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Characterisation and CPUