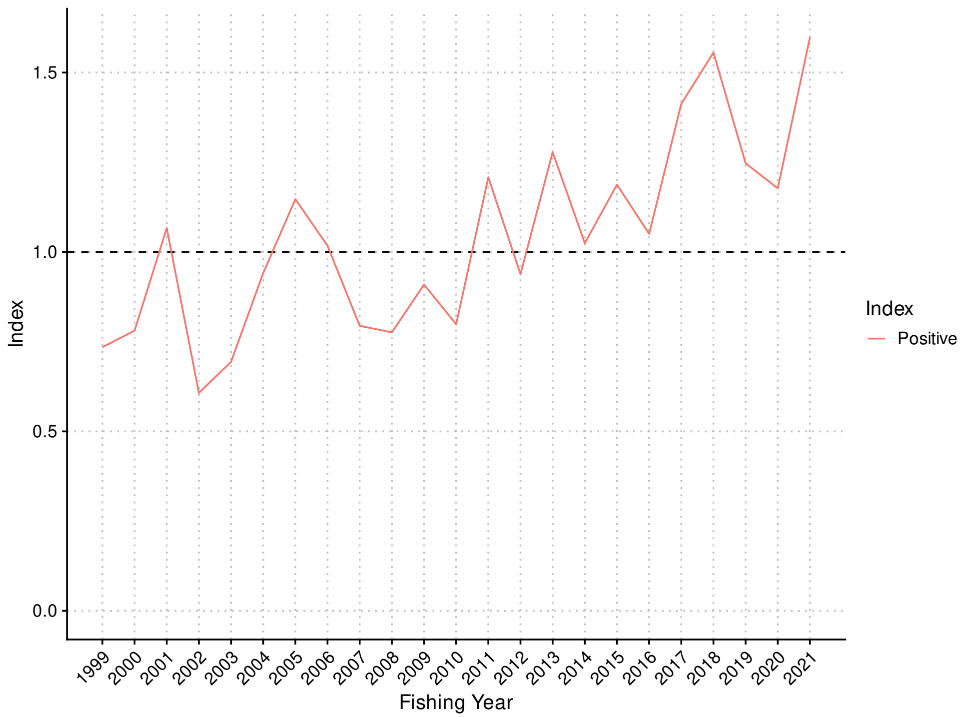

Figure C.104: Standardised indices for the JMD7 MW observer no trip misID dataset.

Table C.32: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in JMD7 MW observer no trip misID.

	Positive			
Fishing year	index	SE	LCI	UCI
1999	0.735	0.088	0.571	0.918
2000	0.781	0.109	0.587	1.013
2001	1.067	0.144	0.804	1.366
2002	0.607	0.075	0.476	0.770
2003	0.694	0.075	0.558	0.852
2004	0.941	0.126	0.727	1.221
2005	1.147	0.300	0.673	1.849
2006	1.017	0.065	0.892	1.147
2007	0.794	0.045	0.711	0.889
2008	0.776	0.046	0.690	0.869
2009	0.909	0.051	0.814	1.015
2010	0.799	0.078	0.659	0.965
2011	1.208	0.148	0.941	1.521
2012	0.938	0.166	0.634	1.284
2013	1.278	0.137	1.025	1.561
2014	1.025	0.129	0.807	1.312
2015	1.188	0.090	1.025	1.377
2016	1.050	0.126	0.822	1.314
2017	1.413	0.142	1.141	1.699
2018	1.556	0.241	1.153	2.100
2019	1.247	0.208	0.890	1.705
2020	1.177	0.192	0.852	1.603
2021	1.598	0.141	1.336	1.887

C.7 JMN7 MW observer no trip misID

Table C.33: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the JMN7 MW observer no trip misID CPUE series.

Series	JMN7 MW observer no trip misID
QMS stock	JMA7
Reporting forms	
Fishing methods	MW
Target species	JMA, JMD, JMM, JMN
Statistical Areas	037, 039, 040, 041, 042, 045
Period	1998-10-01, 2021-09-30
Resolution	Observed event
Core fleet years	4
Core fleet trips	1
Default model	jmnkg ~ fyear + vessel_key + month + stat_area + ns(log(fishing_duration), 3) + ns(log(start_time), 3) + ns(log(start_seabed_depth), 3) + ns(log(headline_height), 3) + ns(fishing_speed, 3)
Stepwise selection	Yes
Positive catch distribution	Weibull

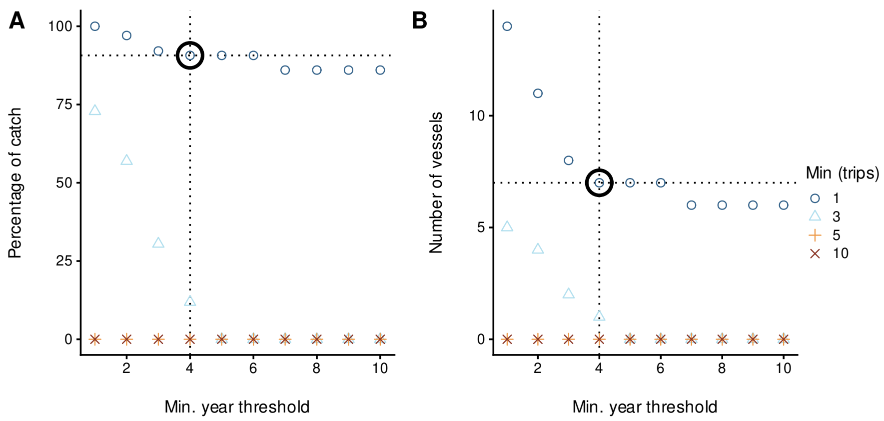

Figure C.105: Percentage of catch and number of vessels for different core vessel selection criteria for the JMN7 MW observer no trip misID CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel was observed in the fishery and the number of observed trips per year.

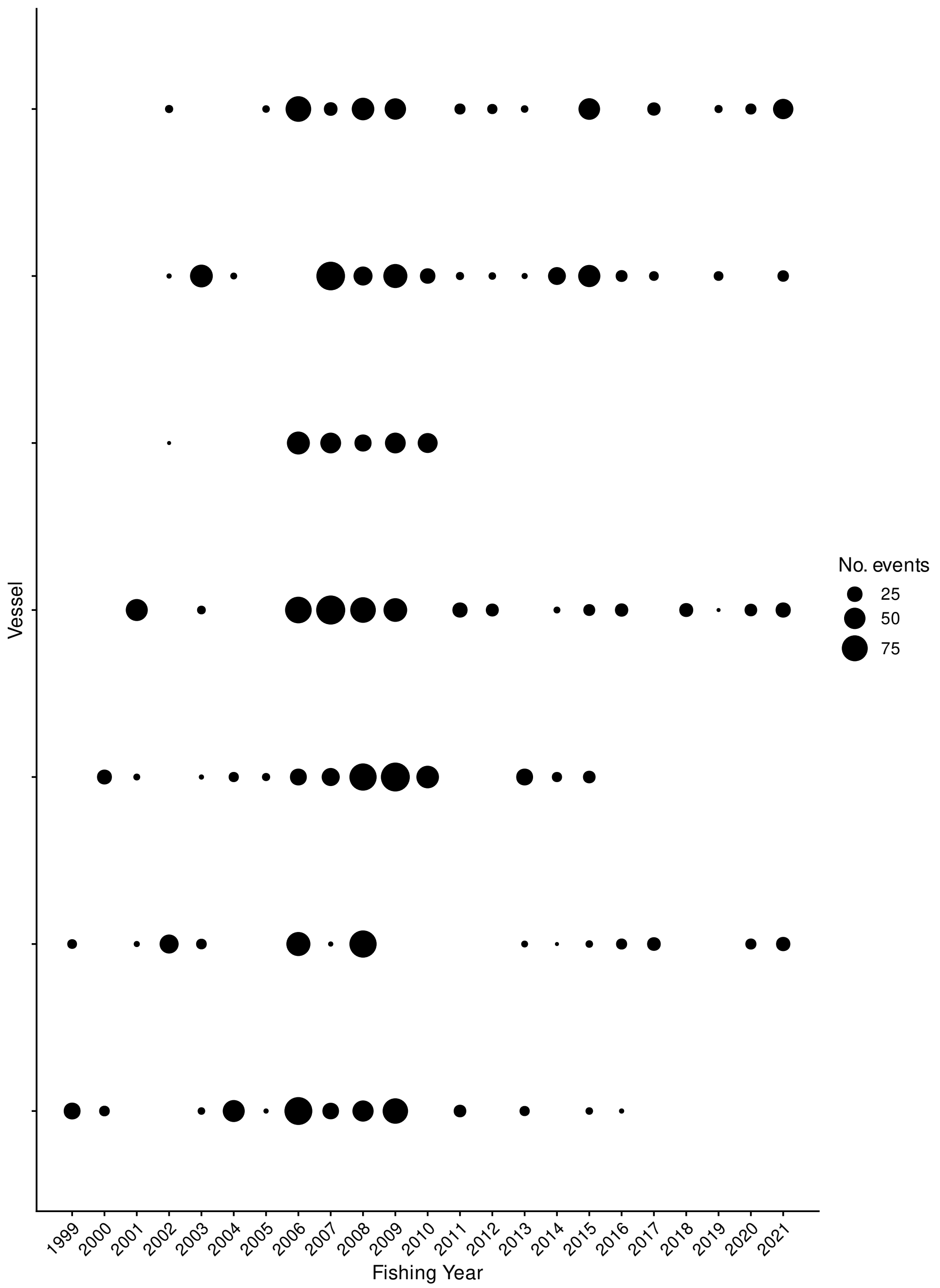

Figure C.106: Number of events by fishing year for core vessels. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table C.34: Summary of the JMN7 MW observer no trip misID 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	1999	2000	2001	2002	2003	2004	2005	2006	2007
Ungroomed data	304 (100%) n: 45	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 84	403 (100%) n: 76	2571 (100%) n: 243	1541 (100%) n: 397	1331 (100%) n: 327
Fishing speed not null	304 (100%) n: 44	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 84	403 (100%) n: 76	2568 (100%) n: 241	1541 (100%) n: 397	1331 (100%) n: 327
Start date not null	304 (100%) n: 44	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 84	403 (100%) n: 76	2568 (100%) n: 241	1541 (100%) n: 397	1331 (100%) n: 327
End date not null	304 (100%) n: 44	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 84	403 (100%) n: 76	2568 (100%) n: 241	1541 (100%) n: 397	1331 (100%) n: 327
Start depth not null	304 (100%) n: 44	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 84	403 (100%) n: 76	2568 (100%) n: 241	1541 (100%) n: 397	1331 (100%) n: 327
Headline height not null	294 (100%) n: 43	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 83	403 (100%) n: 76	2568 (100%) n: 241	1541 (100%) n: 397	1331 (100%) n: 327
Fishing speed >3.5kn	294 (100%) n: 43	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 83	403 (100%) n: 76	2568 (100%) n: 241	1541 (100%) n: 397	1331 (100%) n: 326
Headline height >15m	294 (100%) n: 43	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	386 (100%) n: 82	403 (100%) n: 76	2566 (100%) n: 240	1539 (100%) n: 396	1307 (100%) n: 322
Headline height <90m	294 (100%) n: 43	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	386 (100%) n: 82	403 (100%) n: 76	2566 (100%) n: 240	1539 (100%) n: 396	1307 (100%) n: 322
Fishing duration >15mins	289 (95%) n: 42	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	386 (100%) n: 82	403 (100%) n: 76	2566 (100%) n: 239	1539 (100%) n: 396	1307 (100%) n: 322
Seabed depth >50m	289 (95%) n: 42	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	386 (100%) n: 82	403 (100%) n: 76	2566 (100%) n: 239	1539 (100%) n: 396	1307 (100%) n: 322
Seabed depth <200m	289 (95%) n: 42	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	386 (100%) n: 82	394 (100%) n: 67	2417 (94%) n: 230	1539 (100%) n: 395	1307 (100%) n: 322
Start time >0	289 (95%) n: 42	100 (100%) n: 34	178 (100%) n: 60	228 (88%) n: 48	386 (100%) n: 82	394 (100%) n: 67	2400 (93%) n: 229	1519 (100%) n: 391	1261 (95%) n: 319
No trip misID	289 (95%) n: 42	100 (100%) n: 34	178 (100%) n: 60	228 (88%) n: 48	386 (100%) n: 82	394 (100%) n: 67	304 (12%) n: 13	1519 (100%) n: 391	1261 (95%) n: 319
Core fleet selection	268 (88%) n: 39	100 (100%) n: 34	178 (100%) n: 60	228 (88%) n: 48	386 (100%) n: 82	394 (100%) n: 67	304 (12%) n: 13	1519 (100%) n: 391	1261 (95%) n: 319

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	2365 (100%) n: 435	2171 (100%) n: 428	2177 (100%) n: 464	1501 (100%) n: 271	4646 (100%) n: 669	4978 (100%) n: 563	3725 (100%) n: 480	5772 (100%) n: 485	3096 (100%) n: 312
Fishing speed not null	2363 (100%) n: 434	2171 (100%) n: 428	2176 (100%) n: 463	1501 (100%) n: 271	4646 (100%) n: 669	4978 (100%) n: 562	3725 (100%) n: 480	5772 (100%) n: 485	3096 (100%) n: 311
Start date not null	2363 (100%) n: 434	2171 (100%) n: 428	2176 (100%) n: 463	1501 (100%) n: 271	4646 (100%) n: 669	4978 (100%) n: 562	3725 (100%) n: 480	5772 (100%) n: 485	3096 (100%) n: 311
End date not null	2363 (100%) n: 434	2171 (100%) n: 428	2176 (100%) n: 463	1501 (100%) n: 271	4646 (100%) n: 669	4978 (100%) n: 562	3725 (100%) n: 480	5772 (100%) n: 485	3096 (100%) n: 311
Start depth not null	2363 (100%) n: 433	2046 (94%) n: 405	2171 (100%) n: 460	1476 (100%) n: 267	4285 (92%) n: 634	4879 (100%) n: 542	3705 (100%) n: 478	5512 (100%) n: 469	3096 (100%) n: 311
Headline height not null	2363 (100%) n: 433	2007 (92%) n: 404	2114 (100%) n: 452	1476 (100%) n: 266	4265 (92%) n: 627	4847 (100%) n: 538	3705 (100%) n: 477	5508 (100%) n: 468	3096 (100%) n: 311
Fishing speed >3.5kn	2363 (100%) n: 433	2007 (92%) n: 404	2114 (100%) n: 452	1476 (100%) n: 266	4265 (92%) n: 627	4847 (100%) n: 538	3705 (100%) n: 477	5508 (100%) n: 468	3076 (100%) n: 310
Headline height >15m	2363 (100%) n: 433	2007 (92%) n: 403	2111 (100%) n: 451	1476 (100%) n: 266	4265 (92%) n: 627	4845 (100%) n: 535	3705 (100%) n: 477	5508 (100%) n: 468	3076 (100%) n: 310
Headline height <90m	2363 (100%) n: 433	2007 (92%) n: 403	2111 (100%) n: 451	1454 (100%) n: 265	4265 (92%) n: 626	4845 (100%) n: 535	3705 (100%) n: 477	5508 (100%) n: 468	3076 (100%) n: 310
Fishing duration >15mins	2363 (100%) n: 432	2007 (92%) n: 403	2111 (100%) n: 451	1425 (95%) n: 263	4265 (92%) n: 626	4835 (100%) n: 533	3704 (100%) n: 475	5508 (100%) n: 468	3076 (100%) n: 309
Seabed depth >50m	2363 (100%) n: 432	2005 (92%) n: 401	2086 (100%) n: 450	1425 (95%) n: 263	4264 (92%) n: 625	4835 (100%) n: 532	3704 (100%) n: 475	5504 (100%) n: 467	3076 (100%) n: 309
Seabed depth <200m	2347 (100%) n: 419	1936 (89%) n: 390	2074 (100%) n: 438	1425 (95%) n: 262	4250 (91%) n: 612	4820 (100%) n: 524	3690 (100%) n: 472	5474 (95%) n: 457	3000 (100%) n: 305
Start time >0	2332 (100%) n: 414	1936 (89%) n: 389	2074 (100%) n: 435	1416 (94%) n: 259	4160 (90%) n: 606	4801 (100%) n: 522	3630 (100%) n: 465	5427 (94%) n: 454	2931 (95%) n: 302
No trip misID	2332 (100%) n: 414	1936 (89%) n: 389	498 (23%) n: 125	372 (25%) n: 58	209 (4%) n: 32	296 (6%) n: 52	358 (1e+01%) n: 68	1767 (31%) n: 150	588 (19%) n: 46
Core fleet selection	2332 (100%) n: 414	1936 (89%) n: 389	496 (23%) n: 124	372 (25%) n: 58	209 (4%) n: 32	296 (6%) n: 52	240 (6%) n: 49	1766 (31%) n: 145	588 (19%) n: 46

Filter	2017	2018	2019	2020	2021
Ungroomed data	2640 (100%) n: 238	4601 (100%) n: 346	2822 (100%) n: 302	2942 (100%) n: 329	2320 (100%) n: 205
Fishing speed not null	2638 (100%) n: 236	4601 (100%) n: 346	2822 (100%) n: 302	2942 (100%) n: 328	2299 (100%) n: 201
Start date not null	2638 (100%) n: 236	4601 (100%) n: 346	2822 (100%) n: 302	2942 (100%) n: 328	2299 (100%) n: 201
End date not null	2638 (100%) n: 236	4601 (100%) n: 346	2822 (100%) n: 302	2942 (100%) n: 328	2299 (100%) n: 201
Start depth not null	2605 (100%) n: 234	4587 (100%) n: 345	2822 (100%) n: 302	2879 (100%) n: 323	2177 (94%) n: 195
Headline height not null	2605 (100%) n: 230	4582 (100%) n: 343	2822 (100%) n: 302	2879 (100%) n: 322	2177 (94%) n: 195
Fishing speed >3.5kn	2605 (100%) n: 230	4582 (100%) n: 343	2822 (100%) n: 302	2879 (100%) n: 322	2177 (94%) n: 195
Headline height >15m	2582 (100%) n: 229	4582 (100%) n: 343	2822 (100%) n: 302	2879 (100%) n: 322	2177 (94%) n: 195
Headline height <90m	2582 (100%) n: 229	4582 (100%) n: 343	2822 (100%) n: 302	2879 (100%) n: 322	2177 (94%) n: 195
Fishing duration >15mins	2564 (100%) n: 228	4582 (100%) n: 343	2822 (100%) n: 302	2879 (100%) n: 322	2177 (94%) n: 195
Seabed depth >50m	2564 (100%) n: 228	4573 (100%) n: 342	2822 (100%) n: 302	2879 (100%) n: 322	2177 (94%) n: 195
Seabed depth <200m	2564 (100%) n: 226	4403 (100%) n: 332	2758 (100%) n: 279	2878 (100%) n: 317	2176 (94%) n: 194
Start time >0	2558 (100%) n: 225	4393 (100%) n: 331	2758 (100%) n: 279	2823 (100%) n: 314	2114 (91%) n: 193
No trip misID	721 (27%) n: 54	223 (5%) n: 30	145 (5%) n: 16	971 (33%) n: 73	2114 (91%) n: 193
Core fleet selection	685 (26%) n: 46	182 (4%) n: 20	145 (5%) n: 16	556 (19%) n: 40	1146 (49%) n: 103

Table C.35: Summary of the JMN7 MW observer no trip misID dataset after core fleet selection. 'Records' indicates the number of rows (events) in the dataset, and 'Records caught' indicates the percentage of events with catches of jack mackerels.

Fishing year	Vessels	Trips	Records	Hrs	Catch (t)	Records caught
1999	2	2	39	80.15	267.96	76.92
2000	2	2	34	89.50	99.83	88.24
2001	3	4	60	156.45	178.19	85.00
2002	4	4	48	181.12	228.40	79.17
2003	5	5	82	285.33	386.14	87.80
2004	3	3	67	277.55	393.81	73.13
2005	3	3	13	59.33	304.04	100.00
2006	6	8	391	1 430.92	1 519.19	89.26
2007	7	15	319	1 200.18	1 260.50	72.41
2008	7	15	414	1 648.47	2 331.50	69.81
2009	6	11	389	1 644.73	1 935.68	84.06
2010	3	4	124	510.83	496.21	70.16
2011	4	4	58	271.67	372.36	63.79
2012	3	4	32	145.25	208.59	81.25
2013	5	9	52	226.42	296.44	48.08
2014	4	7	49	203.57	239.71	81.63
2015	6	13	145	757.80	1 766.16	84.14
2016	4	7	46	208.65	587.80	80.43
2017	3	5	46	299.03	685.37	91.30
2018	1	2	20	129.12	182.05	65.00
2019	3	4	16	80.83	144.80	75.00
2020	3	7	40	247.05	555.66	67.50
2021	4	12	103	625.67	1 145.78	81.55

Table C.36: Summary of stepwise selection for occurrence of positive catch. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	21.00	2 611	4.70	4.70	*
+ ns(log(start_seabed_depth), 3)	3.00	2 351	14.60	9.90	*
+ stat_area	5.00	2 198	20.70	6.00	*
+ month	11.00	2 171	22.50	1.80	*
+ ns(log(fishing_duration), 3)	3.00	2 154	23.30	0.90	
+ vessel_key	6.00	2 147	24.10	0.70	

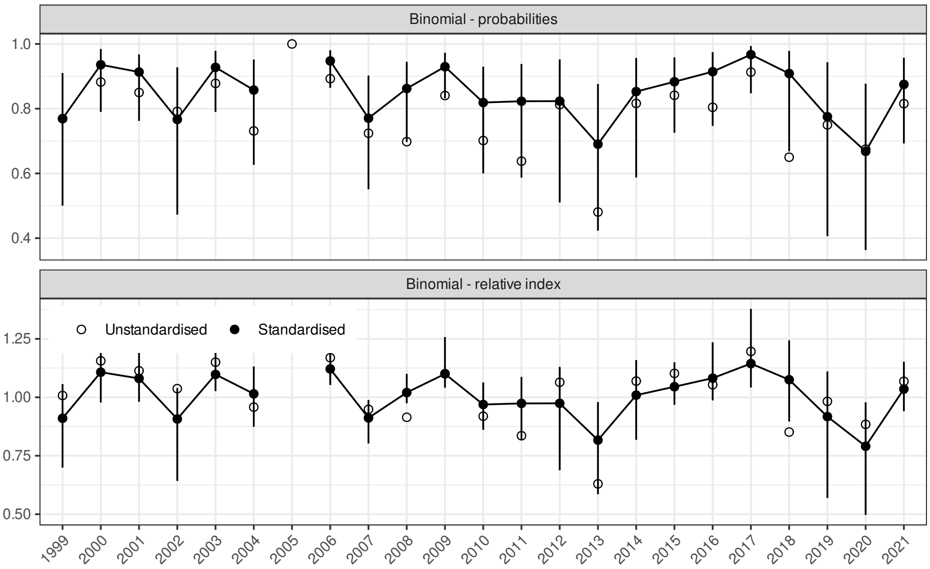

Figure C.107: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the JMN7 MW observer no trip misID dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

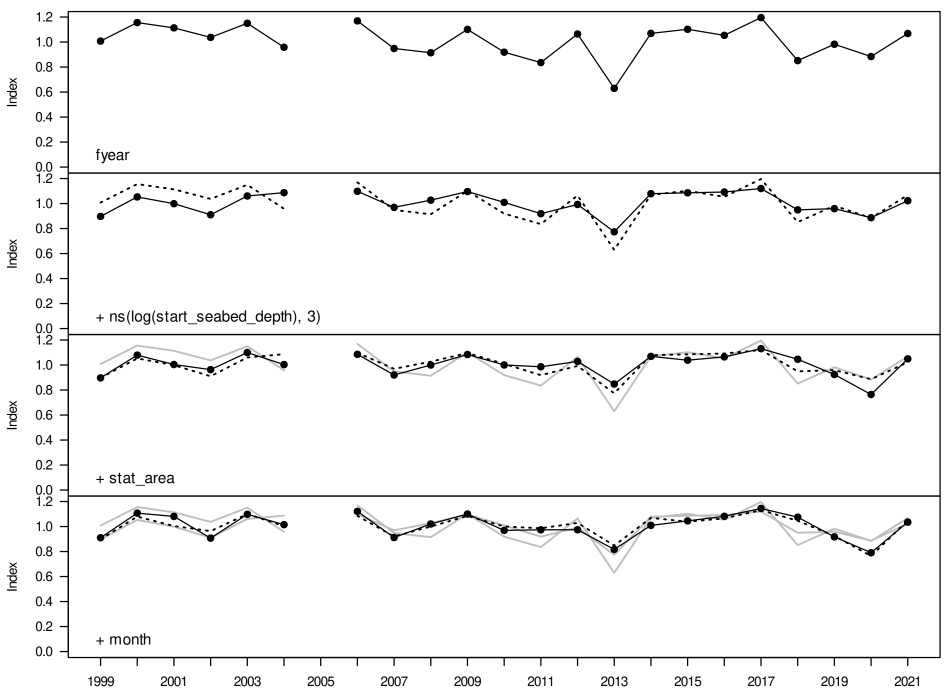

Figure C.108: Step plot for occurrence of catch in the JMN7 MW observer no trip misID dataset.

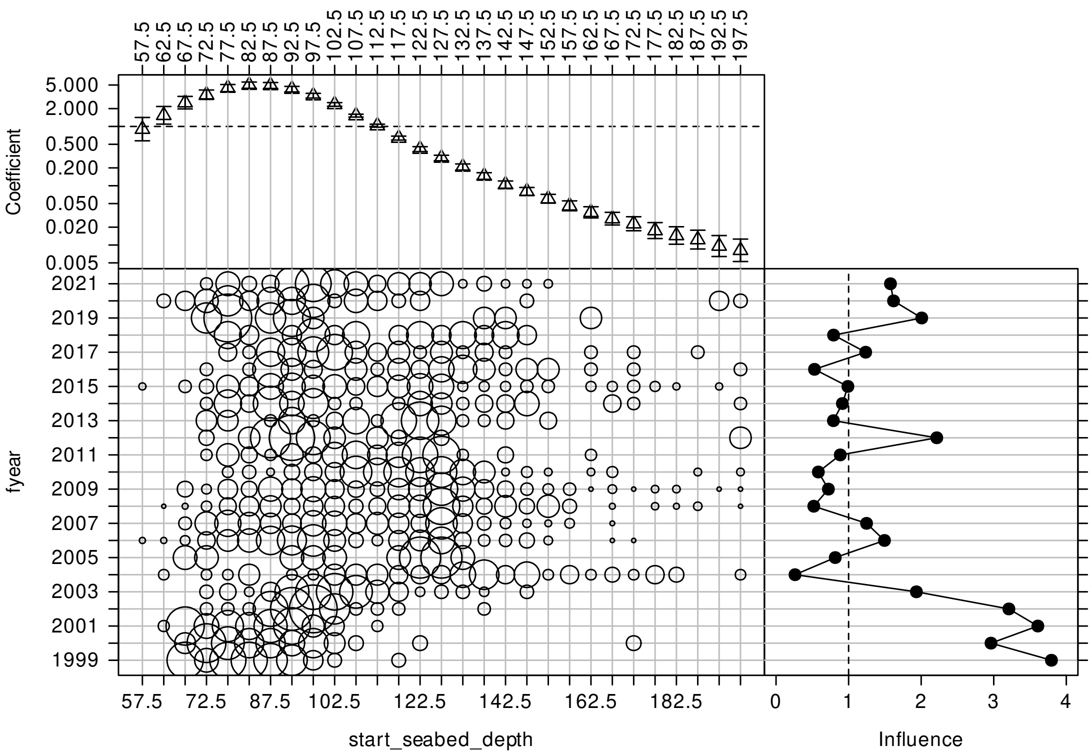

Figure C.109: CDI plot for start seabed depth (m) for the occurrence of positive catch JMN7 MW observer no trip misID catch-per-unit-effort dataset.

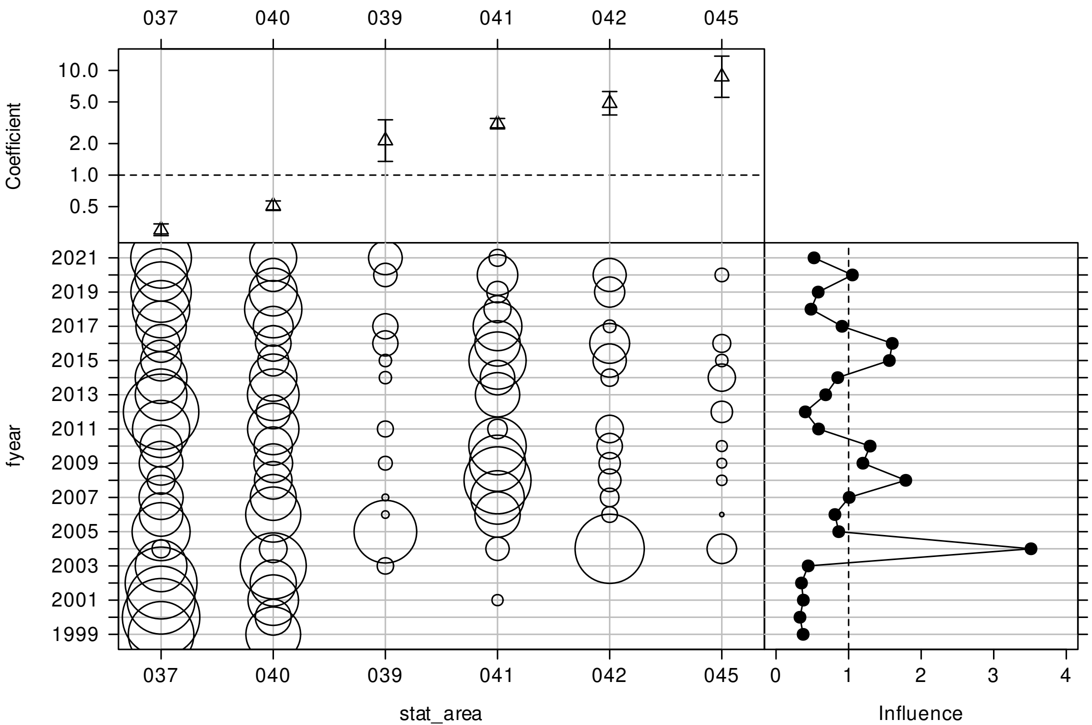

Figure C.110: CDI plot for statistical area for the occurrence of positive catch JMN7 MW observer no trip misID catch-per-unit-effort dataset.

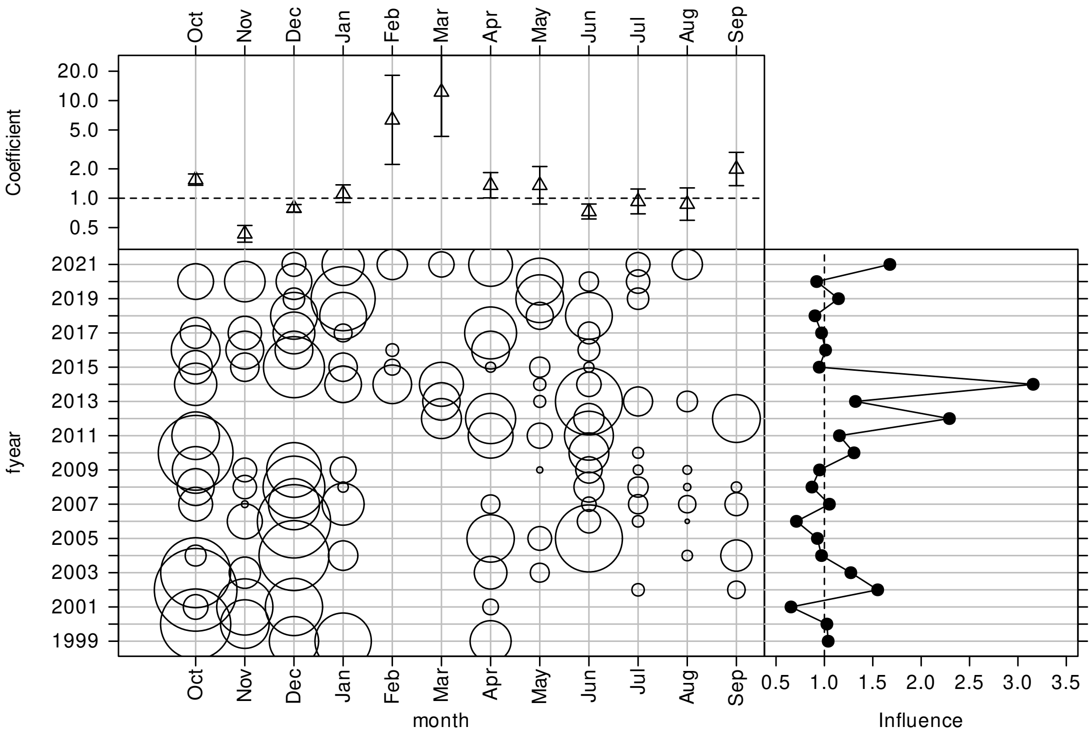

Figure C.111: CDI plot for month for the occurrence of positive catch JMN7 MW observer no trip misID catch-per-unit-effort dataset.

Table C.37: Summary of stepwise selection for the Weibull model. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	24	39 736	11.8	11.8	*
+ stat area	5	39 632	16.6	4.8	*
+ month	11	39 564	20.5	3.8	*
+ ns(log(start seabed depth), 3)	3	39 489	23.9	3.4	*
+ ns(log(start time), 3)	3	39 461	25.3	1.4	*
+ vessel key	6	39 443	26.6	1.3	*
+ ns(log(fishing duration), 3)	3	39 431	27.4	0.7	
+ ns(log(headline height), 3)	3	39 424	27.9	0.6	

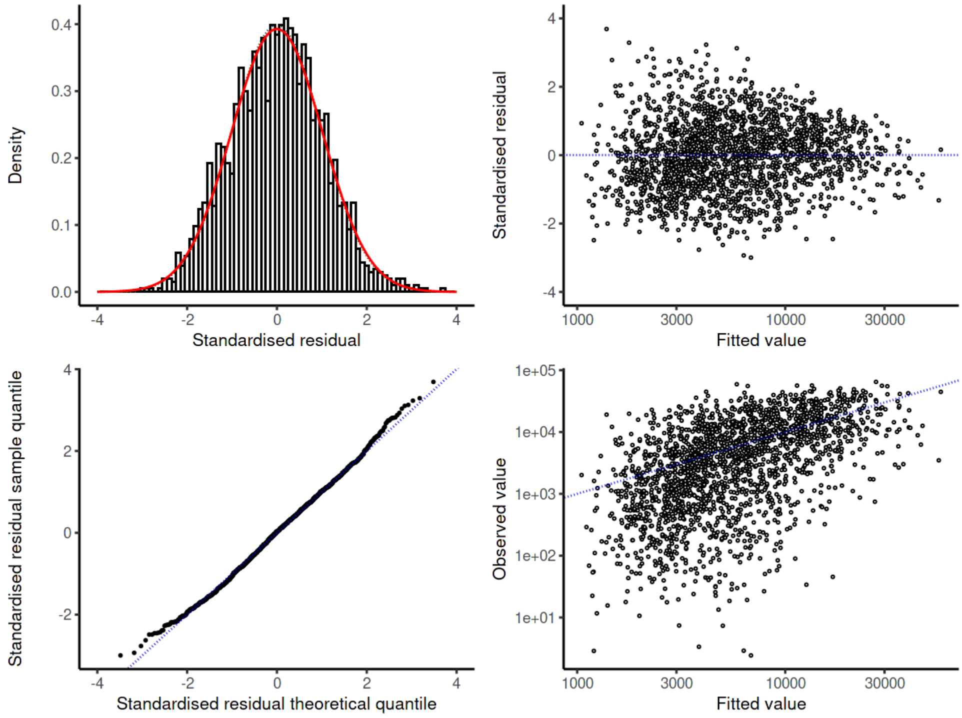

Figure C.112: Diagnostic plots for the Weibull model for the JMN7 MW observer no trip misID dataset.

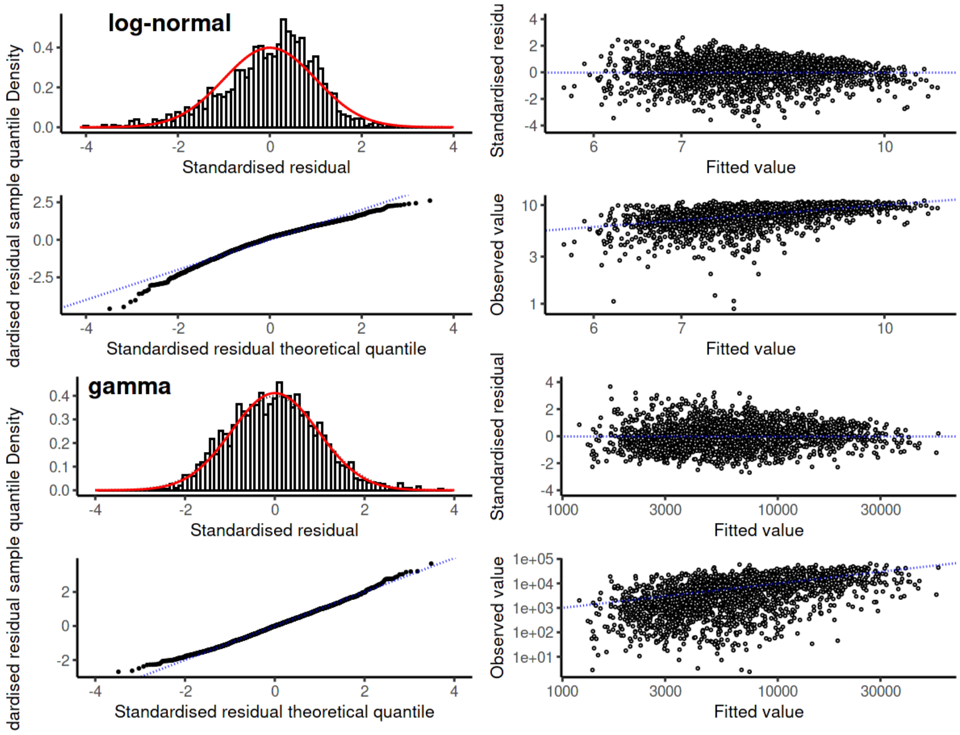

Figure C.113: Diagnostic plots for the log-normal and gamma model for the JMN7 MW observer no trip misID dataset.

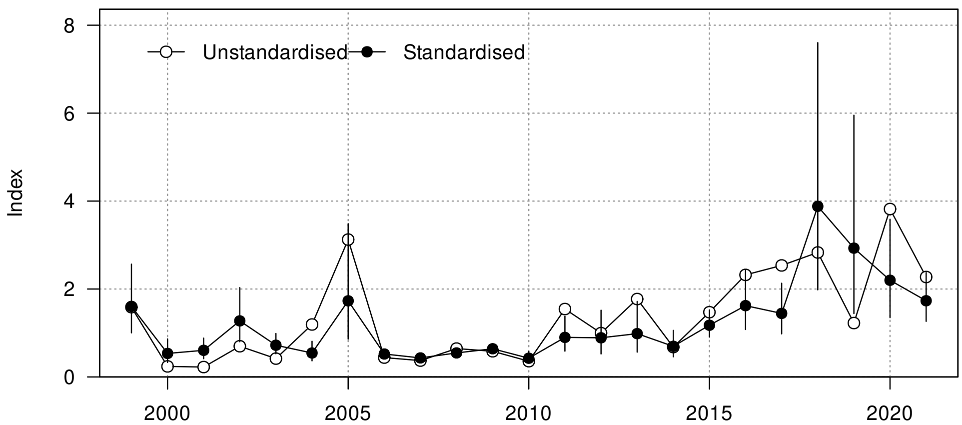

Figure C.114: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch in the JMN7 MW observer no trip misID dataset.

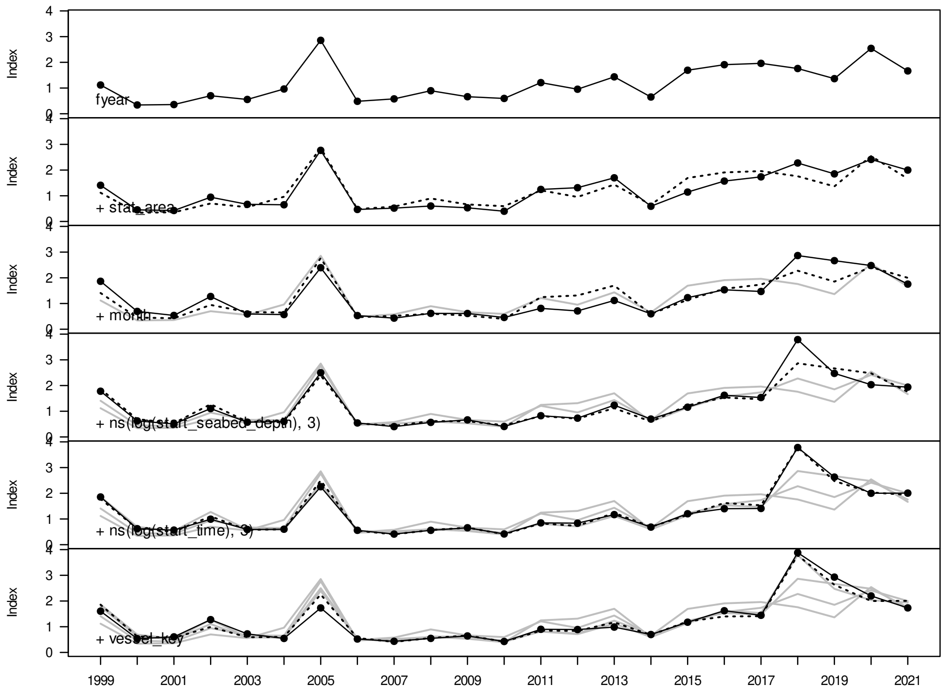

Figure C.115: Changes to the JMN7 MW observer no trip misID positive catch index as terms are successively entered into the model.

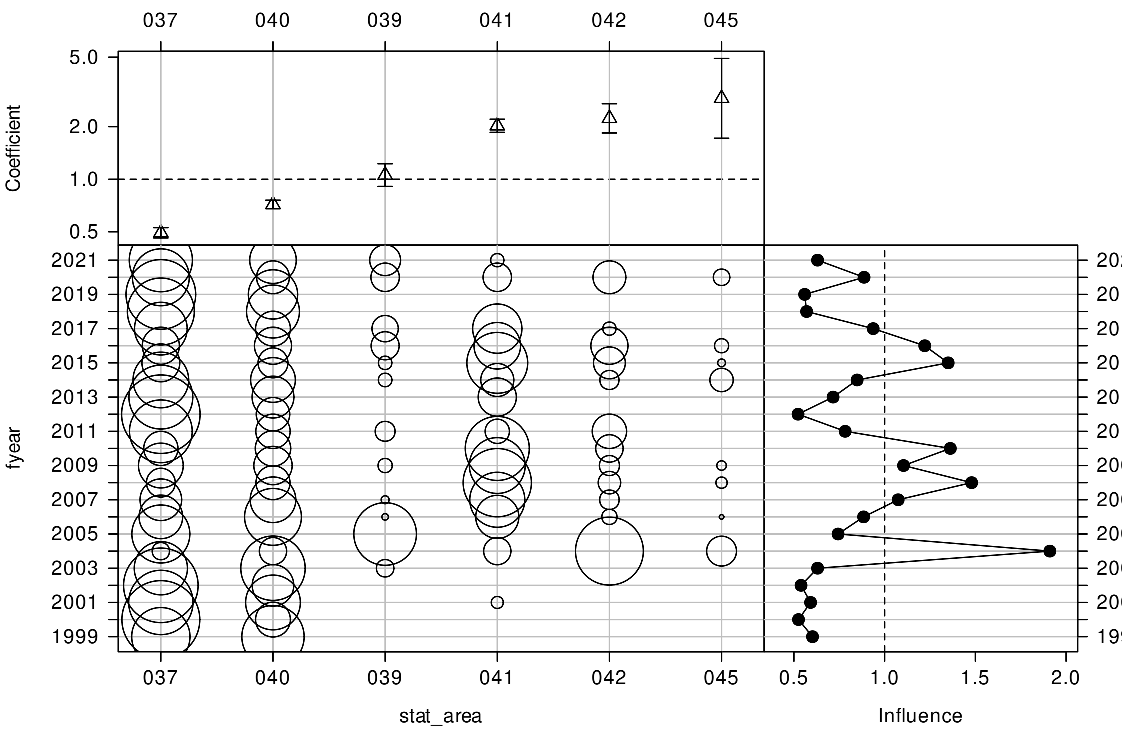

Figure C.116: CDI plot for statistical area for the positive catch JMN7 MW observer no trip misID catch-per-unit-effort dataset.

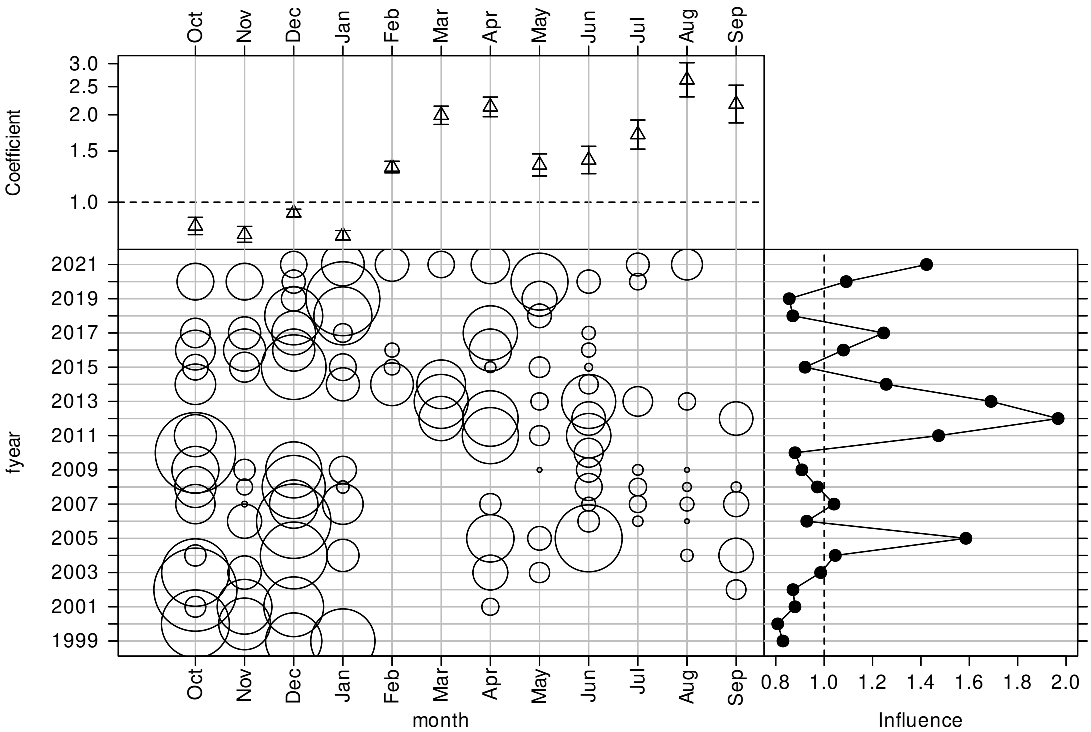

Figure C.117: CDI plot for month for the positive catch JMN7 MW observer no trip misID catch-per-unit-effort dataset.

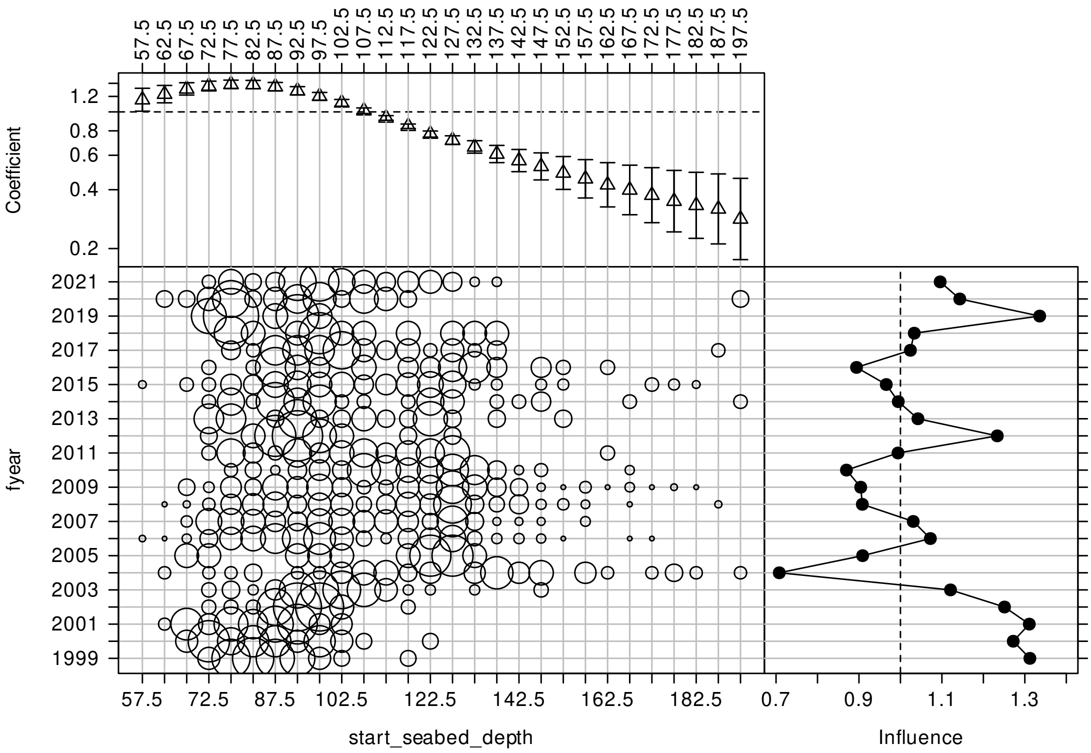

Figure C.118: CDI plot for start seabed depth (m) for the positive catch JMN7 MW observer no trip misID catch-per-unit-effort dataset.

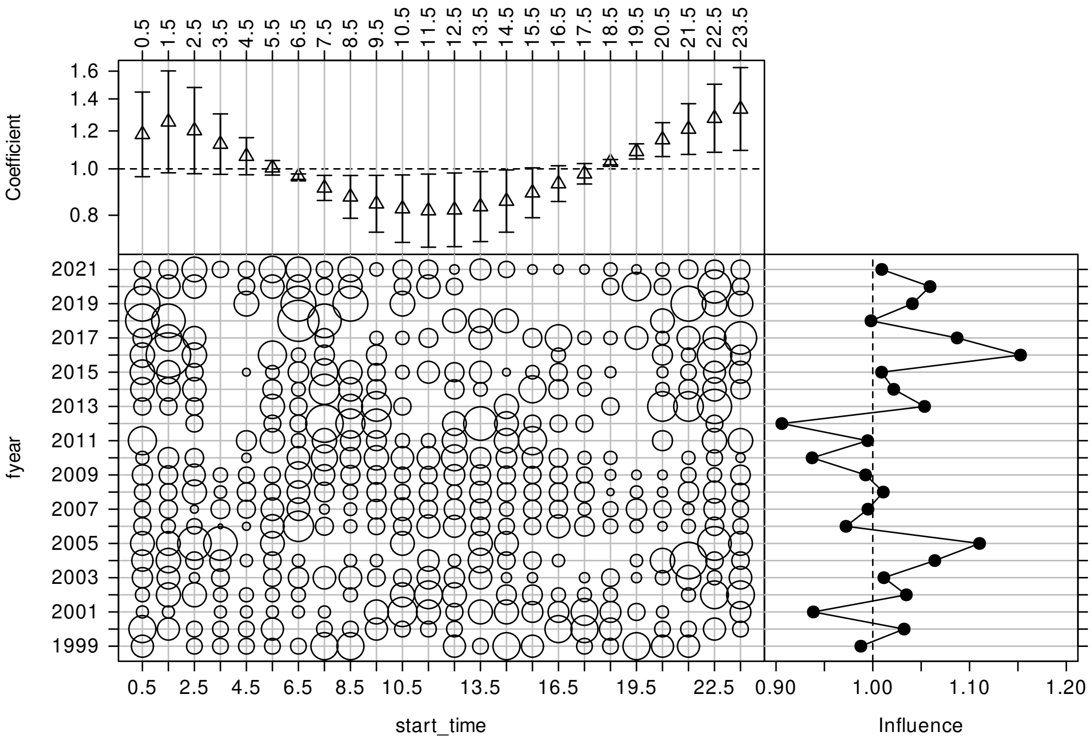

Figure C.119: CDI plot for start time for the positive catch JMN7 MW observer no trip misID catch-per-unit-effort dataset.

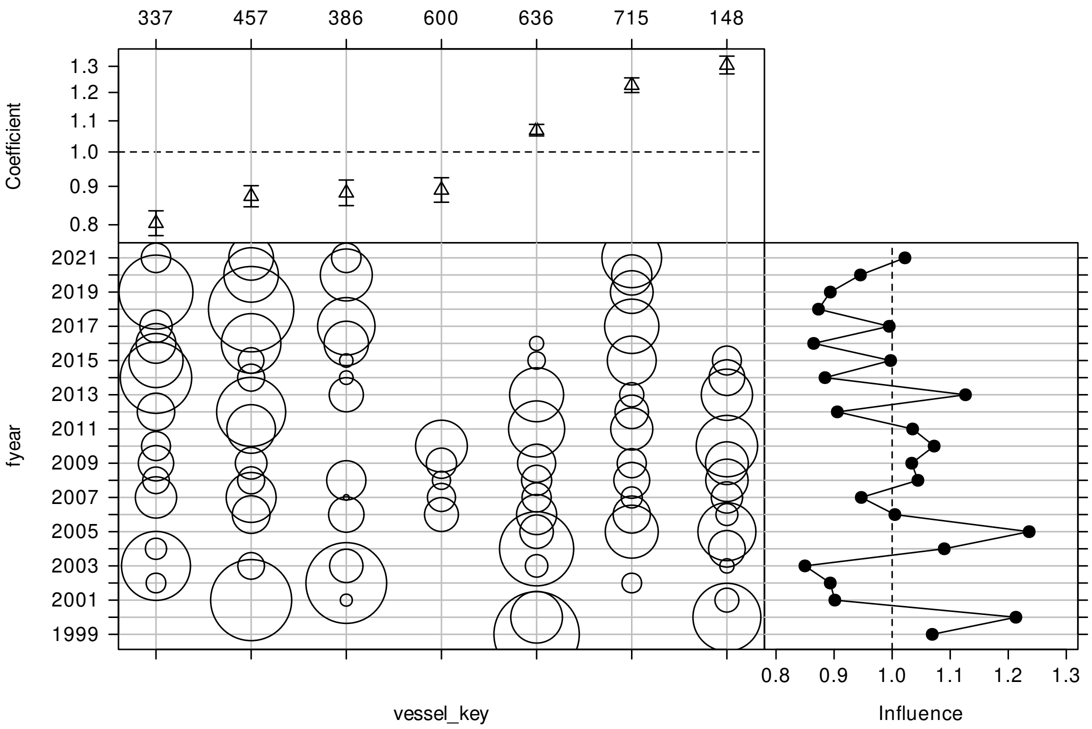

Figure C.120: CDI plot for vessel key for the positive catch JMN7 MW observer no trip misID catch-per-unit-effort dataset.

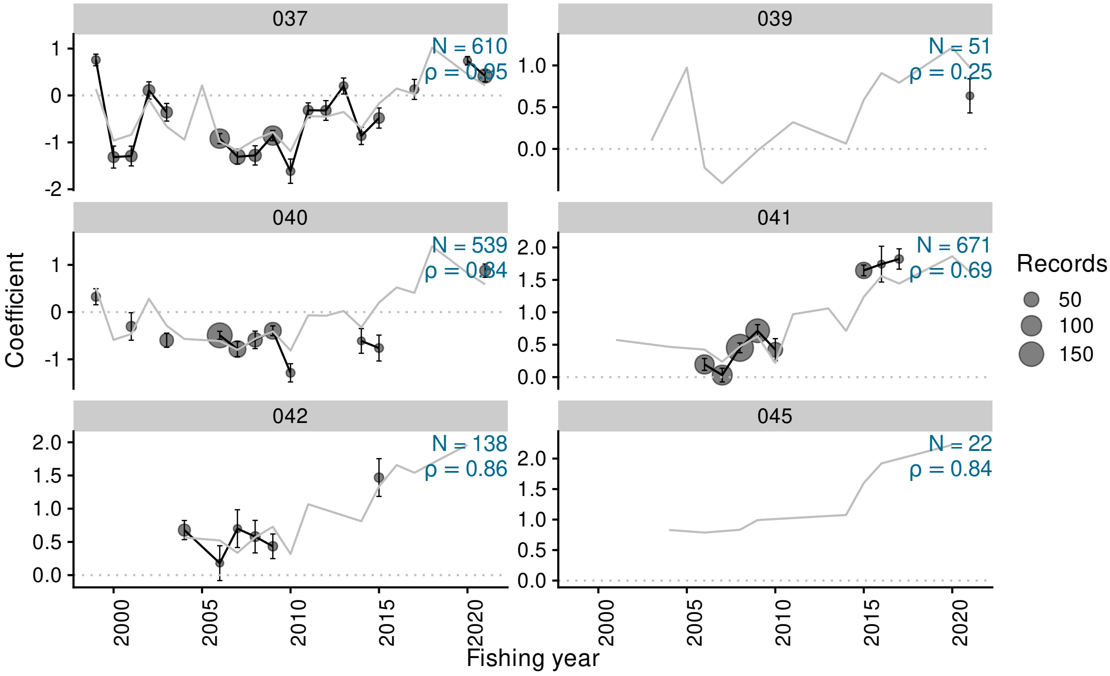

Figure C.121: Residual implied coefficients for area-year in the Weibull positive catch model for the JMN7 MW observer no trip misID dataset.

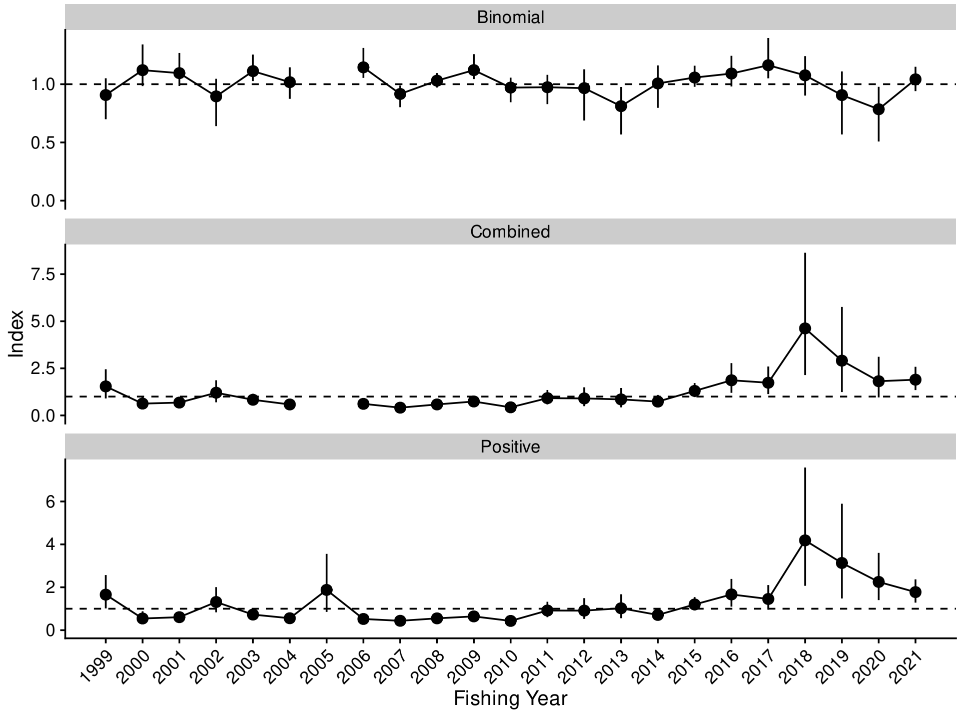

Figure C.122: Standardised indices and 95% confidence intervals for the JMN7 MW observer no trip misID dataset.

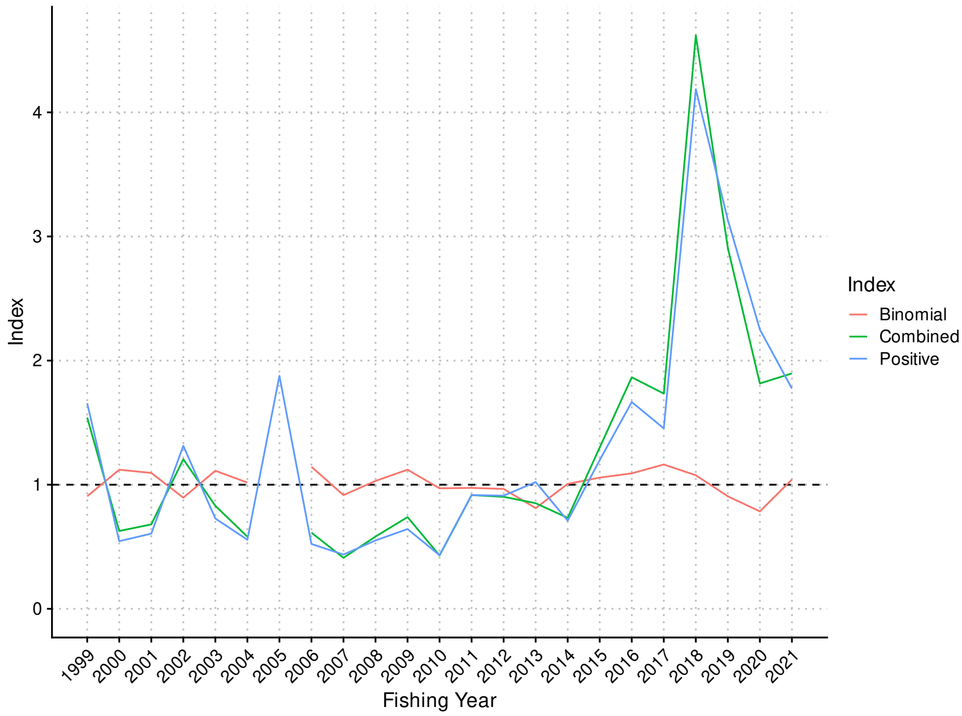

Figure C.123: Standardised indices for the JMN7 MW observer no trip misID dataset.

Table C.38: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in JMN7 MW observer no trip misID.

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
1999	0.907	0.090	0.699	1.051	1.541	0.396	0.901	2.452	1.656	0.396	1.015	2.570
2000	1.121	0.091	0.984	1.341	0.627	0.167	0.369	1.024	0.545	0.141	0.327	0.881
2001	1.095	0.072	0.985	1.268	0.680	0.130	0.462	0.973	0.606	0.109	0.424	0.849
2002	0.896	0.104	0.640	1.046	1.205	0.299	0.696	1.867	1.313	0.300	0.833	2.007
2003	1.112	0.058	1.027	1.254	0.830	0.144	0.580	1.147	0.728	0.117	0.523	0.983
2004	1.017	0.069	0.874	1.145	0.581	0.121	0.380	0.855	0.557	0.108	0.374	0.796
2005	-	-	-	-	-	-	-	-	1.877	0.691	0.851	3.557
2006	1.145	0.066	1.054	1.311	0.613	0.070	0.497	0.770	0.522	0.050	0.435	0.629
2007	0.916	0.048	0.803	0.989	0.411	0.044	0.325	0.500	0.437	0.042	0.354	0.519
2008	1.030	0.032	0.971	1.096	0.582	0.057	0.476	0.700	0.551	0.051	0.457	0.658
2009	1.121	0.055	1.044	1.258	0.739	0.072	0.610	0.894	0.643	0.055	0.541	0.755
2010	0.971	0.054	0.845	1.056	0.430	0.070	0.304	0.578	0.432	0.068	0.309	0.577
2011	0.974	0.064	0.829	1.080	0.916	0.196	0.584	1.350	0.917	0.184	0.605	1.325
2012	0.966	0.112	0.688	1.128	0.903	0.256	0.490	1.492	0.912	0.247	0.526	1.493
2013	0.811	0.104	0.568	0.976	0.851	0.262	0.427	1.456	1.021	0.285	0.558	1.674
2014	1.007	0.093	0.797	1.161	0.733	0.162	0.452	1.087	0.710	0.141	0.471	1.023
2015	1.057	0.046	0.977	1.159	1.300	0.191	0.972	1.719	1.199	0.159	0.919	1.542
2016	1.091	0.067	0.981	1.244	1.866	0.402	1.199	2.777	1.666	0.330	1.097	2.389
2017	1.163	0.088	1.051	1.397	1.734	0.374	1.132	2.598	1.454	0.293	0.955	2.103
2018	1.076	0.086	0.902	1.241	4.620	1.657	2.143	8.636	4.186	1.407	2.068	7.582
2019	0.906	0.138	0.568	1.110	2.907	1.153	1.240	5.760	3.133	1.127	1.479	5.895
2020	0.785	0.120	0.508	0.977	1.816	0.550	0.956	3.113	2.250	0.562	1.402	3.603
2021	1.042	0.053	0.941	1.150	1.897	0.315	1.345	2.582	1.775	0.277	1.283	2.369

C.8 JMD7 MW observer zero misID

Table C.39: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the JMD7 MW observer zero misID CPUE series.

Series	JMD7 MW observer zero misID
QMS stock	JMA7
Reporting forms	
Fishing methods	MW
Target species	JMA, JMD, JMM, JMN
Statistical Areas	034, 035, 036, 037, 039, 040, 041, 042, 045, 801
Period	2007-10-01, 2020-09-30
Resolution	Observed event
Core fleet years	4
Core fleet trips	1
Default model	jmdkg ~ fyear + vessel_key + month + stat_area + ns(log(fishing_duration), 3) + ns(log(start_time), 3) + ns(log(start_seabed_depth), 3) + ns(log(headline_height), 3) + ns(fishing_speed, 3)
Stepwise selection	Yes
Positive catch distribution	Weibull

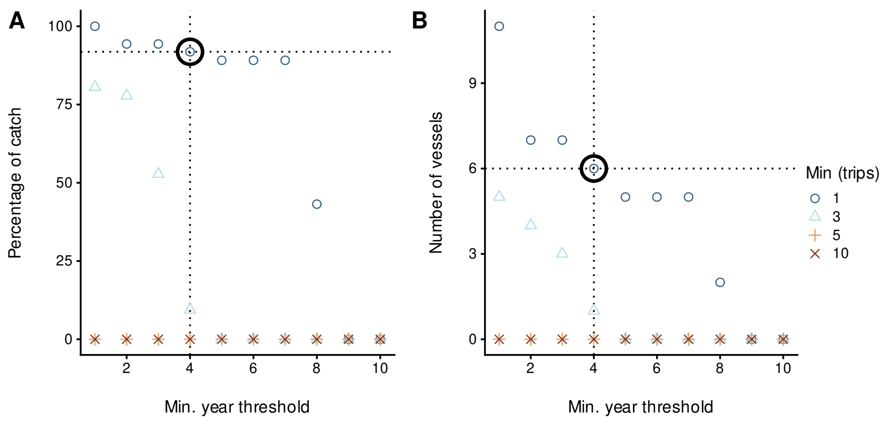

Figure C.124: Percentage of catch and number of vessels for different core vessel selection criteria for the JMD7 MW observer zero misID CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel was observed in the fishery and the number of observed trips per year.

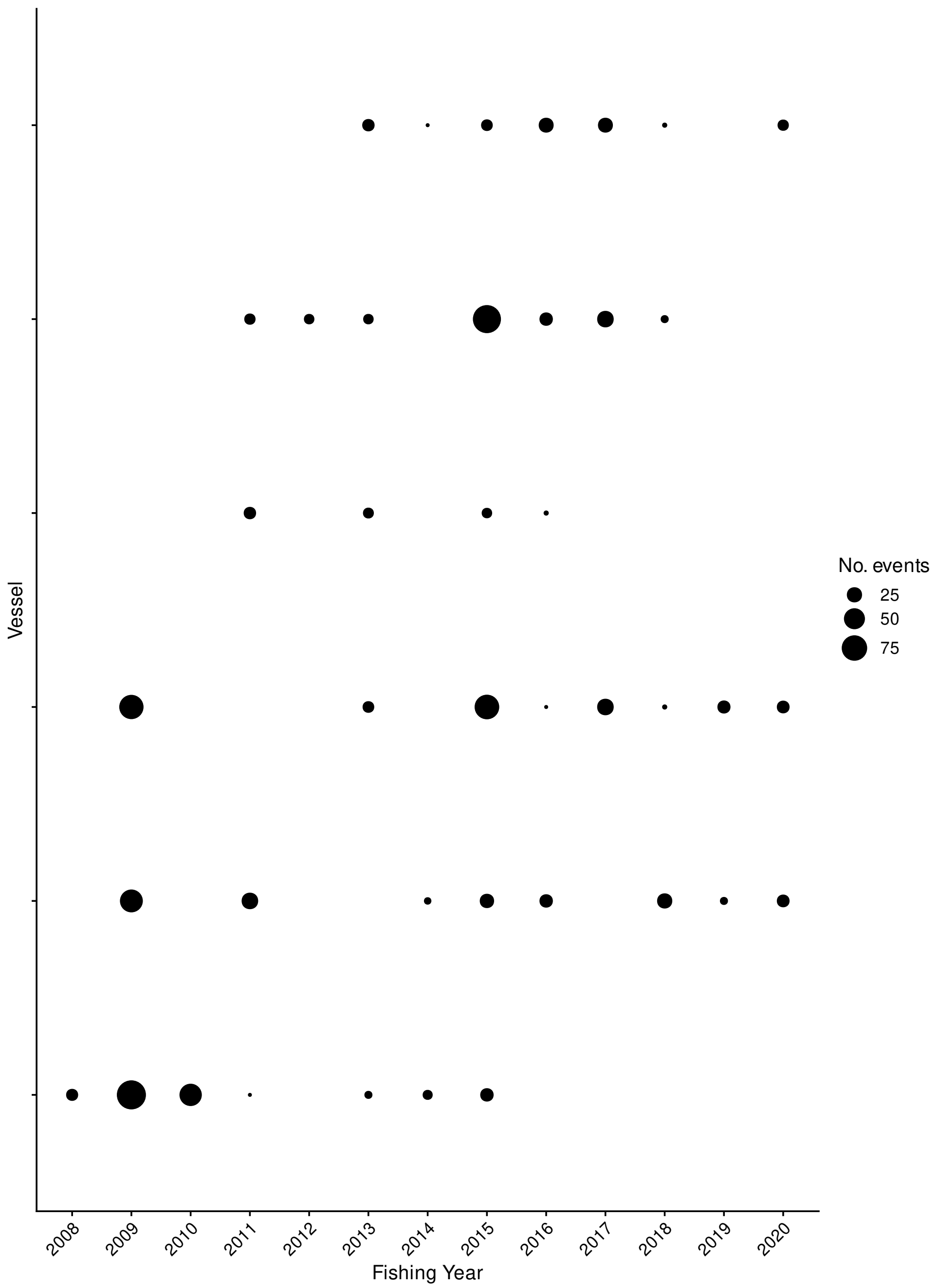

Figure C.125: Number of events by fishing year for core vessels. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table C.40: Summary of the JMD7 MW observer zero misID 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	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	4954 (100%) n: 511	5884 (100%) n: 526	4425 (100%) n: 487	4219 (100%) n: 310	9664 (100%) n: 713	9872 (100%) n: 643	11383 (100%) n: 669	9856 (100%) n: 593	6348 (100%) n: 389
Fishing speed not null	4895 (100%) n: 510	5884 (100%) n: 526	4406 (100%) n: 486	4219 (100%) n: 310	9664 (100%) n: 713	9834 (100%) n: 642	11383 (100%) n: 669	9856 (100%) n: 593	6333 (100%) n: 388
Start date not null	4895 (100%) n: 510	5884 (100%) n: 526	4406 (100%) n: 486	4219 (100%) n: 310	9664 (100%) n: 713	9834 (100%) n: 642	11383 (100%) n: 669	9856 (100%) n: 593	6333 (100%) n: 388
End date not null	4895 (100%) n: 510	5884 (100%) n: 526	4406 (100%) n: 486	4219 (100%) n: 310	9664 (100%) n: 713	9834 (100%) n: 642	11383 (100%) n: 669	9856 (100%) n: 593	6333 (100%) n: 388
Start depth not null	4884 (100%) n: 508	5628 (100%) n: 501	4358 (100%) n: 483	4146 (100%) n: 306	9122 (94%) n: 677	9346 (95%) n: 621	11338 (100%) n: 666	9786 (100%) n: 577	6333 (100%) n: 388
Headline height not null	4884 (100%) n: 508	5606 (100%) n: 499	4269 (100%) n: 475	4104 (100%) n: 305	9018 (93%) n: 670	9291 (94%) n: 617	11249 (100%) n: 663	9786 (100%) n: 576	6333 (100%) n: 388
Fishing speed >3.5kn	4884 (100%) n: 508	5606 (100%) n: 499	4269 (100%) n: 475	4104 (100%) n: 305	9018 (93%) n: 670	9291 (94%) n: 617	11249 (100%) n: 663	9786 (100%) n: 576	6331 (100%) n: 387
Headline height >15m	4884 (100%) n: 508	5586 (95%) n: 497	4233 (100%) n: 474	4104 (100%) n: 305	8954 (93%) n: 669	9216 (93%) n: 614	11249 (100%) n: 663	9786 (100%) n: 576	6331 (100%) n: 387
Headline height <90m	4884 (100%) n: 508	5586 (95%) n: 497	4233 (100%) n: 474	4094 (100%) n: 304	8943 (93%) n: 668	9216 (93%) n: 614	11231 (100%) n: 662	9771 (100%) n: 575	6331 (100%) n: 387
Fishing duration >15mins	4884 (100%) n: 507	5586 (95%) n: 497	4233 (100%) n: 474	4016 (100%) n: 301	8922 (92%) n: 667	9178 (93%) n: 612	11226 (100%) n: 660	9771 (100%) n: 575	6328 (100%) n: 386
Seabed depth >50m	4884 (100%) n: 507	5573 (95%) n: 495	4226 (100%) n: 473	4016 (100%) n: 301	8922 (92%) n: 666	9159 (93%) n: 611	11226 (100%) n: 660	9755 (100%) n: 574	6328 (100%) n: 386
Seabed depth <400m	4865 (100%) n: 504	5573 (95%) n: 495	4217 (100%) n: 472	4016 (100%) n: 301	8809 (91%) n: 659	9134 (93%) n: 609	11222 (100%) n: 659	9675 (100%) n: 571	6328 (100%) n: 386
Start time >0	4675 (94%) n: 495	5549 (94%) n: 492	4137 (93%) n: 468	4002 (95%) n: 298	8778 (91%) n: 652	9075 (92%) n: 606	11067 (100%) n: 649	9618 (100%) n: 568	6287 (100%) n: 383
Only good trip	102 (2%) n: 15	1962 (33%) n: 227	742 (17%) n: 107	776 (18%) n: 60	169 (2%) n: 11	1097 (11%) n: 59	178 (2%) n: 16	4737 (48%) n: 240	1202 (19%) n: 69
Core fleet selection	102 (2%) n: 15	1962 (33%) n: 227	500 (11%) n: 57	776 (18%) n: 60	169 (2%) n: 11	1097 (11%) n: 59	178 (2%) n: 16	4382 (44%) n: 228	1031 (16%) n: 65

Filter	2017	2018	2019	2020
Ungroomed data	5899 (100%) n: 309	8658 (100%) n: 433	8557 (100%) n: 380	6557 (100%) n: 397
Fishing speed not null	5820 (100%) n: 307	8658 (100%) n: 433	8557 (100%) n: 380	6477 (100%) n: 395
Start date not null	5820 (100%) n: 307	8658 (100%) n: 433	8557 (100%) n: 380	6477 (100%) n: 395
End date not null	5820 (100%) n: 307	8658 (100%) n: 433	8557 (100%) n: 380	6477 (100%) n: 395
Start depth not null	5764 (100%) n: 304	8646 (100%) n: 432	8557 (100%) n: 380	6477 (100%) n: 389
Headline height not null	5646 (100%) n: 300	8618 (100%) n: 430	8557 (100%) n: 380	6447 (100%) n: 387
Fishing speed >3.5kn	5646 (100%) n: 300	8618 (100%) n: 430	8557 (100%) n: 380	6447 (100%) n: 387
Headline height >15m	5636 (100%) n: 299	8618 (100%) n: 430	8557 (100%) n: 380	6447 (100%) n: 387
Headline height <90m	5636 (100%) n: 299	8577 (100%) n: 428	8557 (100%) n: 380	6447 (100%) n: 387
Fishing duration >15mins	5624 (100%) n: 298	8577 (100%) n: 428	8522 (100%) n: 379	6447 (100%) n: 387
Seabed depth >50m	5624 (100%) n: 298	8532 (100%) n: 427	8522 (100%) n: 379	6447 (100%) n: 387
Seabed depth <400m	5624 (100%) n: 298	8510 (100%) n: 425	8406 (100%) n: 377	6447 (100%) n: 387
Start time >0	5546 (94%) n: 296	8505 (100%) n: 424	8366 (100%) n: 376	6401 (100%) n: 384
Only good trip	2248 (38%) n: 101	1751 (20%) n: 52	698 (8%) n: 24	965 (15%) n: 81
Core fleet selection	1960 (33%) n: 84	913 (11%) n: 35	698 (8%) n: 24	652 (1e+01%) n: 47

Table C.41: Summary of the JMD7 MW observer zero misID dataset after core fleet selection. 'Records' indicates the number of rows (events) in the dataset, and 'Records caught' indicates the percentage of events with catches of jack mackerels.

Fishing year	Vessels	Trips	Records	Hrs	Catch (t)	Records caught
2008	1	2	15	66.35	102.49	100.00
2009	3	3	227	892.72	1 961.64	98.68
2010	1	1	57	299.27	500.43	92.98
2011	4	4	60	266.60	775.69	95.00
2012	1	3	11	43.15	169.39	90.91
2013	5	10	59	235.25	1 097.39	89.83
2014	3	3	16	85.73	178.46	93.75
2015	6	19	228	1 080.50	4 382.38	95.18
2016	5	12	65	256.63	1 030.83	98.46
2017	3	7	84	413.83	1 960.04	100.00
2018	4	6	35	169.90	912.66	100.00
2019	2	6	24	80.80	698.38	100.00
2020	3	7	47	288.55	651.95	80.85

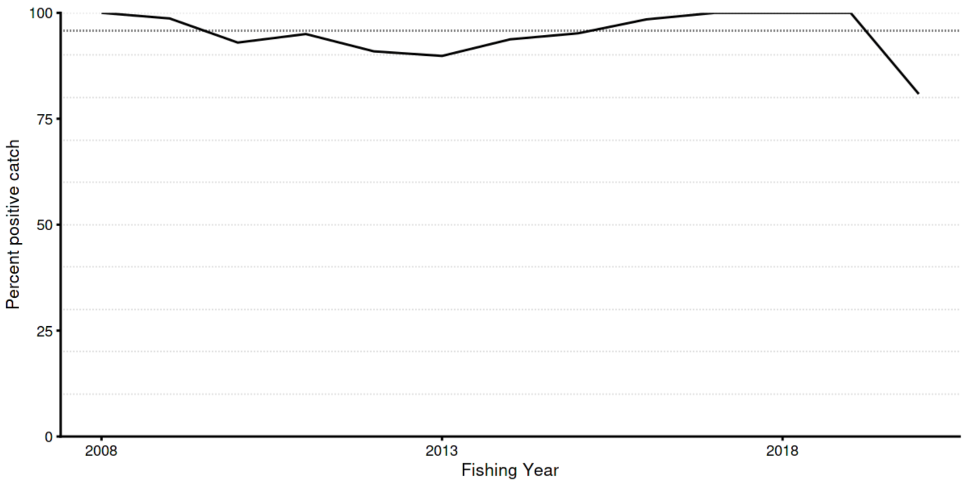

Figure C.126: Percentage of positive catch records in the JMD7 MW observer zero misID catch-per-unit-effort dataset.

Table C.42: Summary of stepwise selection for the Weibull model. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	14	18 900	11.9	11.9	*
+ ns(log(start seabed depth), 3)	3	18 755	26.2	14.3	*
+ ns(log(headline height), 3)	3	18 739	28.2	2.0	*
+ month	11	18 721	32.0	3.8	*
+ vessel key	5	18 717	33.3	1.3	*
+ ns(log(fishing duration), 3)	3	18 712	34.3	1.0	*
+ stat area	9	18 707	36.5	2.2	*

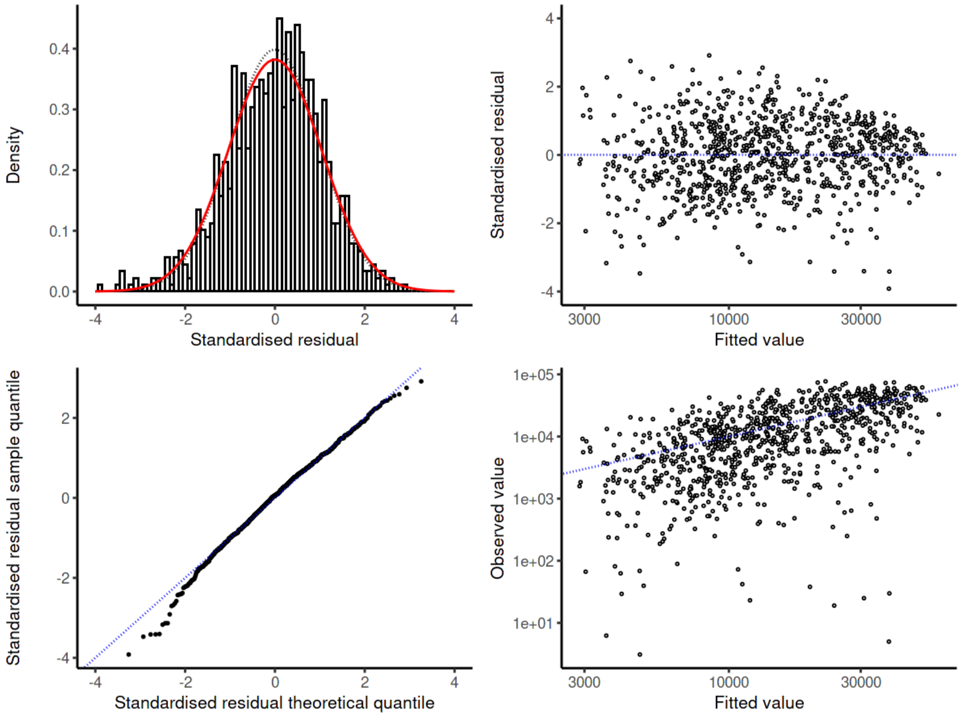

Figure C.127: Diagnostic plots for the Weibull model for the JMD7 MW observer zero misID dataset.

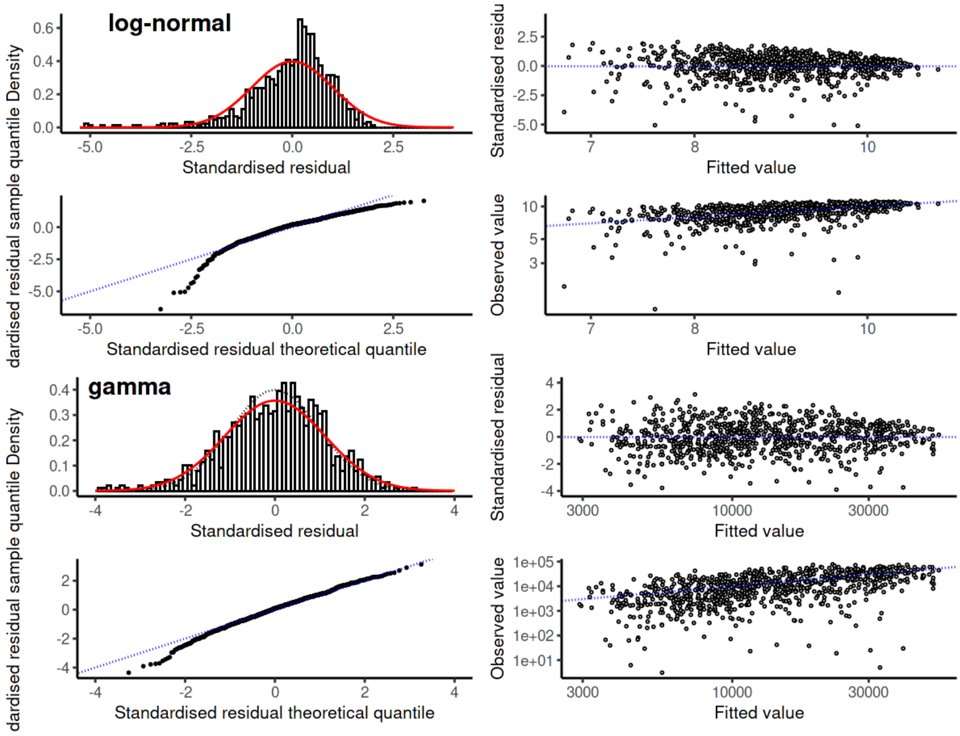

Figure C.128: Diagnostic plots for the log-normal and gamma model for the JMD7 MW observer zero misID dataset.

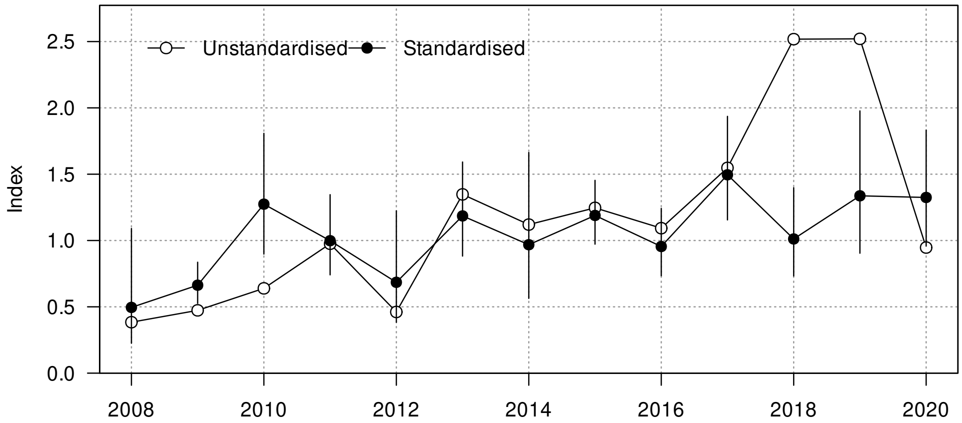

Figure C.129: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch in the JMD7 MW observer zero misID dataset.

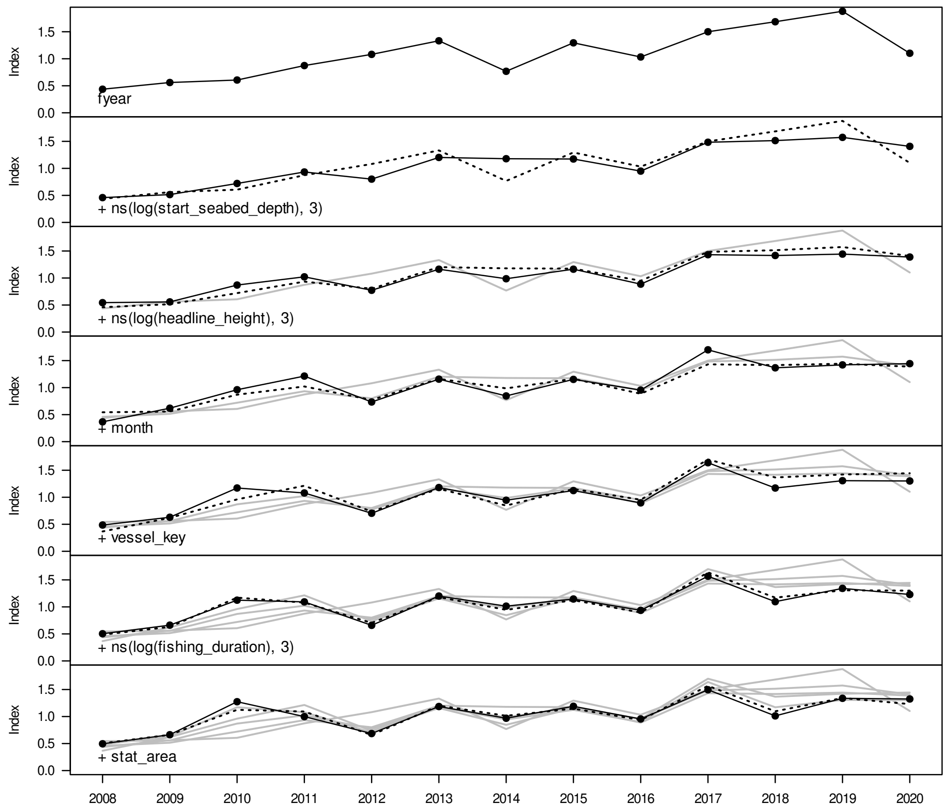

Figure C.130: Changes to the JMD7 MW observer zero misID positive catch index as terms are successively entered into the model.

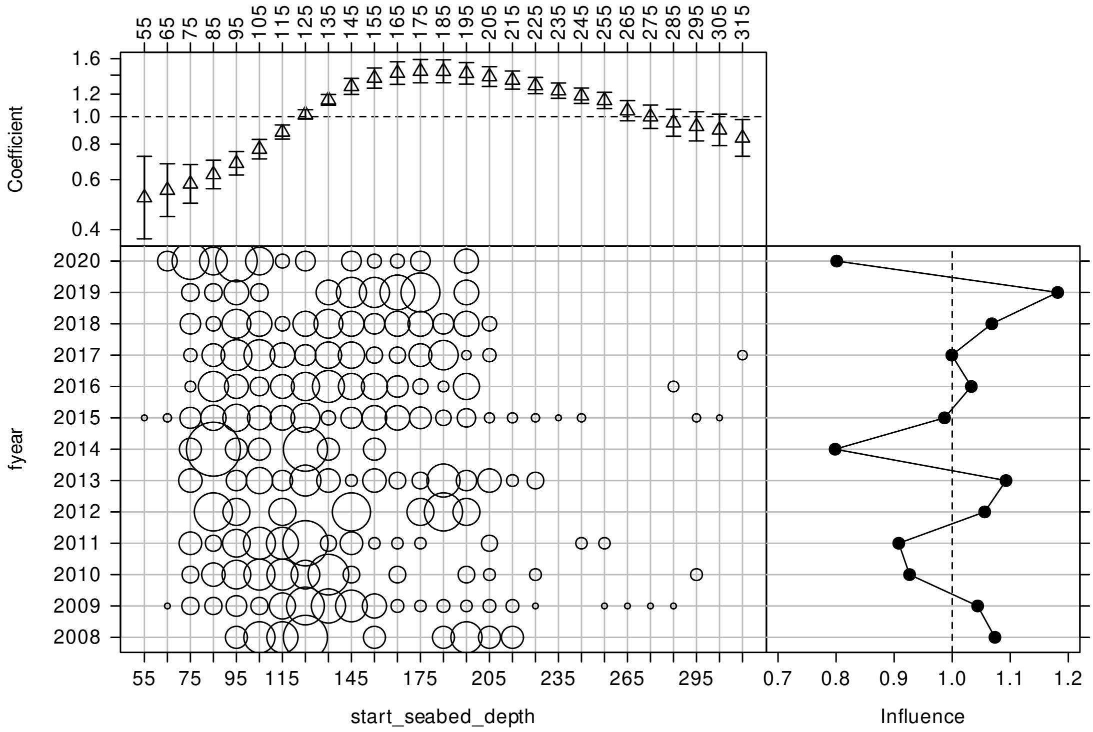

Figure C.131: CDI plot for start seabed depth (m) for the positive catch JMD7 MW observer zero misID catch-per-unit-effort dataset.

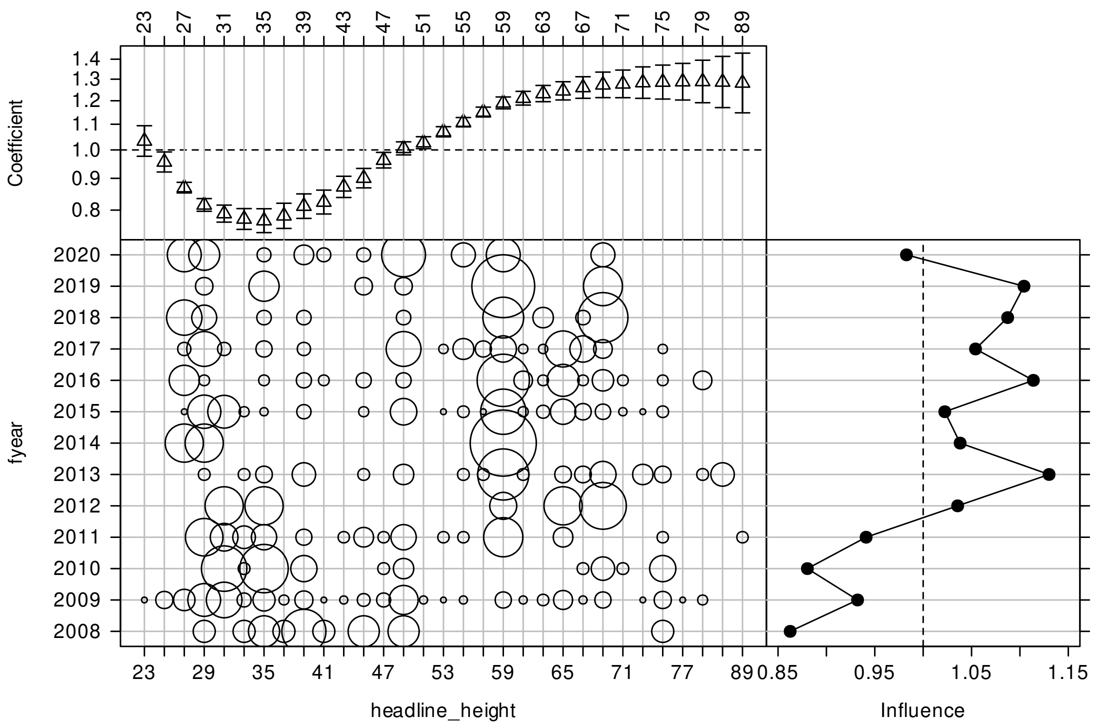

Figure C.132: CDI plot for headline height (m) for the positive catch JMD7 MW observer zero misID catch-per-unit-effort dataset.

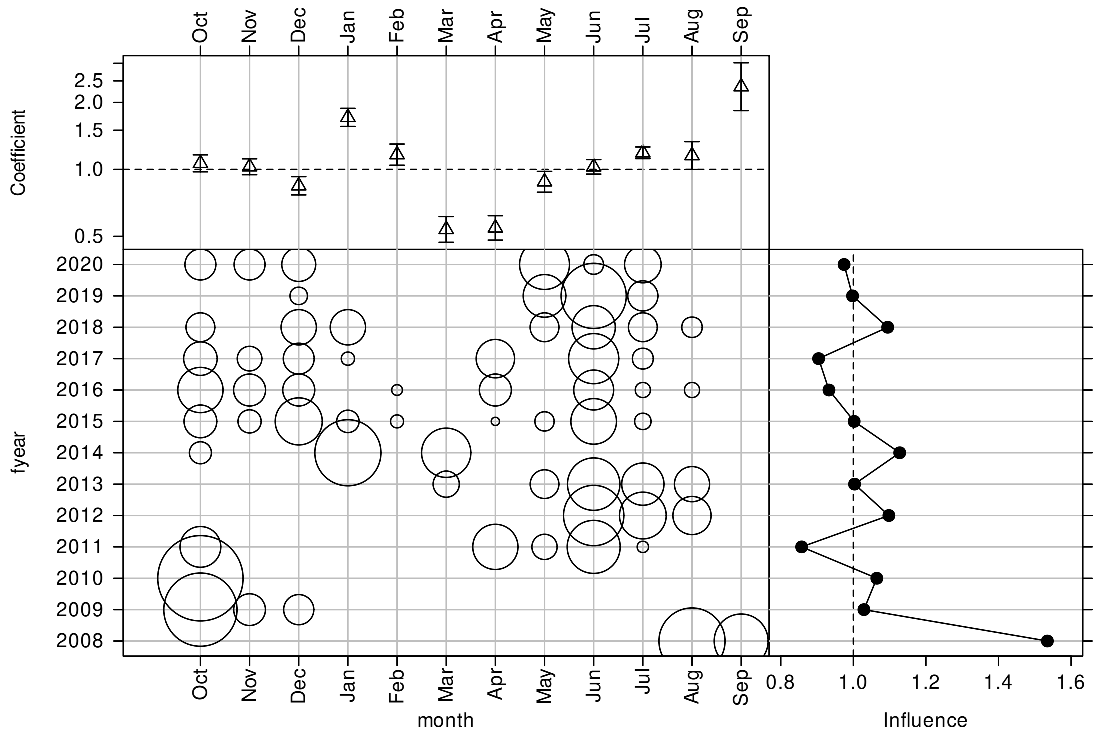

Figure C.133: CDI plot for month for the positive catch JMD7 MW observer zero misID catch-per-unit-effort dataset.

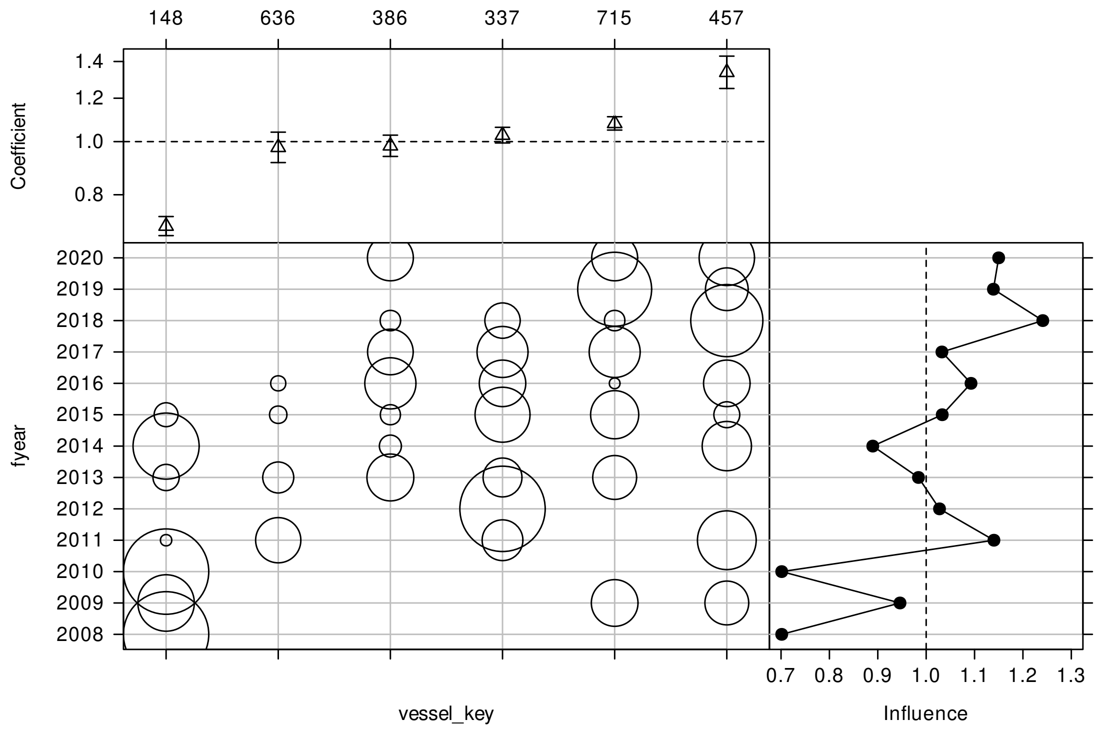

Figure C.134: CDI plot for vessel key for the positive catch JMD7 MW observer zero misID catch-per-unit-effort dataset.

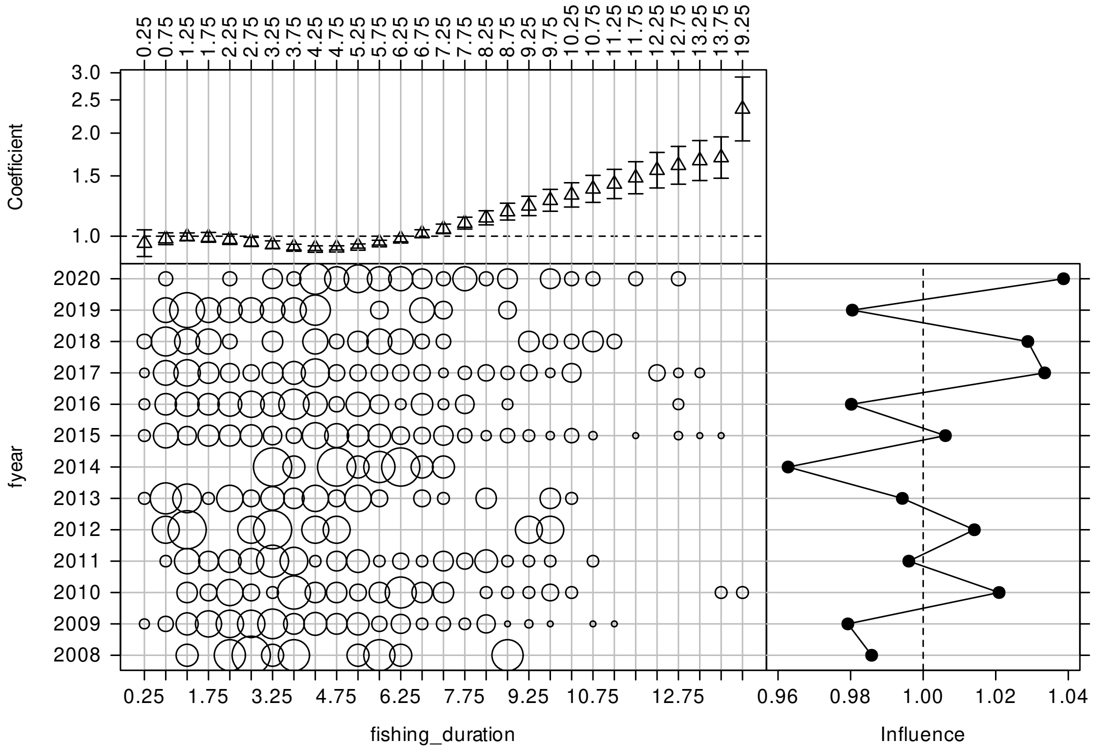

Figure C.135: CDI plot for fishing duration (h) for the positive catch JMD7 MW observer zero misID catch-per-unit-effort dataset.

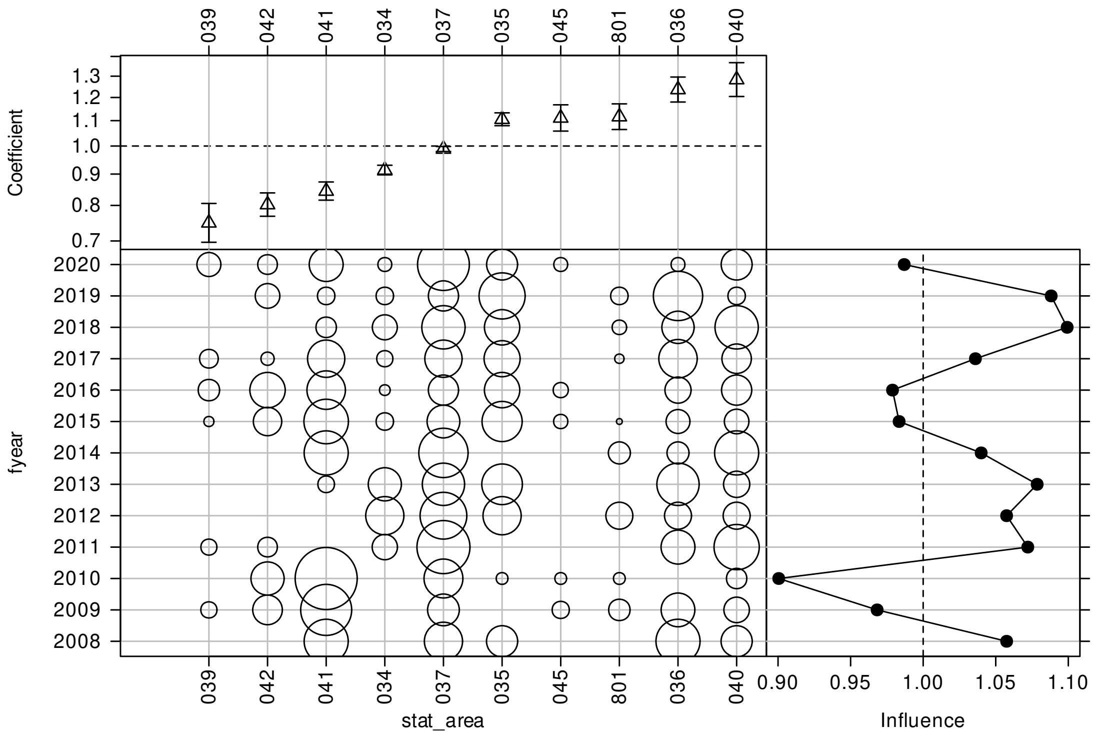

Figure C.136: CDI plot for statistical area for the positive catch JMD7 MW observer zero misID catch-per-unit-effort dataset.

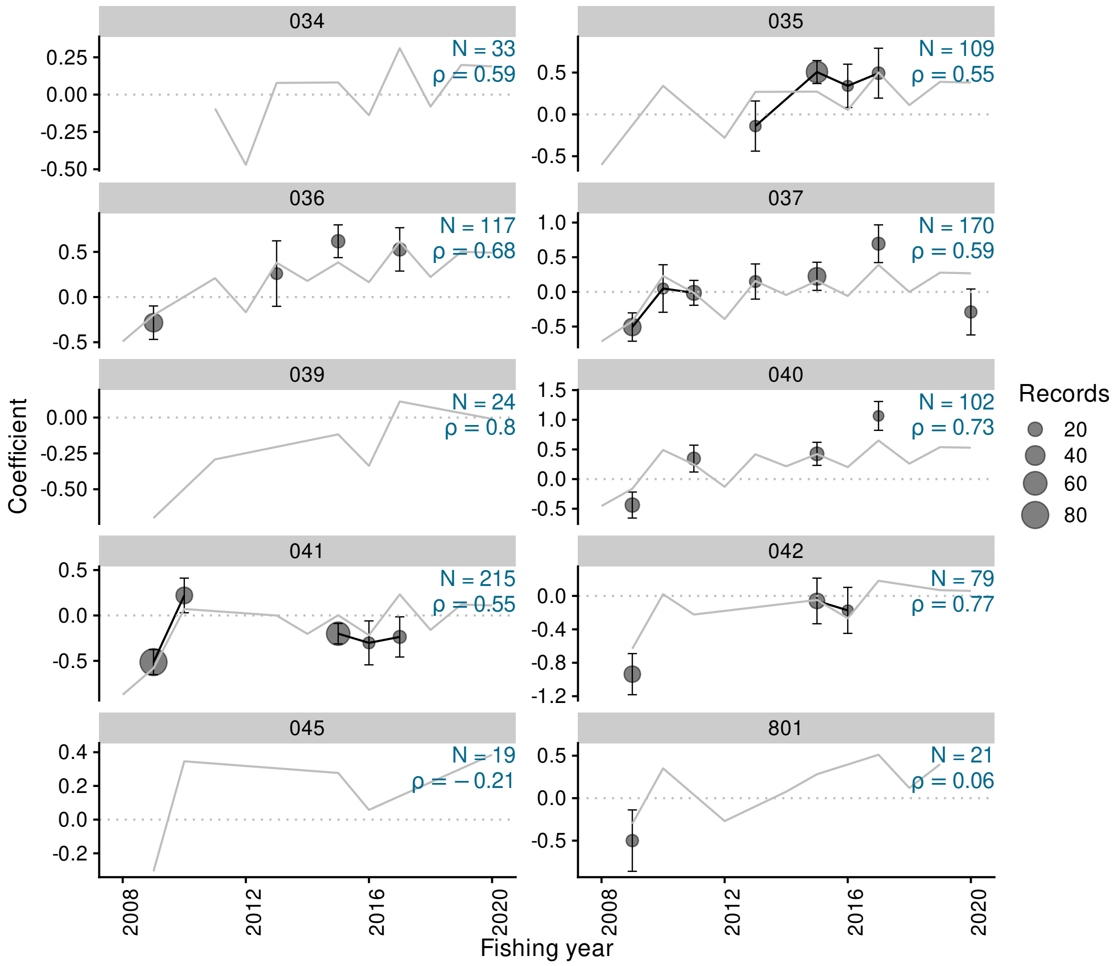

Figure C.137: Residual implied coefficients for area-year in the Weibull positive catch model for the JMD7 MW observer zero misID dataset.

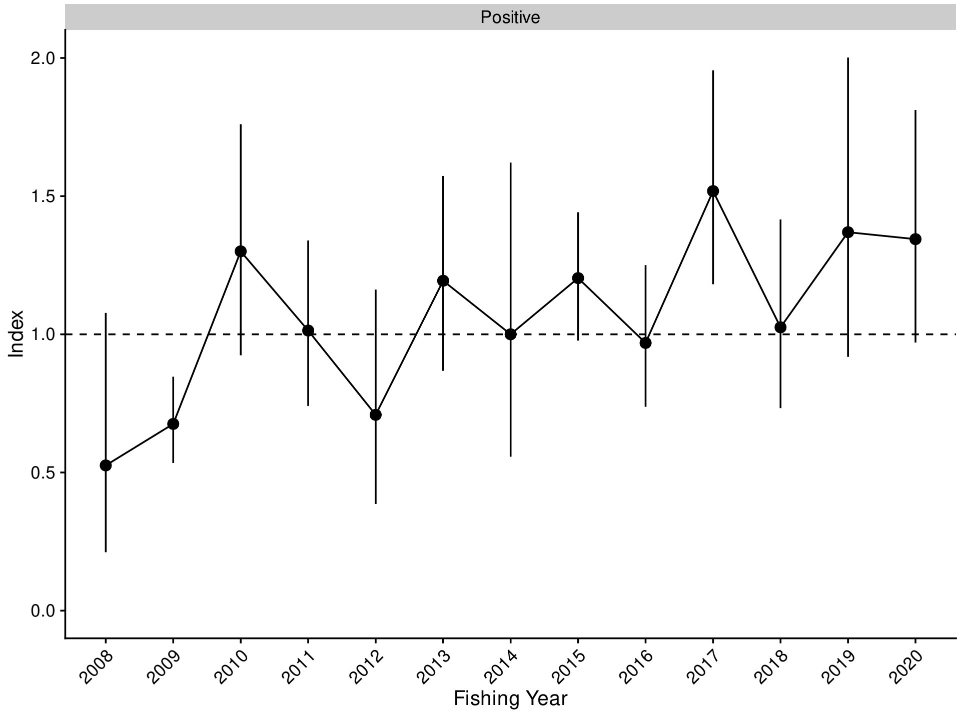

Figure C.138: Standardised indices and 95% confidence intervals for the JMD7 MW observer zero misID dataset.

Figure C.139: Standardised indices for the JMD7 MW observer zero misID dataset.

Table C.43: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in JMD7 MW observer zero misID.

	Positive			
Fishing year	index	SE	LCI	UCI
2008	0.526	0.221	0.211	1.077
2009	0.676	0.080	0.534	0.847
2010	1.300	0.213	0.924	1.760
2011	1.014	0.153	0.741	1.340
2012	0.709	0.198	0.386	1.162
2013	1.194	0.180	0.868	1.573
2014	1.000	0.272	0.557	1.621
2015	1.203	0.118	0.977	1.442
2016	0.969	0.131	0.738	1.250
2017	1.518	0.197	1.181	1.955
2018	1.025	0.174	0.733	1.416
2019	1.370	0.276	0.919	2.002
2020	1.344	0.215	0.970	1.812

C.9 JMN7 MW observer zero misID

Table C.44: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the JMN7 MW observer zero misID CPUE series.

Series	JMN7 MW observer zero misID
QMS stock	JMA7
Reporting forms	
Fishing methods	MW
Target species	JMA, JMD, JMM, JMN
Statistical Areas	037, 039, 040, 041, 042, 045
Period	2007-10-01, 2020-09-30
Resolution	Observed event
Core fleet years	4
Core fleet trips	1
Default model	jmnkg ~ fyear + vessel_key + month + stat_area + ns(log(fishing_duration), 3) + ns(log(start_time), 3) + ns(log(start_seabed_depth), 3) + ns(log(headline_height), 3) + ns(fishing_speed, 3)
Stepwise selection	Yes
Positive catch distribution	Weibull

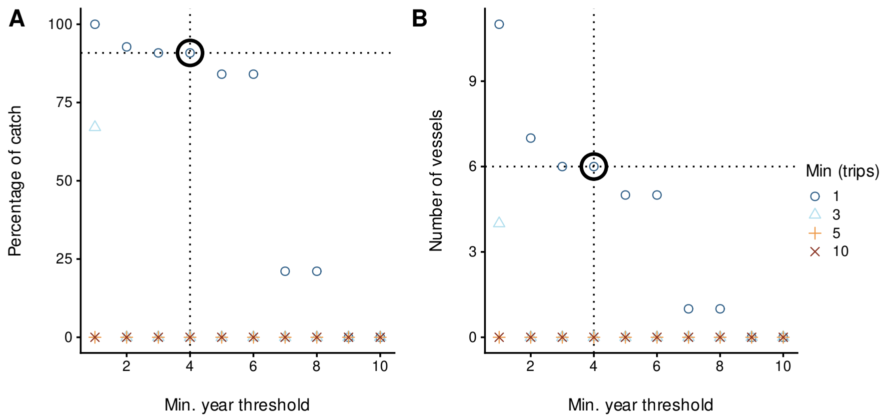

Figure C.140: Percentage of catch and number of vessels for different core vessel selection criteria for the JMN7 MW observer zero misID CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel was observed in the fishery and the number of observed trips per year.

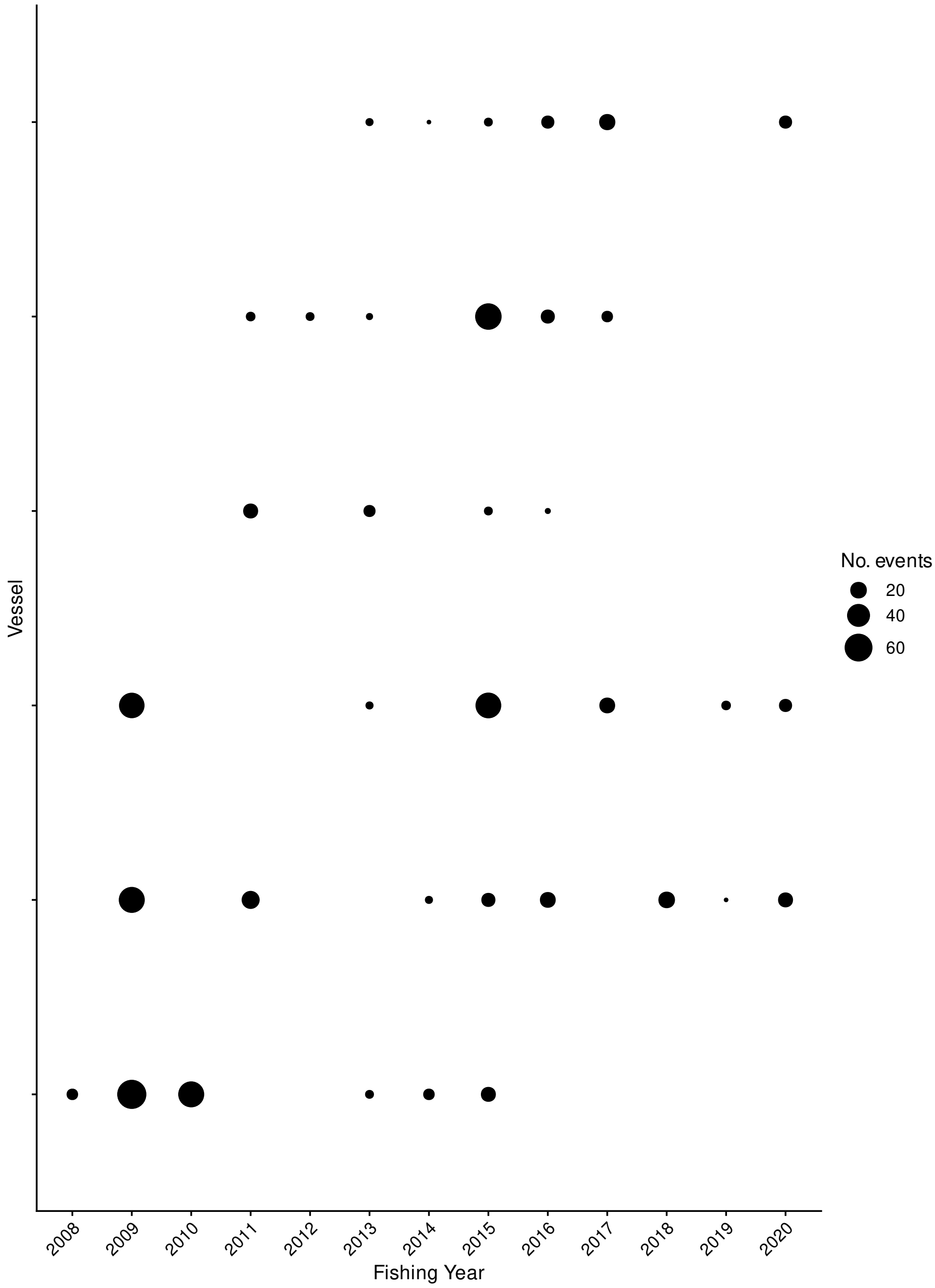

Figure C.141: Number of events by fishing year for core vessels. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table C.45: Summary of the JMN7 MW observer zero misID 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	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	2365 (100%) n: 435	2171 (100%) n: 428	2177 (100%) n: 464	1501 (100%) n: 271	4646 (100%) n: 669	4978 (100%) n: 563	3725 (100%) n: 480	5772 (100%) n: 485	3096 (100%) n: 312
Fishing speed not null	2363 (100%) n: 434	2171 (100%) n: 428	2176 (100%) n: 463	1501 (100%) n: 271	4646 (100%) n: 669	4978 (100%) n: 562	3725 (100%) n: 480	5772 (100%) n: 485	3096 (100%) n: 311
Start date not null	2363 (100%) n: 434	2171 (100%) n: 428	2176 (100%) n: 463	1501 (100%) n: 271	4646 (100%) n: 669	4978 (100%) n: 562	3725 (100%) n: 480	5772 (100%) n: 485	3096 (100%) n: 311
End date not null	2363 (100%) n: 434	2171 (100%) n: 428	2176 (100%) n: 463	1501 (100%) n: 271	4646 (100%) n: 669	4978 (100%) n: 562	3725 (100%) n: 480	5772 (100%) n: 485	3096 (100%) n: 311
Start depth not null	2363 (100%) n: 433	2046 (94%) n: 405	2171 (100%) n: 460	1476 (100%) n: 267	4285 (92%) n: 634	4879 (100%) n: 542	3705 (100%) n: 478	5512 (100%) n: 469	3096 (100%) n: 311
Headline height not null	2363 (100%) n: 433	2007 (92%) n: 404	2114 (100%) n: 452	1476 (100%) n: 266	4265 (92%) n: 627	4847 (100%) n: 538	3705 (100%) n: 477	5508 (100%) n: 468	3096 (100%) n: 311
Fishing speed >3.5kn	2363 (100%) n: 433	2007 (92%) n: 404	2114 (100%) n: 452	1476 (100%) n: 266	4265 (92%) n: 627	4847 (100%) n: 538	3705 (100%) n: 477	5508 (100%) n: 468	3076 (100%) n: 310
Headline height >15m	2363 (100%) n: 433	2007 (92%) n: 403	2111 (100%) n: 451	1476 (100%) n: 266	4265 (92%) n: 627	4845 (100%) n: 535	3705 (100%) n: 477	5508 (100%) n: 468	3076 (100%) n: 310
Headline height <90m	2363 (100%) n: 433	2007 (92%) n: 403	2111 (100%) n: 451	1454 (100%) n: 265	4265 (92%) n: 626	4845 (100%) n: 535	3705 (100%) n: 477	5508 (100%) n: 468	3076 (100%) n: 310
Fishing duration >15mins	2363 (100%) n: 432	2007 (92%) n: 403	2111 (100%) n: 451	1425 (95%) n: 263	4265 (92%) n: 626	4835 (100%) n: 533	3704 (100%) n: 475	5508 (100%) n: 468	3076 (100%) n: 309
Seabed depth >50m	2363 (100%) n: 432	2005 (92%) n: 401	2086 (100%) n: 450	1425 (95%) n: 263	4264 (92%) n: 625	4835 (100%) n: 532	3704 (100%) n: 475	5504 (100%) n: 467	3076 (100%) n: 309
Seabed depth <200m	2347 (100%) n: 419	1936 (89%) n: 390	2074 (100%) n: 438	1425 (95%) n: 262	4250 (91%) n: 612	4820 (100%) n: 524	3690 (100%) n: 472	5474 (95%) n: 457	3000 (100%) n: 305
Start time >0	2332 (100%) n: 414	1936 (89%) n: 389	2074 (100%) n: 435	1416 (94%) n: 259	4160 (90%) n: 606	4801 (100%) n: 522	3630 (100%) n: 465	5427 (94%) n: 454	2931 (95%) n: 302
Only good trip	86 (4%) n: 9	800 (37%) n: 168	451 (21%) n: 95	339 (23%) n: 46	19 (0.4%) n: 5	253 (5%) n: 26	80 (2%) n: 14	1767 (31%) n: 150	588 (19%) n: 46
Core fleet selection	86 (4%) n: 9	800 (37%) n: 168	365 (17%) n: 52	339 (23%) n: 46	19 (0.4%) n: 5	253 (5%) n: 26	80 (2%) n: 14	1766 (31%) n: 145	588 (19%) n: 46

Filter	2017	2018	2019	2020
Ungroomed data	2640 (100%) n: 238	4601 (100%) n: 346	2822 (100%) n: 302	2942 (100%) n: 329
Fishing speed not null	2638 (100%) n: 236	4601 (100%) n: 346	2822 (100%) n: 302	2942 (100%) n: 328
Start date not null	2638 (100%) n: 236	4601 (100%) n: 346	2822 (100%) n: 302	2942 (100%) n: 328
End date not null	2638 (100%) n: 236	4601 (100%) n: 346	2822 (100%) n: 302	2942 (100%) n: 328
Start depth not null	2605 (100%) n: 234	4587 (100%) n: 345	2822 (100%) n: 302	2879 (100%) n: 323
Headline height not null	2605 (100%) n: 230	4582 (100%) n: 343	2822 (100%) n: 302	2879 (100%) n: 322
Fishing speed >3.5kn	2605 (100%) n: 230	4582 (100%) n: 343	2822 (100%) n: 302	2879 (100%) n: 322
Headline height >15m	2582 (100%) n: 229	4582 (100%) n: 343	2822 (100%) n: 302	2879 (100%) n: 322
Headline height <90m	2582 (100%) n: 229	4582 (100%) n: 343	2822 (100%) n: 302	2879 (100%) n: 322
Fishing duration >15mins	2564 (100%) n: 228	4582 (100%) n: 343	2822 (100%) n: 302	2879 (100%) n: 322
Seabed depth >50m	2564 (100%) n: 228	4573 (100%) n: 342	2822 (100%) n: 302	2879 (100%) n: 322
Seabed depth <200m	2564 (100%) n: 226	4403 (100%) n: 332	2758 (100%) n: 279	2878 (100%) n: 317
Start time >0	2558 (100%) n: 225	4393 (100%) n: 331	2758 (100%) n: 279	2823 (100%) n: 314
Only good trip	721 (27%) n: 54	223 (5%) n: 30	7.3 (0.3%) n: 7	971 (33%) n: 73
Core fleet selection	685 (26%) n: 46	182 (4%) n: 20	7.3 (0.3%) n: 7	556 (19%) n: 40

Table C.46: Summary of the JMN7 MW observer zero misID dataset after core fleet selection. 'Records' indicates the number of rows (events) in the dataset, and 'Records caught' indicates the percentage of events with catches of jack mackerels.

Fishing year	Vessels	Trips	Records	Hrs	Catch (t)	Records caught
2008	1	2	9	39.18	85.70	77.78
2009	3	3	168	650.93	799.92	81.55
2010	1	1	52	277.90	365.32	86.54
2011	3	3	46	215.47	339.13	60.87
2012	1	2	5	17.87	18.60	100.00
2013	5	7	26	122.85	252.98	69.23
2014	3	3	14	74.57	80.20	78.57
2015	6	13	145	757.80	1 766.16	84.14
2016	4	7	46	208.65	587.80	80.43
2017	3	5	46	299.03	685.37	91.30
2018	1	2	20	129.12	182.05	65.00
2019	2	3	7	29.63	7.30	42.86
2020	3	7	40	247.05	555.66	67.50

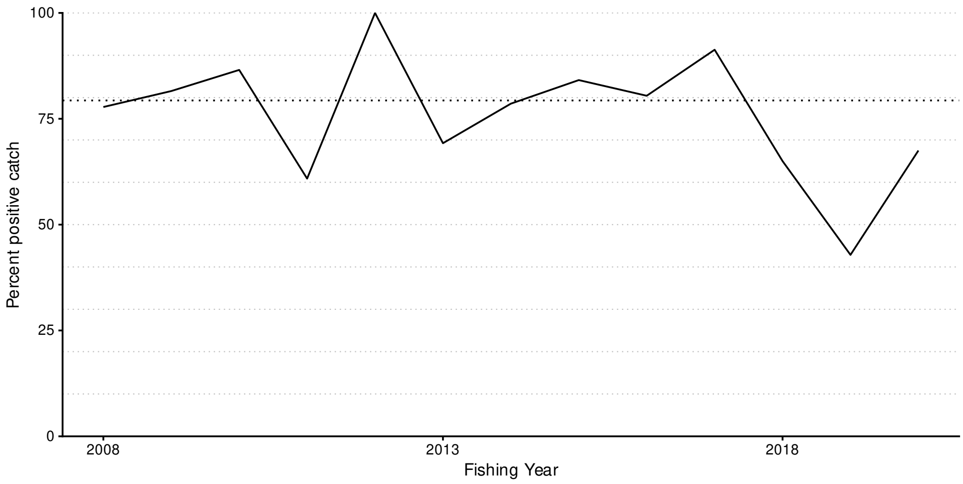

Figure C.142: Percentage of positive catch records in the JMN7 MW observer zero misID catch-per-unit-effort dataset.

Table C.47: Summary of stepwise selection for the Weibull model. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	14	10 175	13.0	13.0	*
+ stat area	5	10 105	26.2	13.3	*
+ ns(log(start seabed depth), 3)	3	10 099	28.4	2.2	*
+ ns(log(start time), 3)	3	10 091	30.6	2.2	*
+ ns(log(fishing duration), 3)	3	10 090	31.8	1.2	*
+ ns(log(headline height), 3)	3	10 090	32.8	1.0	*

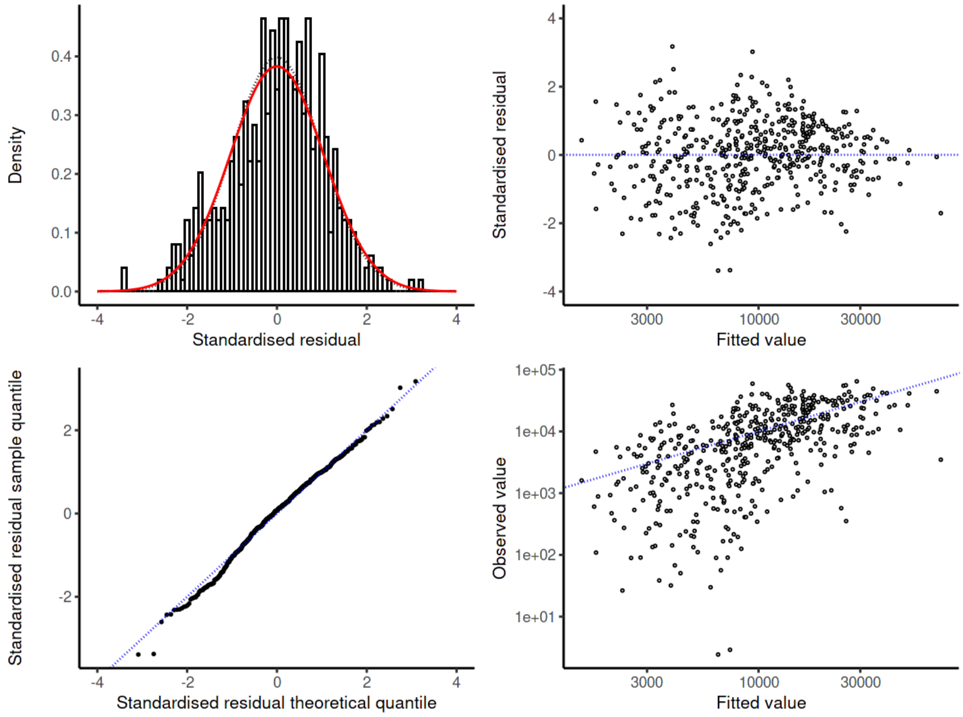

Figure C.143: Diagnostic plots for the Weibull model for the JMN7 MW observer zero misID dataset.

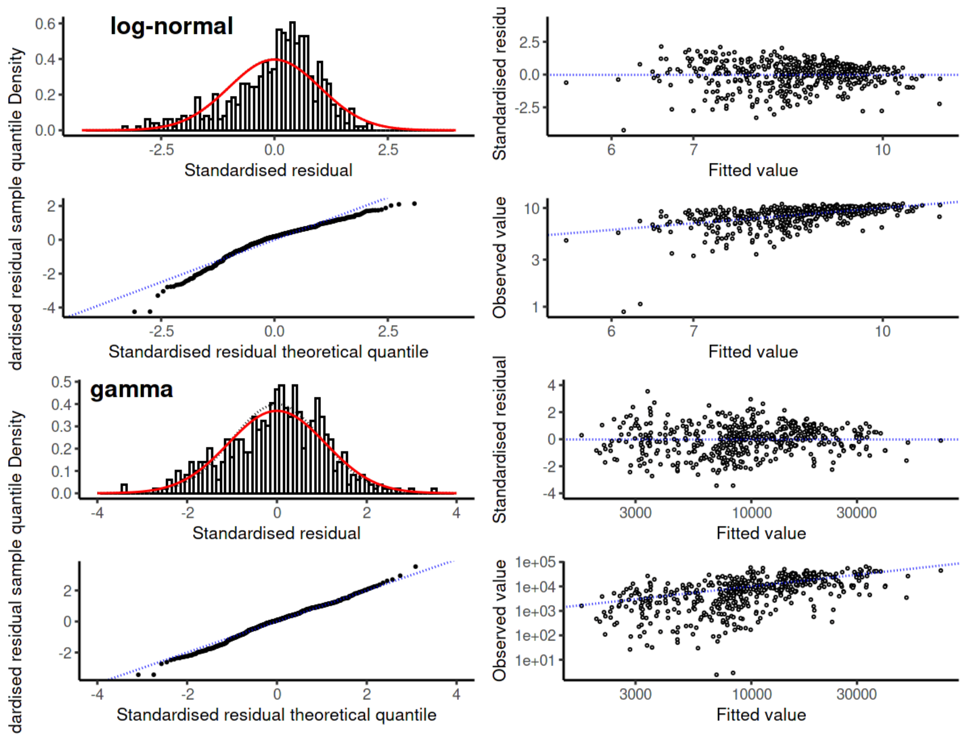

Figure C.144: Diagnostic plots for the log-normal and gamma model for the JMN7 MW observer zero misID dataset.

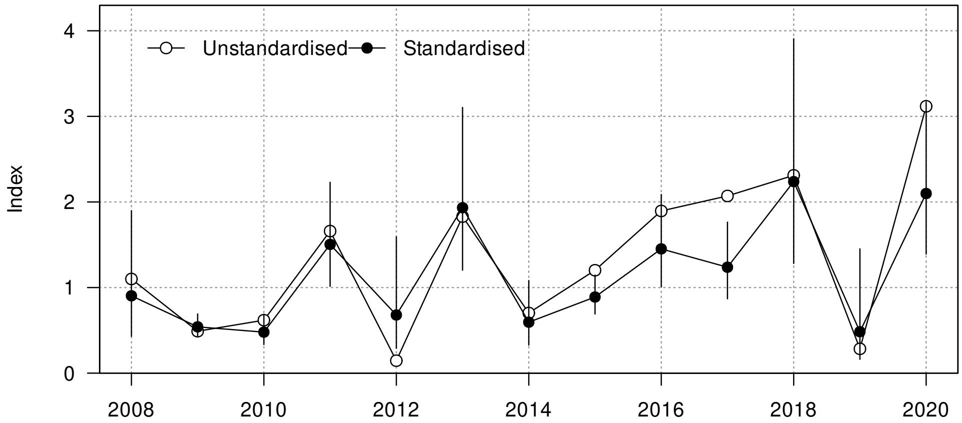

Figure C.145: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch in the JMN7 MW observer zero misID dataset.

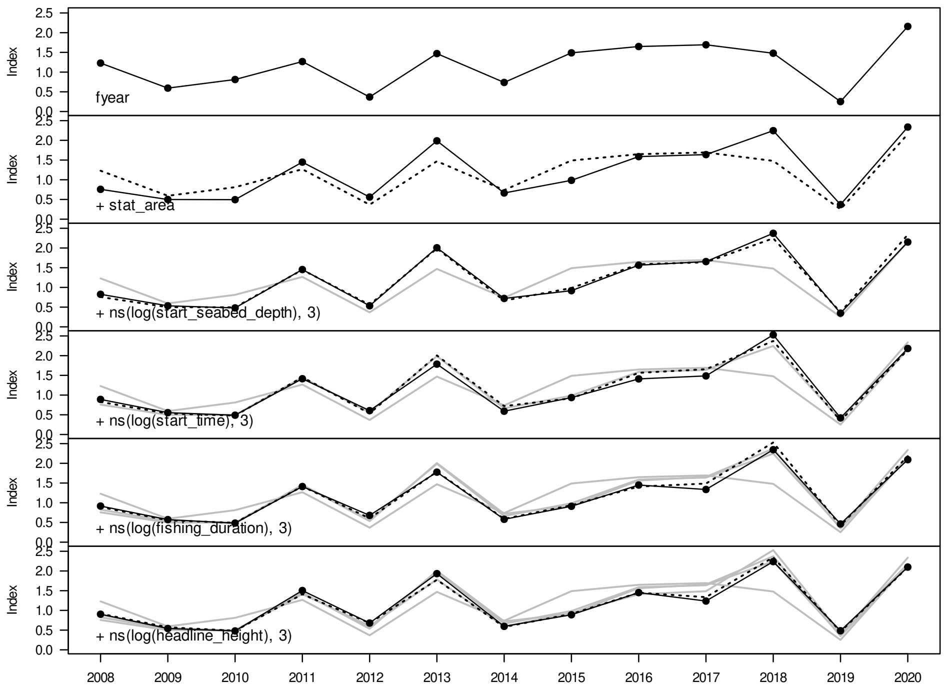

Figure C.146: Changes to the JMN7 MW observer zero misID positive catch index as terms are successively entered into the model.

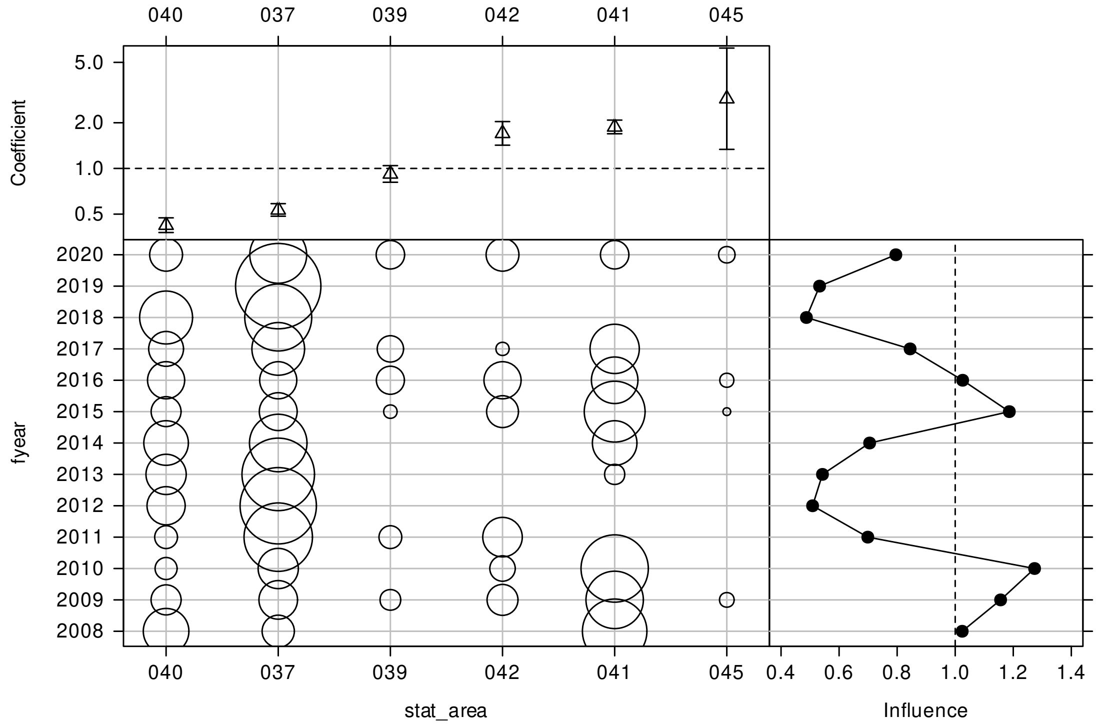

Figure C.147: CDI plot for statistical area for the positive catch JMN7 MW observer zero misID catch-per-unit-effort dataset.

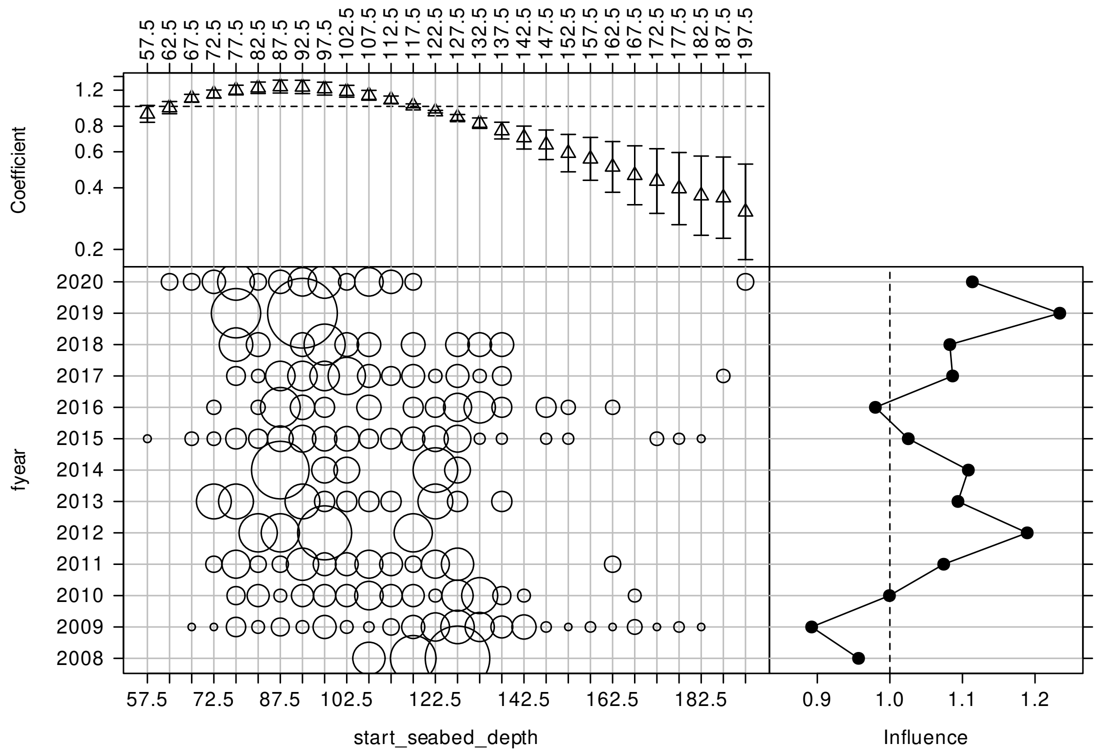

Figure C.148: CDI plot for start seabed depth (m) for the positive catch JMN7 MW observer zero misID catch-per-unit-effort dataset.

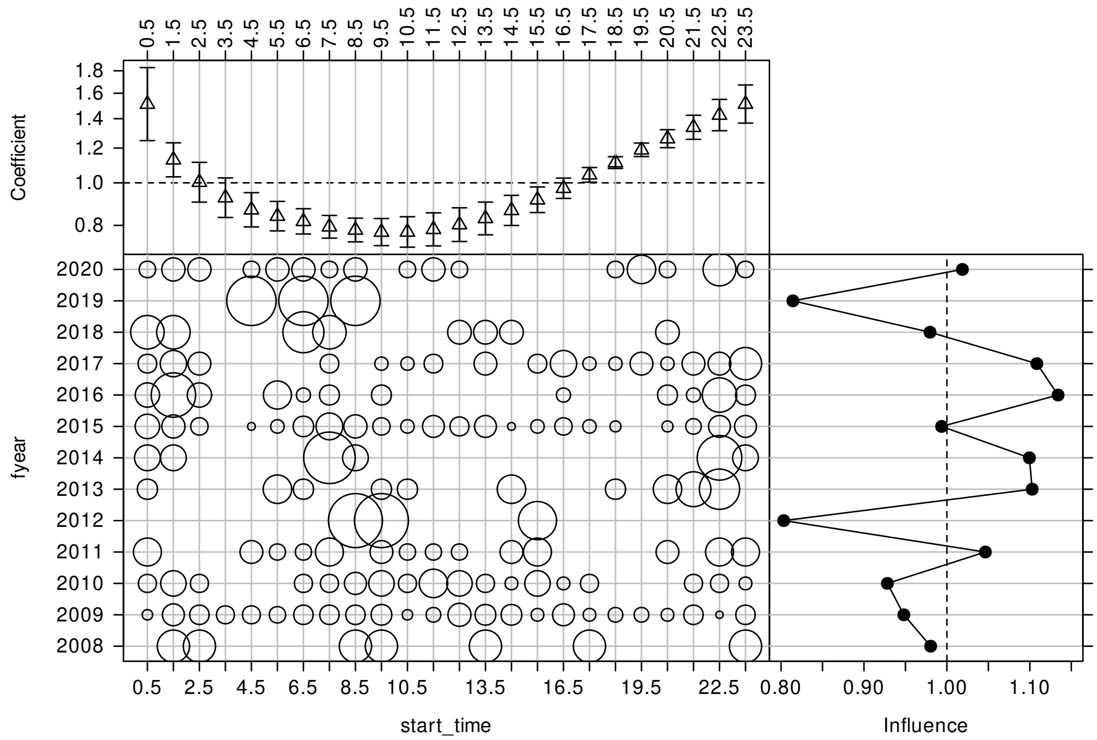

Figure C.149: CDI plot for start time for the positive catch JMN7 MW observer zero misID catch-per-unit-effort dataset.

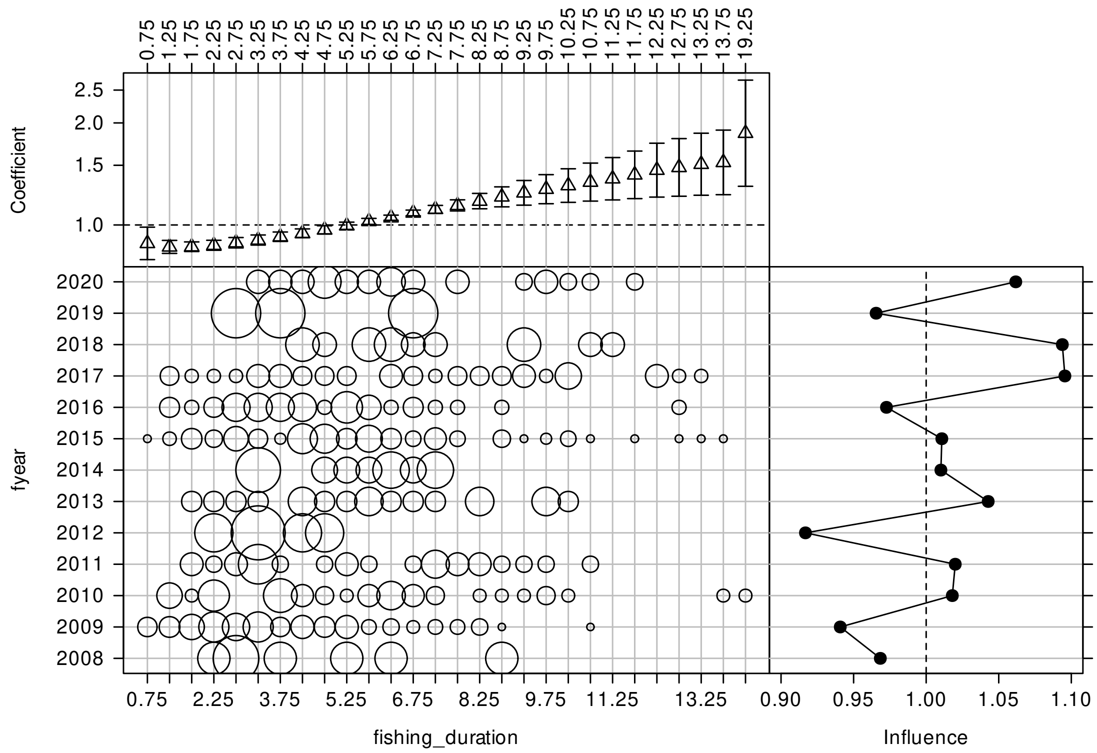

Figure C.150: CDI plot for fishing duration (h) for the positive catch JMN7 MW observer zero misID catch-per-unit-effort dataset.

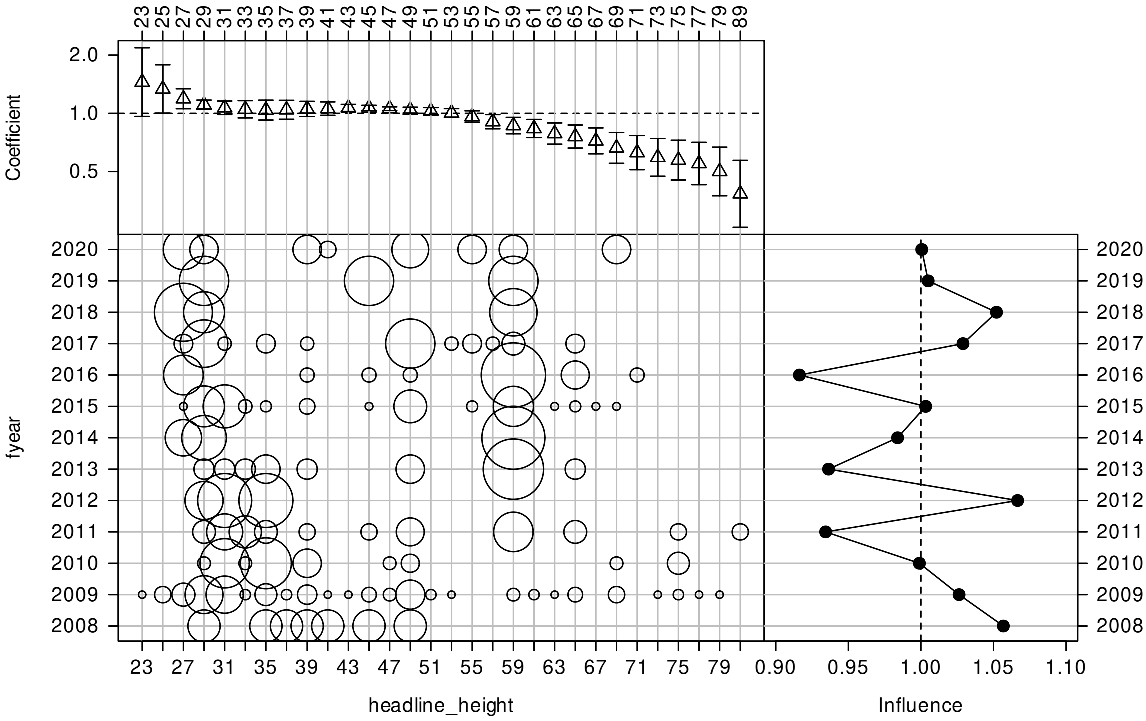

Figure C.151: CDI plot for headline height (m) for the positive catch JMN7 MW observer zero misID catch-per-unit-effort dataset.

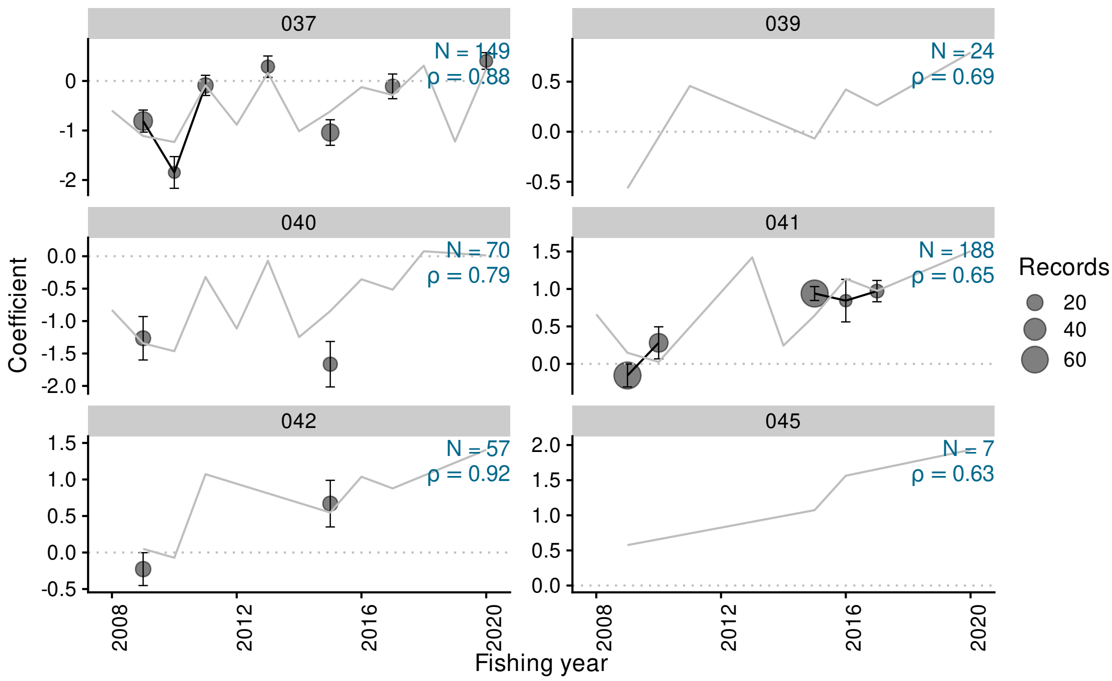

Figure C.152: Residual implied coefficients for area-year in the Weibull positive catch model for the JMN7 MW observer zero misID dataset.

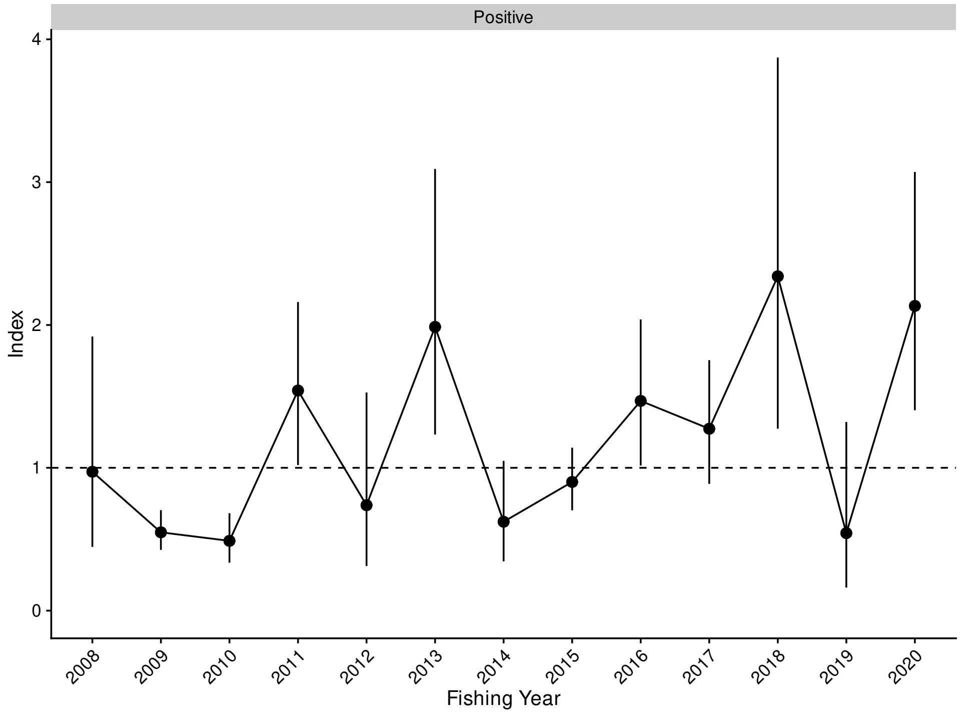

Figure C.153: Standardised indices and 95% confidence intervals for the JMN7 MW observer zero misID dataset.

Figure C.154: Standardised indices for the JMN7 MW observer zero misID dataset.

Table C.48: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in JMN7 MW observer zero misID.

	Positive			
Fishing year	index	SE	LCI	UCI
2008	0.972	0.376	0.447	1.919
2009	0.548	0.071	0.425	0.704
2010	0.489	0.088	0.336	0.682
2011	1.541	0.291	1.019	2.160
2012	0.738	0.310	0.313	1.527
2013	1.987	0.474	1.233	3.092
2014	0.622	0.179	0.345	1.048
2015	0.901	0.112	0.703	1.141
2016	1.468	0.261	1.016	2.039
2017	1.273	0.221	0.888	1.754
2018	2.341	0.663	1.274	3.872
2019	0.543	0.296	0.162	1.321
2020	2.133	0.426	1.403	3.071

C.10 JMD7 MW observer split vessels

Table C.49: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the JMD7 MW observer split vessels CPUE series.

Series	JMD7 MW observer split vessels
QMS stock	JMA7
Reporting forms	
Fishing methods	MW
Target species	JMA, JMD, JMM, JMN
Statistical Areas	034, 035, 036, 037, 039, 040, 041, 042, 045, 801
Period	1998-10-01, 2021-09-30
Resolution	Observed event
Core fleet years	4
Core fleet trips	1
Default model	jmdkg ~ fyear + vessel_key + month + stat_area + ns(log(fishing_duration), 3) + ns(log(start_time), 3) + ns(log(start_seabed_depth), 3) + ns(log(headline_height), 3) + ns(fishing_speed, 3)
Stepwise selection	Yes
Positive catch distribution	Weibull

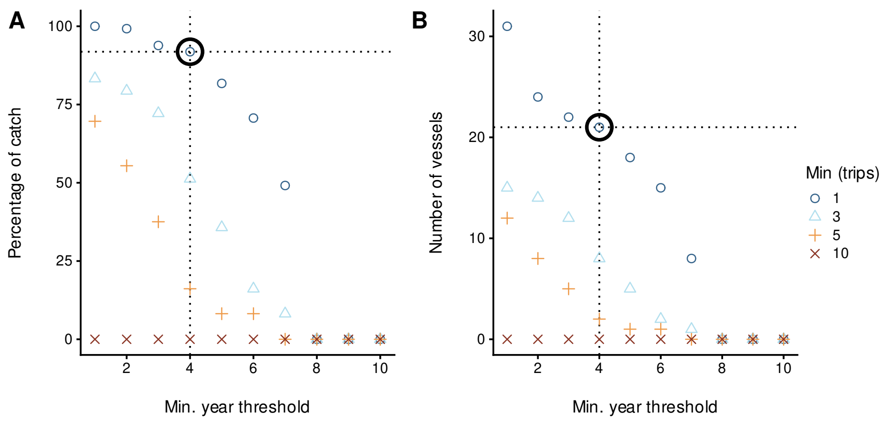

Figure C.155: Percentage of catch and number of vessels for different core vessel selection criteria for the JMD7 MW observer split vessels CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel was observed in the fishery and the number of observed trips per year.

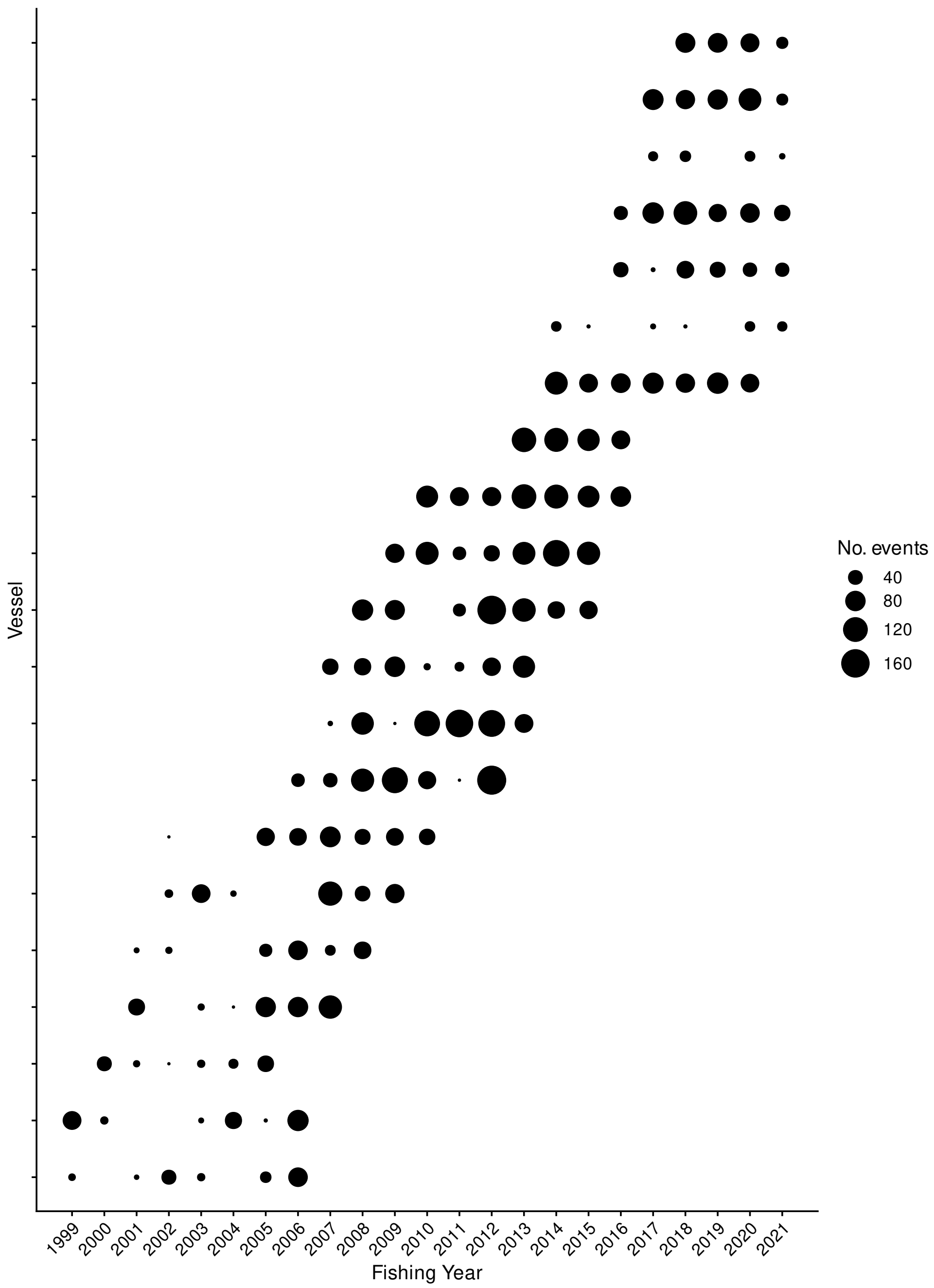

Figure C.156: Number of events by fishing year for core vessels. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table C.50: Summary of the JMD7 MW observer split vessels 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	1999	2000	2001	2002	2003	2004	2005	2006	2007
Ungroomed data	974 (100%) n: 116	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	687 (100%) n: 103	1171 (100%) n: 79	2467 (100%) n: 258	4706 (100%) n: 409	4247 (100%) n: 427
Fishing speed not null	926 (100%) n: 112	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	687 (100%) n: 103	1171 (100%) n: 79	2435 (100%) n: 256	4706 (100%) n: 409	4247 (100%) n: 427
Start date not null	926 (100%) n: 112	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	687 (100%) n: 103	1171 (100%) n: 79	2435 (100%) n: 256	4706 (100%) n: 409	4247 (100%) n: 427
End date not null	926 (100%) n: 112	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	687 (100%) n: 103	1171 (100%) n: 79	2435 (100%) n: 256	4706 (100%) n: 409	4247 (100%) n: 427
Start depth not null	926 (100%) n: 112	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	687 (100%) n: 103	1171 (100%) n: 79	2435 (100%) n: 256	4706 (100%) n: 409	4247 (100%) n: 427
Headline height not null	919 (94%) n: 111	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	679 (100%) n: 102	1171 (100%) n: 79	2435 (100%) n: 256	4706 (100%) n: 409	4247 (100%) n: 427
Fishing speed >3.5kn	919 (94%) n: 111	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	679 (100%) n: 102	1171 (100%) n: 79	2435 (100%) n: 256	4706 (100%) n: 409	4247 (100%) n: 426
Headline height >15m	919 (94%) n: 111	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	676 (100%) n: 101	1171 (100%) n: 79	2434 (100%) n: 255	4697 (100%) n: 408	4213 (100%) n: 422
Headline height <90m	919 (94%) n: 111	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	676 (100%) n: 101	1171 (100%) n: 79	2434 (100%) n: 255	4697 (100%) n: 408	4213 (100%) n: 422
Fishing duration >15mins	898 (92%) n: 109	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	676 (100%) n: 101	1171 (100%) n: 79	2433 (100%) n: 254	4628 (100%) n: 407	4159 (100%) n: 421
Seabed depth >50m	898 (92%) n: 109	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	676 (100%) n: 101	1171 (100%) n: 79	2433 (100%) n: 254	4628 (100%) n: 407	4159 (100%) n: 421
Seabed depth <400m	885 (91%) n: 108	390 (100%) n: 53	838 (100%) n: 75	474 (100%) n: 66	676 (100%) n: 101	1171 (100%) n: 79	2423 (100%) n: 252	4628 (100%) n: 407	4159 (100%) n: 421
Start time >0	883 (91%) n: 107	388 (100%) n: 52	838 (100%) n: 75	438 (92%) n: 63	676 (100%) n: 101	1171 (100%) n: 79	2399 (100%) n: 249	4613 (100%) n: 403	4073 (100%) n: 415
Core fleet selection	710 (73%) n: 76	388 (100%) n: 52	834 (100%) n: 70	438 (92%) n: 63	676 (100%) n: 101	1171 (100%) n: 79	2399 (100%) n: 249	4613 (100%) n: 403	4073 (100%) n: 415

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	4954 (100%) n: 511	5884 (100%) n: 526	4425 (100%) n: 487	4219 (100%) n: 310	9664 (100%) n: 713	9872 (100%) n: 643	11383 (100%) n: 669	9856 (100%) n: 593	6348 (100%) n: 389
Fishing speed not null	4895 (100%) n: 510	5884 (100%) n: 526	4406 (100%) n: 486	4219 (100%) n: 310	9664 (100%) n: 713	9834 (100%) n: 642	11383 (100%) n: 669	9856 (100%) n: 593	6333 (100%) n: 388
Start date not null	4895 (100%) n: 510	5884 (100%) n: 526	4406 (100%) n: 486	4219 (100%) n: 310	9664 (100%) n: 713	9834 (100%) n: 642	11383 (100%) n: 669	9856 (100%) n: 593	6333 (100%) n: 388
End date not null	4895 (100%) n: 510	5884 (100%) n: 526	4406 (100%) n: 486	4219 (100%) n: 310	9664 (100%) n: 713	9834 (100%) n: 642	11383 (100%) n: 669	9856 (100%) n: 593	6333 (100%) n: 388
Start depth not null	4884 (100%) n: 508	5628 (100%) n: 501	4358 (100%) n: 483	4146 (100%) n: 306	9122 (94%) n: 677	9346 (95%) n: 621	11338 (100%) n: 666	9786 (100%) n: 577	6333 (100%) n: 388
Headline height not null	4884 (100%) n: 508	5606 (100%) n: 499	4269 (100%) n: 475	4104 (100%) n: 305	9018 (93%) n: 670	9291 (94%) n: 617	11249 (100%) n: 663	9786 (100%) n: 576	6333 (100%) n: 388
Fishing speed >3.5kn	4884 (100%) n: 508	5606 (100%) n: 499	4269 (100%) n: 475	4104 (100%) n: 305	9018 (93%) n: 670	9291 (94%) n: 617	11249 (100%) n: 663	9786 (100%) n: 576	6331 (100%) n: 387
Headline height >15m	4884 (100%) n: 508	5586 (95%) n: 497	4233 (100%) n: 474	4104 (100%) n: 305	8954 (93%) n: 669	9216 (93%) n: 614	11249 (100%) n: 663	9786 (100%) n: 576	6331 (100%) n: 387
Headline height <90m	4884 (100%) n: 508	5586 (95%) n: 497	4233 (100%) n: 474	4094 (100%) n: 304	8943 (93%) n: 668	9216 (93%) n: 614	11231 (100%) n: 662	9771 (100%) n: 575	6331 (100%) n: 387
Fishing duration >15mins	4884 (100%) n: 507	5586 (95%) n: 497	4233 (100%) n: 474	4016 (100%) n: 301	8922 (92%) n: 667	9178 (93%) n: 612	11226 (100%) n: 660	9771 (100%) n: 575	6328 (100%) n: 386
Seabed depth >50m	4884 (100%) n: 507	5573 (95%) n: 495	4226 (100%) n: 473	4016 (100%) n: 301	8922 (92%) n: 666	9159 (93%) n: 611	11226 (100%) n: 660	9755 (100%) n: 574	6328 (100%) n: 386
Seabed depth <400m	4865 (100%) n: 504	5573 (95%) n: 495	4217 (100%) n: 472	4016 (100%) n: 301	8809 (91%) n: 659	9134 (93%) n: 609	11222 (100%) n: 659	9675 (100%) n: 571	6328 (100%) n: 386
Start time >0	4675 (94%) n: 495	5549 (94%) n: 492	4137 (93%) n: 468	4002 (95%) n: 298	8778 (91%) n: 652	9075 (92%) n: 606	11067 (100%) n: 649	9618 (100%) n: 568	6287 (100%) n: 383
Core fleet selection	4675 (94%) n: 495	5549 (94%) n: 492	3937 (89%) n: 445	4002 (95%) n: 298	8778 (91%) n: 652	9075 (92%) n: 606	8002 (70%) n: 541	6576 (67%) n: 425	4707 (74%) n: 301

Filter	2017	2018	2019	2020	2021
Ungroomed data	5899 (100%) n: 309	8658 (100%) n: 433	8557 (100%) n: 380	6557 (100%) n: 397	5650 (100%) n: 259
Fishing speed not null	5820 (100%) n: 307	8658 (100%) n: 433	8557 (100%) n: 380	6477 (100%) n: 395	5497 (100%) n: 255
Start date not null	5820 (100%) n: 307	8658 (100%) n: 433	8557 (100%) n: 380	6477 (100%) n: 395	5497 (100%) n: 255
End date not null	5820 (100%) n: 307	8658 (100%) n: 433	8557 (100%) n: 380	6477 (100%) n: 395	5497 (100%) n: 255
Start depth not null	5764 (100%) n: 304	8646 (100%) n: 432	8557 (100%) n: 380	6477 (100%) n: 389	5438 (100%) n: 249
Headline height not null	5646 (100%) n: 300	8618 (100%) n: 430	8557 (100%) n: 380	6447 (100%) n: 387	5438 (100%) n: 249
Fishing speed >3.5kn	5646 (100%) n: 300	8618 (100%) n: 430	8557 (100%) n: 380	6447 (100%) n: 387	5438 (100%) n: 249
Headline height >15m	5636 (100%) n: 299	8618 (100%) n: 430	8557 (100%) n: 380	6447 (100%) n: 387	5438 (100%) n: 249
Headline height <90m	5636 (100%) n: 299	8577 (100%) n: 428	8557 (100%) n: 380	6447 (100%) n: 387	5438 (100%) n: 249
Fishing duration >15mins	5624 (100%) n: 298	8577 (100%) n: 428	8522 (100%) n: 379	6447 (100%) n: 387	5438 (100%) n: 249
Seabed depth >50m	5624 (100%) n: 298	8532 (100%) n: 427	8522 (100%) n: 379	6447 (100%) n: 387	5438 (100%) n: 249
Seabed depth <400m	5624 (100%) n: 298	8510 (100%) n: 425	8406 (100%) n: 377	6447 (100%) n: 387	5438 (100%) n: 249
Start time >0	5546 (94%) n: 296	8505 (100%) n: 424	8366 (100%) n: 376	6401 (100%) n: 384	5374 (100%) n: 247
Core fleet selection	5421 (92%) n: 282	7749 (90%) n: 411	7672 (90%) n: 349	6401 (100%) n: 384	3743 (66%) n: 162

Table C.51: Summary of the JMD7 MW observer split vessels dataset after core fleet selection. 'Records' indicates the number of rows (events) in the dataset, and 'Records caught' indicates the percentage of events with catches of jack mackerels.

Fishing year	Vessels	Trips	Records	Hrs	Catch (t)	Records caught
1999	2	3	76	165.32	709.60	100.00
2000	2	2	52	137.25	387.78	98.08
2001	4	6	70	184.40	833.85	100.00
2002	5	5	63	221.45	437.53	100.00
2003	5	5	101	365.42	675.58	98.02
2004	4	4	79	333.28	1 171.09	96.20
2005	6	9	249	847.98	2 399.42	98.80
2006	6	8	403	1 479.25	4 613.02	97.52
2007	7	15	415	1 505.27	4 072.75	96.39
2008	7	16	495	1 925.52	4 675.39	94.55
2009	7	15	492	2 046.68	5 549.46	96.14
2010	6	10	445	1 957.63	3 936.90	97.53
2011	6	8	298	1 368.33	4 002.27	96.98
2012	6	20	652	3 372.07	8 777.71	96.17
2013	6	31	606	2 907.90	9 074.99	94.88
2014	6	28	541	2 524.40	8 002.28	93.53
2015	6	27	425	2 058.35	6 575.54	93.65
2016	5	26	301	1 374.25	4 707.38	91.69
2017	6	25	282	1 483.97	5 420.54	95.04
2018	7	30	411	2 455.30	7 749.00	89.78
2019	5	23	349	1 854.87	7 671.65	97.99
2020	7	30	384	1 995.42	6 401.29	87.50
2021	6	17	162	902.87	3 742.88	97.53

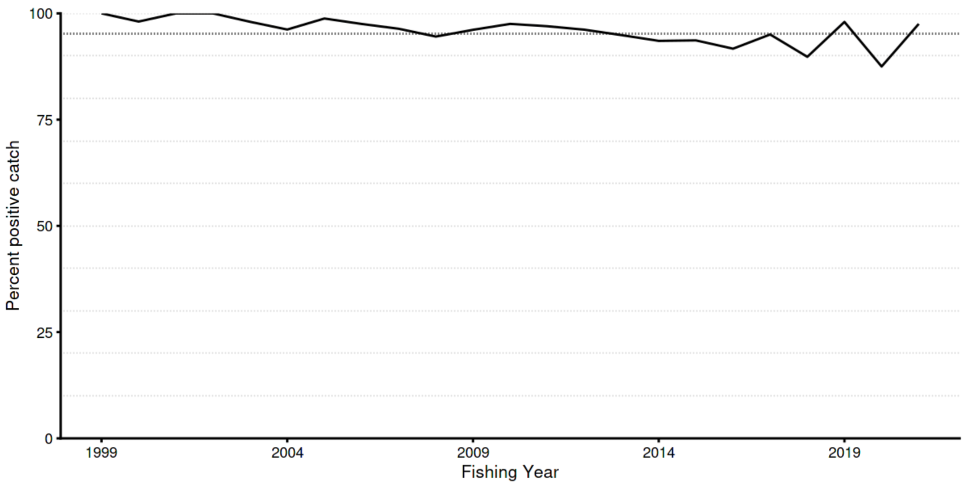

Figure C.157: Percentage of positive catch records in the JMD7 MW observer split vessels catch-per-unit-effort dataset.

Table C.52: Summary of stepwise selection for the Weibull model. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	24	147 448	7.3	7.3	*
+ ns(log(start seabed depth), 3)	3	146 965	13.3	6.0	*
+ month	11	146 790	15.7	2.4	*
+ ns(log(headline height), 3)	3	146 647	17.5	1.8	*
+ ns(log(fishing duration), 3)	3	146 550	18.8	1.3	*
+ stat area	9	146 466	20.0	1.2	*
+ vessel key	20	146 403	21.3	1.3	*
+ ns(log(start time), 3)	3	146 401	21.4	0.1	

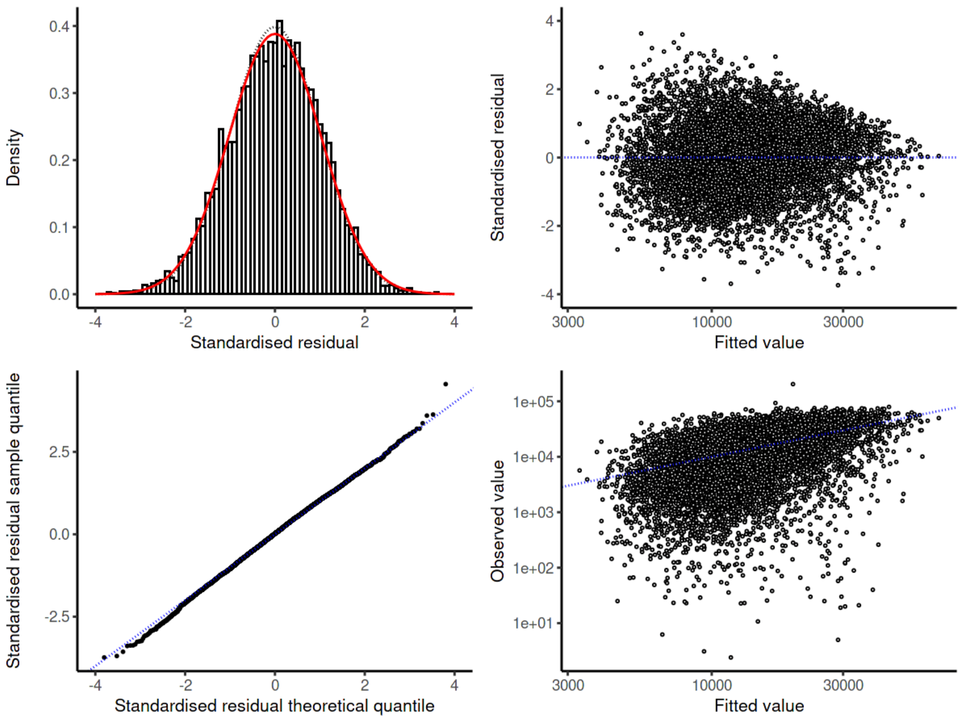

Figure C.158: Diagnostic plots for the Weibull model for the JMD7 MW observer split vessels dataset.

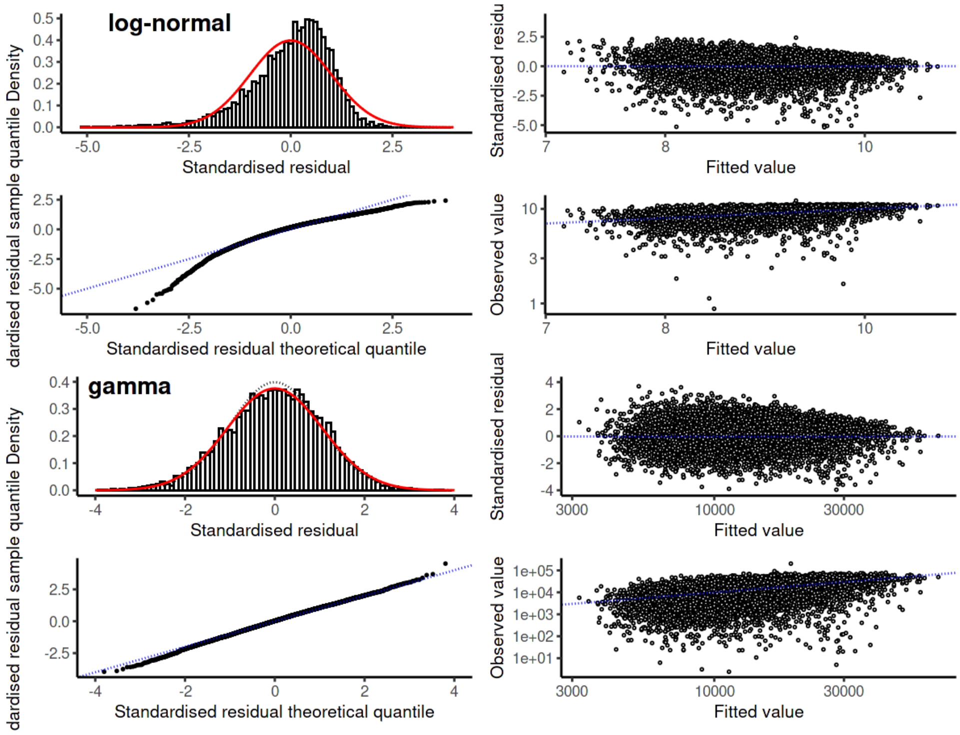

Figure C.159: Diagnostic plots for the log-normal and gamma model for the JMD7 MW observer split vessels dataset.

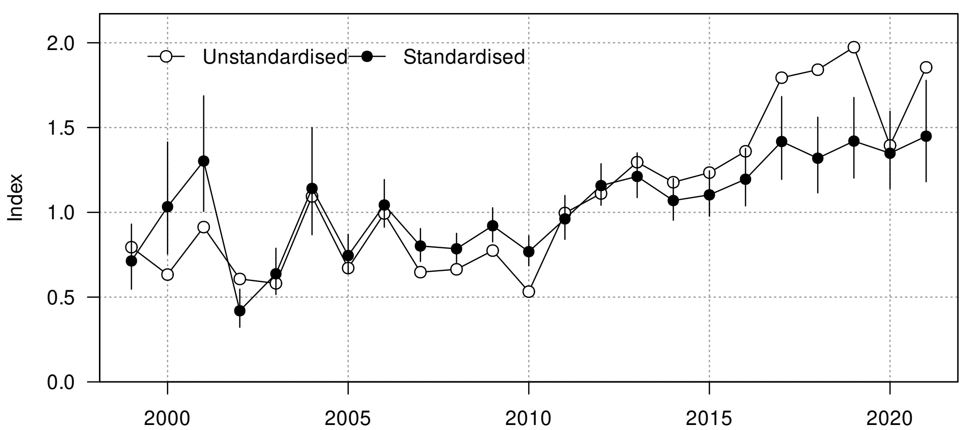

Figure C.160: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch in the JMD7 MW observer split vessels dataset.

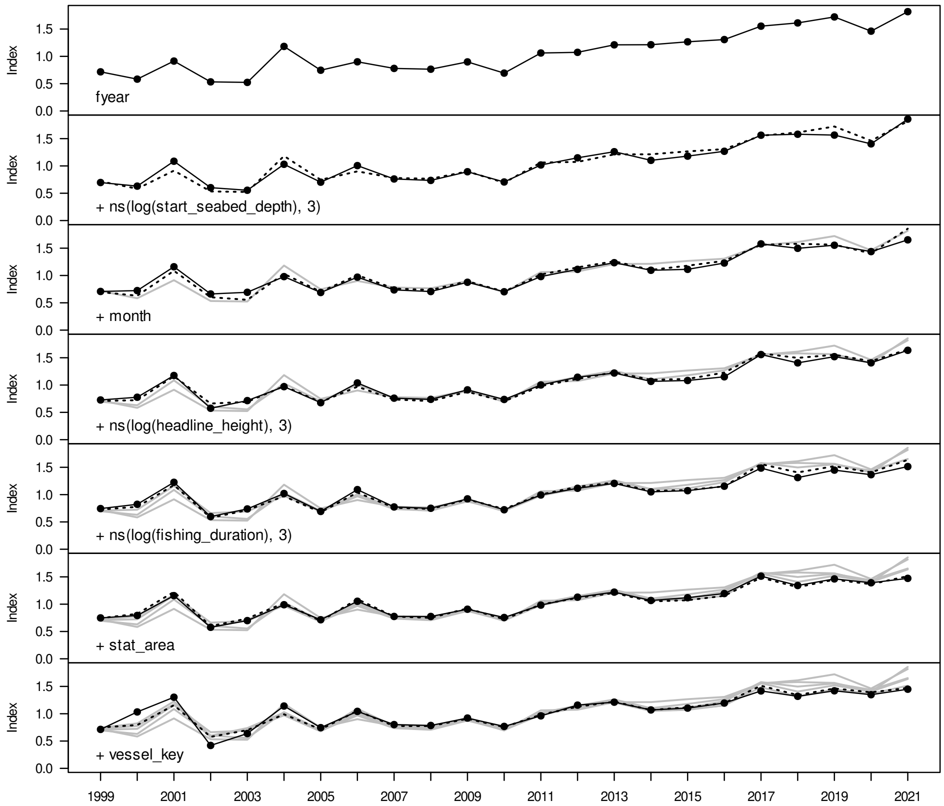

Figure C.161: Changes to the JMD7 MW observer split vessels positive catch index as terms are successively entered into the model.

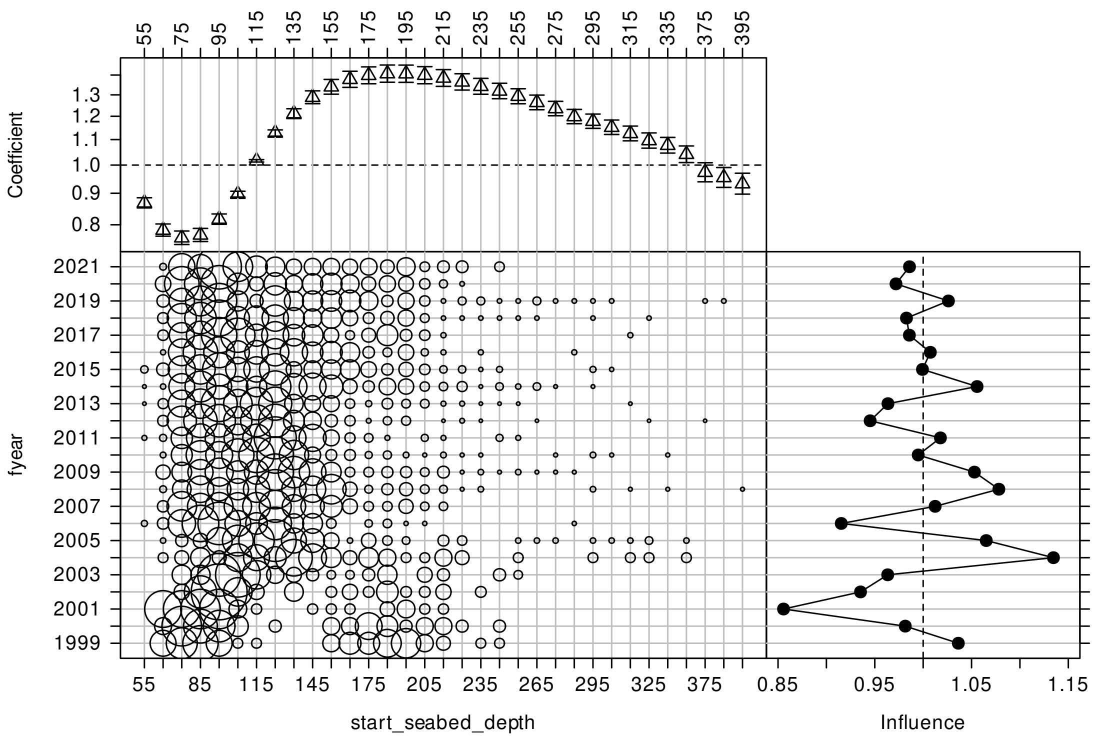

Figure C.162: CDI plot for start seabed depth (m) for the positive catch JMD7 MW observer split vessels catch-per-unit-effort dataset.

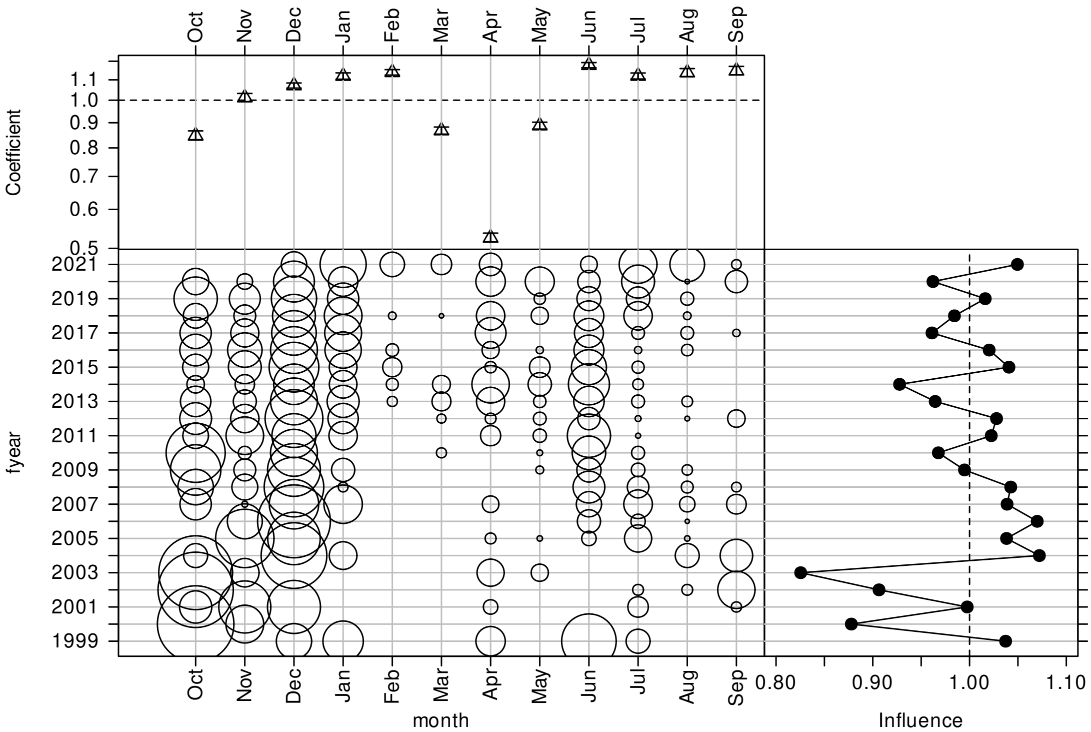

Figure C.163: CDI plot for month for the positive catch JMD7 MW observer split vessels catch-per-unit-effort dataset.

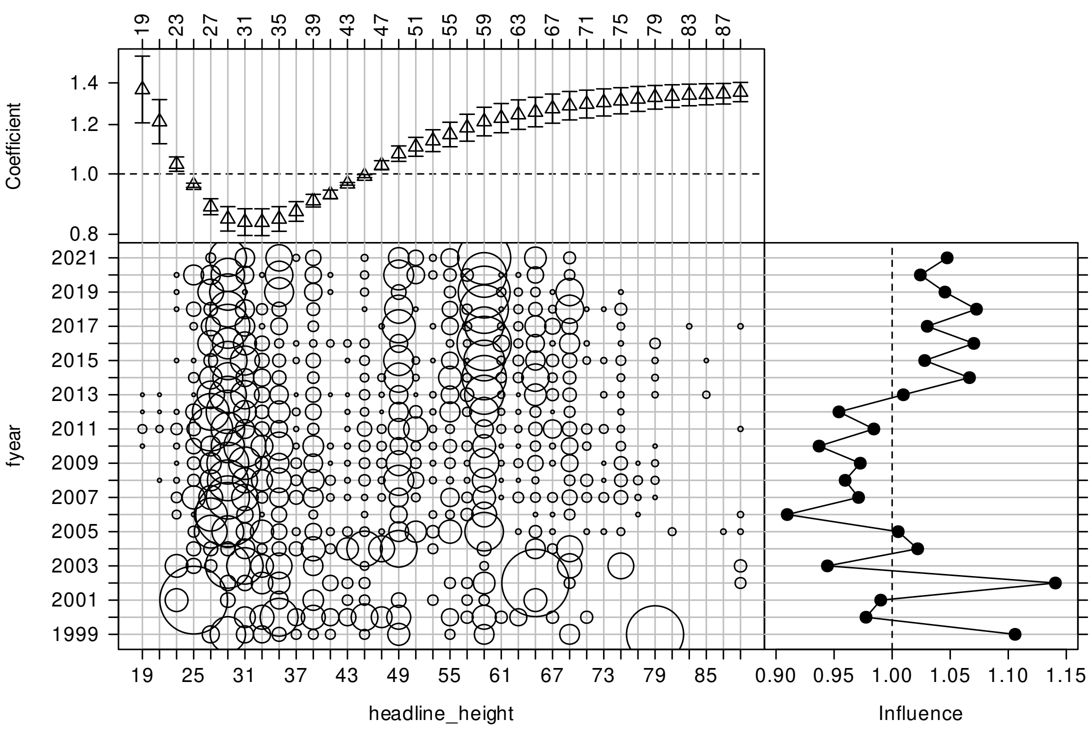

Figure C.164: CDI plot for headline height (m) for the positive catch JMD7 MW observer split vessels catch-per-unit-effort dataset.

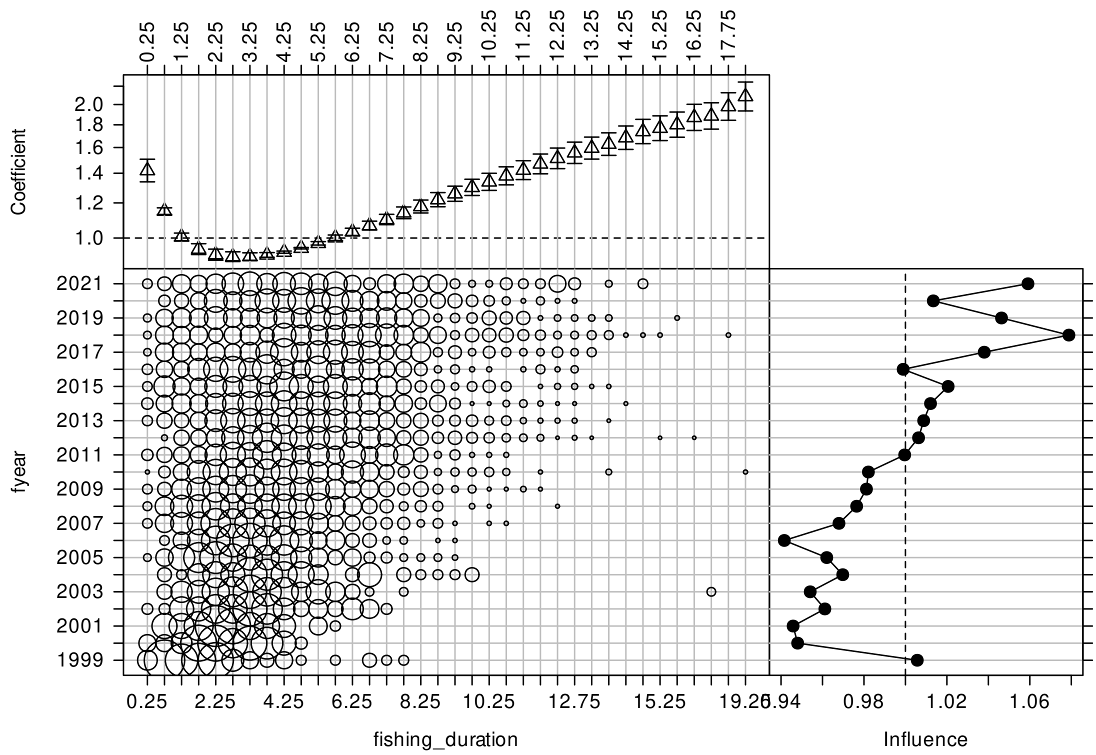

Figure C.165: CDI plot for fishing duration (h) for the positive catch JMD7 MW observer split vessels catch-per-unit-effort dataset.

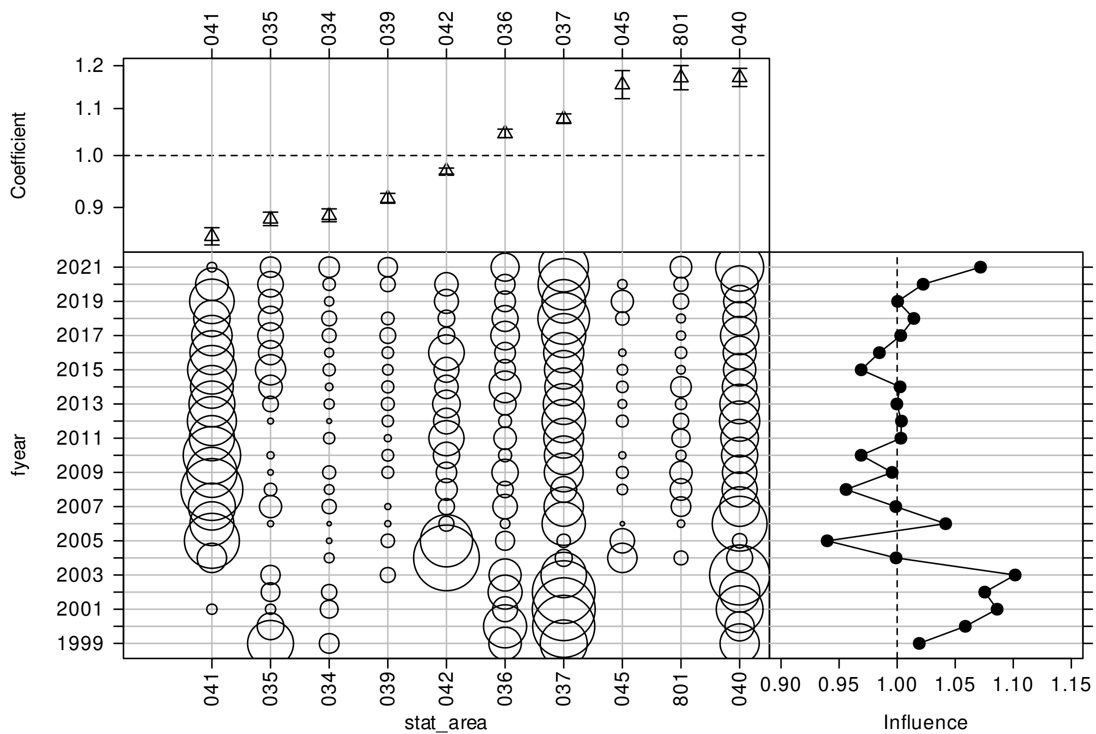

Figure C.166: CDI plot for statistical area for the positive catch JMD7 MW observer split vessels catch-per-unit-effort dataset.

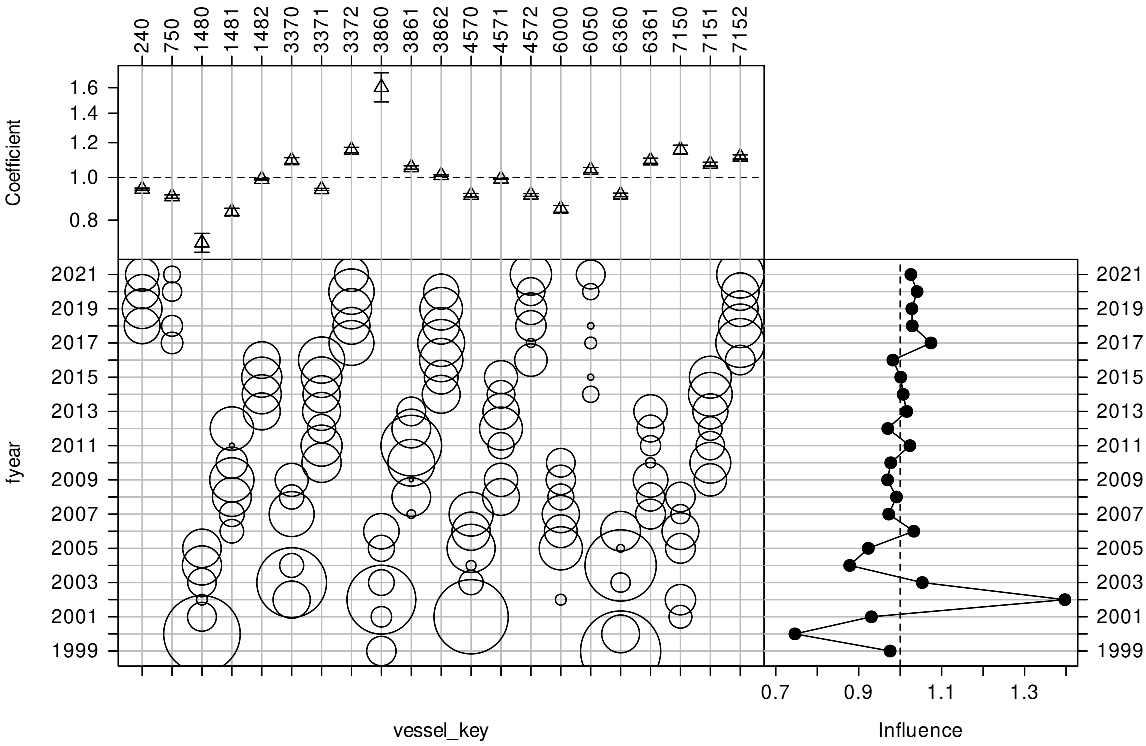

Figure C.167: CDI plot for vessel key for the positive catch JMD7 MW observer split vessels catch-per-unit-effort dataset.

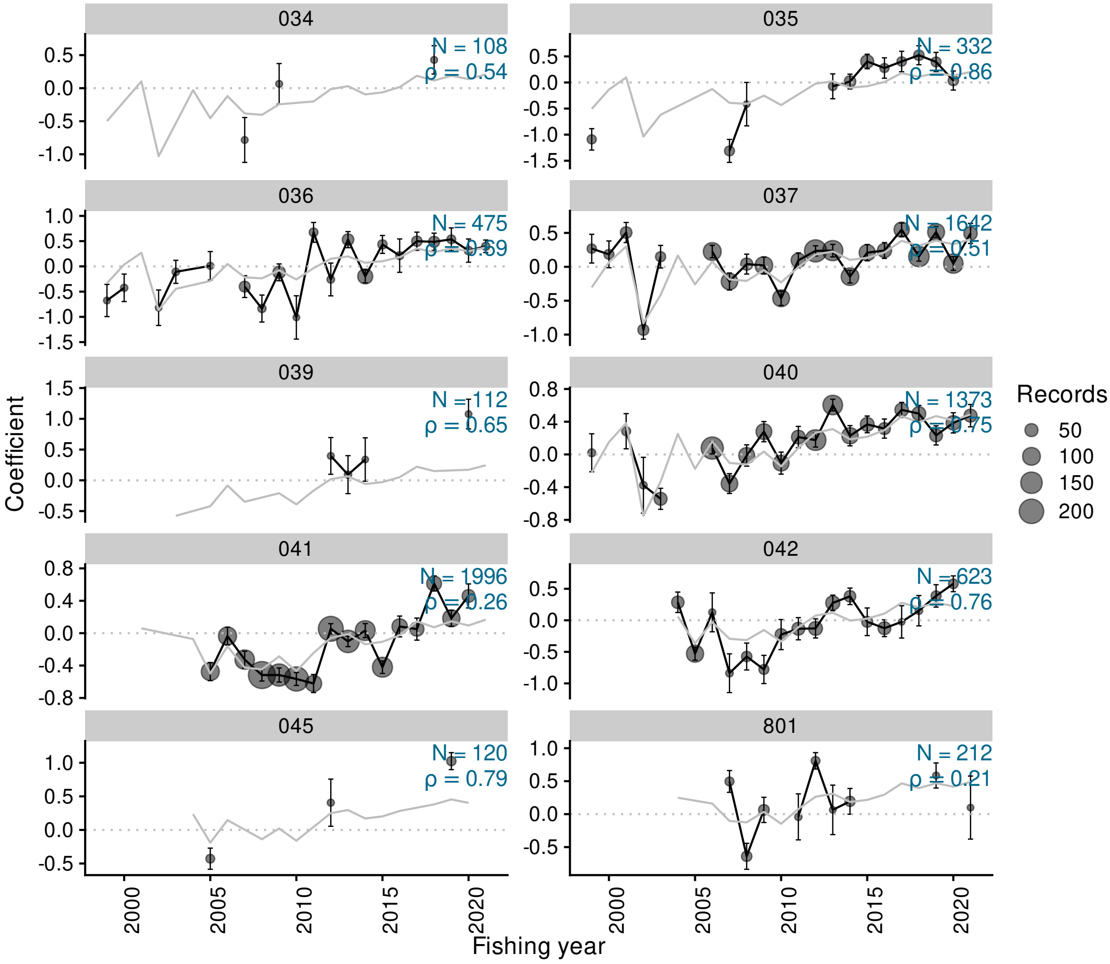

Figure C.168: Residual implied coefficients for area-year in the Weibull positive catch model for the JMD7 MW observer split vessels dataset.

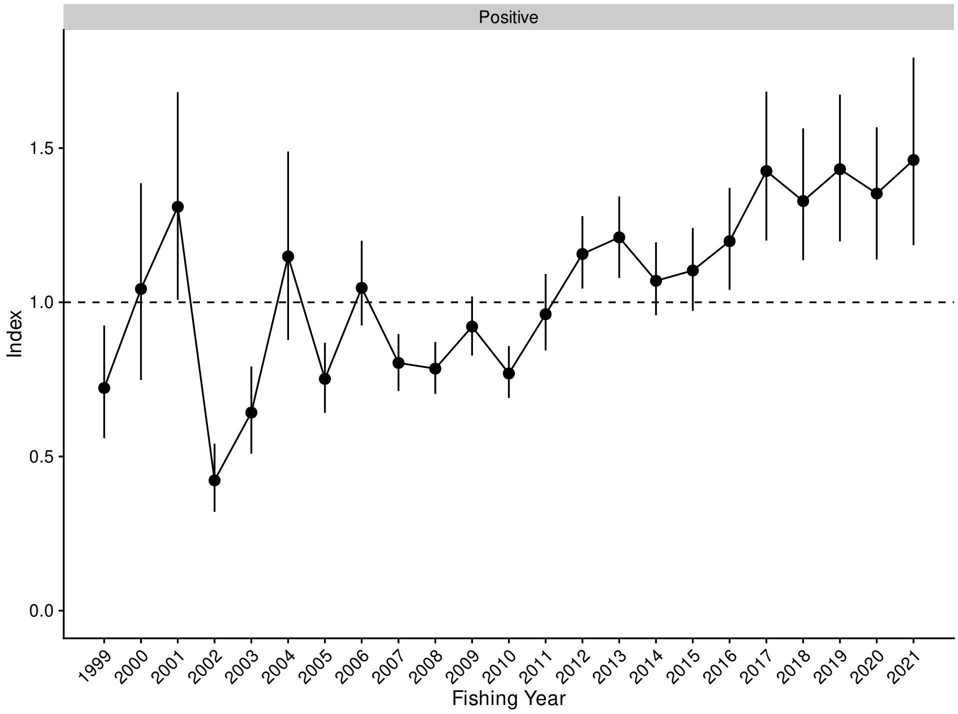

Figure C.169: Standardised indices and 95% confidence intervals for the JMD7 MW observer split vessels dataset.

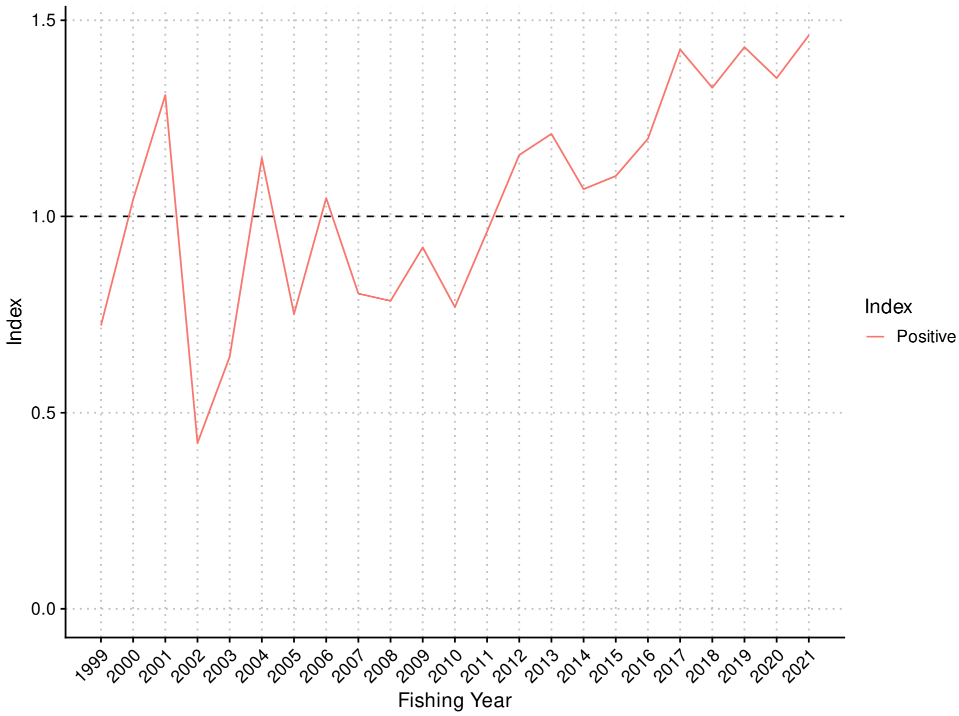

Figure C.170: Standardised indices for the JMD7 MW observer split vessels dataset.

Table C.53: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in JMD7 MW observer split vessels.

	Positive			
Fishing year	index	SE	LCI	UCI
1999	0.722	0.093	0.559	0.925
2000	1.043	0.163	0.748	1.386
2001	1.309	0.172	1.007	1.681
2002	0.423	0.056	0.320	0.542
2003	0.642	0.072	0.509	0.792
2004	1.149	0.156	0.878	1.489
2005	0.752	0.058	0.641	0.869
2006	1.047	0.070	0.925	1.200
2007	0.803	0.047	0.712	0.897
2008	0.785	0.043	0.703	0.871
2009	0.921	0.049	0.827	1.019
2010	0.769	0.043	0.690	0.858
2011	0.961	0.063	0.844	1.092
2012	1.157	0.060	1.044	1.279
2013	1.210	0.067	1.079	1.343
2014	1.070	0.060	0.958	1.195
2015	1.103	0.069	0.972	1.241
2016	1.198	0.084	1.040	1.371
2017	1.426	0.123	1.200	1.683
2018	1.328	0.109	1.136	1.564
2019	1.432	0.121	1.198	1.673
2020	1.353	0.109	1.139	1.568
2021	1.461	0.155	1.185	1.794

C.11 JMN7 MW observer split vessels

Table C.54: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the JMN7 MW observer split vessels CPUE series.

Series	JMN7 MW observer split vessels
QMS stock	JMA7
Reporting forms	
Fishing methods	MW
Target species	JMA, JMD, JMM, JMN
Statistical Areas	037, 039, 040, 041, 042, 045
Period	1998-10-01, 2021-09-30
Resolution	Observed event
Core fleet years	4
Core fleet trips	1
Default model	jmnkg ~ fyear + vessel_key + month + stat_area + ns(log(fishing_duration), 3) + ns(log(start_time), 3) + ns(log(start_seabed_depth), 3) + ns(log(headline_height), 3) + ns(fishing_speed, 3)
Stepwise selection	Yes
Positive catch distribution	Weibull

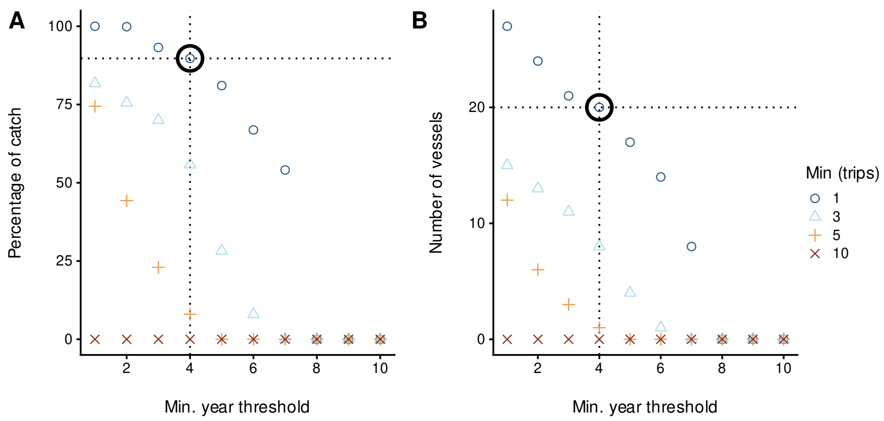

Figure C.171: Percentage of catch and number of vessels for different core vessel selection criteria for the JMN7 MW observer split vessels CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel was observed in the fishery and the number of observed trips per year.

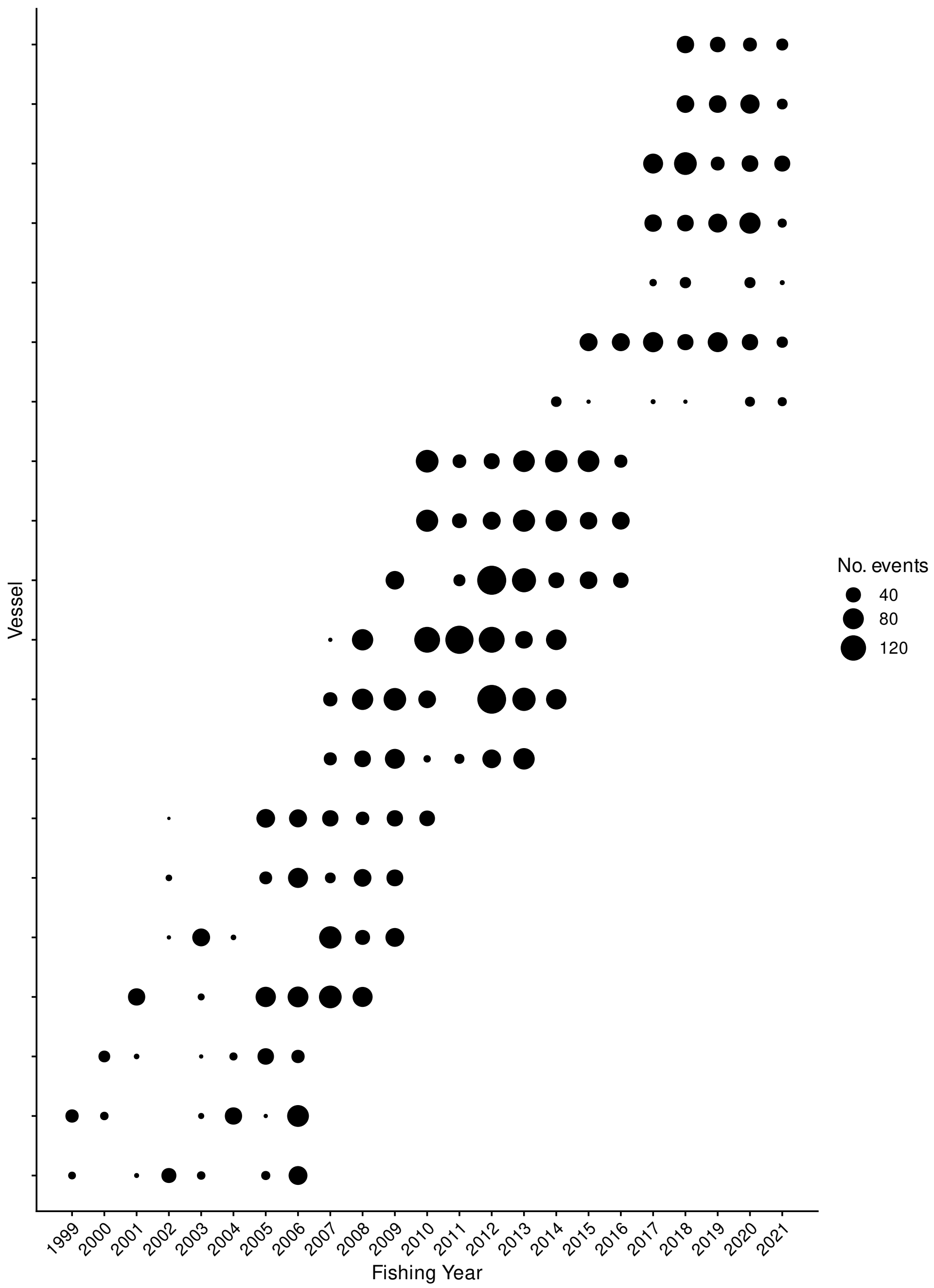

Figure C.172: Number of events by fishing year for core vessels. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table C.55: Summary of the JMN7 MW observer split vessels 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	1999	2000	2001	2002	2003	2004	2005	2006	2007
Ungroomed data	304 (100%) n: 45	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 84	403 (100%) n: 76	2571 (100%) n: 243	1541 (100%) n: 397	1331 (100%) n: 327
Fishing speed not null	304 (100%) n: 44	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 84	403 (100%) n: 76	2568 (100%) n: 241	1541 (100%) n: 397	1331 (100%) n: 327
Start date not null	304 (100%) n: 44	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 84	403 (100%) n: 76	2568 (100%) n: 241	1541 (100%) n: 397	1331 (100%) n: 327
End date not null	304 (100%) n: 44	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 84	403 (100%) n: 76	2568 (100%) n: 241	1541 (100%) n: 397	1331 (100%) n: 327
Start depth not null	304 (100%) n: 44	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 84	403 (100%) n: 76	2568 (100%) n: 241	1541 (100%) n: 397	1331 (100%) n: 327
Headline height not null	294 (100%) n: 43	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 83	403 (100%) n: 76	2568 (100%) n: 241	1541 (100%) n: 397	1331 (100%) n: 327
Fishing speed >3.5kn	294 (100%) n: 43	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 83	403 (100%) n: 76	2568 (100%) n: 241	1541 (100%) n: 397	1331 (100%) n: 326
Headline height >15m	294 (100%) n: 43	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	386 (100%) n: 82	403 (100%) n: 76	2566 (100%) n: 240	1539 (100%) n: 396	1307 (100%) n: 322
Headline height <90m	294 (100%) n: 43	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	386 (100%) n: 82	403 (100%) n: 76	2566 (100%) n: 240	1539 (100%) n: 396	1307 (100%) n: 322
Fishing duration >15mins	289 (95%) n: 42	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	386 (100%) n: 82	403 (100%) n: 76	2566 (100%) n: 239	1539 (100%) n: 396	1307 (100%) n: 322
Seabed depth >50m	289 (95%) n: 42	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	386 (100%) n: 82	403 (100%) n: 76	2566 (100%) n: 239	1539 (100%) n: 396	1307 (100%) n: 322
Seabed depth <200m	289 (95%) n: 42	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	386 (100%) n: 82	394 (100%) n: 67	2417 (94%) n: 230	1539 (100%) n: 395	1307 (100%) n: 322
Start time >0	289 (95%) n: 42	100 (100%) n: 34	178 (100%) n: 60	228 (88%) n: 48	386 (100%) n: 82	394 (100%) n: 67	2400 (93%) n: 229	1519 (100%) n: 391	1261 (95%) n: 319
Core fleet selection	268 (88%) n: 39	100 (100%) n: 34	178 (100%) n: 60	228 (88%) n: 48	386 (100%) n: 82	394 (100%) n: 67	2400 (93%) n: 229	1519 (100%) n: 391	1261 (95%) n: 319

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	2365 (100%) n: 435	2171 (100%) n: 428	2177 (100%) n: 464	1501 (100%) n: 271	4646 (100%) n: 669	4978 (100%) n: 563	3725 (100%) n: 480	5772 (100%) n: 485	3096 (100%) n: 312
Fishing speed not null	2363 (100%) n: 434	2171 (100%) n: 428	2176 (100%) n: 463	1501 (100%) n: 271	4646 (100%) n: 669	4978 (100%) n: 562	3725 (100%) n: 480	5772 (100%) n: 485	3096 (100%) n: 311
Start date not null	2363 (100%) n: 434	2171 (100%) n: 428	2176 (100%) n: 463	1501 (100%) n: 271	4646 (100%) n: 669	4978 (100%) n: 562	3725 (100%) n: 480	5772 (100%) n: 485	3096 (100%) n: 311
End date not null	2363 (100%) n: 434	2171 (100%) n: 428	2176 (100%) n: 463	1501 (100%) n: 271	4646 (100%) n: 669	4978 (100%) n: 562	3725 (100%) n: 480	5772 (100%) n: 485	3096 (100%) n: 311
Start depth not null	2363 (100%) n: 433	2046 (94%) n: 405	2171 (100%) n: 460	1476 (100%) n: 267	4285 (92%) n: 634	4879 (100%) n: 542	3705 (100%) n: 478	5512 (100%) n: 469	3096 (100%) n: 311
Headline height not null	2363 (100%) n: 433	2007 (92%) n: 404	2114 (100%) n: 452	1476 (100%) n: 266	4265 (92%) n: 627	4847 (100%) n: 538	3705 (100%) n: 477	5508 (100%) n: 468	3096 (100%) n: 311
Fishing speed >3.5kn	2363 (100%) n: 433	2007 (92%) n: 404	2114 (100%) n: 452	1476 (100%) n: 266	4265 (92%) n: 627	4847 (100%) n: 538	3705 (100%) n: 477	5508 (100%) n: 468	3076 (100%) n: 310
Headline height >15m	2363 (100%) n: 433	2007 (92%) n: 403	2111 (100%) n: 451	1476 (100%) n: 266	4265 (92%) n: 627	4845 (100%) n: 535	3705 (100%) n: 477	5508 (100%) n: 468	3076 (100%) n: 310
Headline height <90m	2363 (100%) n: 433	2007 (92%) n: 403	2111 (100%) n: 451	1454 (100%) n: 265	4265 (92%) n: 626	4845 (100%) n: 535	3705 (100%) n: 477	5508 (100%) n: 468	3076 (100%) n: 310
Fishing duration >15mins	2363 (100%) n: 432	2007 (92%) n: 403	2111 (100%) n: 451	1425 (95%) n: 263	4265 (92%) n: 626	4835 (100%) n: 533	3704 (100%) n: 475	5508 (100%) n: 468	3076 (100%) n: 309
Seabed depth >50m	2363 (100%) n: 432	2005 (92%) n: 401	2086 (100%) n: 450	1425 (95%) n: 263	4264 (92%) n: 625	4835 (100%) n: 532	3704 (100%) n: 475	5504 (100%) n: 467	3076 (100%) n: 309
Seabed depth <200m	2347 (100%) n: 419	1936 (89%) n: 390	2074 (100%) n: 438	1425 (95%) n: 262	4250 (91%) n: 612	4820 (100%) n: 524	3690 (100%) n: 472	5474 (95%) n: 457	3000 (100%) n: 305
Start time >0	2332 (100%) n: 414	1936 (89%) n: 389	2074 (100%) n: 435	1416 (94%) n: 259	4160 (90%) n: 606	4801 (100%) n: 522	3630 (100%) n: 465	5427 (94%) n: 454	2931 (95%) n: 302
Core fleet selection	2332 (100%) n: 414	1936 (89%) n: 389	2023 (93%) n: 416	1416 (94%) n: 259	4160 (90%) n: 606	4801 (100%) n: 522	2980 (80%) n: 391	2752 (48%) n: 255	1738 (56%) n: 185

Filter	2017	2018	2019	2020	2021
Ungroomed data	2640 (100%) n: 238	4601 (100%) n: 346	2822 (100%) n: 302	2942 (100%) n: 329	2320 (100%) n: 205
Fishing speed not null	2638 (100%) n: 236	4601 (100%) n: 346	2822 (100%) n: 302	2942 (100%) n: 328	2299 (100%) n: 201
Start date not null	2638 (100%) n: 236	4601 (100%) n: 346	2822 (100%) n: 302	2942 (100%) n: 328	2299 (100%) n: 201
End date not null	2638 (100%) n: 236	4601 (100%) n: 346	2822 (100%) n: 302	2942 (100%) n: 328	2299 (100%) n: 201
Start depth not null	2605 (100%) n: 234	4587 (100%) n: 345	2822 (100%) n: 302	2879 (100%) n: 323	2177 (94%) n: 195
Headline height not null	2605 (100%) n: 230	4582 (100%) n: 343	2822 (100%) n: 302	2879 (100%) n: 322	2177 (94%) n: 195
Fishing speed >3.5kn	2605 (100%) n: 230	4582 (100%) n: 343	2822 (100%) n: 302	2879 (100%) n: 322	2177 (94%) n: 195
Headline height >15m	2582 (100%) n: 229	4582 (100%) n: 343	2822 (100%) n: 302	2879 (100%) n: 322	2177 (94%) n: 195
Headline height <90m	2582 (100%) n: 229	4582 (100%) n: 343	2822 (100%) n: 302	2879 (100%) n: 322	2177 (94%) n: 195
Fishing duration >15mins	2564 (100%) n: 228	4582 (100%) n: 343	2822 (100%) n: 302	2879 (100%) n: 322	2177 (94%) n: 195
Seabed depth >50m	2564 (100%) n: 228	4573 (100%) n: 342	2822 (100%) n: 302	2879 (100%) n: 322	2177 (94%) n: 195
Seabed depth <200m	2564 (100%) n: 226	4403 (100%) n: 332	2758 (100%) n: 279	2878 (100%) n: 317	2176 (94%) n: 194
Start time >0	2558 (100%) n: 225	4393 (100%) n: 331	2758 (100%) n: 279	2823 (100%) n: 314	2114 (91%) n: 193
Core fleet selection	2428 (92%) n: 211	4393 (100%) n: 323	2674 (95%) n: 266	2823 (100%) n: 314	1630 (70%) n: 138

Table C.56: Summary of the JMN7 MW observer split vessels dataset after core fleet selection. 'Records' indicates the number of rows (events) in the dataset, and 'Records caught' indicates the percentage of events with catches of jack mackerels.

Fishing year	Vessels	Trips	Records	Hrs	Catch (t)	Records caught
1999	2	2	39	80.15	267.96	76.92
2000	2	2	34	89.50	99.83	88.24
2001	3	4	60	156.45	178.19	85.00
2002	4	4	48	181.12	228.40	79.17
2003	5	5	82	285.33	386.14	87.80
2004	3	3	67	277.55	393.81	73.13
2005	6	8	229	778.45	2 400.03	89.52
2006	6	8	391	1 430.92	1 519.19	89.26
2007	7	15	319	1 200.18	1 260.50	72.41
2008	7	15	414	1 648.47	2 331.50	69.81
2009	6	11	389	1 644.73	1 935.68	84.06
2010	6	10	416	1 848.45	2 023.50	83.17
2011	5	7	259	1 220.35	1 416.43	71.81
2012	6	18	606	3 091.70	4 159.54	81.68
2013	6	28	522	2 615.75	4 800.95	82.38
2014	6	28	391	1 978.32	2 980.25	81.07
2015	5	18	255	1 327.95	2 751.63	81.57
2016	4	17	185	888.53	1 738.09	80.54
2017	5	19	211	1 236.70	2 427.90	89.10
2018	7	23	323	2 120.23	4 392.70	76.78
2019	5	18	266	1 554.73	2 673.63	83.08
2020	7	29	314	1 637.30	2 823.50	71.02
2021	7	17	138	845.38	1 630.08	86.23

Table C.57: Summary of stepwise selection for occurrence of positive catch. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	21.00	5 776	2.30	2.30	*
+ ns(log(start_seabed_depth), 3)	3.00	5 409	8.70	6.40	*
+ stat_area	5.00	5 140	13.40	4.80	*
+ month	11.00	5 072	15.00	1.50	*
+ vessel_key	19.00	5 030	16.30	1.40	*
+ ns(log(fishing_duration), 3)	3.00	5 008	16.80	0.50	
+ ns(log(headline_height), 3)	3.00	4 997	17.10	0.30	
+ ns(fishing_speed, 3)	3.00	4 996	17.20	0.10	
+ ns(log(start_time), 3)	3.00	4 996	17.30	0.10	

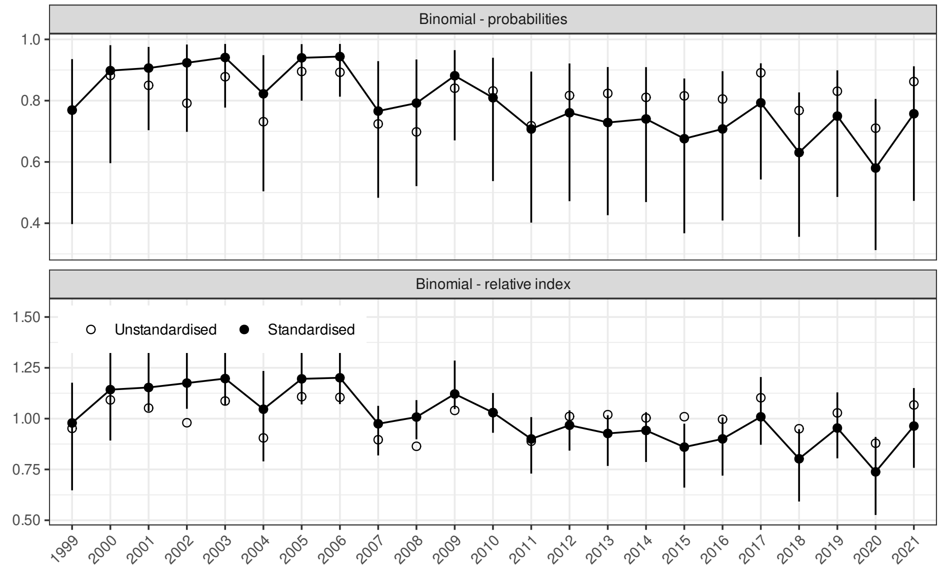

Figure C.173: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the JMN7 MW observer split vessels dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

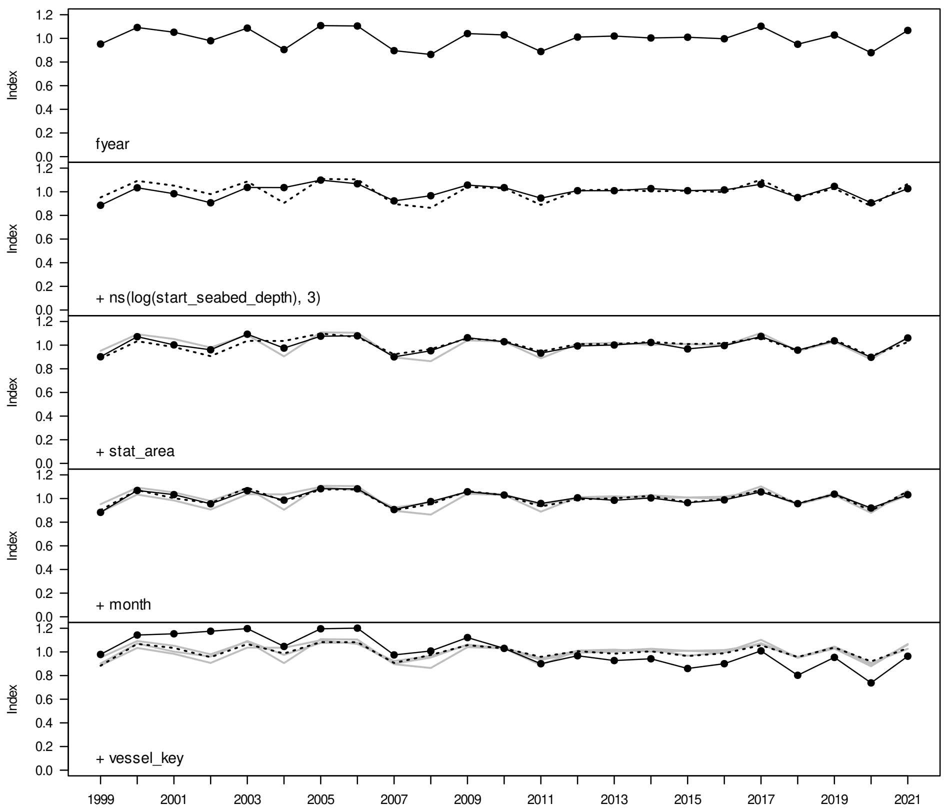

Figure C.174: Step plot for occurrence of catch in the JMN7 MW observer split vessels dataset.

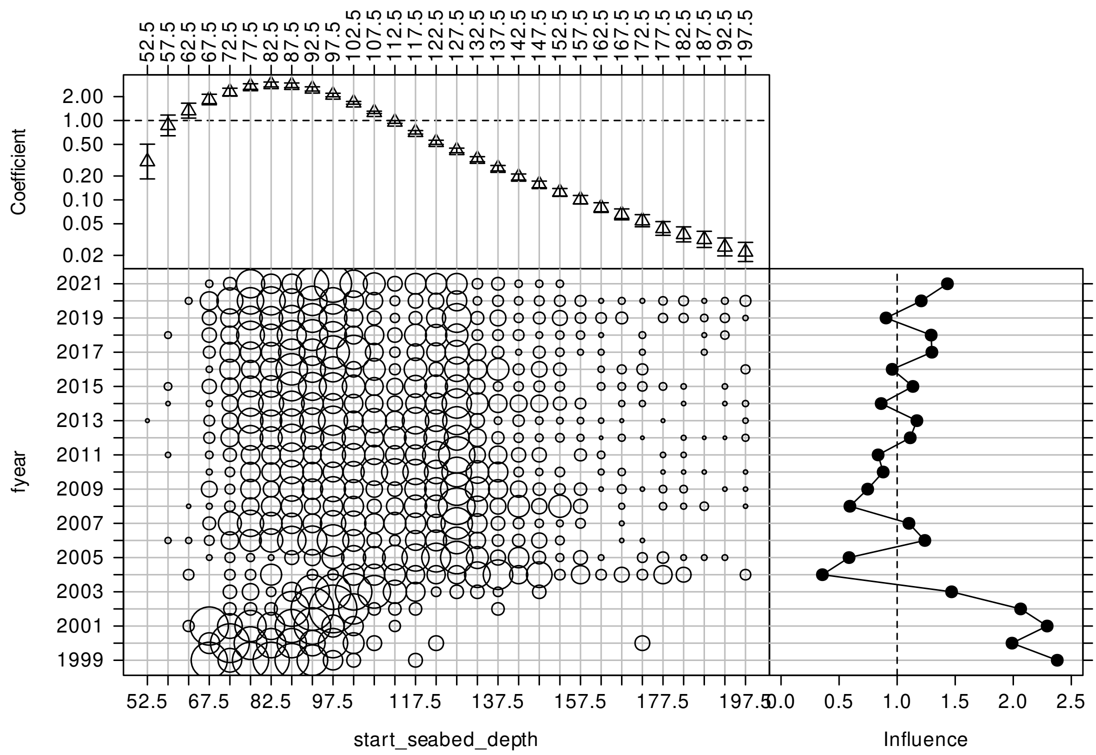

Figure C.175: CDI plot for start seabed depth (m) for the occurrence of positive catch JMN7 MW observer split vessels catch-per-unit-effort dataset.

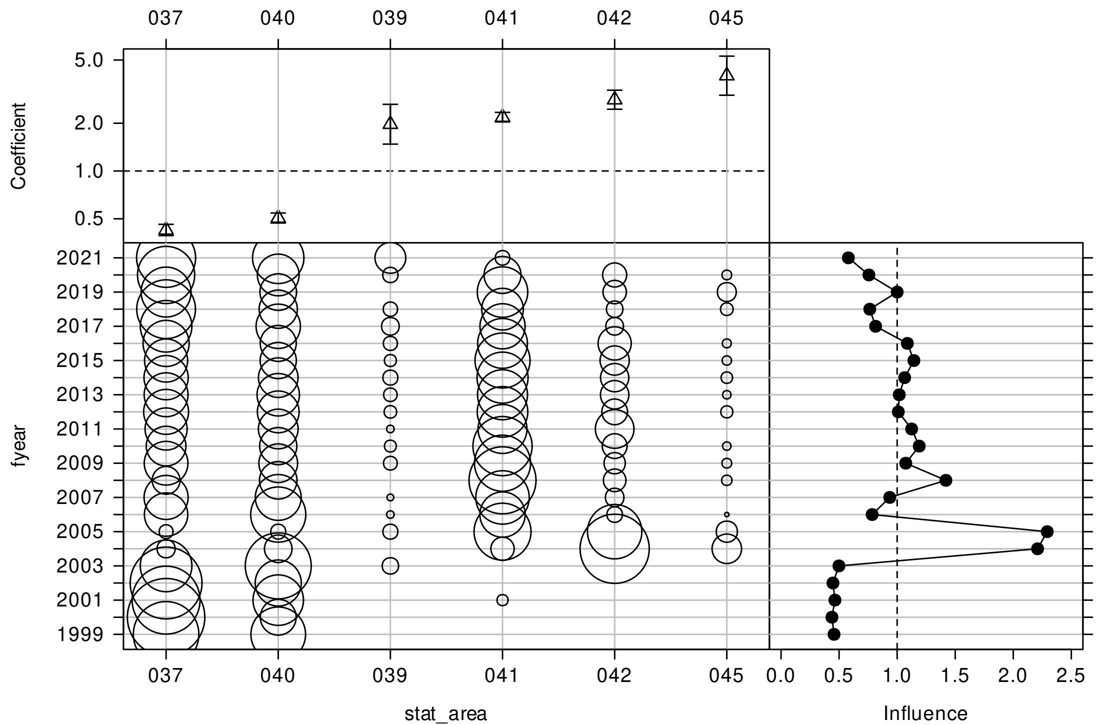

Figure C.176: CDI plot for statistical area for the occurrence of positive catch JMN7 MW observer split vessels catch-per-unit-effort dataset.

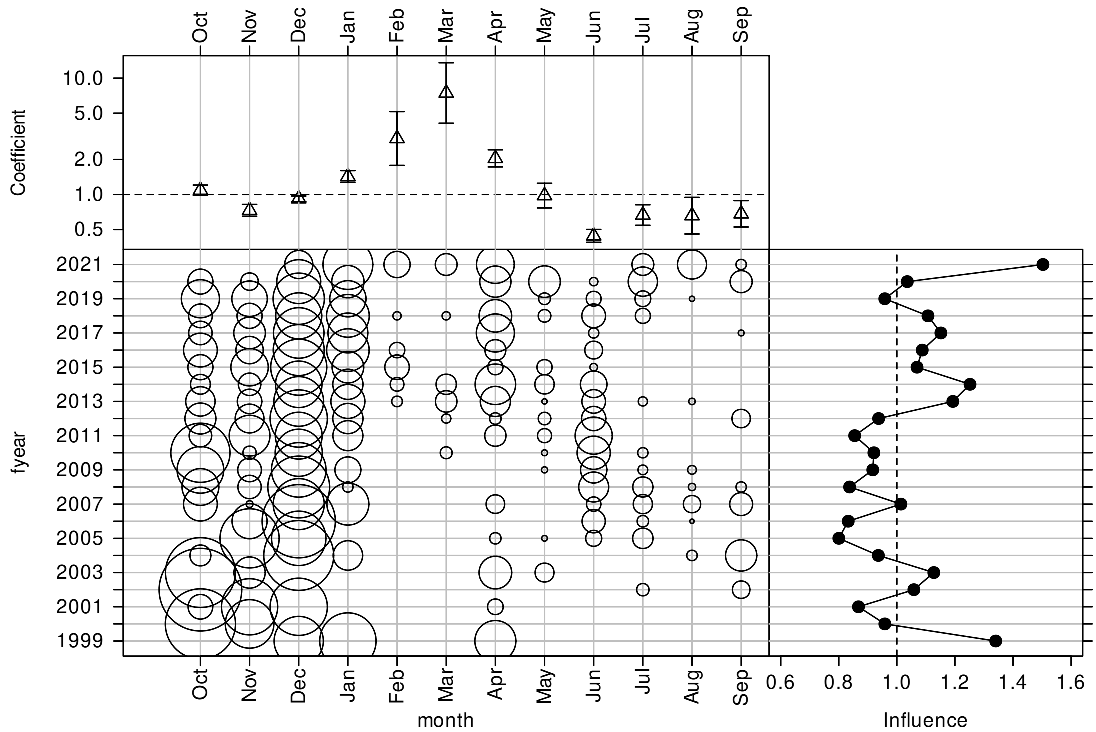

Figure C.177: CDI plot for month for the occurrence of positive catch JMN7 MW observer split vessels catch-per-unit-effort dataset.

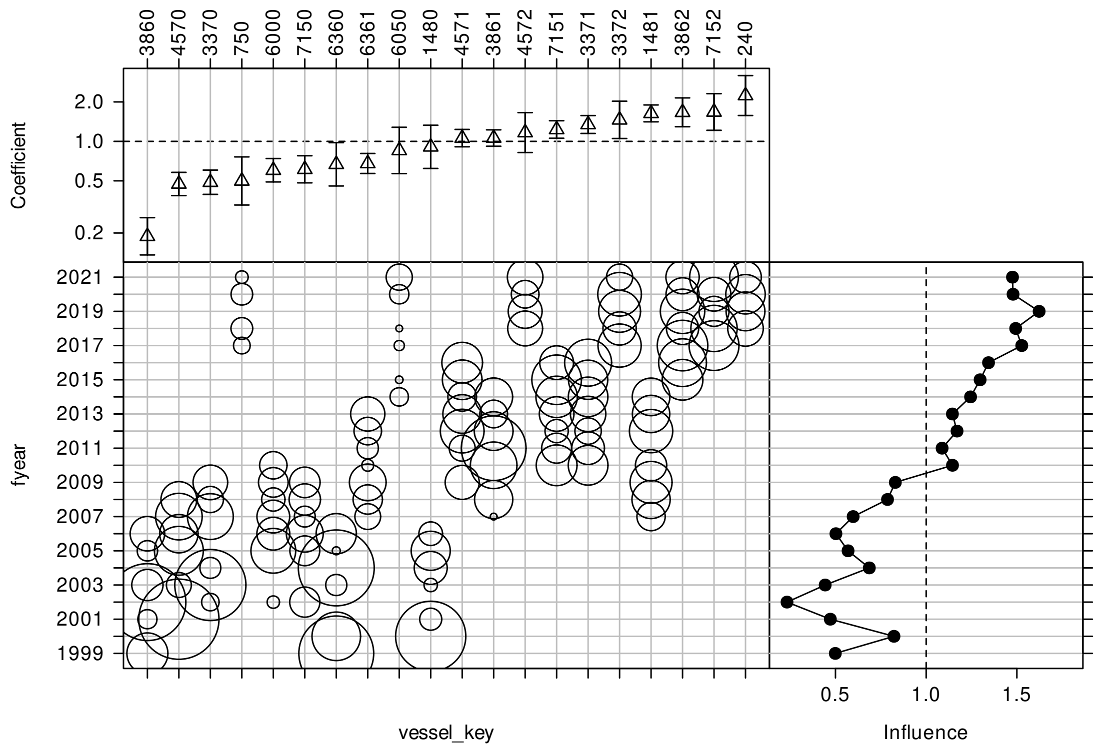

Figure C.178: CDI plot for vessel key for the occurrence of positive catch JMN7 MW observer split vessels catch-per-unit-effort dataset.

Table C.58: Summary of stepwise selection for the Weibull model. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	24	96 372	9.3	9.3	*
+ stat area	5	96 101	14.2	4.9	*
+ month	11	95 893	18.2	4.0	*
+ ns(log(start seabed depth), 3)	3	95 786	20.1	2.0	*
+ ns(log(start time), 3)	3	95 712	21.5	1.4	*
+ ns(log(fishing duration), 3)	3	95 651	22.7	1.2	*
+ vessel key	19	95 602	24.2	1.5	*
+ ns(log(headline height), 3)	3	95 593	24.5	0.3	
+ ns(fishing speed, 3)	3	95 588	24.7	0.2	

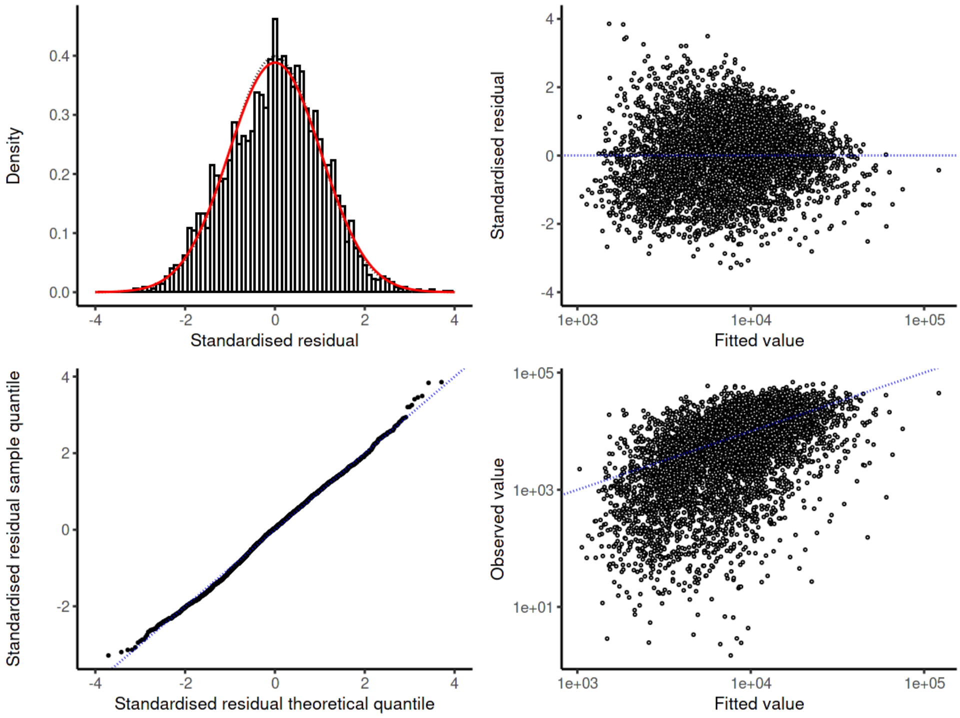

Figure C.179: Diagnostic plots for the Weibull model for the JMN7 MW observer split vessels dataset.

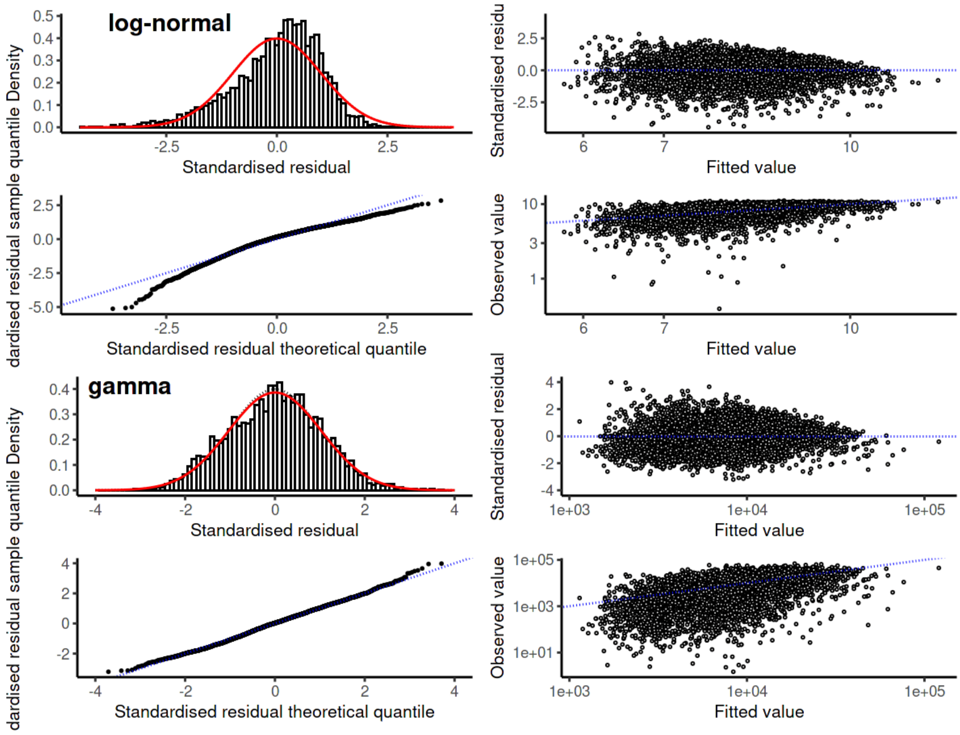

Figure C.180: Diagnostic plots for the log-normal and gamma model for the JMN7 MW observer split vessels dataset.

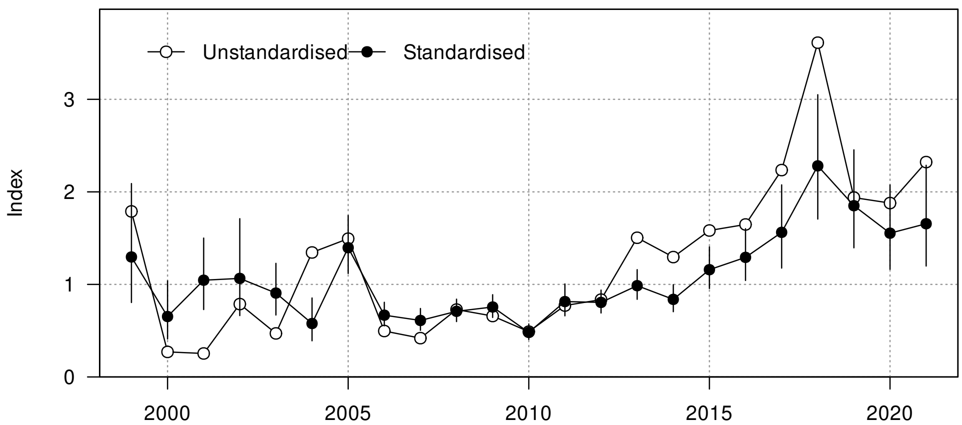

Figure C.181: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch in the JMN7 MW observer split vessels dataset.

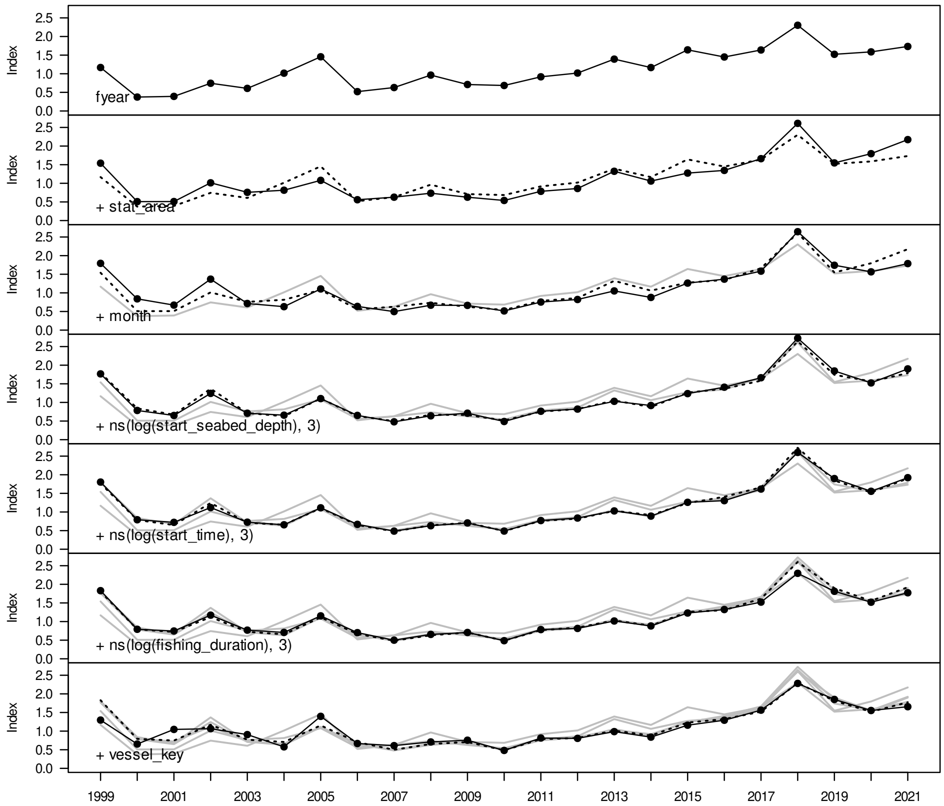

Figure C.182: Changes to the JMN7 MW observer split vessels positive catch index as terms are successively entered into the model.

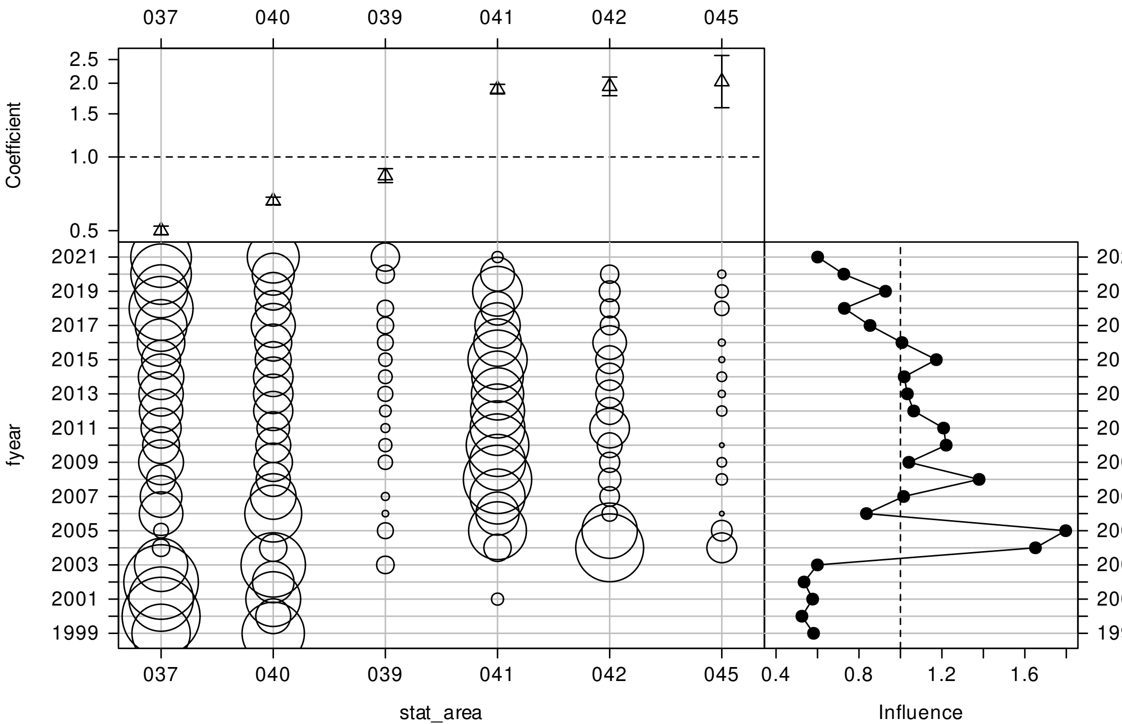

Figure C.183: CDI plot for statistical area for the positive catch JMN7 MW observer split vessels catch-per-unit-effort dataset.

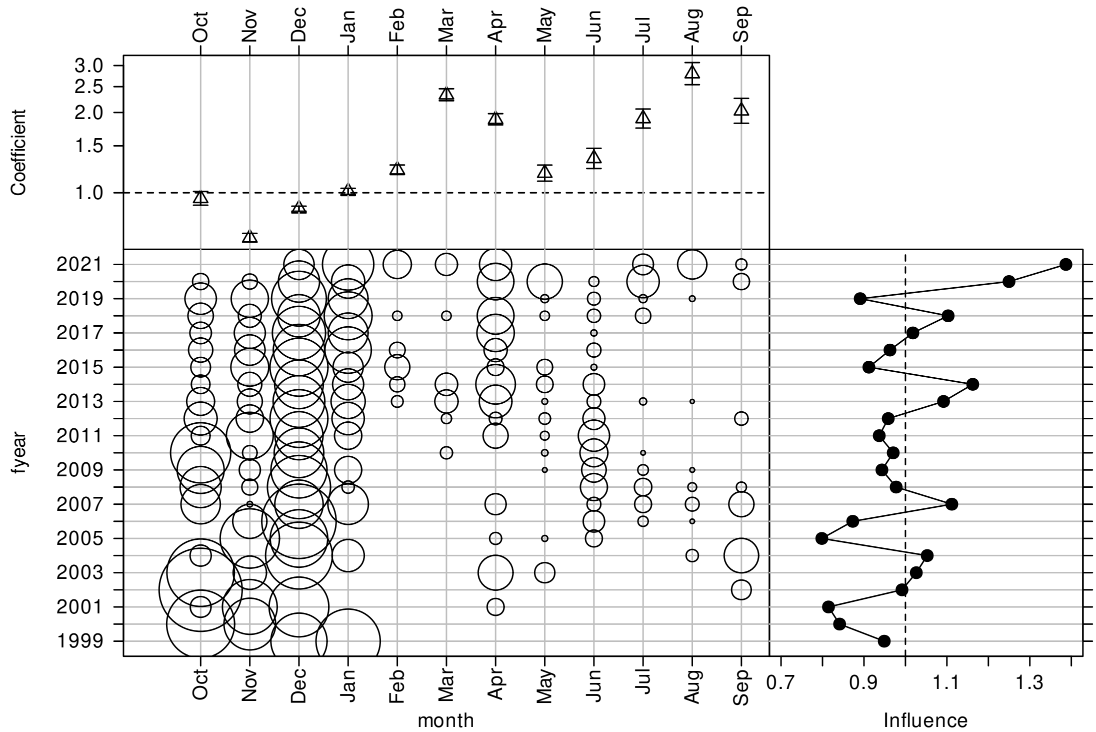

Figure C.184: CDI plot for month for the positive catch JMN7 MW observer split vessels catch-per-unit-effort dataset.

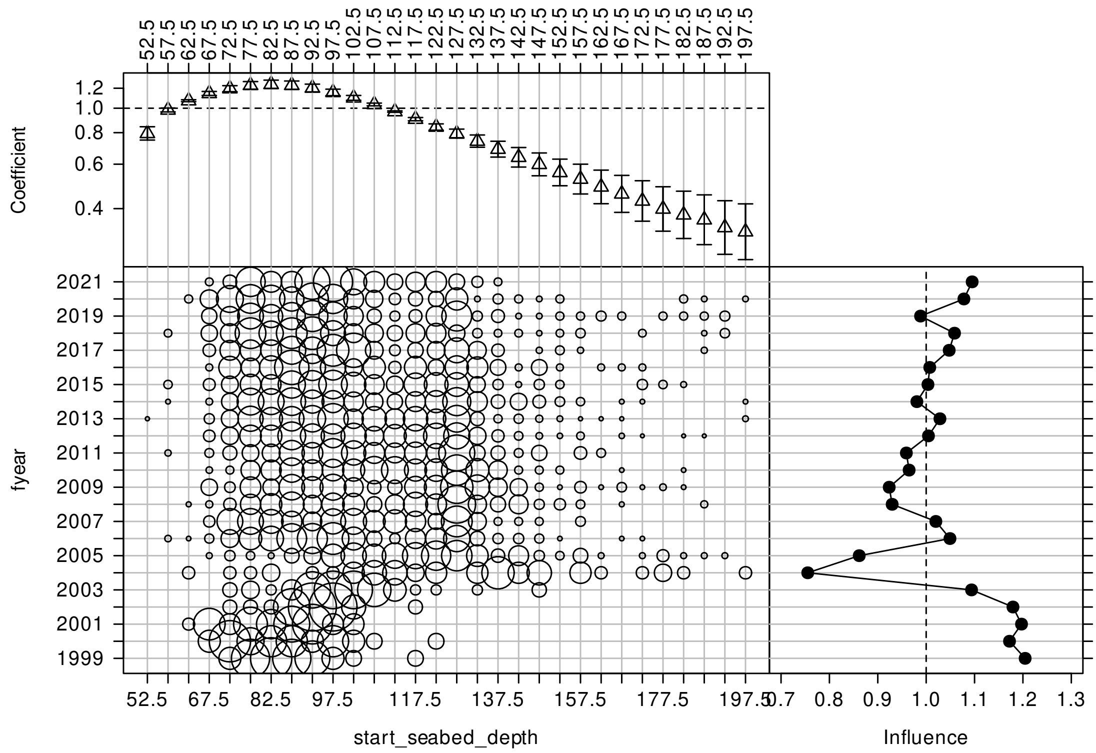

Figure C.185: CDI plot for start seabed depth (m) for the positive catch JMN7 MW observer split vessels catch-per-unit-effort dataset.

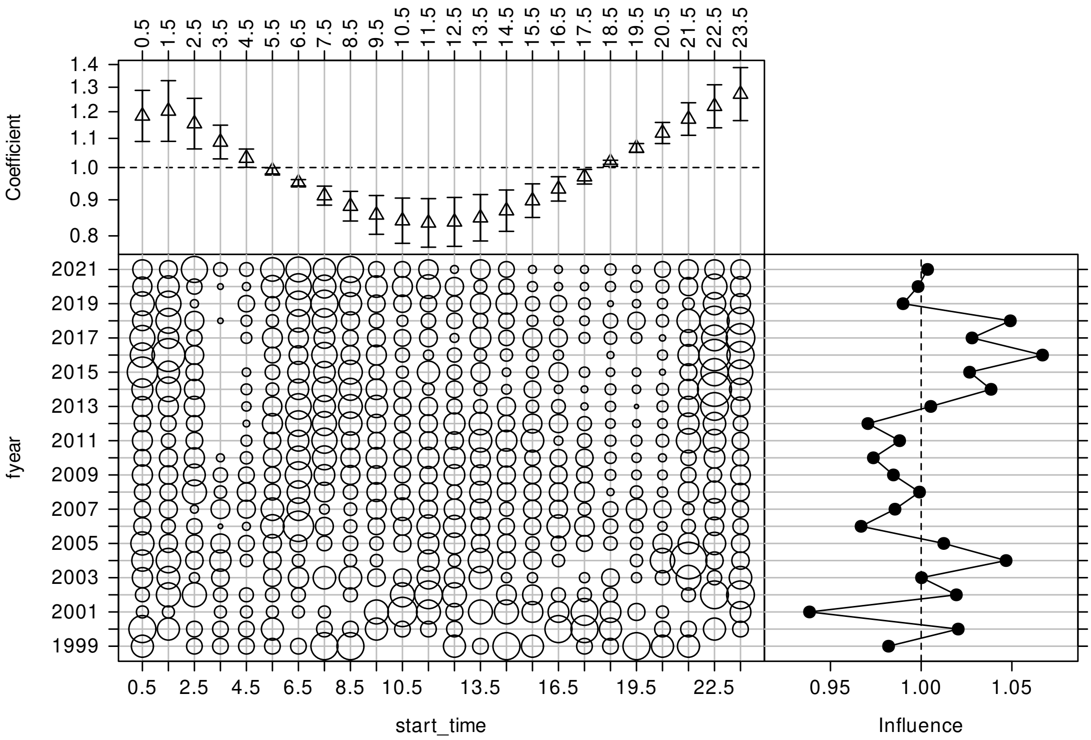

Figure C.186: CDI plot for start time for the positive catch JMN7 MW observer split vessels catch-per-unit-effort dataset.

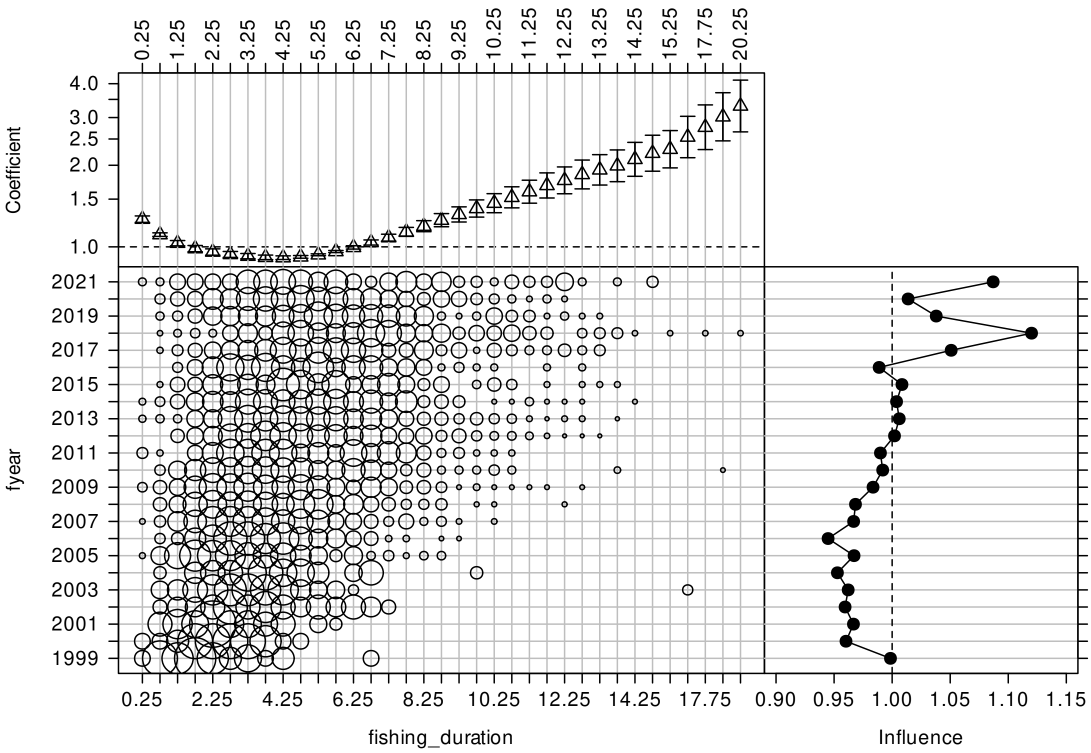

Figure C.187: CDI plot for fishing duration (h) for the positive catch JMN7 MW observer split vessels catch-per-unit-effort dataset.

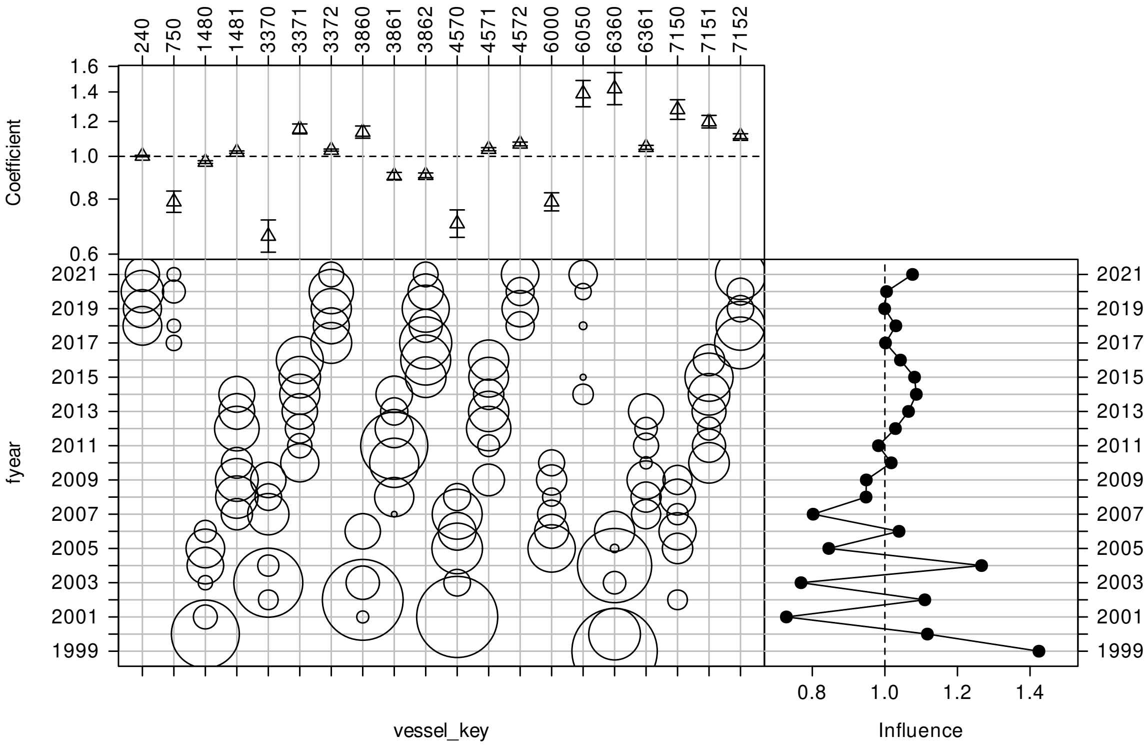

Figure C.188: CDI plot for vessel key for the positive catch JMN7 MW observer split vessels catch-per-unit-effort dataset.

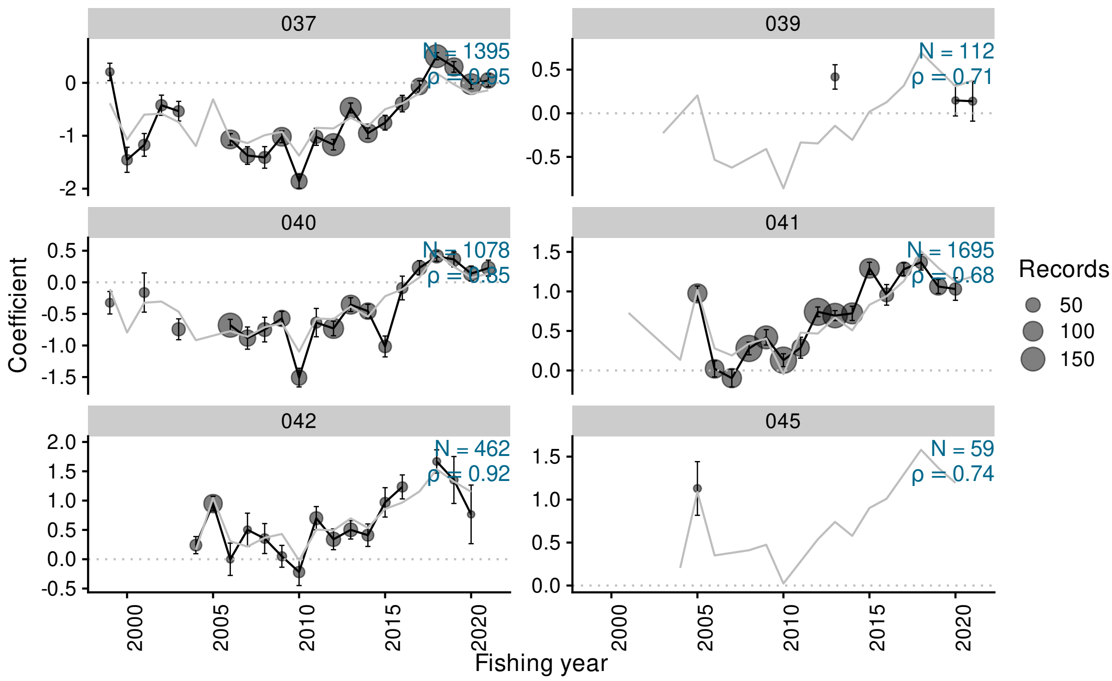

Figure C.189: Residual implied coefficients for area-year in the Weibull positive catch model for the JMN7 MW observer split vessels dataset.

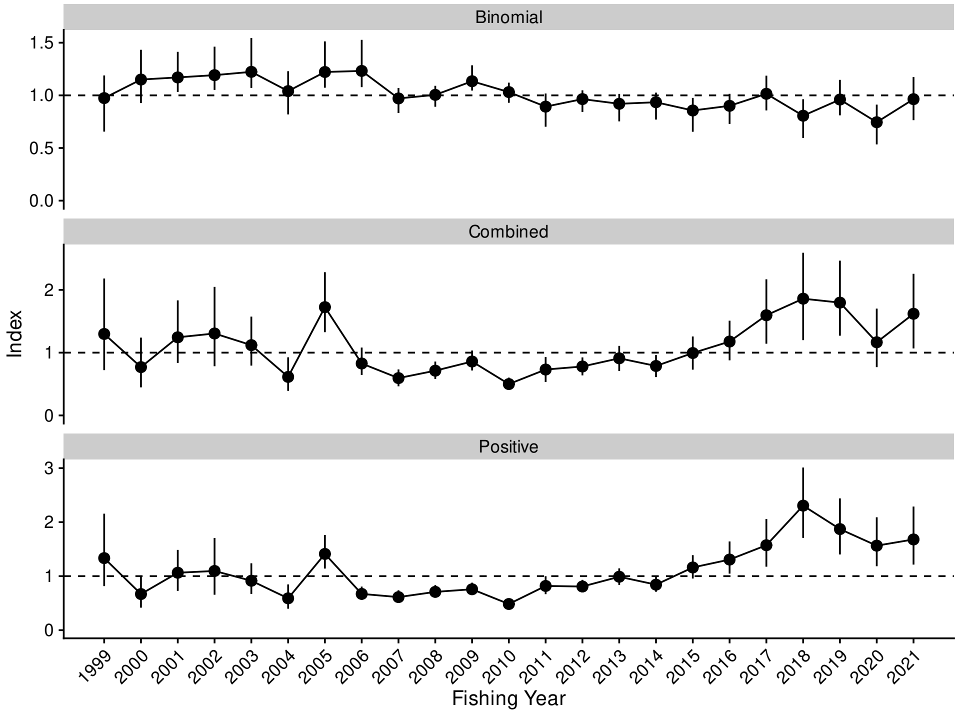

Figure C.190: Standardised indices and 95% confidence intervals for the JMN7 MW observer split vessels dataset.

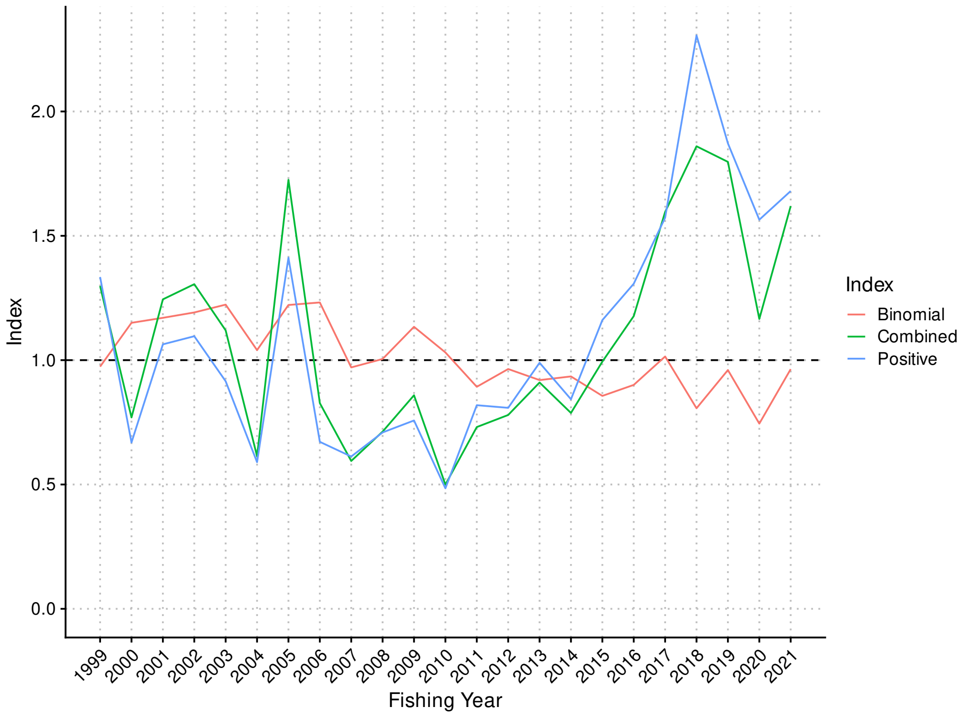

Figure C.191: Standardised indices for the JMN7 MW observer split vessels dataset.

Table C.59: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in JMN7 MW observer split vessels.

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
1999	0.974	0.136	0.656	1.189	1.298	0.372	0.721	2.181	1.334	0.342	0.816	2.157
2000	1.150	0.129	0.927	1.433	0.770	0.202	0.447	1.240	0.669	0.152	0.417	1.013
2001	1.170	0.097	1.033	1.413	1.244	0.254	0.836	1.833	1.064	0.194	0.727	1.486
2002	1.192	0.105	1.052	1.462	1.305	0.323	0.784	2.048	1.096	0.268	0.656	1.706
2003	1.223	0.121	1.070	1.545	1.120	0.199	0.793	1.574	0.915	0.145	0.671	1.239
2004	1.040	0.105	0.819	1.229	0.614	0.136	0.391	0.926	0.590	0.115	0.397	0.847
2005	1.222	0.112	1.073	1.512	1.725	0.244	1.326	2.282	1.412	0.158	1.141	1.762
2006	1.232	0.115	1.078	1.527	0.827	0.111	0.645	1.081	0.672	0.063	0.560	0.807
2007	0.971	0.061	0.832	1.070	0.595	0.069	0.464	0.733	0.612	0.059	0.508	0.739
2008	1.005	0.051	0.892	1.091	0.713	0.071	0.580	0.858	0.709	0.060	0.601	0.834
2009	1.134	0.061	1.045	1.285	0.859	0.081	0.716	1.034	0.757	0.058	0.651	0.879
2010	1.031	0.049	0.929	1.120	0.499	0.048	0.415	0.602	0.484	0.040	0.408	0.566
2011	0.893	0.081	0.702	1.018	0.731	0.101	0.533	0.929	0.819	0.085	0.667	0.999
2012	0.964	0.052	0.842	1.048	0.779	0.073	0.638	0.924	0.808	0.058	0.704	0.932
2013	0.920	0.067	0.753	1.014	0.910	0.102	0.708	1.108	0.989	0.078	0.838	1.145
2014	0.935	0.065	0.770	1.026	0.788	0.089	0.611	0.961	0.843	0.072	0.711	0.993
2015	0.856	0.082	0.654	0.976	0.994	0.135	0.729	1.258	1.161	0.110	0.956	1.389
2016	0.900	0.073	0.729	1.014	1.177	0.161	0.878	1.509	1.307	0.152	1.047	1.643
2017	1.015	0.084	0.857	1.187	1.596	0.262	1.142	2.169	1.573	0.225	1.175	2.058
2018	0.806	0.094	0.595	0.963	1.860	0.355	1.199	2.592	2.306	0.332	1.709	3.012
2019	0.960	0.086	0.810	1.147	1.797	0.305	1.270	2.466	1.872	0.265	1.402	2.440
2020	0.745	0.096	0.534	0.912	1.166	0.238	0.769	1.702	1.565	0.231	1.184	2.090
2021	0.964	0.104	0.764	1.173	1.619	0.303	1.067	2.256	1.680	0.274	1.214	2.289

C.12 JMD7 TR observer

Table C.60: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the JMD7 TR observer CPUE series.

Series	JMD7 TR observer
QMS stock	JMA7
Reporting forms	
Fishing methods	MW, BT
Target species	JMA, JMD, JMM, JMN
Statistical Areas	034, 035, 036, 037, 039, 040, 041, 042, 045, 801
Period	1990-10-01, 2022-09-30
Resolution	Observed event
Core fleet years	2
Core fleet trips	1
Default model	jmdkg ~ fyear + vessel_key + month + stat_area + primary_method + ns(log(fishing_duration), 3) + ns(log(start_time), 3) + ns(log(start_seabed_depth), 3) + ns(log(headline_height), 3) + ns(fishing_speed, 3)
Stepwise selection	Yes
Positive catch distribution	Weibull

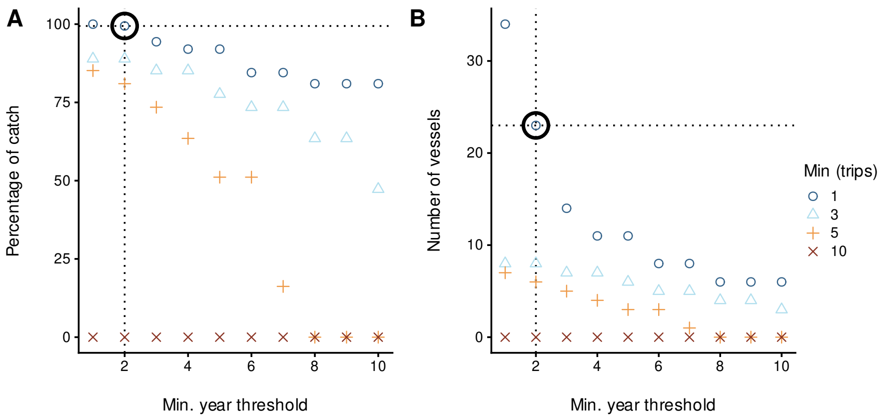

Figure C.192: Percentage of catch and number of vessels for different core vessel selection criteria for the JMD7 TR observer CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel was observed in the fishery and the number of observed trips per year.

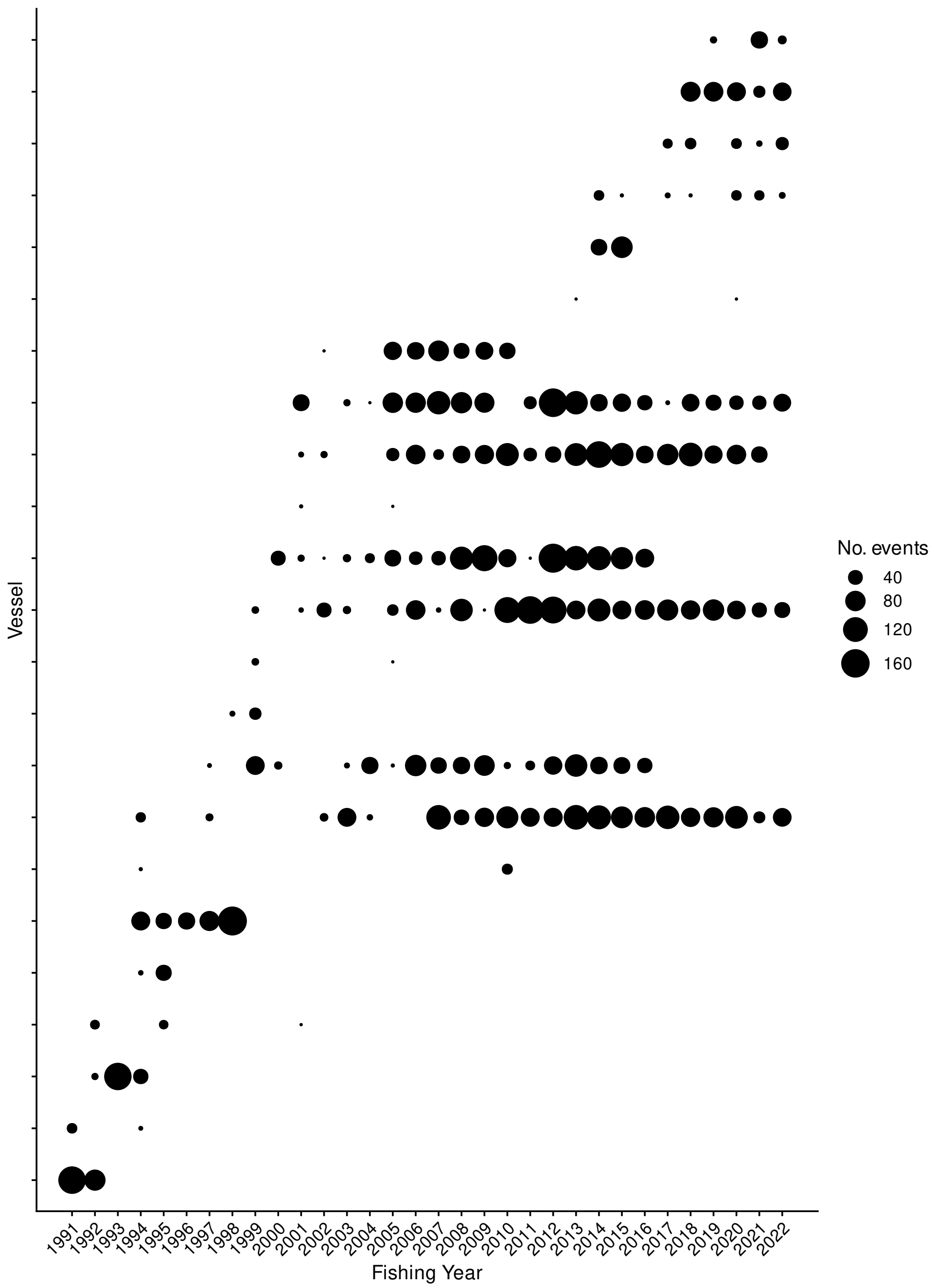

Figure C.193: Number of events by fishing year for core vessels. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table C.61: Summary of the JMD7 TR observer 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	1991	1992	1993	1994	1995	1996	1997	1998	1999
Ungroomed data	635 (100%) n: 188	487 (100%) n: 118	1019 (100%) n: 159	758 (100%) n: 181	365 (100%) n: 145	211 (100%) n: 57	1196 (100%) n: 119	1278 (100%) n: 172	975 (100%) n: 121
Fishing speed not null	627 (100%) n: 187	487 (100%) n: 118	1019 (100%) n: 159	715 (94%) n: 175	365 (100%) n: 145	211 (100%) n: 57	1196 (100%) n: 119	1278 (100%) n: 172	927 (100%) n: 117
Start date not null	627 (100%) n: 187	487 (100%) n: 118	1019 (100%) n: 159	715 (94%) n: 175	365 (100%) n: 145	211 (100%) n: 57	1196 (100%) n: 119	1278 (100%) n: 172	927 (100%) n: 117
End date not null	627 (100%) n: 187	487 (100%) n: 118	1019 (100%) n: 159	715 (94%) n: 175	365 (100%) n: 145	211 (100%) n: 57	1196 (100%) n: 119	1278 (100%) n: 172	927 (100%) n: 117
Start depth not null	627 (100%) n: 187	487 (100%) n: 118	1019 (100%) n: 159	715 (94%) n: 175	365 (100%) n: 145	211 (100%) n: 57	1196 (100%) n: 119	1278 (100%) n: 172	927 (100%) n: 117
Headline height not null	627 (100%) n: 187	487 (100%) n: 118	1019 (100%) n: 159	715 (94%) n: 175	365 (100%) n: 144	211 (100%) n: 57	1196 (100%) n: 119	1278 (100%) n: 172	919 (94%) n: 116
Fishing speed >3.5kn	627 (100%) n: 187	487 (100%) n: 118	1015 (100%) n: 158	715 (94%) n: 175	363 (100%) n: 143	204 (100%) n: 55	1181 (100%) n: 116	1278 (100%) n: 172	919 (94%) n: 116
Headline height <90m	627 (100%) n: 187	487 (100%) n: 118	1015 (100%) n: 158	715 (94%) n: 175	363 (100%) n: 143	204 (100%) n: 55	1181 (100%) n: 116	1278 (100%) n: 172	919 (94%) n: 116
Fishing duration >15mins	627 (100%) n: 187	487 (100%) n: 118	1015 (100%) n: 158	715 (94%) n: 174	363 (100%) n: 143	204 (100%) n: 55	1181 (100%) n: 116	1278 (100%) n: 172	899 (92%) n: 114
Seabed depth >50m	627 (100%) n: 187	487 (100%) n: 118	1015 (100%) n: 158	715 (94%) n: 174	363 (100%) n: 143	204 (100%) n: 55	1181 (100%) n: 116	1278 (100%) n: 172	899 (92%) n: 114
Seabed depth <400m	627 (100%) n: 187	487 (100%) n: 118	1015 (100%) n: 158	715 (94%) n: 174	363 (100%) n: 143	204 (100%) n: 55	1181 (100%) n: 116	1278 (100%) n: 171	886 (91%) n: 113
Start time >0	626 (100%) n: 186	487 (100%) n: 117	1015 (100%) n: 158	710 (94%) n: 173	361 (100%) n: 140	204 (100%) n: 55	1181 (100%) n: 115	1278 (100%) n: 171	884 (91%) n: 112
Core fleet selection	581 (92%) n: 168	480 (100%) n: 110	966 (95%) n: 148	511 (68%) n: 138	230 (63%) n: 112	204 (100%) n: 55	902 (75%) n: 90	1278 (100%) n: 171	884 (91%) n: 112

Filter	2000	2001	2002	2003	2004	2005	2006	2007	2008
Ungroomed data	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	687 (100%) n: 103	1171 (100%) n: 79	2478 (100%) n: 261	4706 (100%) n: 409	4247 (100%) n: 427	4954 (100%) n: 511
Fishing speed not null	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	687 (100%) n: 103	1171 (100%) n: 79	2446 (100%) n: 259	4706 (100%) n: 409	4247 (100%) n: 427	4895 (100%) n: 510
Start date not null	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	687 (100%) n: 103	1171 (100%) n: 79	2446 (100%) n: 259	4706 (100%) n: 409	4247 (100%) n: 427	4895 (100%) n: 510
End date not null	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	687 (100%) n: 103	1171 (100%) n: 79	2446 (100%) n: 259	4706 (100%) n: 409	4247 (100%) n: 427	4895 (100%) n: 510
Start depth not null	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	687 (100%) n: 103	1171 (100%) n: 79	2446 (100%) n: 259	4706 (100%) n: 409	4247 (100%) n: 427	4884 (100%) n: 508
Headline height not null	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	679 (100%) n: 102	1171 (100%) n: 79	2446 (100%) n: 259	4706 (100%) n: 409	4247 (100%) n: 427	4884 (100%) n: 508
Fishing speed >3.5kn	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	679 (100%) n: 102	1171 (100%) n: 79	2446 (100%) n: 259	4706 (100%) n: 409	4247 (100%) n: 426	4884 (100%) n: 508
Headline height <90m	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	679 (100%) n: 102	1171 (100%) n: 79	2446 (100%) n: 259	4706 (100%) n: 409	4247 (100%) n: 426	4884 (100%) n: 508
Fishing duration >15mins	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	679 (100%) n: 102	1171 (100%) n: 79	2444 (100%) n: 258	4637 (100%) n: 408	4194 (100%) n: 425	4884 (100%) n: 507
Seabed depth >50m	404 (100%) n: 54	838 (100%) n: 75	474 (100%) n: 66	679 (100%) n: 102	1171 (100%) n: 79	2444 (100%) n: 258	4637 (100%) n: 408	4194 (100%) n: 425	4884 (100%) n: 507
Seabed depth <400m	390 (100%) n: 53	838 (100%) n: 75	474 (100%) n: 66	679 (100%) n: 102	1171 (100%) n: 79	2434 (100%) n: 256	4637 (100%) n: 408	4194 (100%) n: 425	4865 (100%) n: 504
Start time >0	388 (100%) n: 52	838 (100%) n: 75	438 (92%) n: 63	679 (100%) n: 102	1171 (100%) n: 79	2411 (100%) n: 253	4622 (100%) n: 404	4107 (100%) n: 419	4675 (94%) n: 495
Core fleet selection	388 (100%) n: 52	837 (100%) n: 73	438 (92%) n: 63	679 (100%) n: 102	1171 (100%) n: 79	2411 (100%) n: 253	4622 (100%) n: 404	4107 (100%) n: 419	4675 (94%) n: 495

Filter	2009	2010	2011	2012	2013	2014	2015	2016	2017
Ungroomed data	5884 (100%) n: 526	4455 (100%) n: 488	4219 (100%) n: 310	9664 (100%) n: 713	9876 (100%) n: 644	11390 (100%) n: 670	9856 (100%) n: 593	6599 (100%) n: 411	6310 (100%) n: 332
Fishing speed not null	5884 (100%) n: 526	4436 (100%) n: 487	4219 (100%) n: 310	9664 (100%) n: 713	9838 (100%) n: 643	11390 (100%) n: 670	9856 (100%) n: 593	6584 (100%) n: 410	6231 (100%) n: 330
Start date not null	5884 (100%) n: 526	4436 (100%) n: 487	4219 (100%) n: 310	9664 (100%) n: 713	9838 (100%) n: 643	11390 (100%) n: 670	9856 (100%) n: 593	6584 (100%) n: 410	6231 (100%) n: 330
End date not null	5884 (100%) n: 526	4436 (100%) n: 487	4219 (100%) n: 310	9664 (100%) n: 713	9838 (100%) n: 643	11390 (100%) n: 670	9856 (100%) n: 593	6584 (100%) n: 410	6231 (100%) n: 330
Start depth not null	5628 (100%) n: 501	4388 (100%) n: 484	4146 (100%) n: 306	9122 (94%) n: 677	9350 (95%) n: 622	11345 (100%) n: 667	9786 (100%) n: 577	6584 (100%) n: 410	6175 (100%) n: 327
Headline height not null	5606 (100%) n: 499	4299 (100%) n: 476	4104 (100%) n: 305	9018 (93%) n: 670	9294 (94%) n: 618	11256 (100%) n: 664	9786 (100%) n: 576	6584 (100%) n: 410	6058 (100%) n: 323
Fishing speed >3.5kn	5606 (100%) n: 499	4299 (100%) n: 476	4104 (100%) n: 305	9018 (93%) n: 670	9294 (94%) n: 618	11256 (100%) n: 664	9786 (100%) n: 576	6582 (100%) n: 409	6058 (100%) n: 323
Headline height <90m	5606 (100%) n: 499	4299 (100%) n: 476	4094 (100%) n: 304	9006 (93%) n: 669	9294 (94%) n: 618	11238 (100%) n: 663	9771 (100%) n: 575	6582 (100%) n: 409	6058 (100%) n: 323
Fishing duration >15mins	5606 (100%) n: 499	4299 (100%) n: 476	4016 (100%) n: 301	8986 (93%) n: 668	9256 (94%) n: 616	11233 (100%) n: 661	9771 (100%) n: 575	6579 (100%) n: 408	6046 (100%) n: 322
Seabed depth >50m	5592 (100%) n: 497	4291 (100%) n: 475	4016 (100%) n: 301	8985 (93%) n: 667	9237 (94%) n: 615	11233 (100%) n: 661	9755 (100%) n: 574	6579 (100%) n: 408	6046 (100%) n: 322
Seabed depth <400m	5592 (100%) n: 497	4283 (100%) n: 474	4016 (100%) n: 301	8873 (92%) n: 660	9212 (93%) n: 613	11229 (100%) n: 660	9675 (100%) n: 571	6579 (100%) n: 408	6046 (100%) n: 322
Start time >0	5569 (95%) n: 494	4203 (94%) n: 470	4002 (95%) n: 298	8841 (91%) n: 653	9153 (93%) n: 610	11074 (100%) n: 650	9618 (100%) n: 568	6538 (100%) n: 405	5968 (95%) n: 320
Core fleet selection	5569 (95%) n: 494	4197 (94%) n: 468	4002 (95%) n: 298	8841 (91%) n: 653	9153 (93%) n: 610	11074 (100%) n: 650	9618 (100%) n: 568	5658 (86%) n: 366	5843 (93%) n: 306

Filter	2018	2019	2020	2021	2022
Ungroomed data	8658 (100%) n: 433	8557 (100%) n: 380	6557 (100%) n: 398	5698 (100%) n: 272	5498 (100%) n: 328
Fishing speed not null	8658 (100%) n: 433	8557 (100%) n: 380	6477 (100%) n: 396	5545 (100%) n: 268	5497 (100%) n: 327
Start date not null	8658 (100%) n: 433	8557 (100%) n: 380	6477 (100%) n: 396	5545 (100%) n: 268	5497 (100%) n: 327
End date not null	8658 (100%) n: 433	8557 (100%) n: 380	6477 (100%) n: 396	5545 (100%) n: 268	5497 (100%) n: 327
Start depth not null	8646 (100%) n: 432	8557 (100%) n: 380	6477 (100%) n: 390	5486 (100%) n: 262	4579 (83%) n: 289
Headline height not null	8618 (100%) n: 430	8557 (100%) n: 380	6447 (100%) n: 388	5486 (100%) n: 262	4579 (83%) n: 289
Fishing speed >3.5kn	8618 (100%) n: 430	8557 (100%) n: 380	6447 (100%) n: 388	5486 (100%) n: 262	4579 (83%) n: 289
Headline height <90m	8577 (100%) n: 428	8557 (100%) n: 380	6447 (100%) n: 388	5486 (100%) n: 262	4579 (83%) n: 289
Fishing duration >15mins	8577 (100%) n: 428	8522 (100%) n: 379	6447 (100%) n: 388	5486 (100%) n: 262	4579 (83%) n: 289
Seabed depth >50m	8532 (100%) n: 427	8522 (100%) n: 379	6447 (100%) n: 388	5486 (100%) n: 262	4579 (83%) n: 289
Seabed depth <400m	8510 (100%) n: 425	8406 (100%) n: 377	6447 (100%) n: 388	5486 (100%) n: 262	4579 (83%) n: 289
Start time >0	8505 (100%) n: 424	8366 (100%) n: 376	6401 (100%) n: 385	5421 (100%) n: 260	4579 (83%) n: 289
Core fleet selection	7749 (90%) n: 411	7855 (92%) n: 357	6401 (100%) n: 385	5421 (100%) n: 260	4579 (83%) n: 289

Table C.62: Summary of the JMD7 TR observer dataset after core fleet selection. ‘Records’ indicates the number of rows (events) in the dataset, and ‘Records caught’ indicates the percentage of events with catches of jack mackerels.

Fishing year	Vessels	Trips	Records	Hrs	Catch (t)	Records caught
1991	2	2	168	589.55	581.42	98.21
1992	3	4	110	545.77	480.34	72.73
1993	1	2	148	674.58	965.64	98.65
1994	6	6	138	481.70	511.37	71.74
1995	3	3	112	510.47	230.39	98.21
1996	1	1	55	260.33	203.75	100.00
1997	3	3	90	348.40	902.24	97.78
1998	2	3	171	741.12	1 278.42	97.08
1999	4	6	112	270.07	883.61	96.43
2000	2	2	52	137.25	387.78	98.08
2001	6	8	73	190.02	837.16	97.26
2002	5	5	63	221.45	437.53	100.00
2003	5	5	102	368.00	679.32	98.04
2004	4	4	79	333.28	1 171.09	96.20
2005	8	11	253	857.70	2 410.82	98.81
2006	6	8	404	1 485.25	4 622.09	97.52
2007	7	15	419	1 517.43	4 107.04	96.42
2008	7	16	495	1 925.52	4 675.39	94.55
2009	7	15	494	2 052.37	5 568.81	96.15
2010	7	11	468	2 112.07	4 196.93	97.65
2011	6	8	298	1 368.33	4 002.27	96.98
2012	6	20	653	3 380.90	8 841.23	96.17
2013	7	32	610	2 934.43	9 153.10	94.92
2014	8	35	650	3 037.78	11 074.30	93.85
2015	8	36	568	3 000.35	9 617.96	94.01
2016	6	30	366	1 721.17	5 657.66	93.17
2017	6	26	306	1 592.93	5 842.66	95.42
2018	7	30	411	2 455.30	7 749.00	89.78
2019	6	24	357	1 915.25	7 854.84	97.76
2020	8	31	385	2 001.60	6 401.29	87.27
2021	8	22	260	1 436.48	5 421.48	95.77
2022	7	18	289	1 350.55	4 579.09	92.04

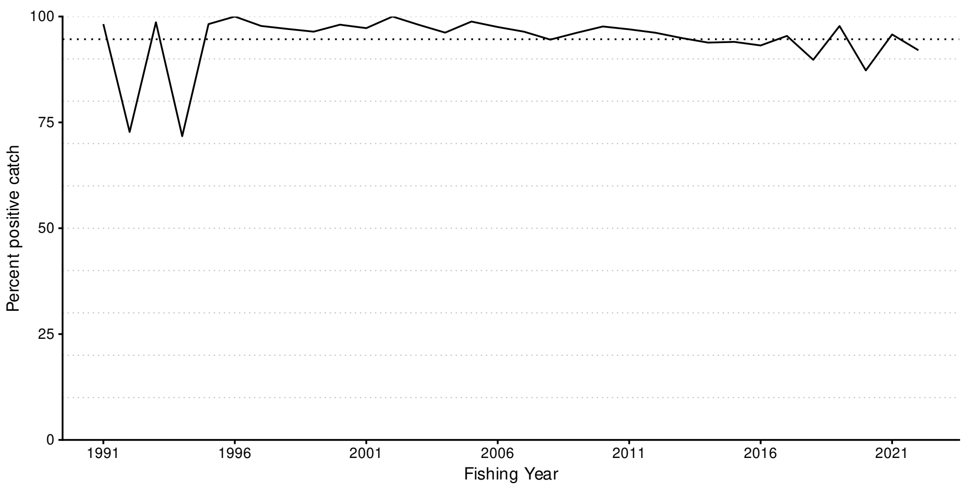

Figure C.194: Percentage of positive catch records in the JMD7 TR observer catch-per-unit-effort dataset.

Table C.63: Summary of stepwise selection for the Weibull model. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	33	181 425	13.8	13.8	*
+ ns(log(start seabed depth), 3)	3	180 878	19.3	5.5	*
+ month	11	180 668	21.7	2.3	*
+ vessel key	22	180 528	23.5	1.8	*
+ ns(log(headline height), 3)	3	180 407	24.8	1.3	*
+ ns(log(fishing duration), 3)	3	180 305	25.9	1.1	*
+ stat area	9	180 203	27.1	1.2	*
+ ns(log(start time), 3)	3	180 192	27.2	0.2	
+ ns(fishing speed, 3)	3	180 188	27.3	0.1	
+ primary method	1	180 188	27.4	0.0	

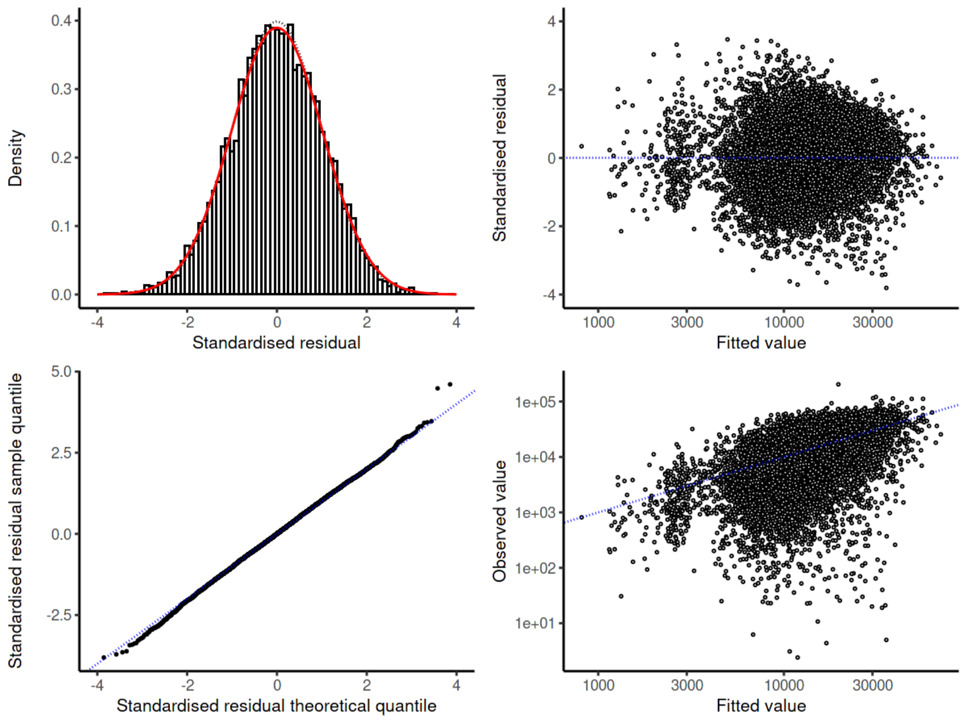

Figure C.195: Diagnostic plots for the Weibull model for the JMD7 TR observer dataset.

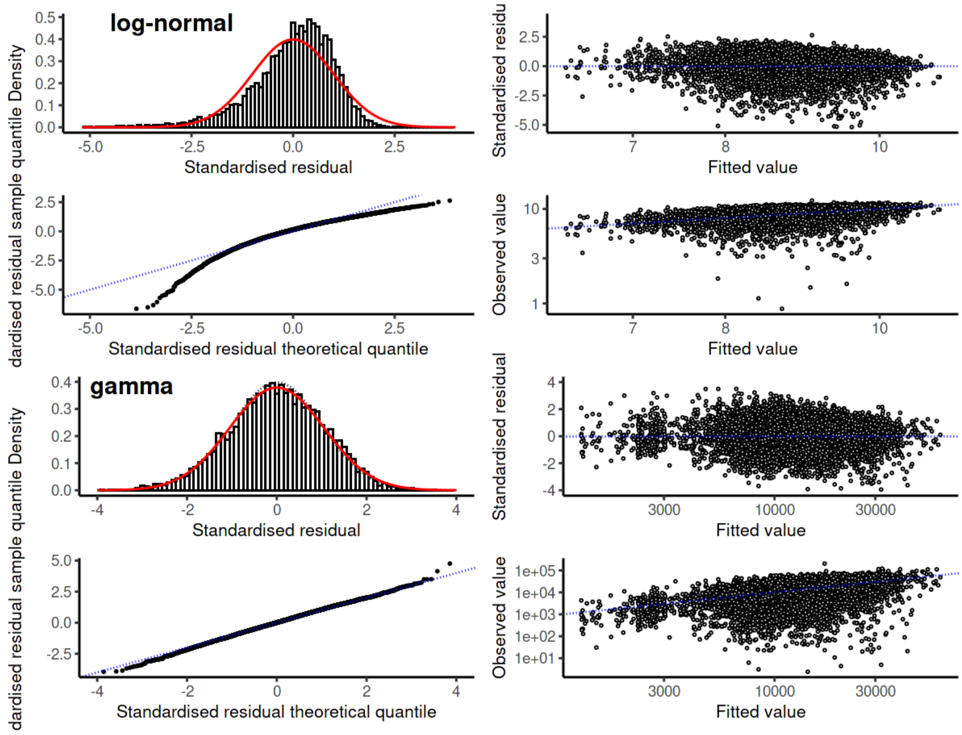

Figure C.196: Diagnostic plots for the log-normal and gamma model for the JMD7 TR observer dataset.

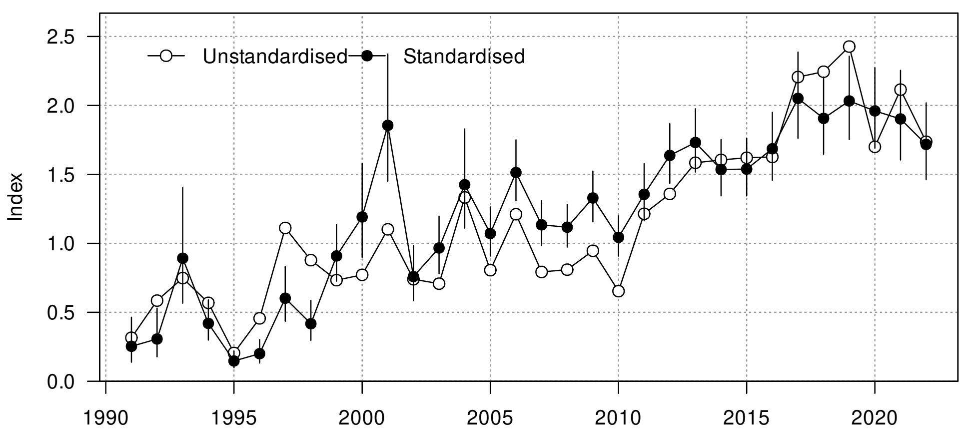

Figure C.197: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch in the JMD7 TR observer dataset.

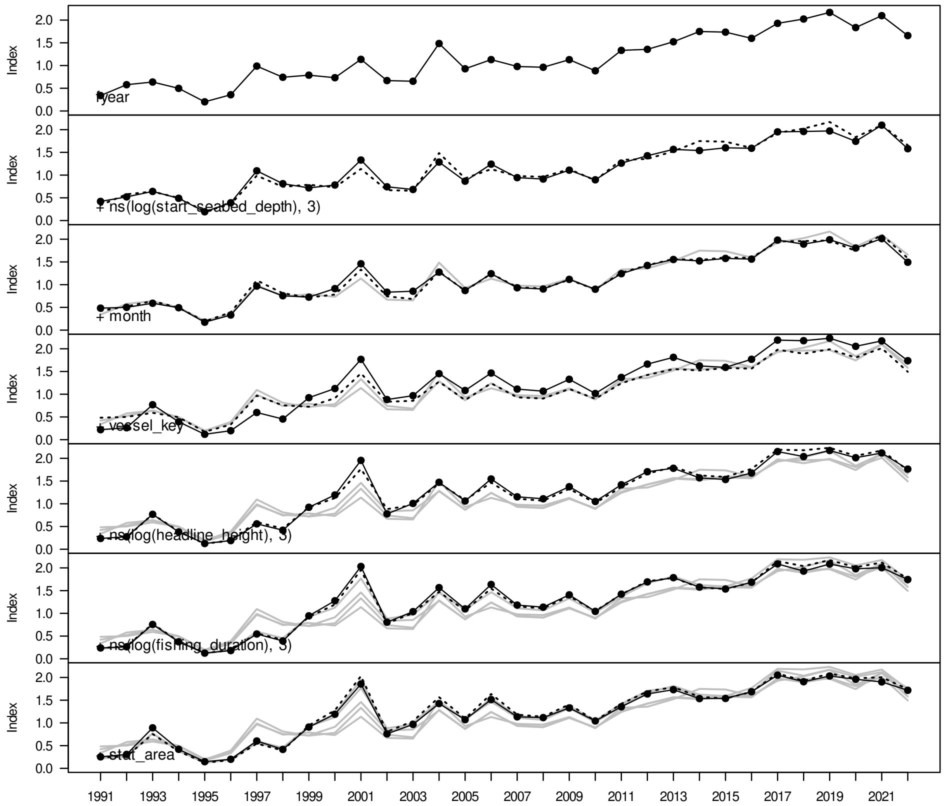

Figure C.198: Changes to the JMD7 TR observer positive catch index as terms are successively entered into the model.

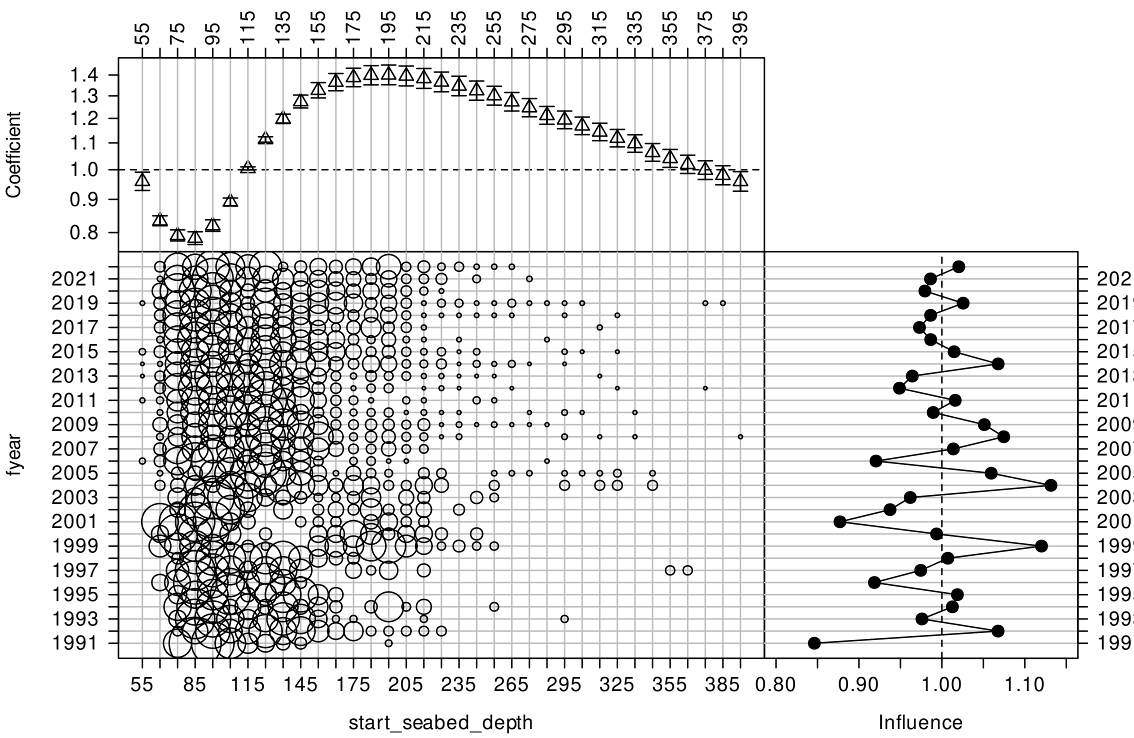

Figure C.199: CDI plot for start seabed depth (m) for the positive catch JMD7 TR observer catch-per-unit-effort dataset.

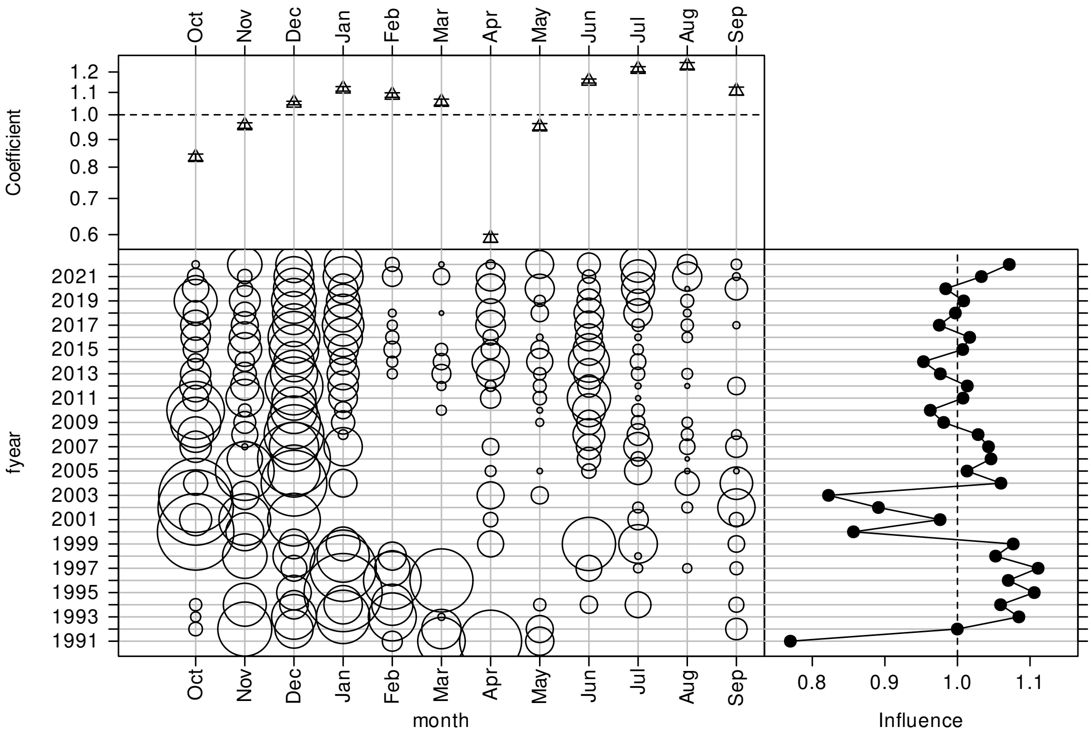

Figure C.200: CDI plot for month for the positive catch JMD7 TR observer catch-per-unit-effort dataset.

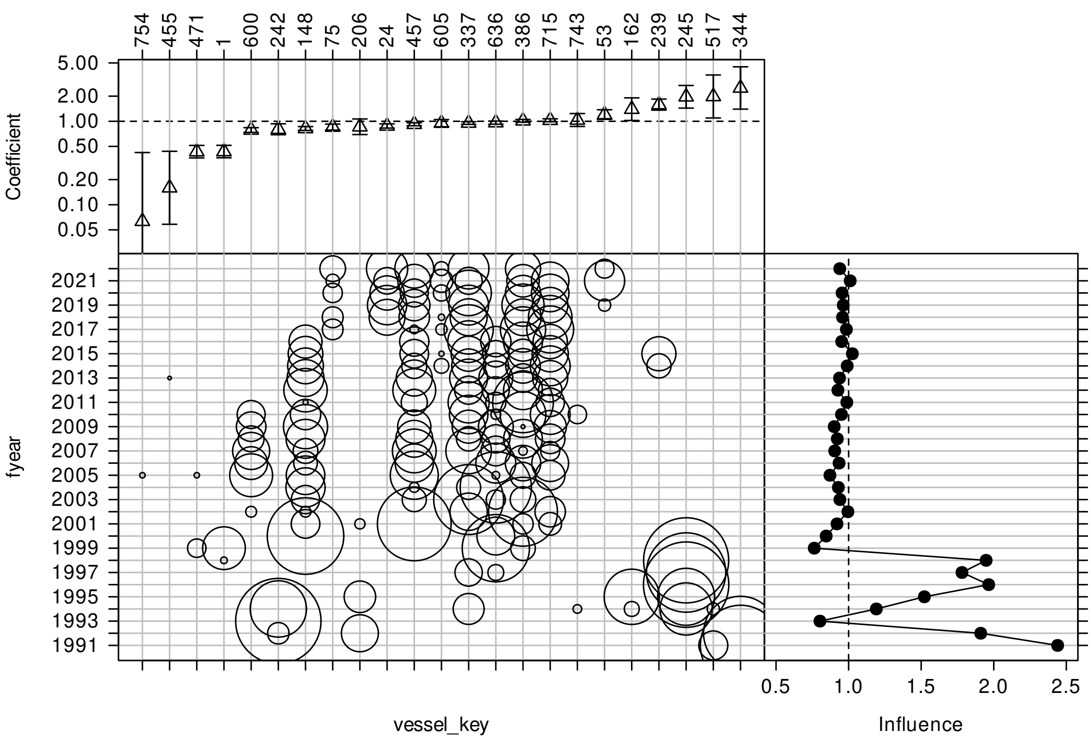

Figure C.201: CDI plot for vessel key for the positive catch JMD7 TR observer catch-per-unit-effort dataset.

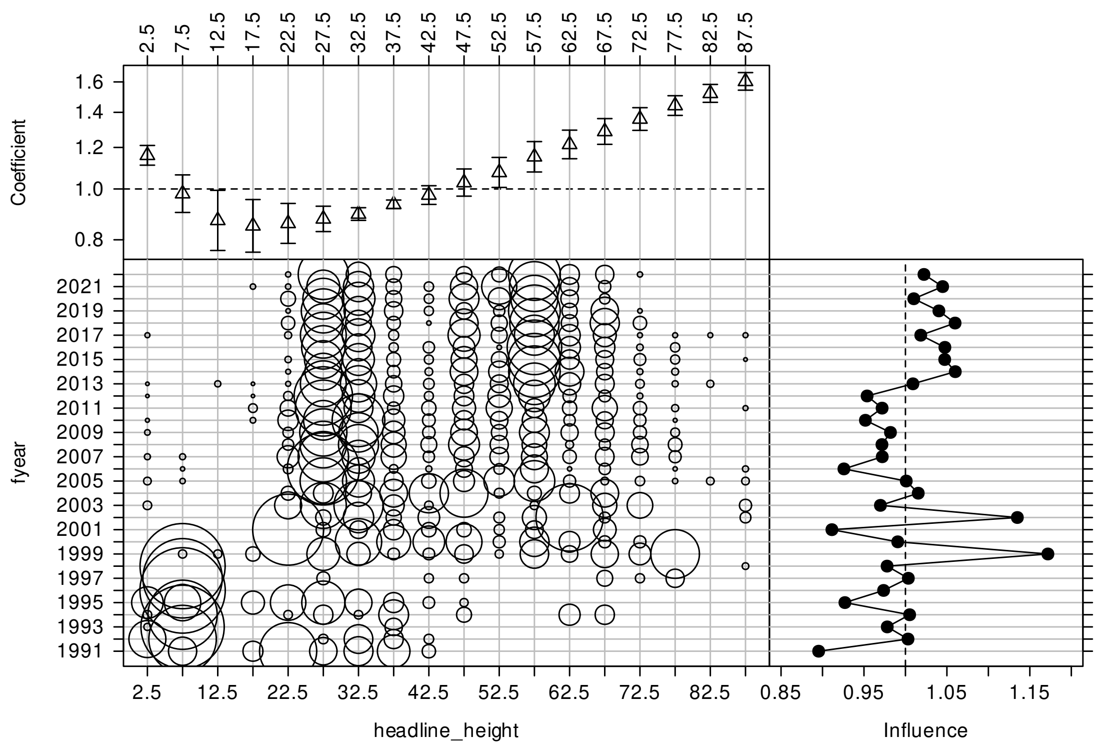

Figure C.202: CDI plot for headline height (m) for the positive catch JMD7 TR observer catch-per-unit-effort dataset.

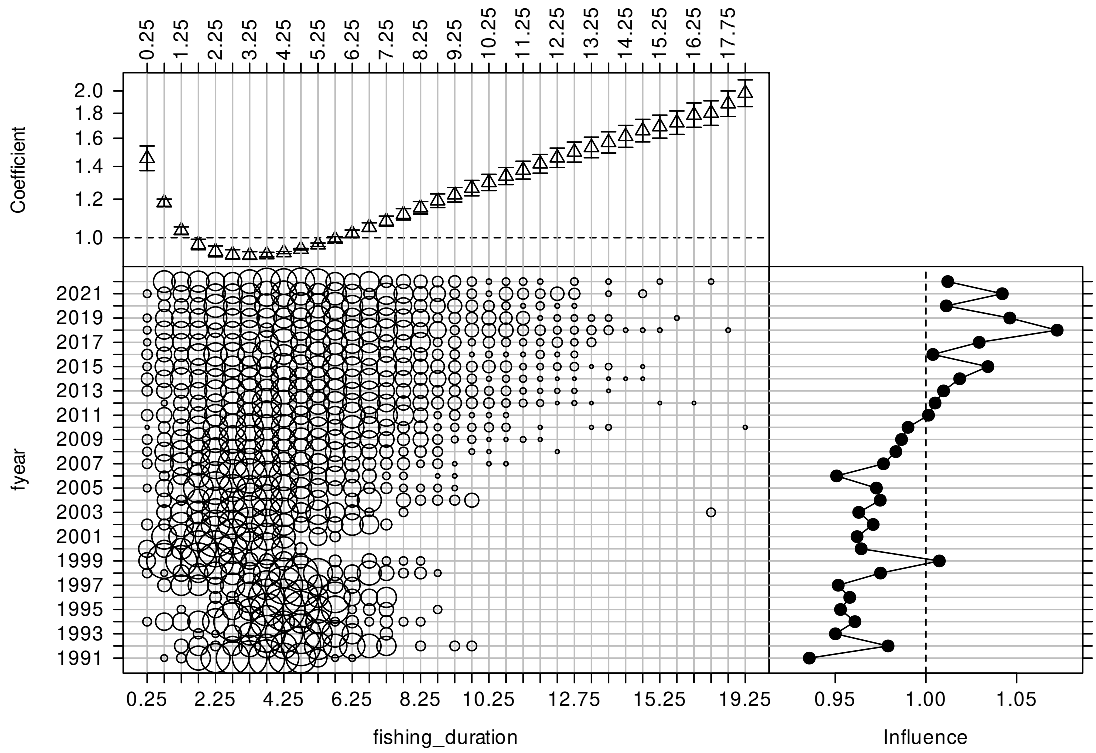

Figure C.203: CDI plot for fishing duration (h) for the positive catch JMD7 TR observer catch-per-unit-effort dataset.

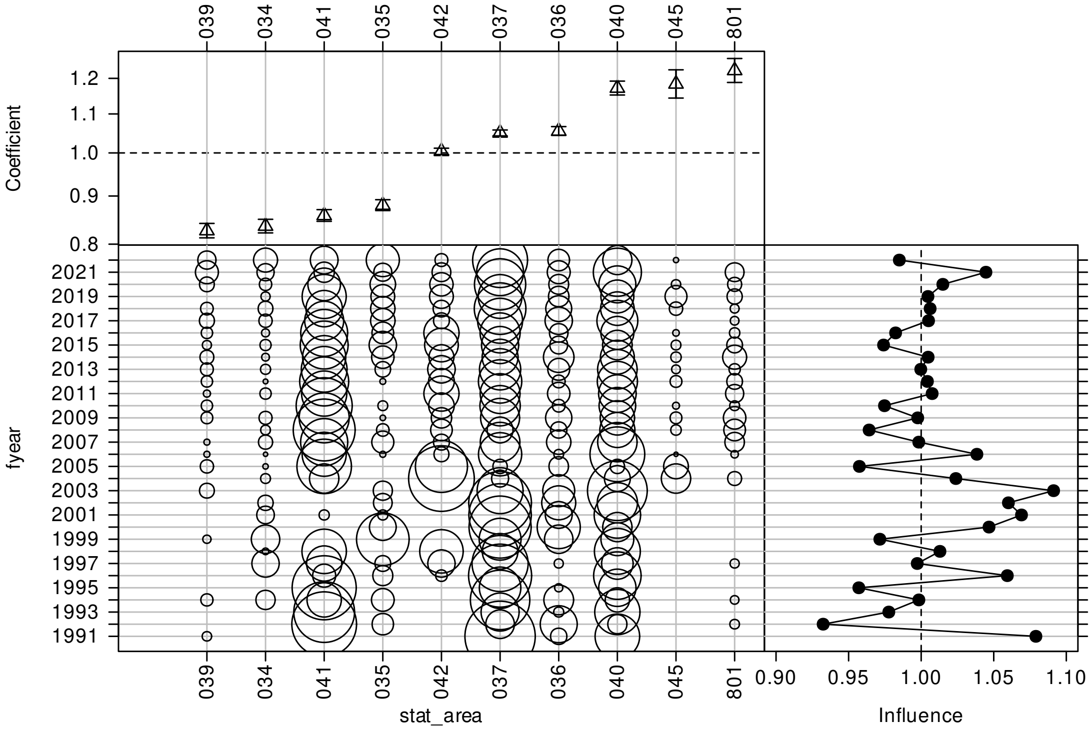

Figure C.204: CDI plot for statistical area for the positive catch JMD7 TR observer catch-per-unit-effort dataset.

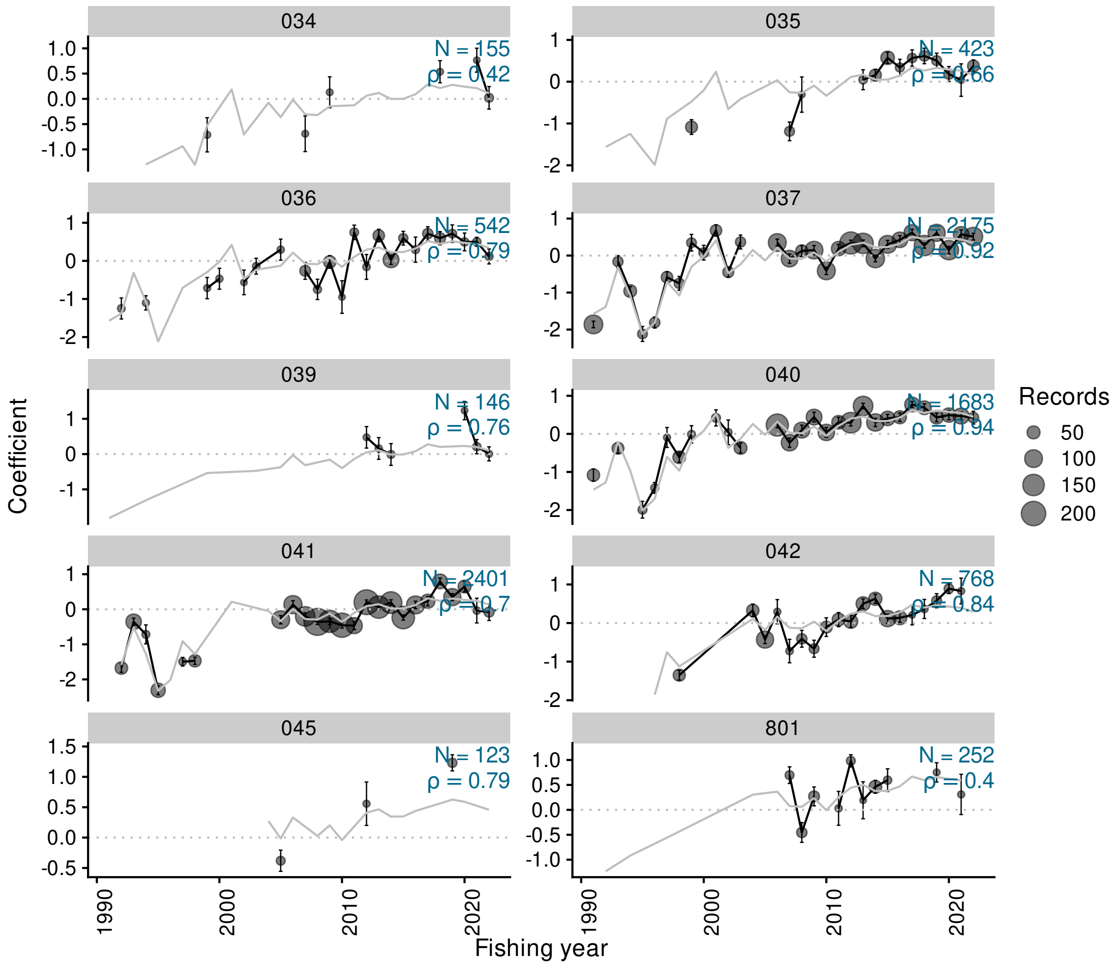

Figure C.205: Residual implied coefficients for area-year in the Weibull positive catch model for the JMD7 TR observer dataset.

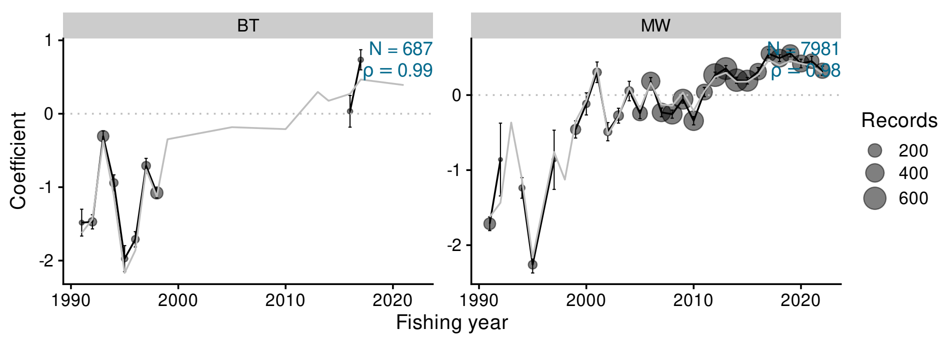

Figure C.206: Residual implied coefficients for primary method-year in the Weibull positive catch model for the JMD7 TR observer dataset.

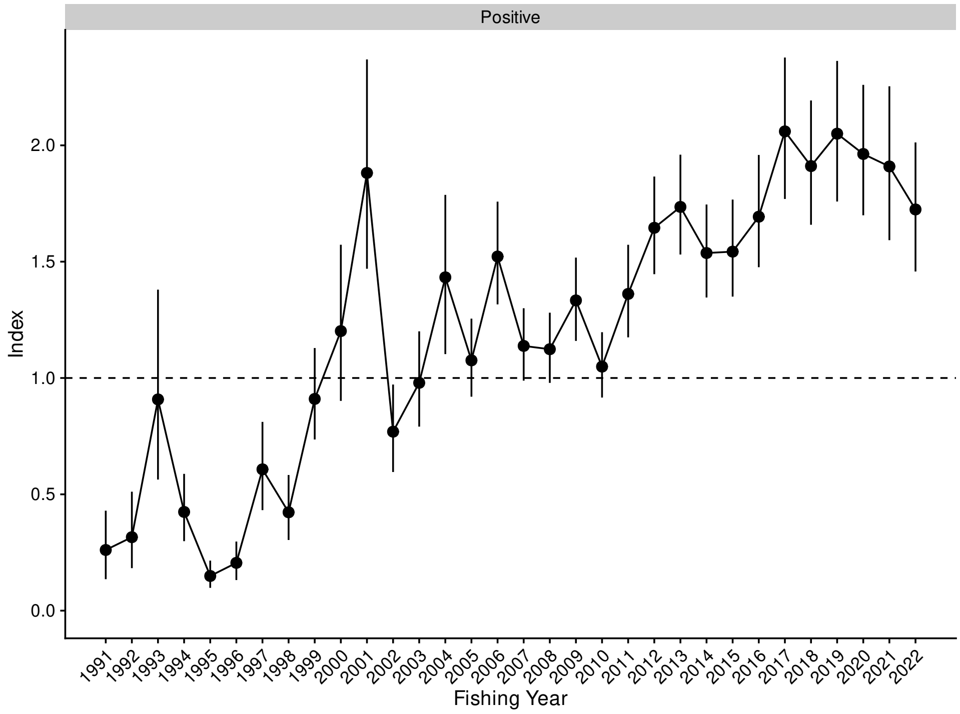

Figure C.207: Standardised indices and 95% confidence intervals for the JMD7 TR observer dataset.

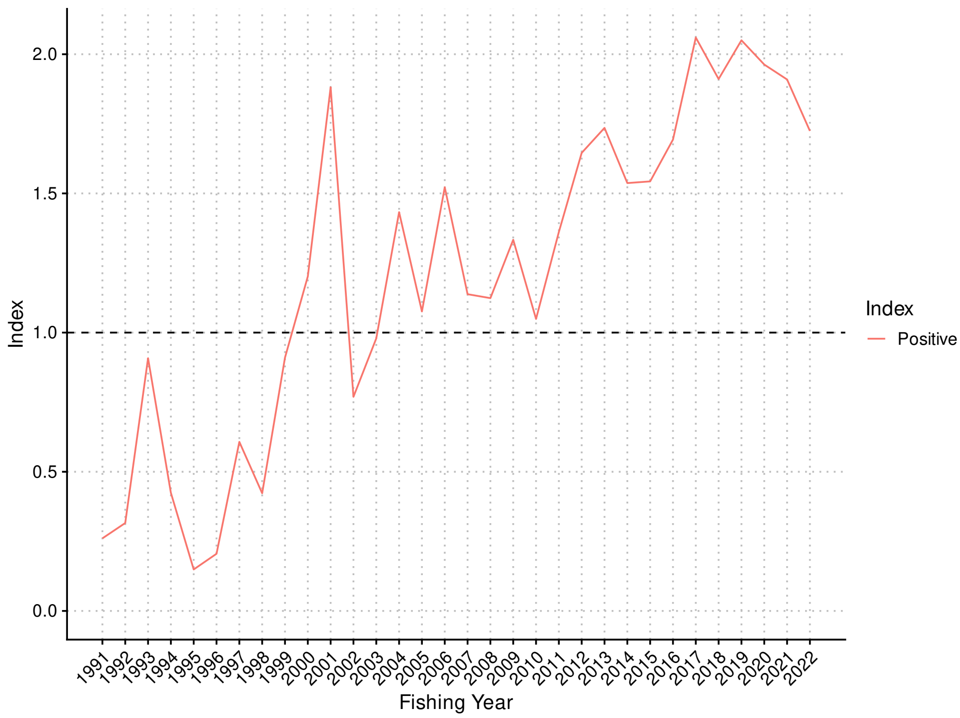

Figure C.208: Standardised indices for the JMD7 TR observer dataset.

Table C.64: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in JMD7 TR observer.

	Positive			
Fishing year	index	SE	LCI	UCI
1991	0.261	0.075	0.135	0.430
1992	0.316	0.084	0.183	0.511
1993	0.908	0.208	0.564	1.380
1994	0.424	0.074	0.299	0.588
1995	0.149	0.030	0.098	0.215
1996	0.205	0.042	0.132	0.297
1997	0.607	0.097	0.432	0.811
1998	0.423	0.071	0.304	0.583
1999	0.910	0.100	0.736	1.129
2000	1.202	0.171	0.902	1.573
2001	1.881	0.230	1.470	2.369
2002	0.769	0.096	0.596	0.972
2003	0.979	0.104	0.791	1.201
2004	1.433	0.175	1.103	1.787
2005	1.076	0.086	0.920	1.255
2006	1.522	0.113	1.316	1.758
2007	1.138	0.079	0.989	1.300
2008	1.124	0.077	0.979	1.281
2009	1.333	0.091	1.159	1.517
2010	1.049	0.072	0.916	1.197
2011	1.361	0.102	1.175	1.573
2012	1.646	0.107	1.446	1.866
2013	1.735	0.109	1.531	1.960
2014	1.537	0.102	1.346	1.746
2015	1.543	0.106	1.350	1.767
2016	1.693	0.123	1.476	1.959
2017	2.060	0.155	1.770	2.378
2018	1.911	0.136	1.659	2.193
2019	2.050	0.154	1.759	2.363
2020	1.963	0.143	1.699	2.260
2021	1.909	0.169	1.592	2.254
2022	1.724	0.142	1.458	2.013

C.13 JMN7 TR observer

Table C.65: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the JMN7 TR observer CPUE series.

Series	JMN7 TR observer
QMS stock	JMA7
Reporting forms	
Fishing methods	MW, BT
Target species	JMA, JMD, JMM, JMN
Statistical Areas	037, 039, 040, 041, 042, 045
Period	1990-10-01, 2022-09-30
Resolution	Observed event
Core fleet years	2
Core fleet trips	1
Default model	jmnkg ~ fyear + vessel_key + month + stat_area + primary_method + ns(log(fishing_duration), 3) + ns(log(start_time), 3) + ns(log(start_seabed_depth), 3) + ns(log(headline_height), 3) + ns(fishing_speed, 3)
Stepwise selection	Yes
Positive catch distribution	Gamma

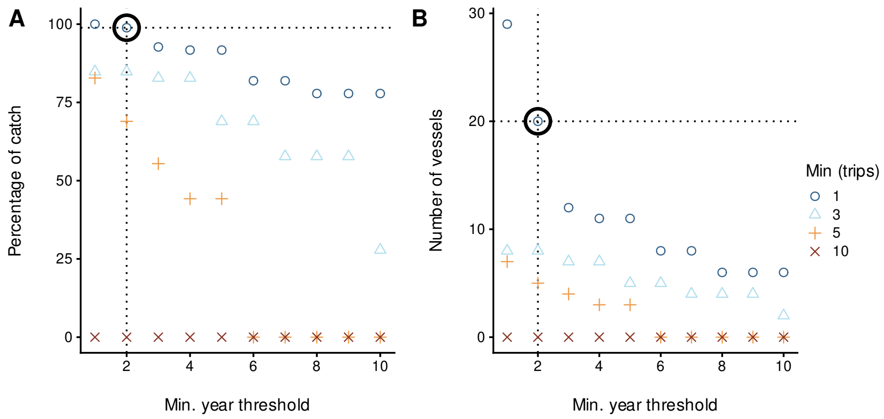

Figure C.209: Percentage of catch and number of vessels for different core vessel selection criteria for the JMN7 TR observer CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel was observed in the fishery and the number of observed trips per year.

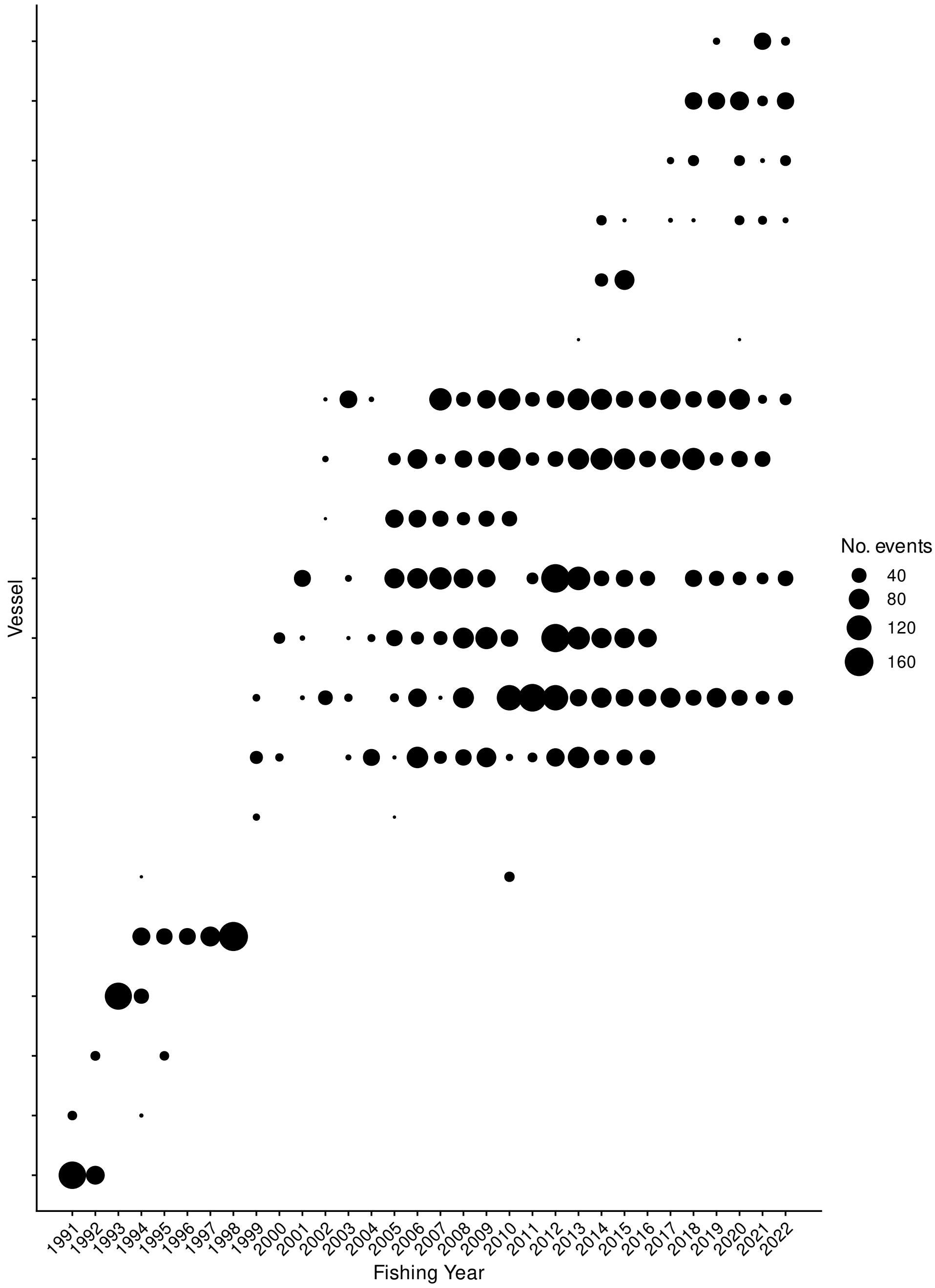

Figure C.210: Number of events by fishing year for core vessels. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table C.66: Summary of the JMN7 TR observer 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	1991	1992	1993	1994	1995	1996	1997	1998	1999
Ungroomed data	1168 (100%) n: 178	478 (100%) n: 89	502 (100%) n: 154	594 (100%) n: 135	486 (100%) n: 144	155 (100%) n: 54	631 (100%) n: 102	1155 (100%) n: 166	321 (100%) n: 50
Fishing speed not null	1167 (100%) n: 177	478 (100%) n: 89	502 (100%) n: 154	560 (94%) n: 131	486 (100%) n: 144	155 (100%) n: 54	631 (100%) n: 102	1155 (100%) n: 166	321 (100%) n: 49
Start date not null	1167 (100%) n: 177	478 (100%) n: 89	502 (100%) n: 154	560 (94%) n: 131	486 (100%) n: 144	155 (100%) n: 54	631 (100%) n: 102	1155 (100%) n: 166	321 (100%) n: 49
End date not null	1167 (100%) n: 177	478 (100%) n: 89	502 (100%) n: 154	560 (94%) n: 131	486 (100%) n: 144	155 (100%) n: 54	631 (100%) n: 102	1155 (100%) n: 166	321 (100%) n: 49
Start depth not null	1167 (100%) n: 177	478 (100%) n: 89	502 (100%) n: 154	560 (94%) n: 131	486 (100%) n: 144	155 (100%) n: 54	631 (100%) n: 102	1155 (100%) n: 166	321 (100%) n: 49
Headline height not null	1167 (100%) n: 177	478 (100%) n: 89	502 (100%) n: 154	560 (94%) n: 131	485 (100%) n: 143	155 (100%) n: 54	631 (100%) n: 102	1155 (100%) n: 166	311 (100%) n: 48
Fishing speed >3.5kn	1167 (100%) n: 177	478 (100%) n: 89	502 (100%) n: 153	560 (94%) n: 131	479 (100%) n: 142	140 (90%) n: 52	627 (100%) n: 100	1155 (100%) n: 166	311 (100%) n: 48
Headline height <90m	1167 (100%) n: 177	478 (100%) n: 89	502 (100%) n: 153	560 (94%) n: 131	479 (100%) n: 142	140 (90%) n: 52	627 (100%) n: 100	1155 (100%) n: 166	311 (100%) n: 48
Fishing duration >15mins	1167 (100%) n: 177	478 (100%) n: 89	502 (100%) n: 153	560 (94%) n: 131	479 (100%) n: 142	140 (90%) n: 52	627 (100%) n: 100	1155 (100%) n: 166	306 (100%) n: 47
Seabed depth >50m	1167 (100%) n: 177	478 (100%) n: 89	502 (100%) n: 153	560 (94%) n: 131	479 (100%) n: 142	140 (90%) n: 52	627 (100%) n: 100	1155 (100%) n: 166	306 (100%) n: 47
Seabed depth <200m	1167 (100%) n: 177	478 (100%) n: 89	502 (100%) n: 152	560 (94%) n: 131	479 (100%) n: 142	140 (90%) n: 52	627 (100%) n: 100	1155 (100%) n: 166	306 (100%) n: 47
Start time >0	1165 (100%) n: 176	475 (100%) n: 88	502 (100%) n: 152	551 (93%) n: 130	466 (100%) n: 139	140 (90%) n: 52	627 (100%) n: 100	1155 (100%) n: 166	306 (100%) n: 47
Core fleet selection	1154 (100%) n: 162	470 (100%) n: 82	467 (93%) n: 143	335 (56%) n: 105	195 (40%) n: 64	140 (90%) n: 52	505 (80%) n: 75	1155 (100%) n: 166	306 (100%) n: 47

Filter	2000	2001	2002	2003	2004	2005	2006	2007	2008
Ungroomed data	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 84	403 (100%) n: 76	2575 (100%) n: 245	1541 (100%) n: 397	1331 (100%) n: 327	2365 (100%) n: 435
Fishing speed not null	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 84	403 (100%) n: 76	2572 (100%) n: 243	1541 (100%) n: 397	1331 (100%) n: 327	2363 (100%) n: 434
Start date not null	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 84	403 (100%) n: 76	2572 (100%) n: 243	1541 (100%) n: 397	1331 (100%) n: 327	2363 (100%) n: 434
End date not null	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 84	403 (100%) n: 76	2572 (100%) n: 243	1541 (100%) n: 397	1331 (100%) n: 327	2363 (100%) n: 434
Start depth not null	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 84	403 (100%) n: 76	2572 (100%) n: 243	1541 (100%) n: 397	1331 (100%) n: 327	2363 (100%) n: 433
Headline height not null	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 83	403 (100%) n: 76	2572 (100%) n: 243	1541 (100%) n: 397	1331 (100%) n: 327	2363 (100%) n: 433
Fishing speed >3.5kn	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 83	403 (100%) n: 76	2572 (100%) n: 243	1541 (100%) n: 397	1331 (100%) n: 326	2363 (100%) n: 433
Headline height <90m	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 83	403 (100%) n: 76	2572 (100%) n: 243	1541 (100%) n: 397	1331 (100%) n: 326	2363 (100%) n: 433
Fishing duration >15mins	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 83	403 (100%) n: 76	2572 (100%) n: 242	1541 (100%) n: 397	1331 (100%) n: 326	2363 (100%) n: 432
Seabed depth >50m	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 83	403 (100%) n: 76	2572 (100%) n: 242	1541 (100%) n: 397	1331 (100%) n: 326	2363 (100%) n: 432
Seabed depth <200m	100 (100%) n: 35	178 (100%) n: 60	260 (100%) n: 51	389 (100%) n: 83	394 (100%) n: 67	2423 (94%) n: 233	1541 (100%) n: 396	1331 (100%) n: 326	2347 (100%) n: 419
Start time >0	100 (100%) n: 34	178 (100%) n: 60	228 (88%) n: 48	389 (100%) n: 83	394 (100%) n: 67	2406 (93%) n: 232	1521 (100%) n: 392	1284 (100%) n: 323	2332 (100%) n: 414
Core fleet selection	100 (100%) n: 34	178 (100%) n: 60	228 (88%) n: 48	389 (100%) n: 83	394 (100%) n: 67	2406 (93%) n: 232	1521 (100%) n: 392	1284 (100%) n: 323	2332 (100%) n: 414

Filter	2009	2010	2011	2012	2013	2014	2015	2016	2017
Ungroomed data	2171 (100%) n: 428	2177 (100%) n: 465	1501 (100%) n: 271	4646 (100%) n: 669	4991 (100%) n: 564	3726 (100%) n: 481	5772 (100%) n: 485	3313 (100%) n: 334	2798 (100%) n: 261
Fishing speed not null	2171 (100%) n: 428	2176 (100%) n: 464	1501 (100%) n: 271	4646 (100%) n: 669	4991 (100%) n: 563	3726 (100%) n: 481	5772 (100%) n: 485	3313 (100%) n: 333	2796 (100%) n: 259
Start date not null	2171 (100%) n: 428	2176 (100%) n: 464	1501 (100%) n: 271	4646 (100%) n: 669	4991 (100%) n: 563	3726 (100%) n: 481	5772 (100%) n: 485	3313 (100%) n: 333	2796 (100%) n: 259
End date not null	2171 (100%) n: 428	2176 (100%) n: 464	1501 (100%) n: 271	4646 (100%) n: 669	4991 (100%) n: 563	3726 (100%) n: 481	5772 (100%) n: 485	3313 (100%) n: 333	2796 (100%) n: 259
Start depth not null	2046 (94%) n: 405	2171 (100%) n: 461	1476 (100%) n: 267	4285 (92%) n: 634	4893 (100%) n: 543	3706 (100%) n: 479	5512 (100%) n: 469	3313 (100%) n: 333	2763 (100%) n: 257
Headline height not null	2007 (92%) n: 404	2114 (100%) n: 453	1476 (100%) n: 266	4265 (92%) n: 627	4861 (100%) n: 539	3706 (100%) n: 478	5508 (100%) n: 468	3313 (100%) n: 333	2763 (100%) n: 253
Fishing speed >3.5kn	2007 (92%) n: 404	2114 (100%) n: 453	1476 (100%) n: 266	4265 (92%) n: 627	4861 (100%) n: 539	3706 (100%) n: 478	5508 (100%) n: 468	3293 (100%) n: 332	2763 (100%) n: 253
Headline height <90m	2007 (92%) n: 404	2114 (100%) n: 453	1454 (100%) n: 265	4265 (92%) n: 626	4861 (100%) n: 539	3706 (100%) n: 478	5508 (100%) n: 468	3293 (100%) n: 332	2763 (100%) n: 253
Fishing duration >15mins	2007 (92%) n: 404	2114 (100%) n: 453	1425 (95%) n: 263	4265 (92%) n: 626	4851 (100%) n: 537	3705 (100%) n: 476	5508 (100%) n: 468	3293 (100%) n: 331	2744 (100%) n: 252
Seabed depth >50m	2006 (92%) n: 402	2089 (100%) n: 452	1425 (95%) n: 263	4264 (92%) n: 625	4851 (100%) n: 536	3705 (100%) n: 476	5504 (100%) n: 467	3293 (100%) n: 331	2744 (100%) n: 252
Seabed depth <200m	1936 (89%) n: 391	2077 (100%) n: 440	1425 (95%) n: 262	4250 (91%) n: 612	4835 (100%) n: 528	3690 (100%) n: 473	5474 (95%) n: 457	3217 (100%) n: 327	2744 (100%) n: 250
Start time >0	1936 (89%) n: 390	2077 (100%) n: 437	1416 (94%) n: 259	4160 (90%) n: 606	4817 (100%) n: 526	3630 (100%) n: 466	5427 (94%) n: 454	3148 (100%) n: 324	2739 (100%) n: 249
Core fleet selection	1936 (89%) n: 390	2075 (100%) n: 436	1416 (94%) n: 259	4160 (90%) n: 606	4817 (100%) n: 526	3630 (100%) n: 466	5427 (94%) n: 454	3142 (95%) n: 315	2609 (93%) n: 235

Filter	2018	2019	2020	2021	2022
Ungroomed data	4601 (100%) n: 346	2822 (100%) n: 302	2947 (100%) n: 330	2627 (100%) n: 218	2359 (100%) n: 241
Fishing speed not null	4601 (100%) n: 346	2822 (100%) n: 302	2947 (100%) n: 329	2606 (100%) n: 214	2359 (100%) n: 240
Start date not null	4601 (100%) n: 346	2822 (100%) n: 302	2947 (100%) n: 329	2606 (100%) n: 214	2359 (100%) n: 240
End date not null	4601 (100%) n: 346	2822 (100%) n: 302	2947 (100%) n: 329	2606 (100%) n: 214	2359 (100%) n: 240
Start depth not null	4587 (100%) n: 345	2822 (100%) n: 302	2884 (100%) n: 324	2484 (95%) n: 208	2026 (86%) n: 204
Headline height not null	4582 (100%) n: 343	2822 (100%) n: 302	2884 (100%) n: 323	2484 (95%) n: 208	2026 (86%) n: 204
Fishing speed >3.5kn	4582 (100%) n: 343	2822 (100%) n: 302	2884 (100%) n: 323	2484 (95%) n: 208	2026 (86%) n: 204
Headline height <90m	4582 (100%) n: 343	2822 (100%) n: 302	2884 (100%) n: 323	2484 (95%) n: 208	2026 (86%) n: 204
Fishing duration >15mins	4582 (100%) n: 343	2822 (100%) n: 302	2884 (100%) n: 323	2484 (95%) n: 208	2026 (86%) n: 204
Seabed depth >50m	4573 (100%) n: 342	2822 (100%) n: 302	2884 (100%) n: 323	2484 (95%) n: 208	2026 (86%) n: 204
Seabed depth <200m	4403 (100%) n: 332	2758 (100%) n: 279	2884 (100%) n: 318	2483 (95%) n: 207	2019 (86%) n: 202
Start time >0	4393 (100%) n: 331	2758 (100%) n: 279	2829 (100%) n: 315	2422 (92%) n: 206	2019 (86%) n: 202
Core fleet selection	4393 (100%) n: 323	2733 (100%) n: 274	2829 (100%) n: 315	2422 (92%) n: 206	2019 (86%) n: 202

Table C.67: Summary of the JMN7 TR observer dataset after core fleet selection. 'Records' indicates the number of rows (events) in the dataset, and 'Records caught' indicates the percentage of events with catches of jack mackerels.

Fishing year	Vessels	Trips	Records	Hrs	Catch (t)	Records caught
1991	2	2	162	571.05	1 154.18	99.38
1992	2	3	82	432.18	469.56	82.93
1993	1	1	143	652.50	466.79	94.41
1994	4	4	105	408.95	335.30	68.57
1995	2	2	64	310.87	194.88	98.44
1996	1	1	52	245.83	139.84	88.46
1997	1	1	75	317.22	504.72	98.67
1998	1	2	166	732.78	1 155.40	97.59
1999	3	4	47	115.18	305.52	80.85
2000	2	2	34	89.50	99.83	88.24
2001	3	4	60	156.45	178.19	85.00
2002	4	4	48	181.12	228.40	79.17
2003	5	5	83	287.92	388.69	87.95
2004	3	3	67	277.55	393.81	73.13
2005	7	9	232	784.32	2 405.56	89.66
2006	6	8	392	1 436.92	1 520.84	89.29
2007	7	15	323	1 212.35	1 283.74	72.45
2008	7	15	414	1 648.47	2 331.50	69.81
2009	6	11	390	1 646.32	1 935.87	84.10
2010	7	11	436	1 982.73	2 074.93	83.26
2011	5	7	259	1 220.35	1 416.43	71.81
2012	6	18	606	3 091.70	4 159.54	81.68
2013	7	29	526	2 642.28	4 816.53	82.32
2014	8	35	466	2 380.72	3 630.49	79.61
2015	8	30	454	2 543.00	5 427.13	83.48
2016	6	24	315	1 589.90	3 142.18	80.63
2017	5	21	235	1 345.67	2 608.63	89.79
2018	7	23	323	2 120.23	4 392.70	76.78
2019	6	19	274	1 615.12	2 733.26	81.75
2020	8	30	315	1 643.48	2 828.58	71.11
2021	8	20	206	1 196.55	2 421.55	88.35
2022	7	16	202	1 035.87	2 019.18	82.67

Table C.68: Summary of stepwise selection for occurrence of positive catch. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	30.00	6 836	4.50	4.50	*
+ ns(log(start_seabed_depth), 3)	3.00	6 444	10.10	5.60	*
+ stat_area	5.00	6 146	14.50	4.30	*
+ month	11.00	6 053	16.10	1.60	*
+ ns(log(fishing_duration), 3)	3.00	6 020	16.70	0.60	
+ vessel_key	19.00	5 993	17.60	0.90	
+ ns(log(headline_height), 3)	3.00	5 981	17.80	0.30	
+ ns(fishing_speed, 3)	3.00	5 976	18.00	0.20	

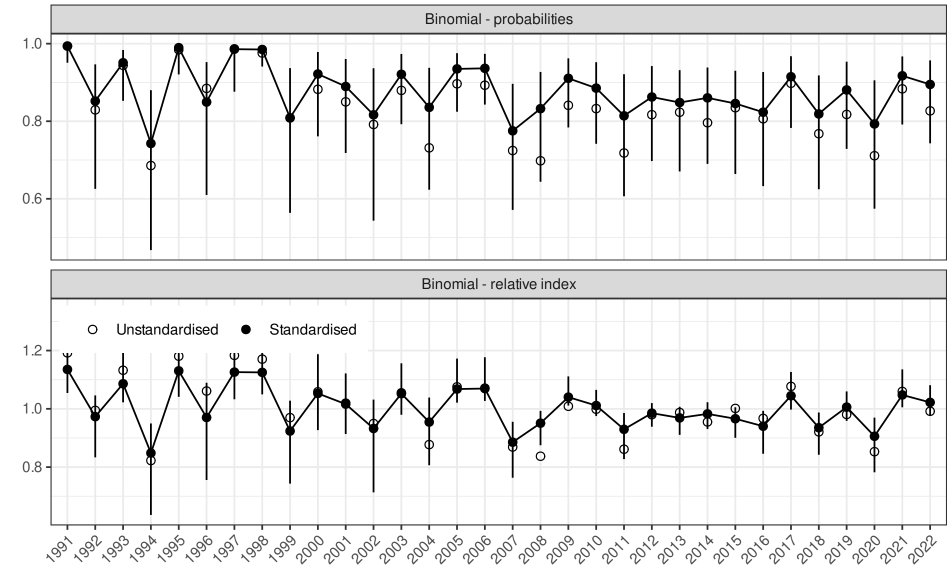

Figure C.211: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the JMN7 TR observer dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

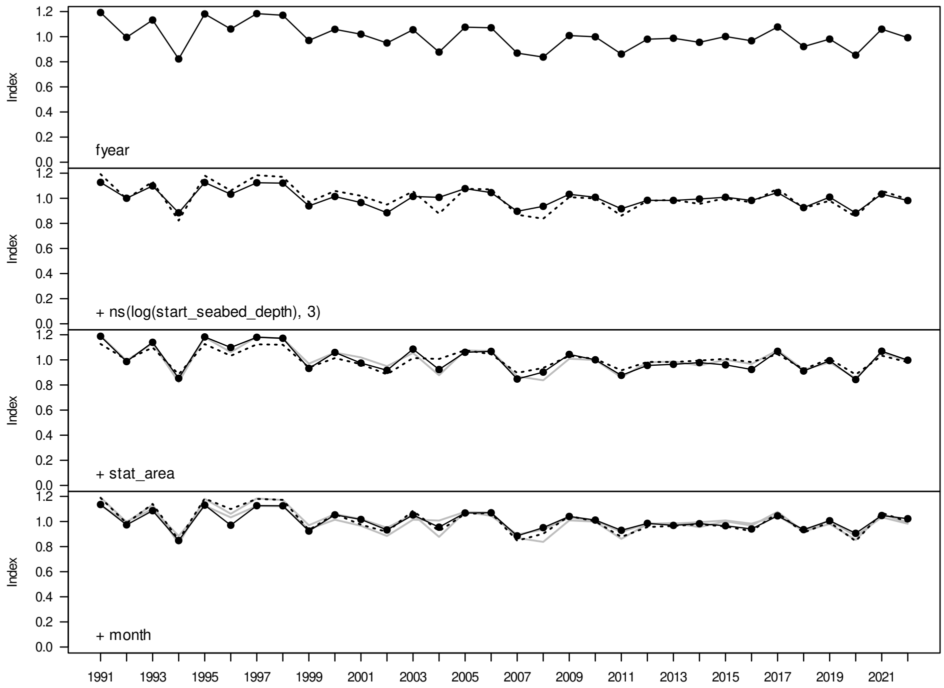

Figure C.212: Step plot for occurrence of catch in the JMN7 TR observer dataset.

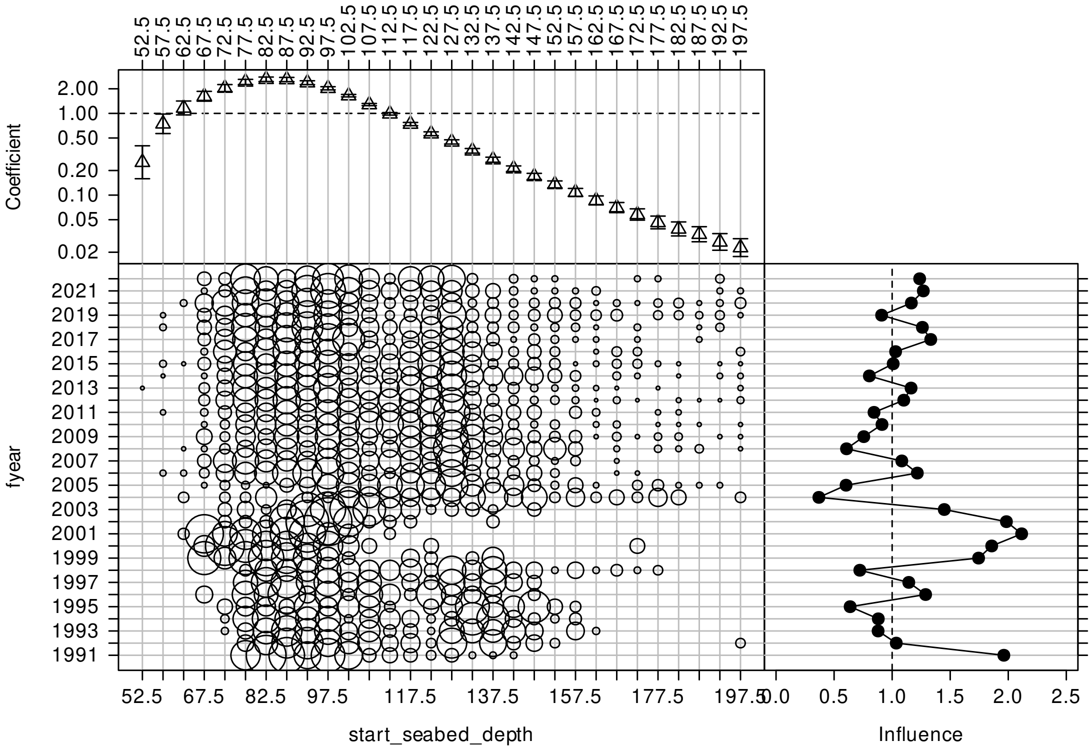

Figure C.213: CDI plot for start seabed depth (m) for the occurrence of positive catch JMN7 TR observer catch-per-unit-effort dataset.

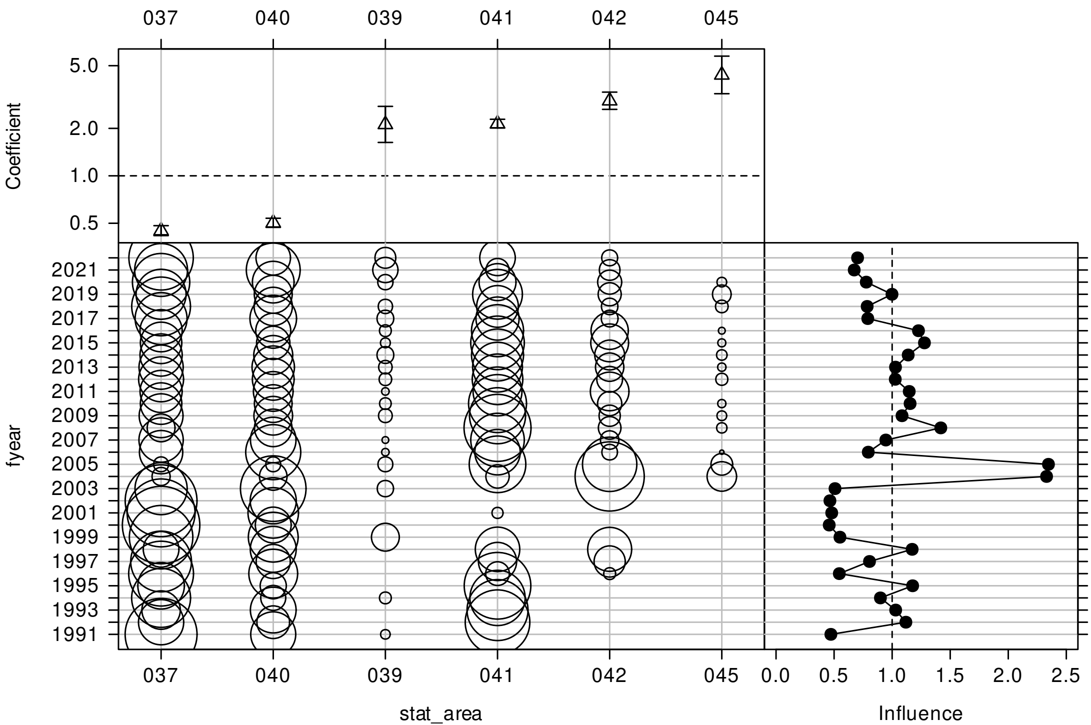

Figure C.214: CDI plot for statistical area for the occurrence of positive catch JMN7 TR observer catch-per-unit-effort dataset.

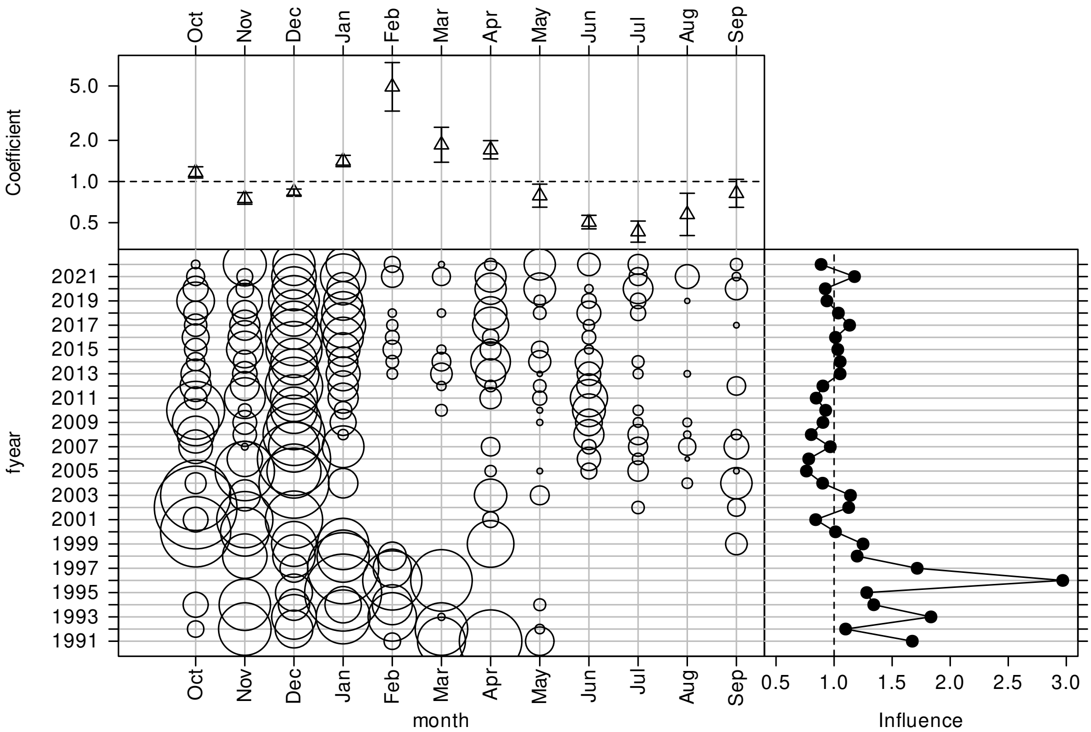

Figure C.215: CDI plot for month for the occurrence of positive catch JMN7 TR observer catch-per-unit-effort dataset.

Table C.69: Summary of stepwise selection for the gamma model. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	30	124 540	10.0	10.0	*
+ stat area	5	124 289	13.0	3.0	*
+ month	11	124 067	15.8	2.8	*
+ ns(log(start seabed depth), 3)	3	123 955	17.1	1.3	*
+ ns(log(fishing duration), 3)	3	123 866	18.2	1.0	*
+ ns(log(start time), 3)	3	123 790	19.1	0.9	
+ vessel key	18	123 770	19.7	0.6	
+ ns(log(headline height), 3)	3	123 758	19.9	0.2	
+ ns(fishing speed, 3)	3	123 755	20.0	0.1	

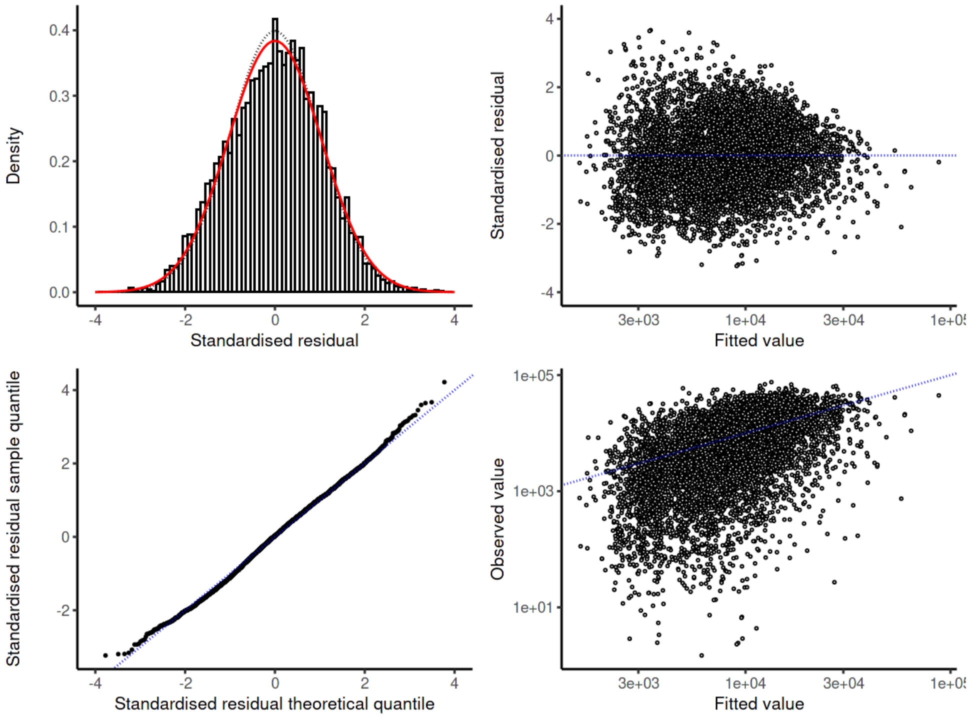

Figure C.216: Diagnostic plots for the gamma model for the JMN7 TR observer dataset.

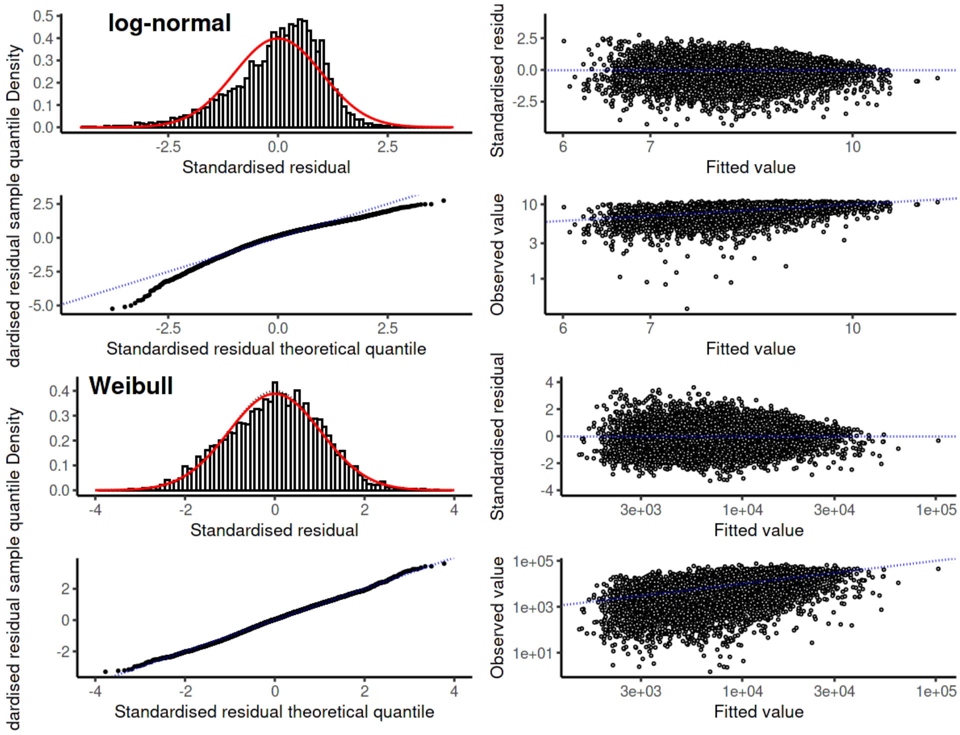

Figure C.217: Diagnostic plots for the log-normal and Weibull model for the JMN7 TR observer dataset.

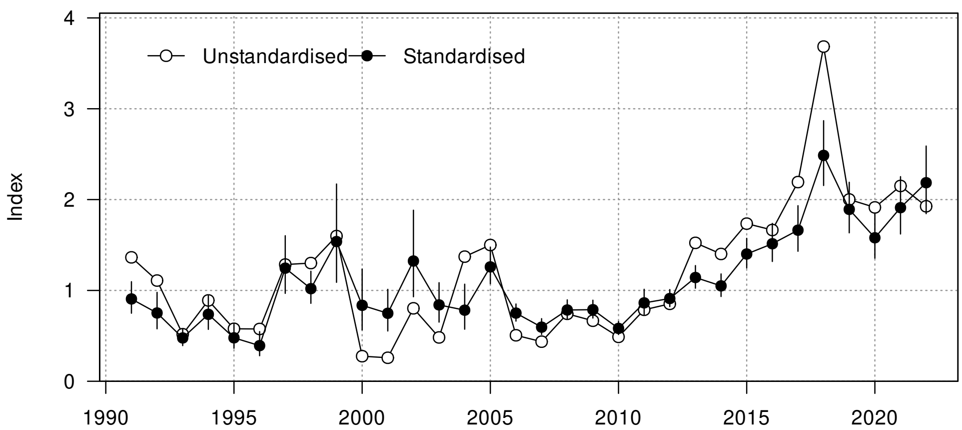

Figure C.218: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch in the JMN7 TR observer dataset.

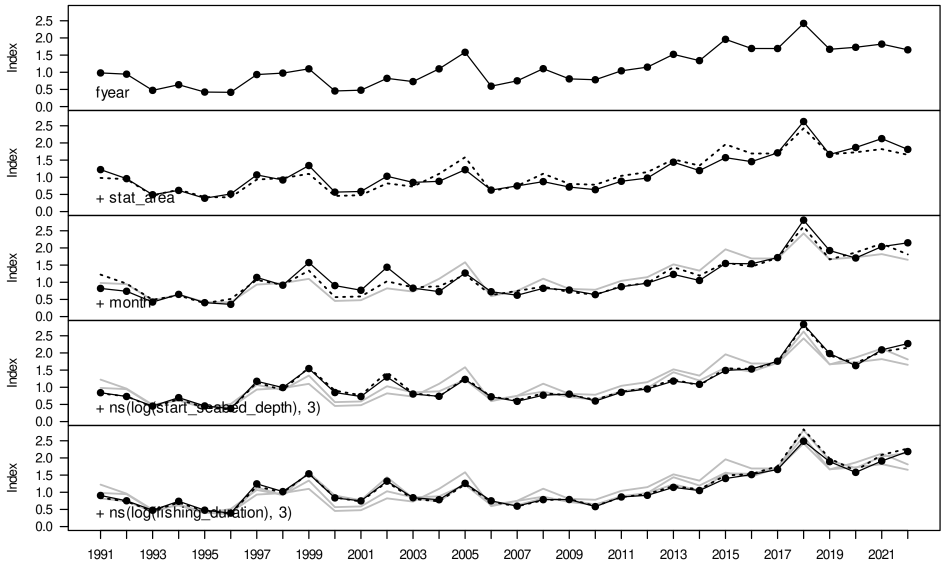

Figure C.219: Changes to the JMN7 TR observer positive catch index as terms are successively entered into the model.

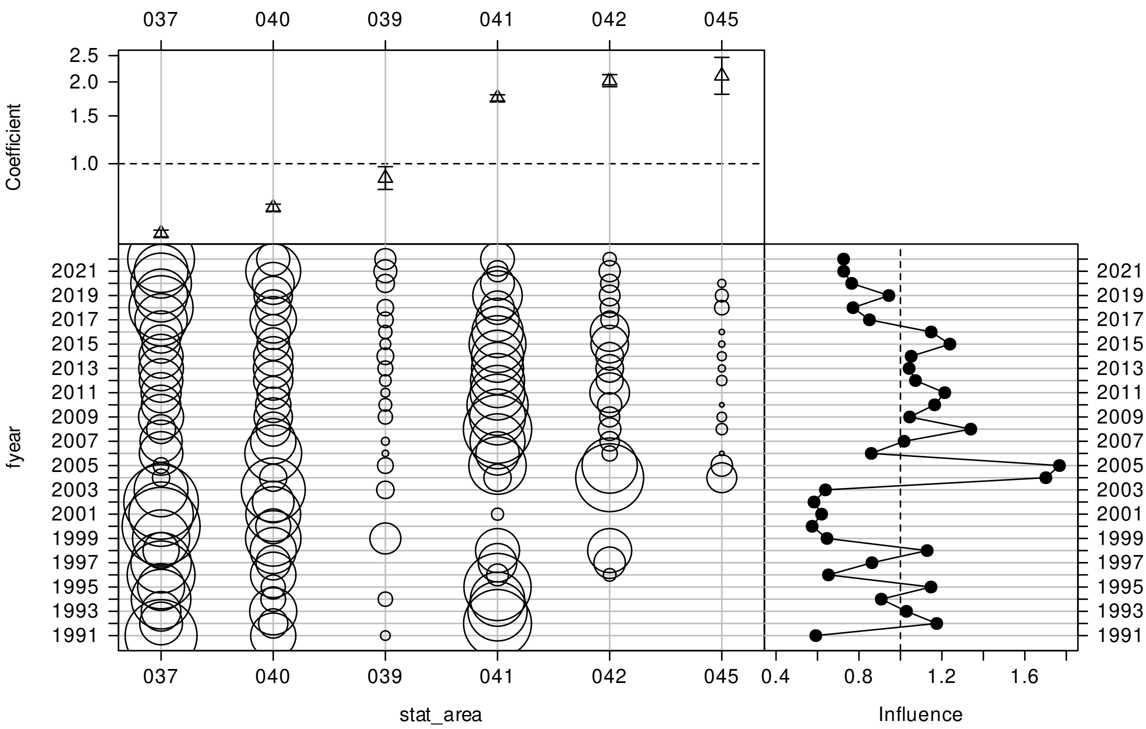

Figure C.220: CDI plot for statistical area for the positive catch JMN7 TR observer catch-per-unit-effort dataset.

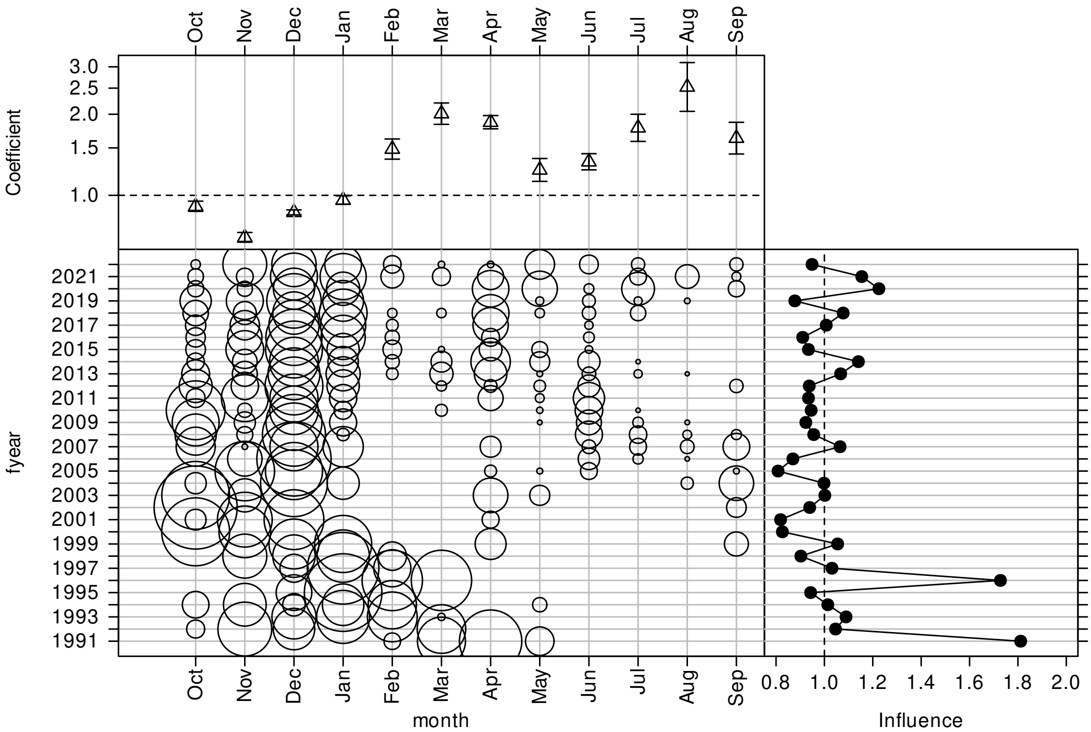

Figure C.221: CDI plot for month for the positive catch JMN7 TR observer catch-per-unit-effort dataset.

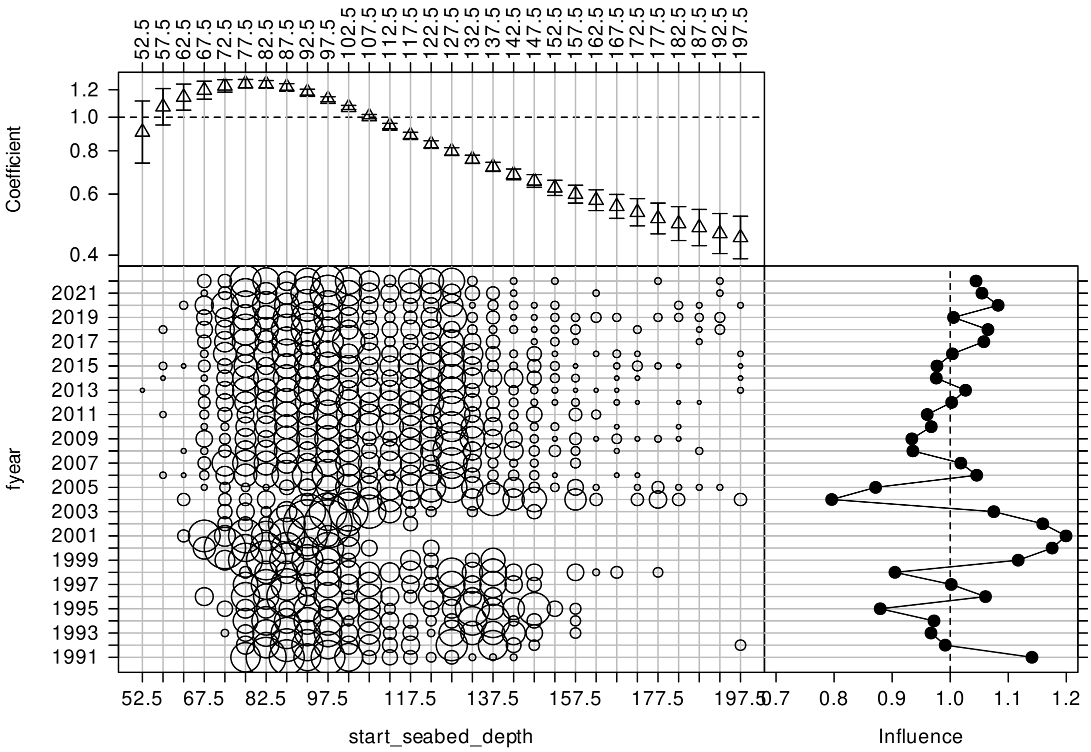

Figure C.222: CDI plot for start seabed depth (m) for the positive catch JMN7 TR observer catch-per-unit-effort dataset.

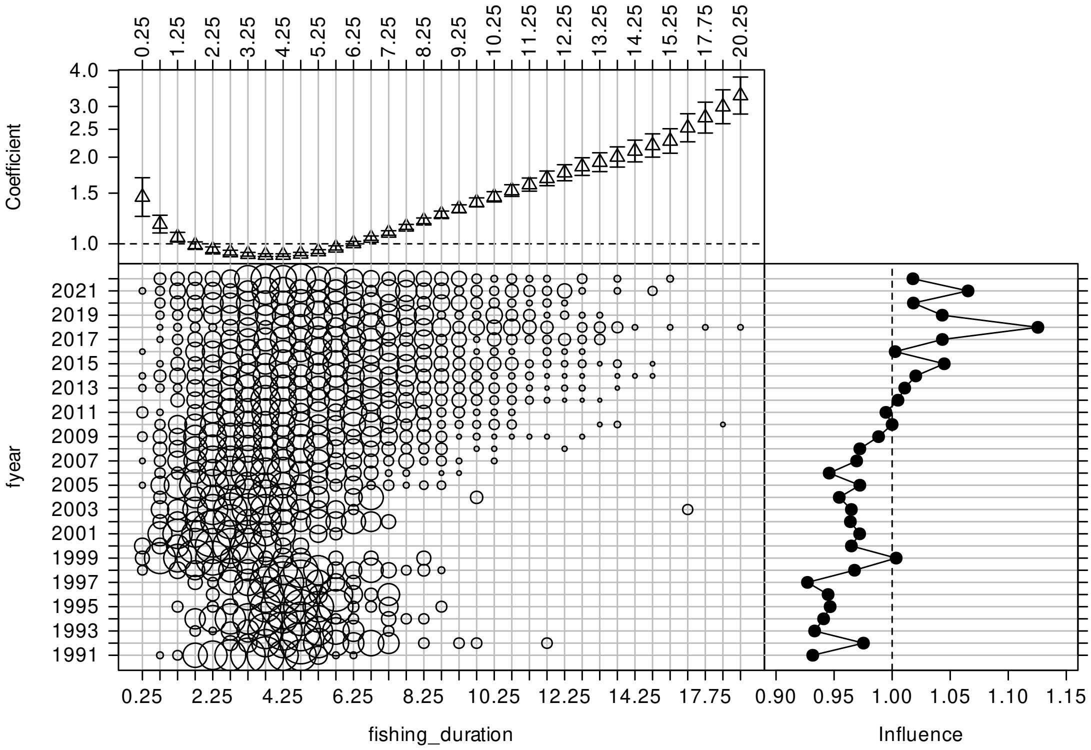

Figure C.223: CDI plot for fishing duration (h) for the positive catch JMN7 TR observer catch-per-unit-effort dataset.

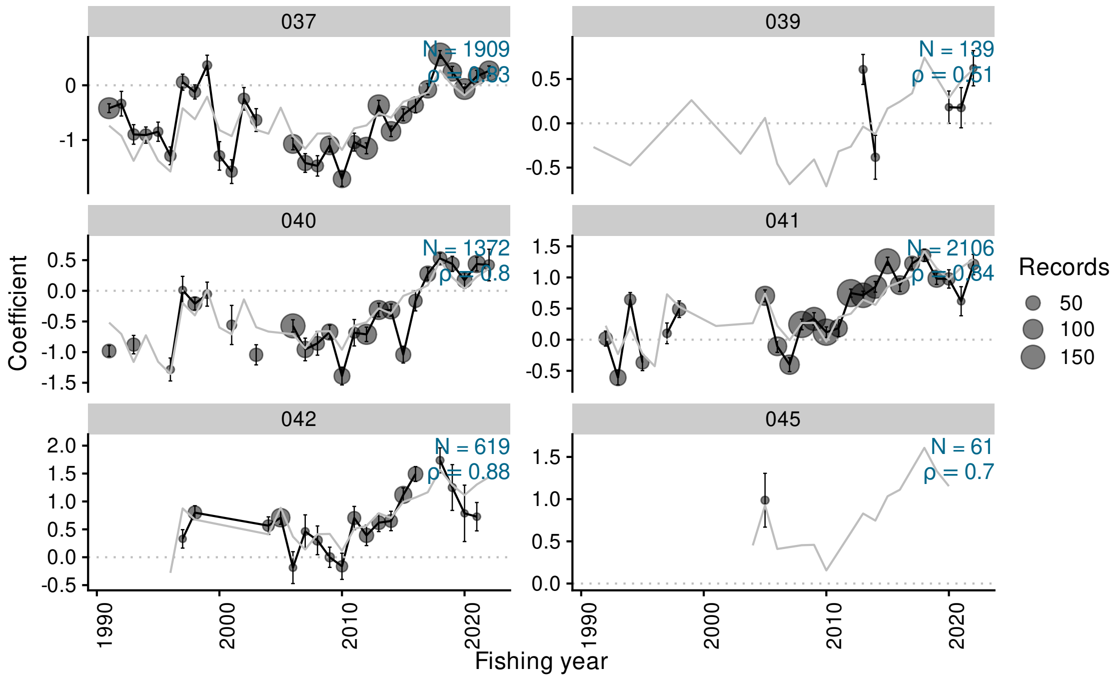

Figure C.224: Residual implied coefficients for area-year in the gamma positive catch model for the JMN7 TR observer dataset.

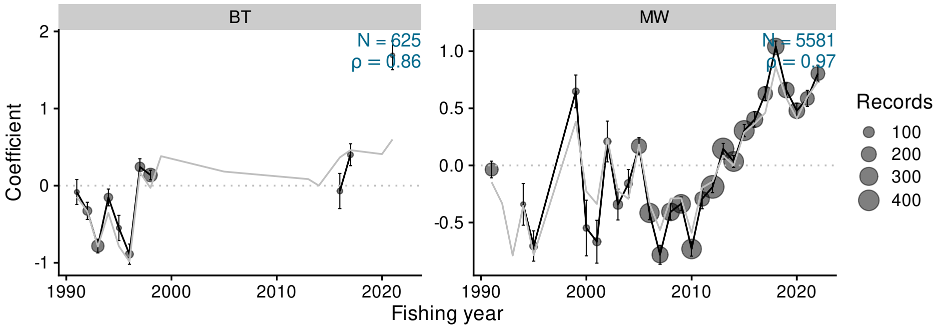

Figure C.225: Residual implied coefficients for primary method-year in the gamma positive catch model for the JMN7 TR observer dataset.

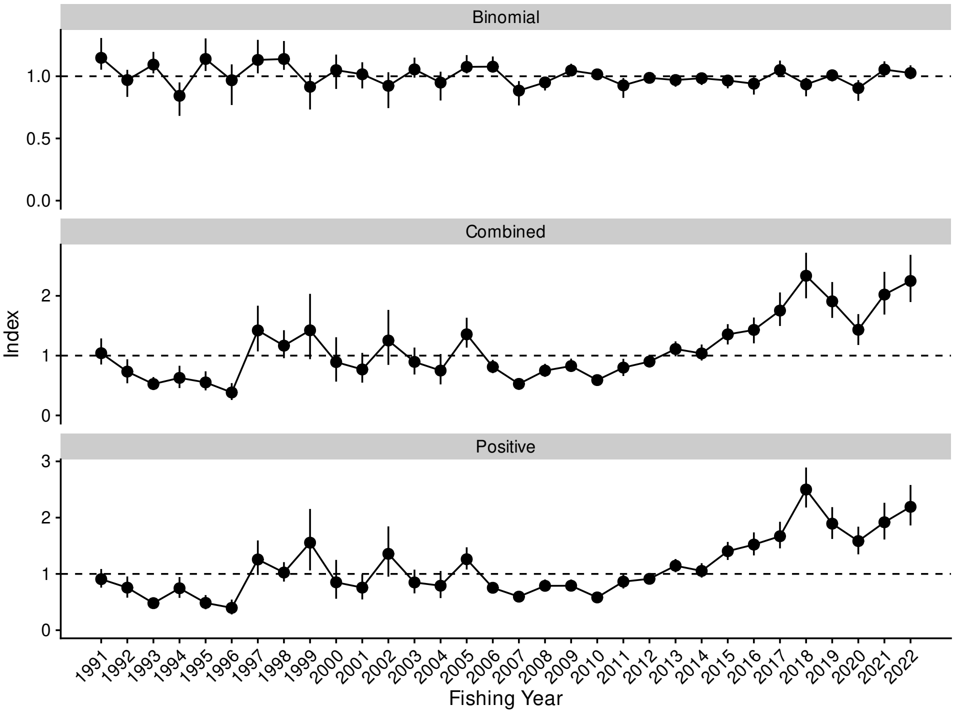

Figure C.226: Standardised indices and 95% confidence intervals for the JMN7 TR observer dataset.

Figure C.227: Standardised indices for the JMN7 TR observer dataset.

Table C.70: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in JMN7 TR observer.

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
1991	1.148	0.065	1.053	1.308	1.041	0.111	0.851	1.288	0.907	0.085	0.756	1.087
1992	0.969	0.055	0.834	1.052	0.733	0.102	0.538	0.939	0.756	0.096	0.577	0.955
1993	1.094	0.044	1.023	1.196	0.525	0.056	0.424	0.642	0.480	0.049	0.389	0.583
1994	0.843	0.069	0.681	0.950	0.628	0.095	0.457	0.831	0.745	0.094	0.574	0.944
1995	1.139	0.067	1.043	1.304	0.552	0.081	0.419	0.738	0.485	0.064	0.372	0.624
1996	0.968	0.083	0.769	1.096	0.384	0.072	0.258	0.540	0.397	0.067	0.280	0.544
1997	1.131	0.069	1.023	1.293	1.422	0.195	1.071	1.835	1.257	0.156	0.982	1.595
1998	1.139	0.059	1.051	1.283	1.167	0.119	0.957	1.425	1.024	0.088	0.863	1.209
1999	0.915	0.075	0.733	1.028	1.423	0.279	0.941	2.033	1.555	0.279	1.062	2.154
2000	1.049	0.070	0.898	1.174	0.892	0.189	0.565	1.308	0.851	0.176	0.558	1.249
2001	1.016	0.054	0.902	1.113	0.769	0.127	0.548	1.046	0.756	0.114	0.546	0.993
2002	0.923	0.074	0.744	1.032	1.253	0.235	0.845	1.765	1.357	0.228	0.951	1.845
2003	1.055	0.041	0.989	1.150	0.895	0.115	0.684	1.135	0.849	0.107	0.654	1.076
2004	0.949	0.059	0.805	1.037	0.750	0.129	0.519	1.027	0.790	0.123	0.570	1.052
2005	1.075	0.038	1.023	1.170	1.356	0.128	1.134	1.634	1.261	0.101	1.078	1.473
2006	1.077	0.033	1.029	1.159	0.811	0.057	0.707	0.929	0.753	0.048	0.664	0.854
2007	0.885	0.050	0.765	0.961	0.527	0.049	0.429	0.620	0.596	0.044	0.515	0.687
2008	0.951	0.027	0.886	0.993	0.749	0.055	0.645	0.862	0.788	0.053	0.695	0.901
2009	1.046	0.023	1.012	1.100	0.826	0.057	0.726	0.950	0.790	0.051	0.699	0.900
2010	1.015	0.022	0.974	1.060	0.591	0.038	0.519	0.668	0.582	0.035	0.516	0.652
2011	0.927	0.041	0.826	0.986	0.800	0.073	0.659	0.946	0.863	0.067	0.741	1.005
2012	0.987	0.019	0.944	1.018	0.901	0.053	0.800	1.010	0.913	0.050	0.818	1.013
2013	0.970	0.023	0.916	1.006	1.111	0.064	0.989	1.238	1.146	0.060	1.030	1.265
2014	0.984	0.023	0.930	1.022	1.036	0.068	0.918	1.186	1.053	0.065	0.935	1.190
2015	0.966	0.026	0.903	1.005	1.355	0.087	1.187	1.526	1.404	0.082	1.248	1.568
2016	0.940	0.036	0.852	0.992	1.430	0.110	1.206	1.637	1.521	0.104	1.329	1.738
2017	1.050	0.032	1.002	1.126	1.753	0.143	1.496	2.057	1.670	0.120	1.454	1.926
2018	0.935	0.038	0.839	0.987	2.336	0.194	1.959	2.720	2.500	0.181	2.180	2.891
2019	1.008	0.025	0.958	1.055	1.908	0.153	1.631	2.231	1.893	0.144	1.621	2.187
2020	0.905	0.042	0.802	0.969	1.432	0.132	1.178	1.695	1.583	0.125	1.348	1.839
2021	1.054	0.029	1.007	1.120	2.021	0.182	1.687	2.401	1.918	0.166	1.612	2.264
2022	1.026	0.028	0.976	1.088	2.249	0.201	1.896	2.686	2.192	0.183	1.861	2.581

C.14 JMM7 TR observer

Table C.71: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the JMM7 TR observer CPUE series.

Series	JMM7 TR observer
QMS stock	JMA7
Reporting forms	
Fishing methods	MW, BT
Target species	JMA, JMD, JMM, JMN
Statistical Areas	034, 035, 036, 037, 039, 040, 041, 042, 045, 801
Period	1990-10-01, 2022-09-30
Resolution	Observed event
Core fleet years	2
Core fleet trips	1
Default model	jmmkg ~ fyear + vessel_key + month + stat_area + primary_method + ns(log(fishing_duration), 3) + ns(log(start_time), 3) + ns(log(start_seabed_depth), 3) + ns(log(headline_height), 3) + ns(fishing_speed, 3)
Stepwise selection	Yes
Positive catch distribution	Lognormal

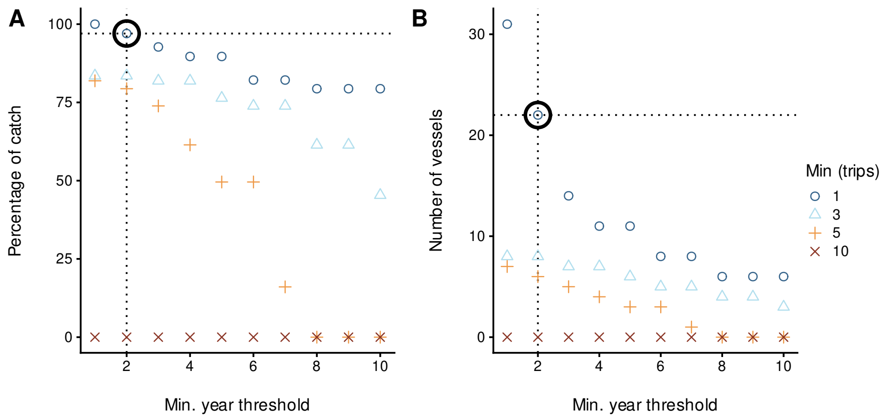

Figure C.228: Percentage of catch and number of vessels for different core vessel selection criteria for the JMM7 TR observer CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel was observed in the fishery and the number of observed trips per year.

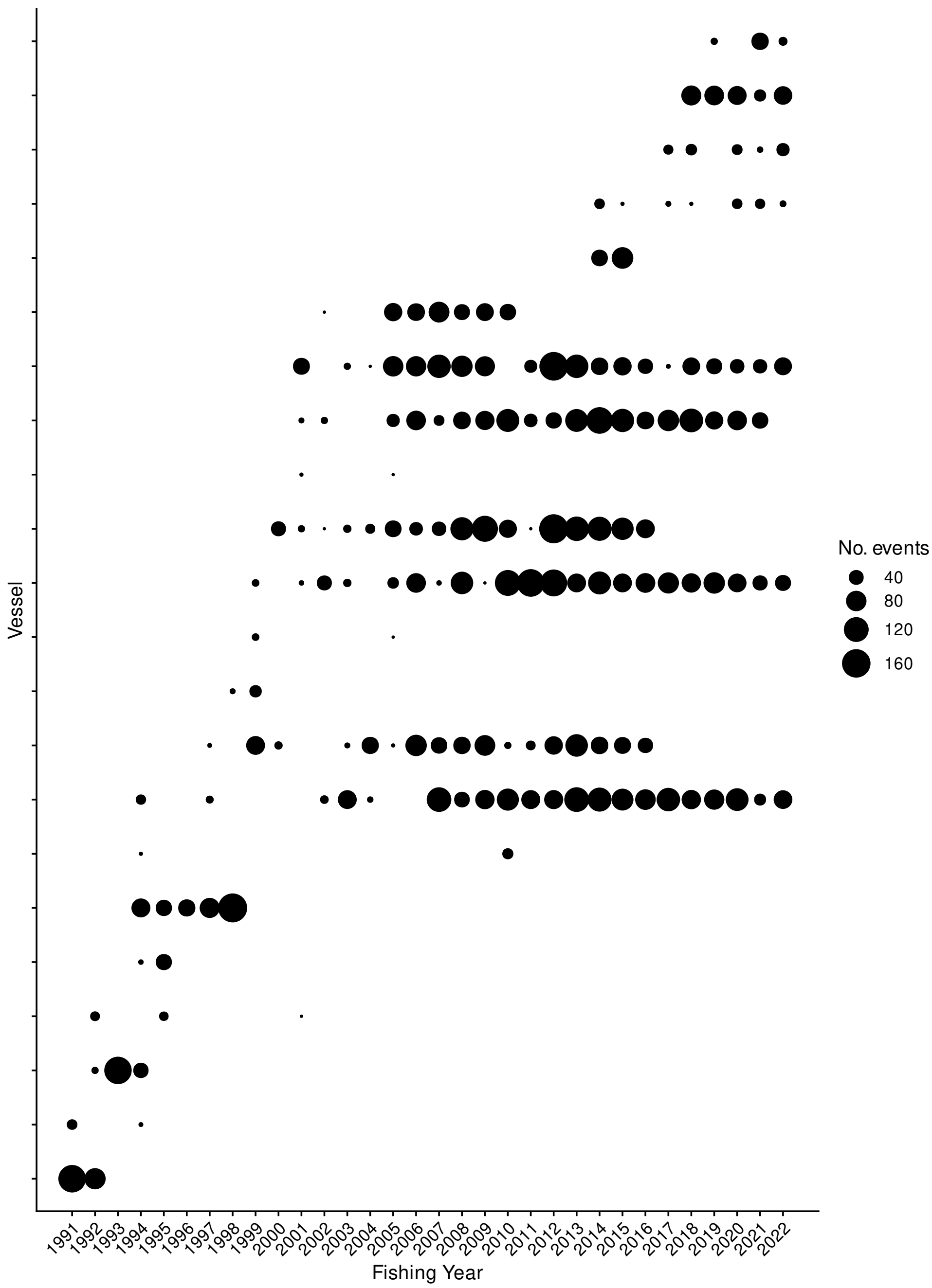

Figure C.229: Number of events by fishing year for core vessels. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table C.72: Summary of the JMM7 TR observer 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	1991	1992	1993	1994	1995	1996	1997	1998	1999
Ungroomed data	7.7 (100%) n: 188	61 (100%) n: 118	251 (100%) n: 159	577 (100%) n: 181	369 (100%) n: 145	85 (100%) n: 57	221 (100%) n: 119	313 (100%) n: 172	138 (100%) n: 121
Fishing speed not null	7.7 (100%) n: 187	61 (100%) n: 118	251 (100%) n: 159	547 (95%) n: 175	369 (100%) n: 145	85 (100%) n: 57	221 (100%) n: 119	313 (100%) n: 172	138 (100%) n: 117
Start date not null	7.7 (100%) n: 187	61 (100%) n: 118	251 (100%) n: 159	547 (95%) n: 175	369 (100%) n: 145	85 (100%) n: 57	221 (100%) n: 119	313 (100%) n: 172	138 (100%) n: 117
End date not null	7.7 (100%) n: 187	61 (100%) n: 118	251 (100%) n: 159	547 (95%) n: 175	369 (100%) n: 145	85 (100%) n: 57	221 (100%) n: 119	313 (100%) n: 172	138 (100%) n: 117
Start depth not null	7.7 (100%) n: 187	61 (100%) n: 118	251 (100%) n: 159	547 (95%) n: 175	369 (100%) n: 145	85 (100%) n: 57	221 (100%) n: 119	313 (100%) n: 172	138 (100%) n: 117
Headline height not null	7.7 (100%) n: 187	61 (100%) n: 118	251 (100%) n: 159	547 (95%) n: 175	369 (100%) n: 144	85 (100%) n: 57	221 (100%) n: 119	313 (100%) n: 172	137 (100%) n: 116
Fishing speed >3.5kn	7.7 (100%) n: 187	61 (100%) n: 118	251 (100%) n: 158	547 (95%) n: 175	369 (100%) n: 143	82 (100%) n: 55	220 (100%) n: 116	313 (100%) n: 172	137 (100%) n: 116
Headline height <90m	7.7 (100%) n: 187	61 (100%) n: 118	251 (100%) n: 158	547 (95%) n: 175	369 (100%) n: 143	82 (100%) n: 55	220 (100%) n: 116	313 (100%) n: 172	137 (100%) n: 116
Fishing duration >15mins	7.7 (100%) n: 187	61 (100%) n: 118	251 (100%) n: 158	508 (88%) n: 174	369 (100%) n: 143	82 (100%) n: 55	220 (100%) n: 116	313 (100%) n: 172	136 (100%) n: 114
Seabed depth >50m	7.7 (100%) n: 187	61 (100%) n: 118	251 (100%) n: 158	508 (88%) n: 174	369 (100%) n: 143	82 (100%) n: 55	220 (100%) n: 116	313 (100%) n: 172	136 (100%) n: 114
Seabed depth <400m	7.7 (100%) n: 187	61 (100%) n: 118	251 (100%) n: 158	508 (88%) n: 174	369 (100%) n: 143	82 (100%) n: 55	220 (100%) n: 116	290 (93%) n: 171	135 (100%) n: 113
Start time >0	7.7 (100%) n: 186	61 (100%) n: 117	251 (100%) n: 158	507 (88%) n: 173	368 (100%) n: 140	82 (100%) n: 55	212 (100%) n: 115	290 (93%) n: 171	135 (100%) n: 112
Core fleet selection	2.1 (27%) n: 168	60 (100%) n: 110	221 (88%) n: 148	433 (75%) n: 138	166 (45%) n: 112	82 (100%) n: 55	183 (83%) n: 90	290 (93%) n: 171	135 (100%) n: 112

Filter	2000	2001	2002	2003	2004	2005	2006	2007	2008
Ungroomed data	99 (100%) n: 54	203 (100%) n: 75	32 (100%) n: 66	56 (100%) n: 103	70 (100%) n: 79	321 (100%) n: 261	365 (100%) n: 409	173 (100%) n: 427	604 (100%) n: 511
Fishing speed not null	99 (100%) n: 54	203 (100%) n: 75	32 (100%) n: 66	56 (100%) n: 103	70 (100%) n: 79	321 (100%) n: 259	365 (100%) n: 409	173 (100%) n: 427	600 (100%) n: 510
Start date not null	99 (100%) n: 54	203 (100%) n: 75	32 (100%) n: 66	56 (100%) n: 103	70 (100%) n: 79	321 (100%) n: 259	365 (100%) n: 409	173 (100%) n: 427	600 (100%) n: 510
End date not null	99 (100%) n: 54	203 (100%) n: 75	32 (100%) n: 66	56 (100%) n: 103	70 (100%) n: 79	321 (100%) n: 259	365 (100%) n: 409	173 (100%) n: 427	600 (100%) n: 510
Start depth not null	99 (100%) n: 54	203 (100%) n: 75	32 (100%) n: 66	56 (100%) n: 103	70 (100%) n: 79	321 (100%) n: 259	365 (100%) n: 409	173 (100%) n: 427	596 (100%) n: 508
Headline height not null	99 (100%) n: 54	203 (100%) n: 75	32 (100%) n: 66	56 (100%) n: 102	70 (100%) n: 79	321 (100%) n: 259	365 (100%) n: 409	173 (100%) n: 427	596 (100%) n: 508
Fishing speed >3.5kn	99 (100%) n: 54	203 (100%) n: 75	32 (100%) n: 66	56 (100%) n: 102	70 (100%) n: 79	321 (100%) n: 259	365 (100%) n: 409	173 (100%) n: 426	596 (100%) n: 508
Headline height <90m	99 (100%) n: 54	203 (100%) n: 75	32 (100%) n: 66	56 (100%) n: 102	70 (100%) n: 79	321 (100%) n: 259	365 (100%) n: 409	173 (100%) n: 426	596 (100%) n: 508
Fishing duration >15mins	99 (100%) n: 54	203 (100%) n: 75	32 (100%) n: 66	56 (100%) n: 102	70 (100%) n: 79	320 (100%) n: 258	365 (100%) n: 408	173 (100%) n: 425	596 (100%) n: 507
Seabed depth >50m	99 (100%) n: 54	203 (100%) n: 75	32 (100%) n: 66	56 (100%) n: 102	70 (100%) n: 79	320 (100%) n: 258	365 (100%) n: 408	173 (100%) n: 425	596 (100%) n: 507
Seabed depth <400m	67 (68%) n: 53	203 (100%) n: 75	32 (100%) n: 66	56 (100%) n: 102	70 (100%) n: 79	318 (100%) n: 256	365 (100%) n: 408	173 (100%) n: 425	587 (100%) n: 504
Start time >0	66 (67%) n: 52	203 (100%) n: 75	32 (100%) n: 63	56 (100%) n: 102	70 (100%) n: 79	308 (100%) n: 253	363 (100%) n: 404	168 (100%) n: 419	574 (100%) n: 495
Core fleet selection	66 (67%) n: 52	203 (100%) n: 73	32 (100%) n: 63	56 (100%) n: 102	70 (100%) n: 79	308 (100%) n: 253	363 (100%) n: 404	168 (100%) n: 419	574 (100%) n: 495

Filter	2009	2010	2011	2012	2013	2014	2015	2016	2017
Ungroomed data	650 (100%) n: 526	493 (100%) n: 488	157 (100%) n: 310	582 (100%) n: 713	497 (100%) n: 644	771 (100%) n: 670	912 (100%) n: 593	1031 (100%) n: 411	415 (100%) n: 332
Fishing speed not null	650 (100%) n: 526	492 (100%) n: 487	157 (100%) n: 310	582 (100%) n: 713	497 (100%) n: 643	771 (100%) n: 670	912 (100%) n: 593	1031 (100%) n: 410	409 (100%) n: 330
Start date not null	650 (100%) n: 526	492 (100%) n: 487	157 (100%) n: 310	582 (100%) n: 713	497 (100%) n: 643	771 (100%) n: 670	912 (100%) n: 593	1031 (100%) n: 410	409 (100%) n: 330
End date not null	650 (100%) n: 526	492 (100%) n: 487	157 (100%) n: 310	582 (100%) n: 713	497 (100%) n: 643	771 (100%) n: 670	912 (100%) n: 593	1031 (100%) n: 410	409 (100%) n: 330
Start depth not null	627 (100%) n: 501	485 (100%) n: 484	153 (100%) n: 306	556 (100%) n: 677	466 (94%) n: 622	770 (100%) n: 667	900 (100%) n: 577	1031 (100%) n: 410	409 (100%) n: 327
Headline height not null	614 (94%) n: 499	483 (100%) n: 476	150 (100%) n: 305	547 (94%) n: 670	466 (94%) n: 618	767 (100%) n: 664	900 (100%) n: 576	1031 (100%) n: 410	383 (92%) n: 323
Fishing speed >3.5kn	614 (94%) n: 499	483 (100%) n: 476	150 (100%) n: 305	547 (94%) n: 670	466 (94%) n: 618	767 (100%) n: 664	900 (100%) n: 576	1026 (100%) n: 409	383 (92%) n: 323
Headline height <90m	614 (94%) n: 499	483 (100%) n: 476	150 (100%) n: 304	546 (94%) n: 669	466 (94%) n: 618	767 (100%) n: 663	900 (100%) n: 575	1026 (100%) n: 409	383 (92%) n: 323
Fishing duration >15mins	614 (94%) n: 499	483 (100%) n: 476	150 (100%) n: 301	546 (94%) n: 668	465 (94%) n: 616	720 (93%) n: 661	900 (100%) n: 575	1026 (100%) n: 408	383 (92%) n: 322
Seabed depth >50m	614 (94%) n: 497	477 (100%) n: 475	150 (100%) n: 301	545 (94%) n: 667	464 (93%) n: 615	720 (93%) n: 661	898 (100%) n: 574	1026 (100%) n: 408	383 (92%) n: 322
Seabed depth <400m	614 (94%) n: 497	477 (100%) n: 474	150 (100%) n: 301	541 (93%) n: 660	462 (93%) n: 613	720 (93%) n: 660	886 (100%) n: 571	1026 (100%) n: 408	383 (92%) n: 322
Start time >0	613 (94%) n: 494	472 (100%) n: 470	147 (94%) n: 298	539 (92%) n: 653	462 (93%) n: 610	717 (93%) n: 650	884 (100%) n: 568	1025 (100%) n: 405	383 (92%) n: 320
Core fleet selection	613 (94%) n: 494	471 (100%) n: 468	147 (94%) n: 298	539 (92%) n: 653	462 (93%) n: 609	717 (93%) n: 650	884 (100%) n: 568	1003 (100%) n: 366	369 (89%) n: 306

Filter	2018	2019	2020	2021	2022
Ungroomed data	835 (100%) n: 433	765 (100%) n: 380	563 (100%) n: 398	300 (100%) n: 272	140 (100%) n: 328
Fishing speed not null	835 (100%) n: 433	765 (100%) n: 380	563 (100%) n: 396	298 (100%) n: 268	113 (81%) n: 327
Start date not null	835 (100%) n: 433	765 (100%) n: 380	563 (100%) n: 396	298 (100%) n: 268	113 (81%) n: 327
End date not null	835 (100%) n: 433	765 (100%) n: 380	563 (100%) n: 396	298 (100%) n: 268	113 (81%) n: 327
Start depth not null	835 (100%) n: 432	765 (100%) n: 380	563 (100%) n: 390	298 (100%) n: 262	46 (33%) n: 289
Headline height not null	832 (100%) n: 430	765 (100%) n: 380	563 (100%) n: 388	298 (100%) n: 262	46 (33%) n: 289
Fishing speed >3.5kn	832 (100%) n: 430	765 (100%) n: 380	563 (100%) n: 388	298 (100%) n: 262	46 (33%) n: 289
Headline height <90m	832 (100%) n: 428	765 (100%) n: 380	563 (100%) n: 388	298 (100%) n: 262	46 (33%) n: 289
Fishing duration >15mins	832 (100%) n: 428	728 (100%) n: 379	563 (100%) n: 388	298 (100%) n: 262	46 (33%) n: 289
Seabed depth >50m	832 (100%) n: 427	728 (100%) n: 379	563 (100%) n: 388	298 (100%) n: 262	46 (33%) n: 289
Seabed depth <400m	830 (100%) n: 425	721 (94%) n: 377	563 (100%) n: 388	298 (100%) n: 262	46 (33%) n: 289
Start time >0	829 (100%) n: 424	721 (94%) n: 376	563 (100%) n: 385	298 (100%) n: 260	46 (33%) n: 289
Core fleet selection	829 (100%) n: 411	719 (94%) n: 357	563 (100%) n: 384	298 (100%) n: 260	46 (33%) n: 289

Table C.73: Summary of the JMM7 TR observer dataset after core fleet selection. 'Records' indicates the number of rows (events) in the dataset, and 'Records caught' indicates the percentage of events with catches of jack mackerels.

Fishing year	Vessels	Trips	Records	Hrs	Catch (t)	Records caught
1991	2	2	168	589.55	2.11	5.95
1992	3	4	110	545.77	60.08	35.45
1993	1	2	148	674.58	221.33	92.57
1994	6	6	138	481.70	433.21	44.93
1995	3	3	112	510.47	166.16	85.71
1996	1	1	55	260.33	81.69	61.82
1997	3	3	90	348.40	182.68	90.00
1998	2	3	171	741.12	290.19	87.13
1999	4	6	112	270.07	134.69	53.57
2000	2	2	52	137.25	66.23	78.85
2001	6	8	73	190.02	203.41	83.56
2002	5	5	63	221.45	31.97	36.51
2003	5	5	102	368.00	55.56	64.71
2004	4	4	79	333.28	69.97	72.15
2005	8	11	253	857.70	307.95	64.43
2006	6	8	404	1 485.25	362.97	73.51
2007	7	15	419	1 517.43	168.16	53.70
2008	7	16	495	1 925.52	574.37	62.02
2009	7	15	494	2 052.37	612.74	71.05
2010	7	11	468	2 112.07	471.29	66.24
2011	6	8	298	1 368.33	147.33	49.33
2012	6	20	653	3 380.90	538.60	52.68
2013	6	31	609	2 924.77	461.71	40.89
2014	8	35	650	3 037.78	717.29	41.54
2015	8	36	568	3 000.35	884.49	52.46
2016	6	30	366	1 721.17	1 003.28	59.29
2017	6	26	306	1 592.93	368.77	38.56
2018	7	30	411	2 455.30	828.56	39.17
2019	6	24	357	1 915.25	719.11	42.30
2020	7	30	384	1 995.42	562.93	23.18
2021	8	22	260	1 436.48	297.97	21.15
2022	7	18	289	1 350.55	45.73	15.57

Table C.74: Summary of stepwise selection for occurrence of positive catch. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	30.00	11 396	10.70	10.70	*
+ month	11.00	10 475	18.10	7.40	*
+ stat_area	9.00	10 044	21.60	3.50	*
+ vessel_key	21.00	9 856	23.50	1.80	*
+ ns(log(start_seabed_depth), 3)	3.00	9 715	24.60	1.20	*
+ ns(log(start_time), 3)	3.00	9 705	24.70	0.10	
+ ns(log(fishing_duration), 3)	3.00	9 698	24.80	0.10	

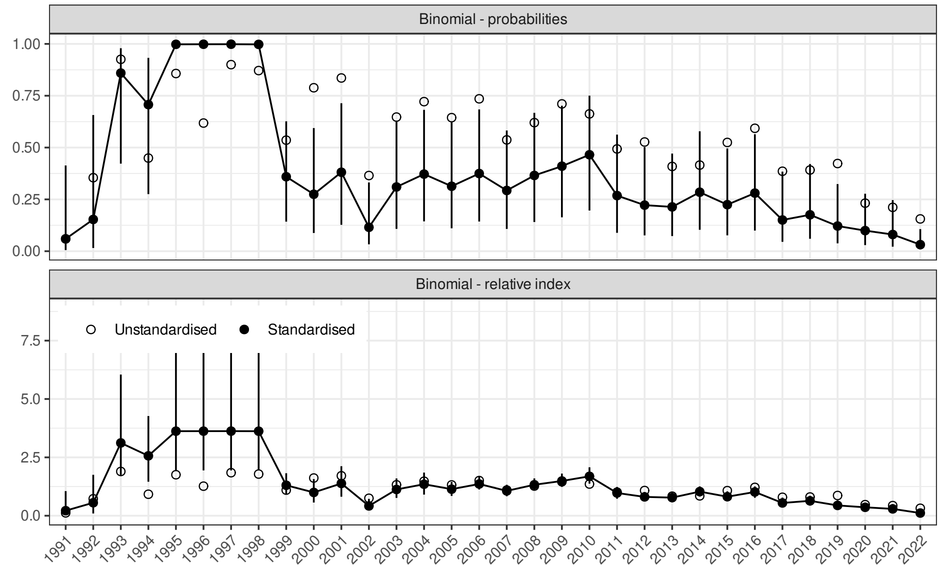

Figure C.230: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the JMM7 TR observer dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

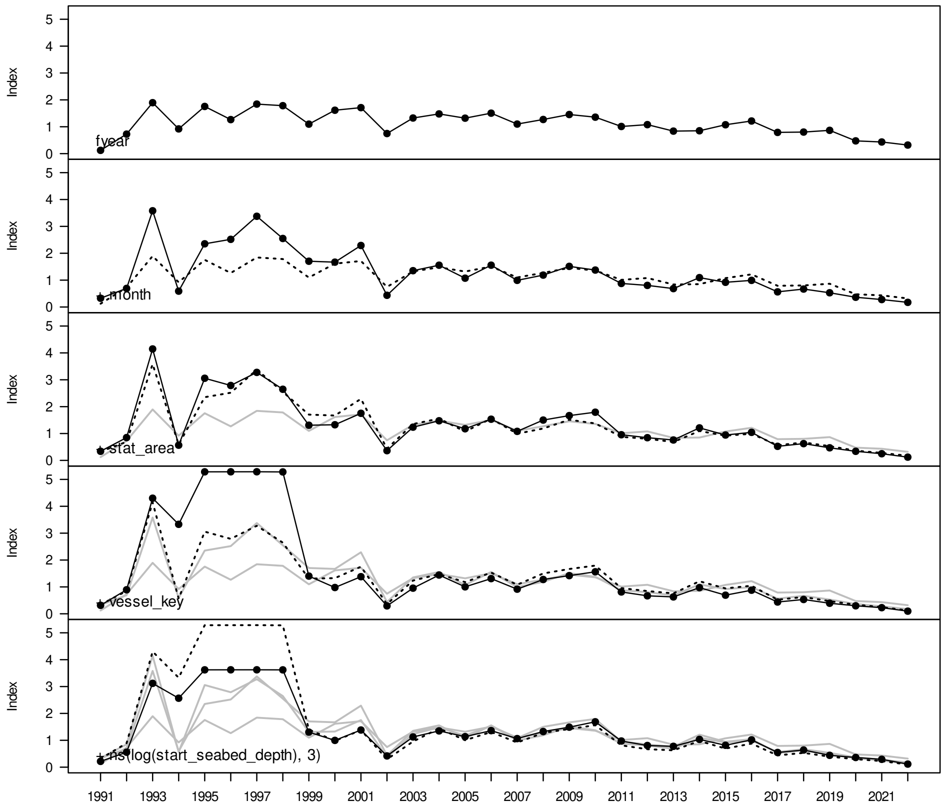

Figure C.231: Step plot for occurrence of catch in the JMM7 TR observer dataset.

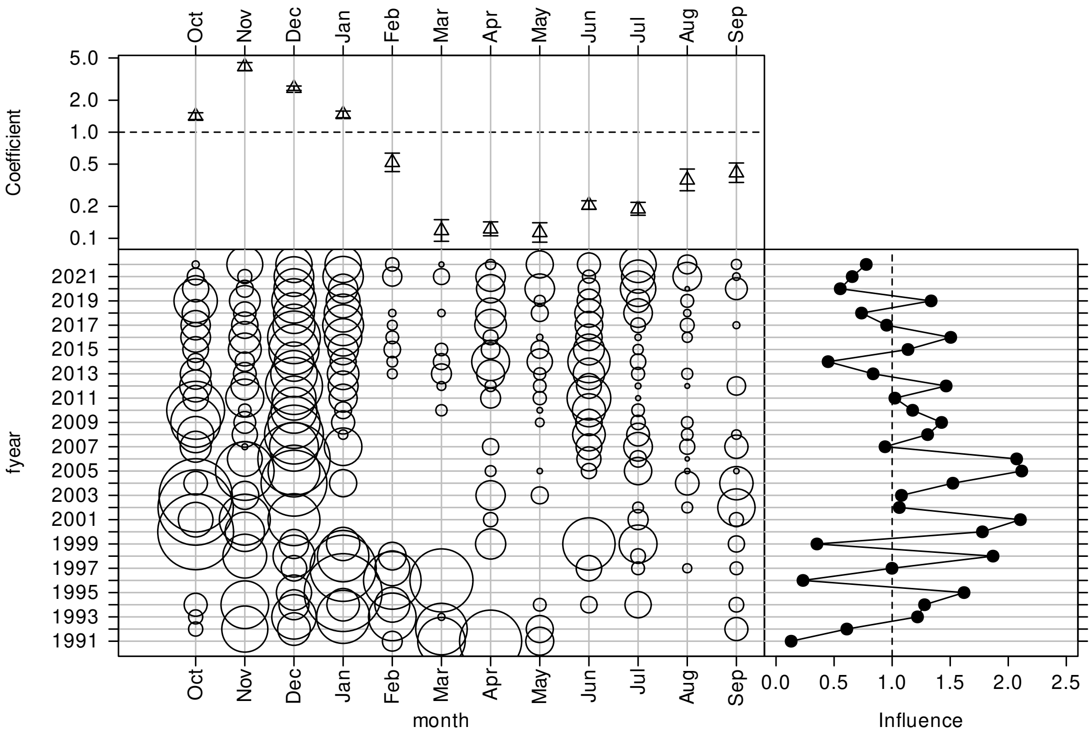

Figure C.232: CDI plot for month for the occurrence of positive catch JMM7 TR observer catch-per-unit-effort dataset.

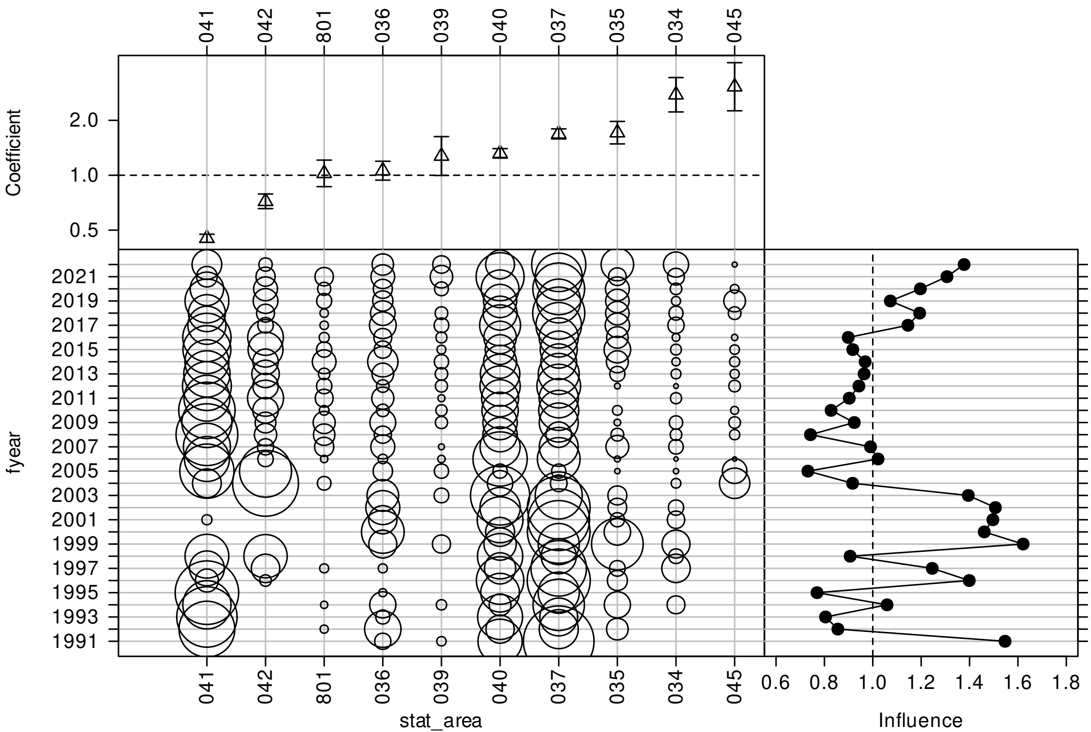

Figure C.233: CDI plot for statistical area for the occurrence of positive catch JMM7 TR observer catch-per-unit-effort dataset.

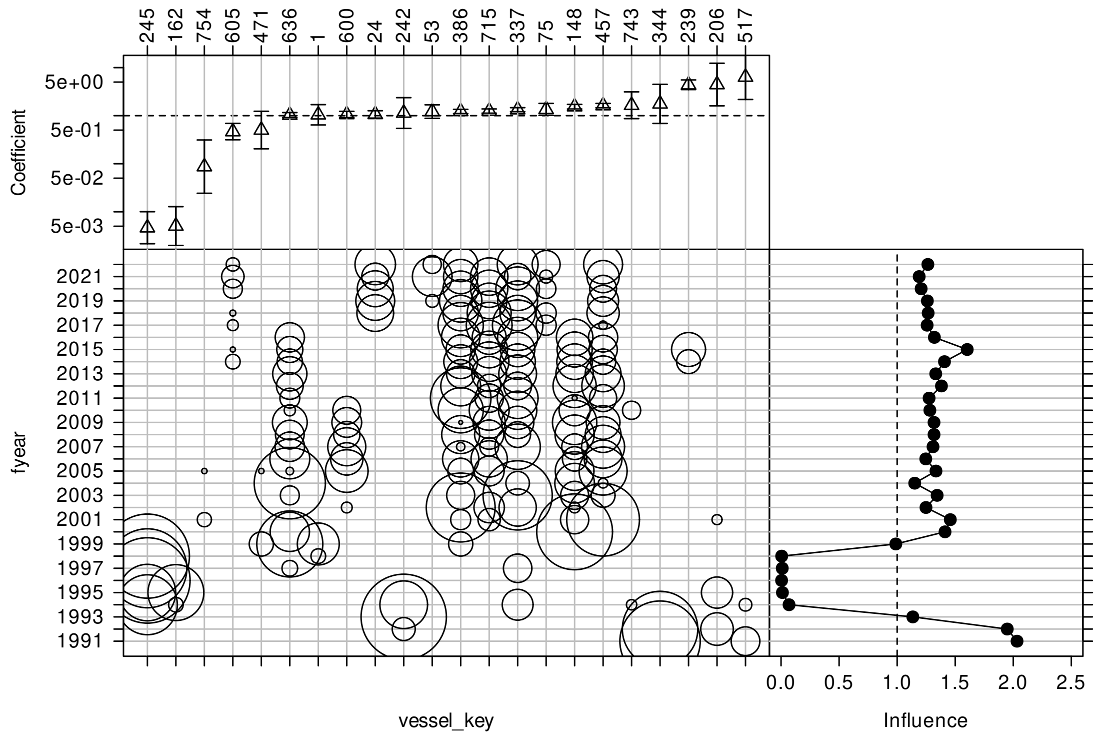

Figure C.234: CDI plot for vessel key for the occurrence of positive catch JMM7 TR observer catch-per-unit-effort dataset.

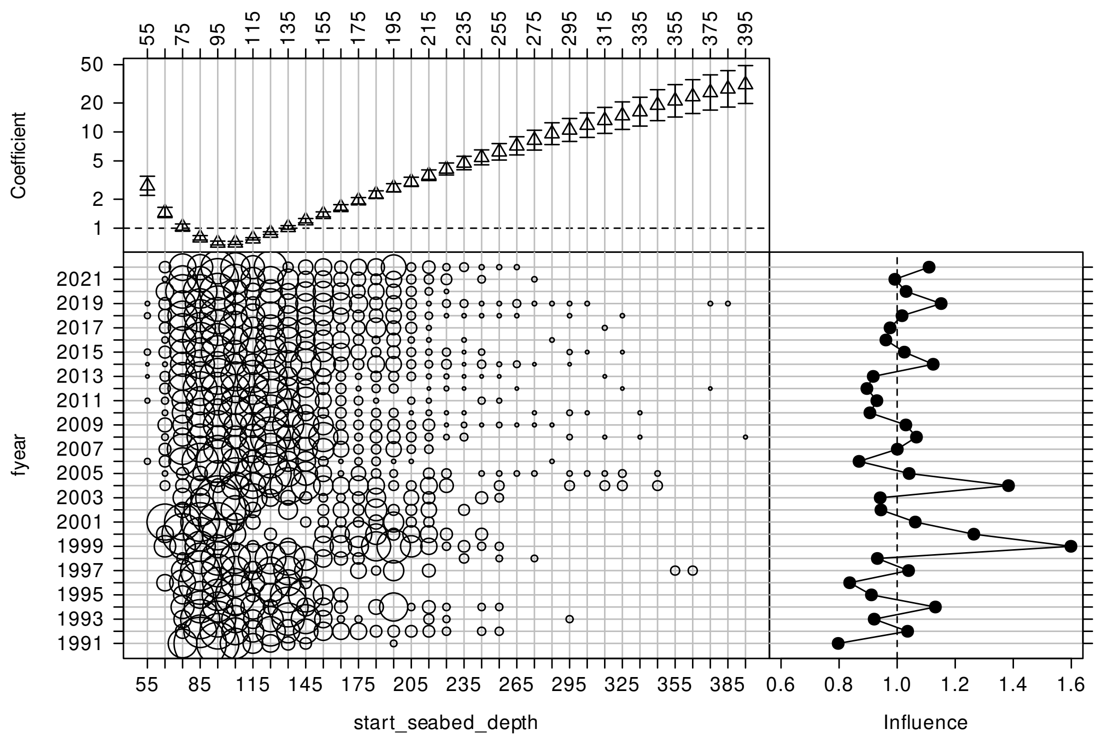

Figure C.235: CDI plot for start seabed depth (m) for the occurrence of positive catch JMM7 TR observer catch-per-unit-effort dataset.

Table C.75: Summary of stepwise selection for the lognormal model. Model terms are listed in the order of acceptance to the model. AIC: Akaike Information Criterion; *: Term included in final model.

Predictor	Df	AIC	% deviance	addl. % deviance	Included
fyear	30	16 023	13.6	13.6	*
+ stat area	9	15 821	17.5	3.9	*
+ vessel key	21	15 723	20.0	2.4	*
+ ns(log(fishing duration), 3)	3	15 659	21.1	1.2	*
+ month	11	15 596	22.5	1.4	*
+ ns(log(start seabed depth), 3)	3	15 571	23.0	0.5	
+ ns(log(headline height), 3)	3	15 558	23.4	0.3	
+ primary method	1	15 557	23.4	0.1	
+ ns(log(start time), 3)	3	15 555	23.5	0.1	

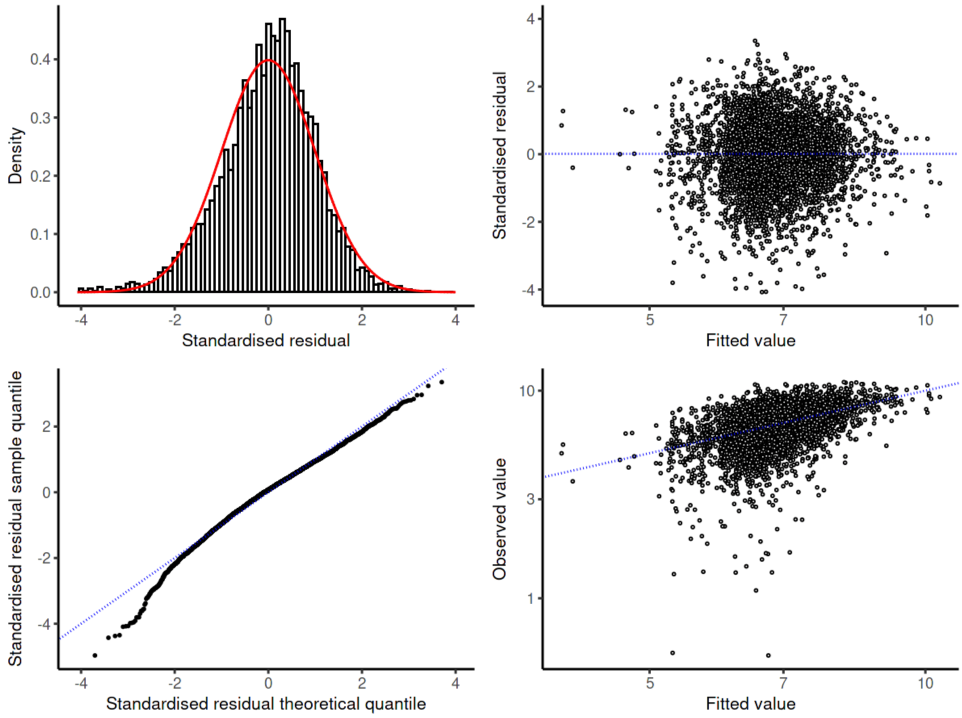

Figure C.236: Diagnostic plots for the lognormal model for the JMM7 TR observer dataset.

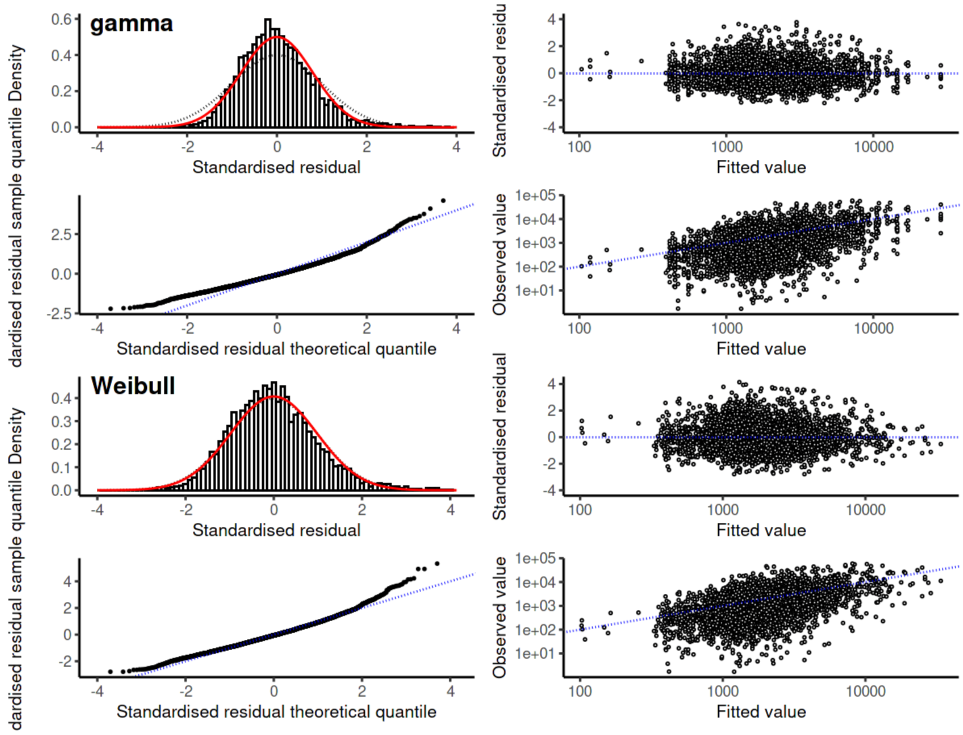

Figure C.237: Diagnostic plots for the gamma and Weibull model for the JMM7 TR observer dataset.

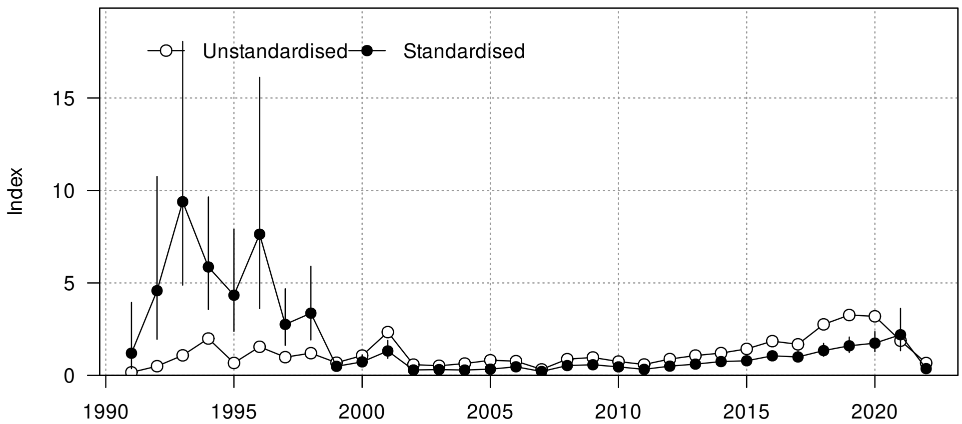

Figure C.238: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch in the JMM7 TR observer dataset.

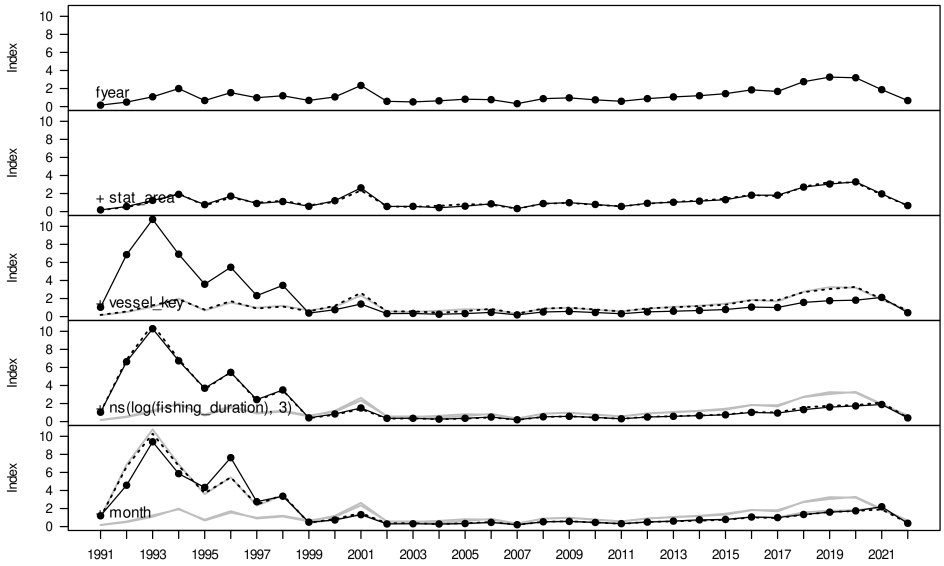

Figure C.239: Changes to the JMM7 TR observer positive catch index as terms are successively entered into the model.

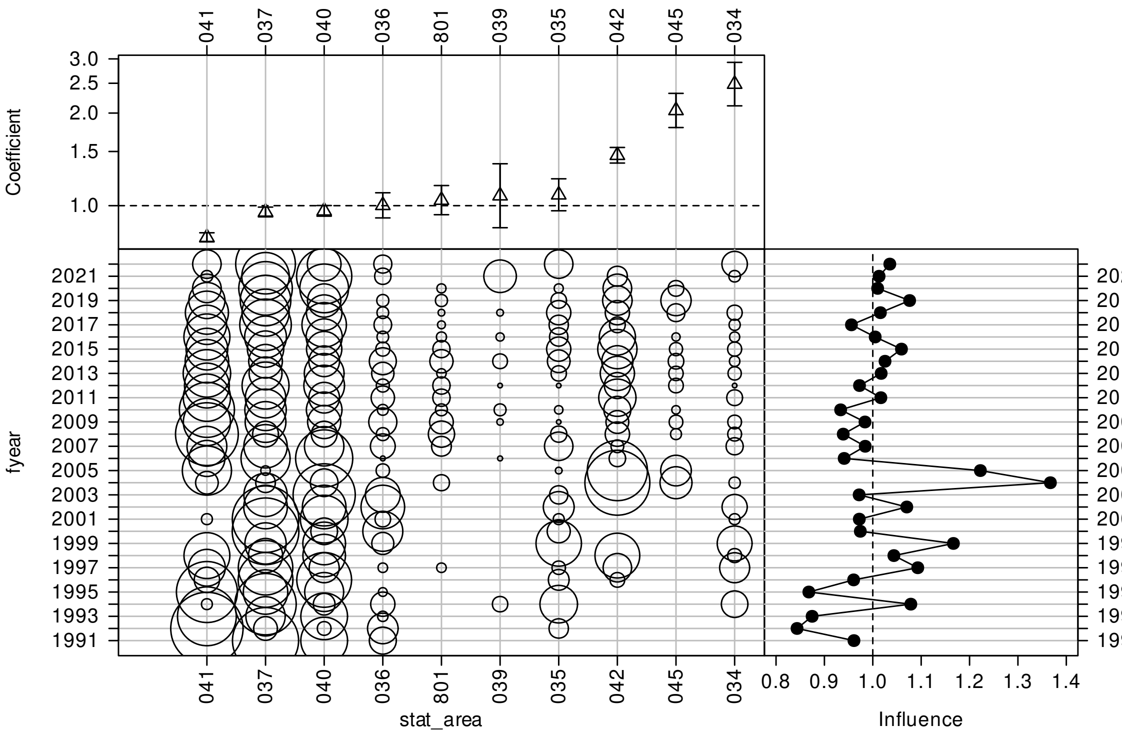

Figure C.240: CDI plot for statistical area for the positive catch JMM7 TR observer catch-per-unit-effort dataset.

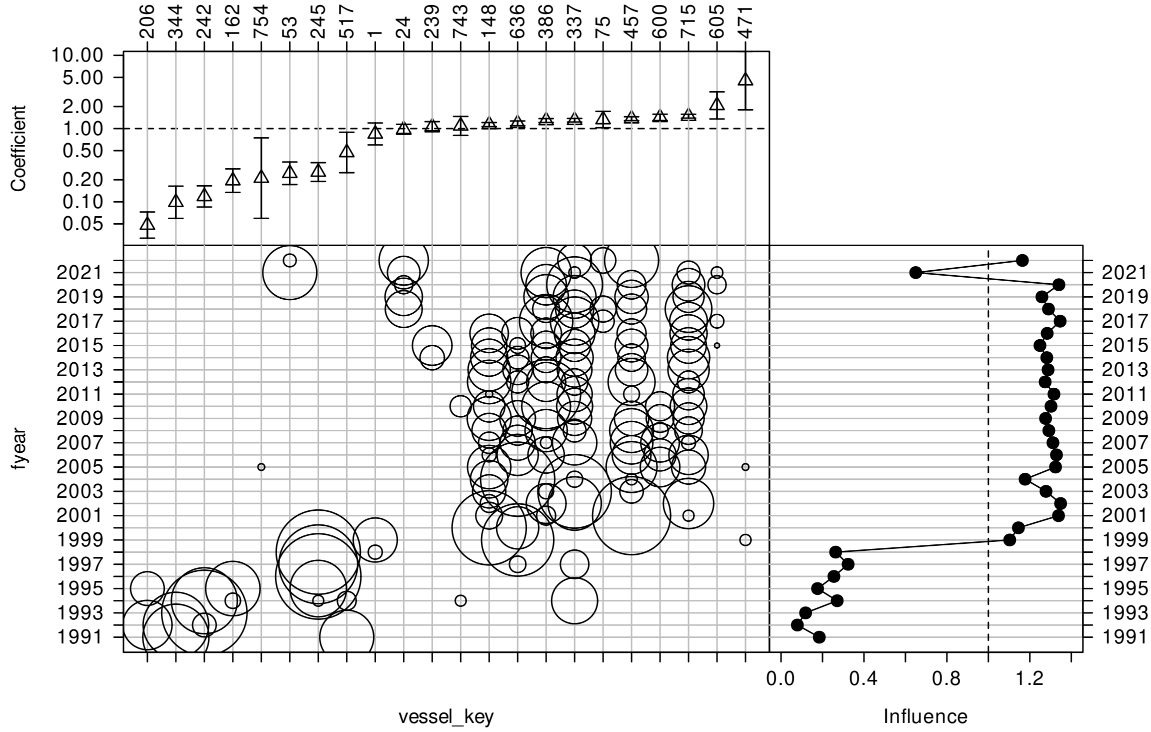

Figure C.241: CDI plot for vessel key for the positive catch JMM7 TR observer catch-per-unit-effort dataset.

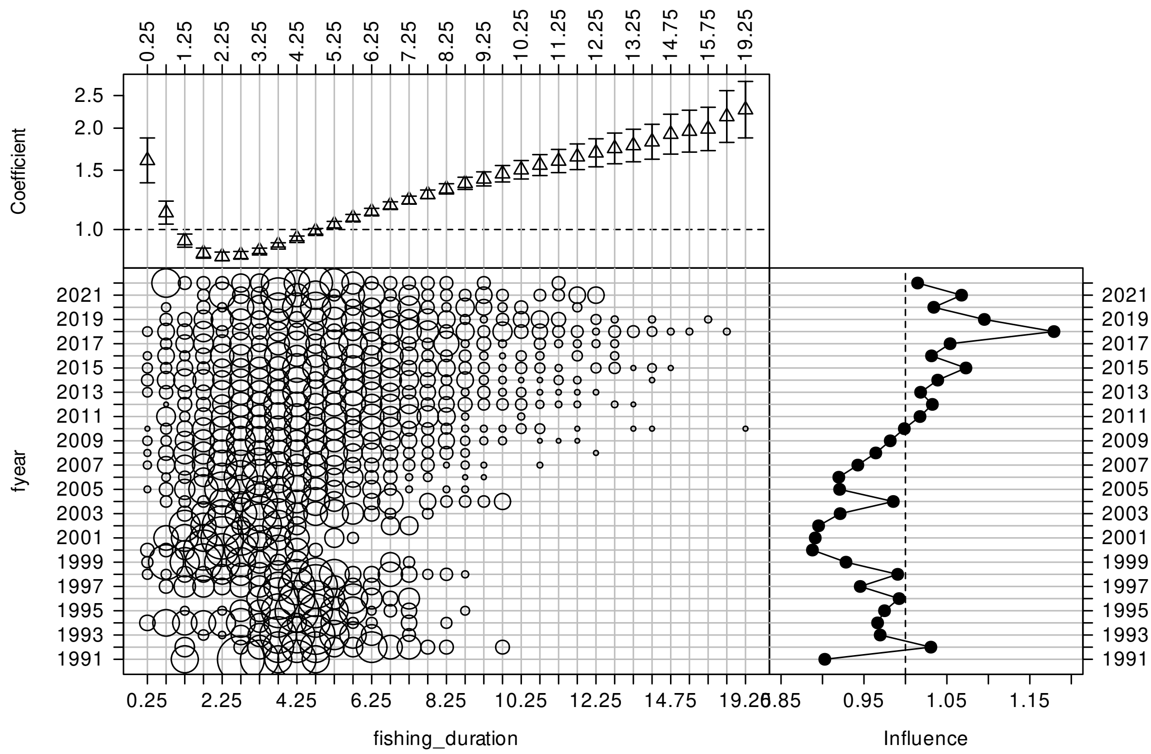

Figure C.242: CDI plot for fishing duration (h) for the positive catch JMM7 TR observer catch-per-unit-effort dataset.

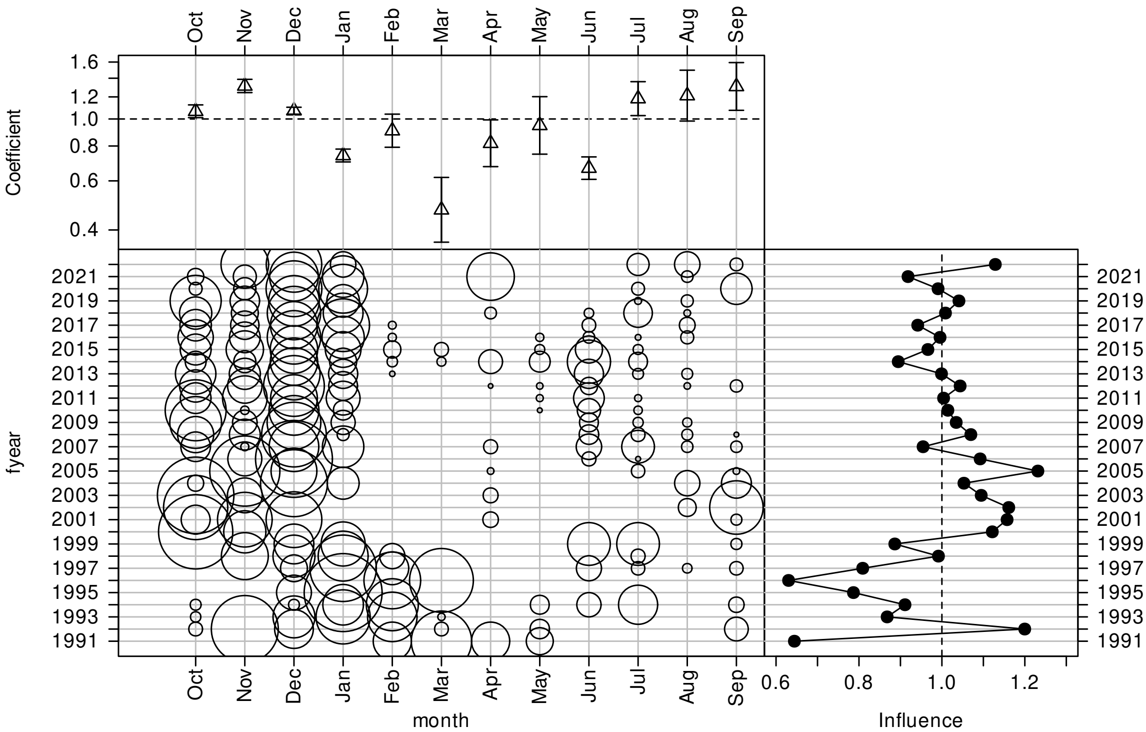

Figure C.243: CDI plot for month for the positive catch JMM7 TR observer catch-per-unit-effort dataset.

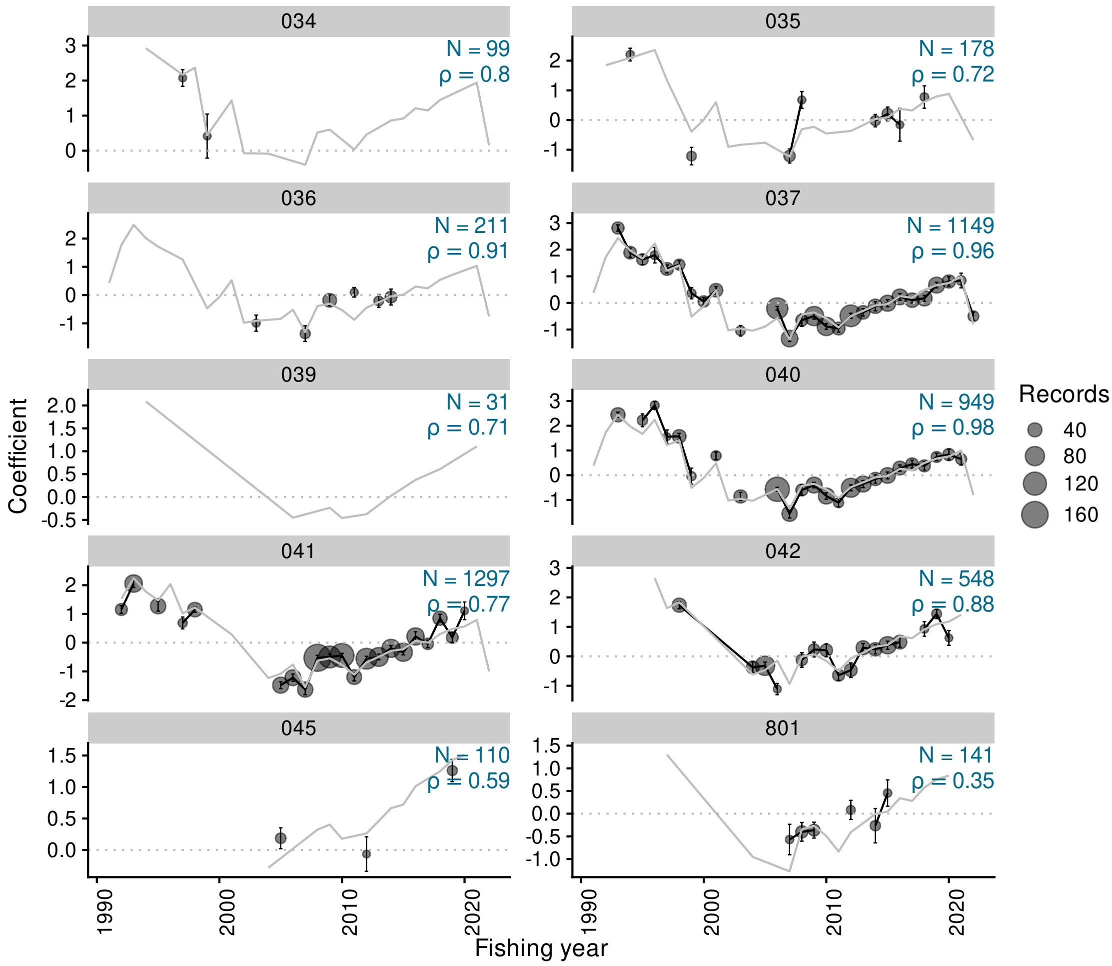

Figure C.244: Residual implied coefficients for area-year in the lognormal positive catch model for the JMM7 TR observer dataset.

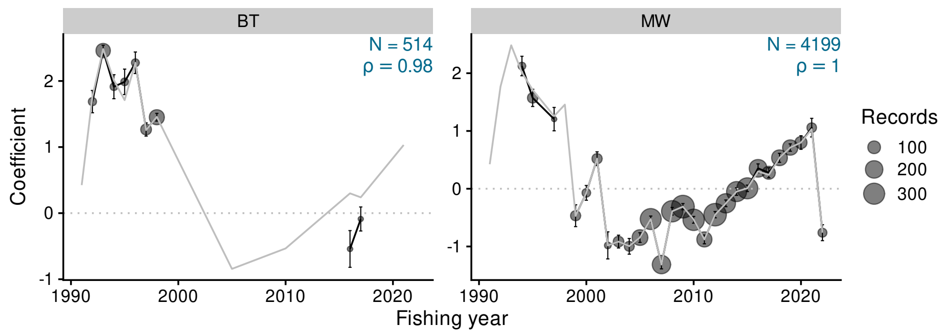

Figure C.245: Residual implied coefficients for primary method-year in the lognormal positive catch model for the JMM7 TR observer dataset.

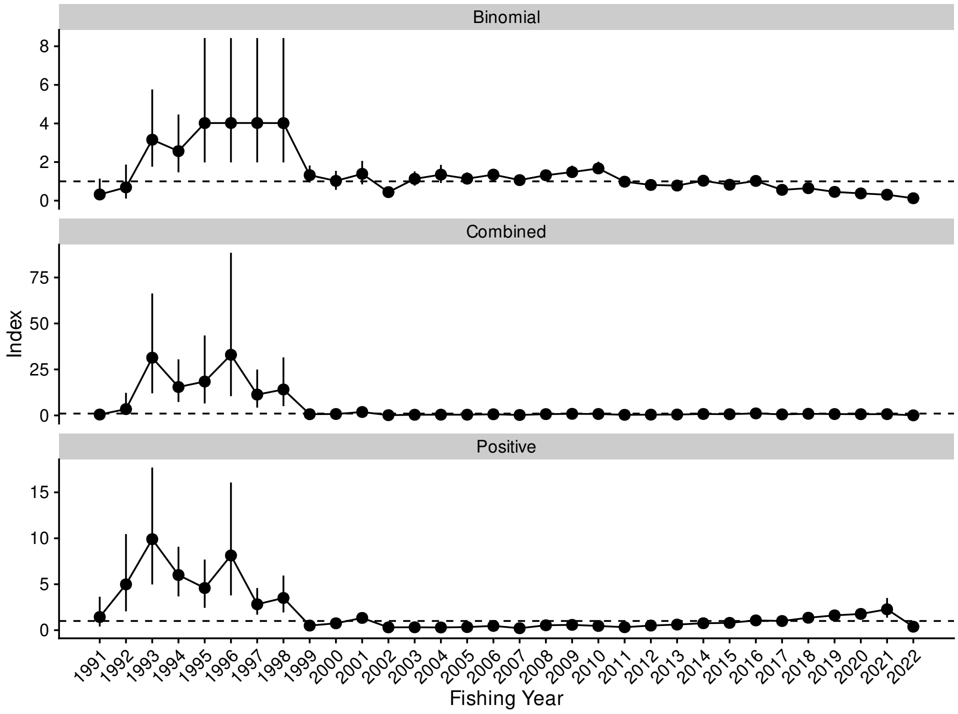

Figure C.246: Standardised indices and 95% confidence intervals for the JMM7 TR observer dataset.

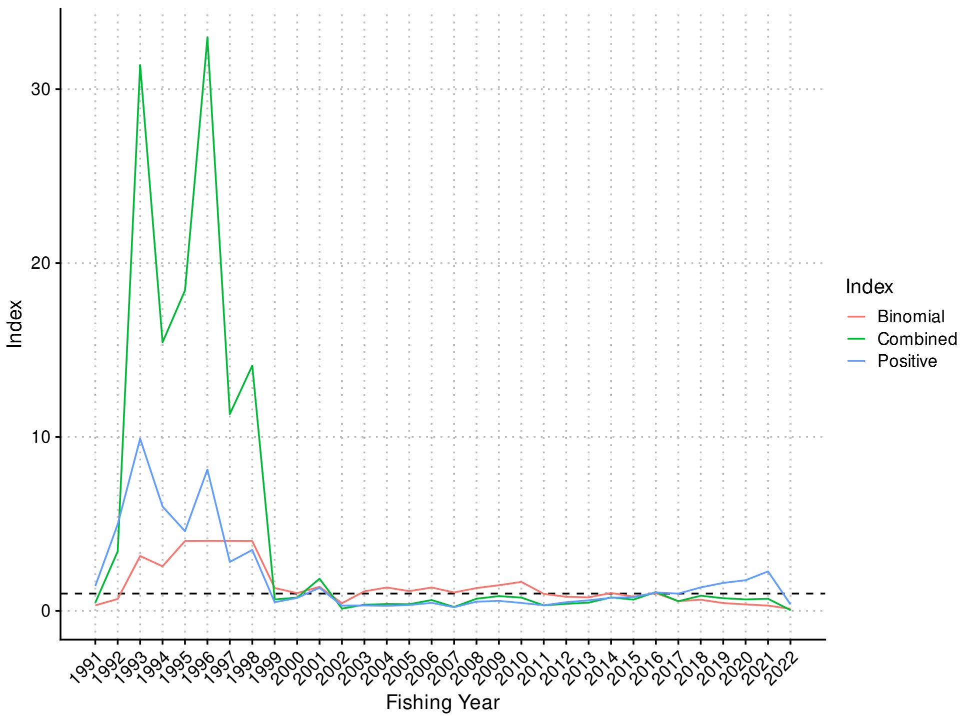

Figure C.247: Standardised indices for the JMM7 TR observer dataset.

Table C.76: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in JMM7 TR observer.

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
1991	0.320	0.281	0.038	1.140	0.473	0.541	0.027	2.147	1.430	0.825	0.402	3.637
1992	0.689	0.449	0.107	1.868	3.429	3.024	0.429	12.284	4.987	2.145	2.051	10.459
1993	3.158	1.022	1.759	5.764	31.389	13.861	11.992	66.328	9.902	3.247	4.974	17.701
1994	2.567	0.764	1.468	4.463	15.442	5.915	7.304	30.492	6.002	1.377	3.679	9.077
1995	4.019	1.645	1.982	8.429	18.429	9.435	6.493	43.480	4.588	1.341	2.429	7.684
1996	4.023	1.643	1.983	8.424	32.966	19.896	10.462	88.455	8.129	3.135	3.786	16.074
1997	4.024	1.644	1.983	8.426	11.320	5.285	4.227	24.944	2.818	0.741	1.684	4.587
1998	4.017	1.644	1.982	8.427	14.105	6.760	5.055	31.553	3.506	1.023	1.935	5.944
1999	1.320	0.224	0.943	1.821	0.661	0.175	0.376	1.061	0.501	0.103	0.333	0.735
2000	1.024	0.252	0.559	1.544	0.767	0.264	0.359	1.395	0.748	0.157	0.494	1.110
2001	1.388	0.310	0.844	2.061	1.852	0.542	0.952	3.078	1.333	0.242	0.915	1.862
2002	0.442	0.126	0.234	0.728	0.136	0.054	0.055	0.266	0.307	0.086	0.175	0.512
2003	1.128	0.189	0.775	1.516	0.358	0.091	0.206	0.562	0.317	0.058	0.216	0.442
2004	1.348	0.239	0.916	1.853	0.398	0.106	0.226	0.642	0.295	0.058	0.195	0.422
2005	1.140	0.157	0.850	1.464	0.387	0.074	0.257	0.547	0.339	0.046	0.257	0.438
2006	1.348	0.141	1.086	1.641	0.628	0.094	0.452	0.820	0.466	0.048	0.377	0.565
2007	1.064	0.121	0.821	1.296	0.227	0.037	0.160	0.306	0.213	0.025	0.168	0.266
2008	1.317	0.123	1.086	1.568	0.703	0.098	0.525	0.908	0.534	0.054	0.436	0.649
2009	1.480	0.145	1.244	1.814	0.854	0.116	0.656	1.110	0.577	0.057	0.474	0.696
2010	1.670	0.160	1.389	2.016	0.768	0.110	0.578	1.009	0.460	0.047	0.374	0.559
2011	0.983	0.134	0.720	1.246	0.320	0.059	0.219	0.448	0.326	0.043	0.246	0.413
2012	0.814	0.106	0.604	1.018	0.408	0.067	0.282	0.544	0.502	0.050	0.407	0.603
2013	0.782	0.102	0.582	0.982	0.479	0.079	0.330	0.641	0.612	0.069	0.491	0.762
2014	1.033	0.107	0.822	1.242	0.777	0.117	0.559	1.017	0.753	0.079	0.599	0.911
2015	0.822	0.105	0.618	1.029	0.654	0.109	0.451	0.880	0.794	0.087	0.634	0.974
2016	1.022	0.118	0.795	1.256	1.087	0.173	0.778	1.457	1.064	0.119	0.853	1.322
2017	0.560	0.099	0.384	0.772	0.559	0.131	0.342	0.854	0.997	0.145	0.749	1.316
2018	0.647	0.113	0.440	0.881	0.875	0.183	0.555	1.273	1.353	0.163	1.062	1.701
2019	0.454	0.093	0.299	0.664	0.733	0.184	0.439	1.161	1.611	0.208	1.253	2.067
2020	0.375	0.080	0.243	0.555	0.664	0.178	0.372	1.071	1.768	0.268	1.298	2.348
2021	0.308	0.080	0.180	0.494	0.698	0.251	0.330	1.316	2.272	0.547	1.359	3.505
2022	0.124	0.038	0.068	0.215	0.047	0.017	0.023	0.089	0.379	0.074	0.257	0.547

APPENDIX D: GLOSSARY

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

Code	Description
DRE	Dressed
FIL	Fillets: skin-on
GRE	Green (or whole)
GUT	Gutted
HGT	Headed, gutted, and tailed
HGU	Headed and gutted
MEA	Fish meal
SKF	Fillets: skin-off
SUR	Surimi

Table D.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)
HTC	High Seas Trawl Catch Effort Return (HS TCER)

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

Code	Description
TWL	Trawling (includes BT & MW)
BT	Bottom trawl
MW	Midwater trawl
PRB	Precision bottom trawl
PRM	Precision midwater trawl
PS	Purse seine

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

Code	Common name	Scientific name
BAR	Barracouta	*Thyrsites atun*
HOK	Hoki	*Macruronus novaezelandiae*
JMA	Jack mackerel	*Trachurus declivis, Trachurus murphyi, Trachurus novaezelandiae*
KAH	Kahawai	*Arripis trutta, Arripis xylabion*
SBW	Southern blue whiting	*Micromesistius australis*
SQU	Arrow squid	*Nototodarus sloanii, Nototodarus gouldi*

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

Code	Description
AKW	Auckland (West) (FMA 9)
CEW	Central (Egmont) (FMA 8)
CHA	Challenger/Central (Plateau) (FMA 7)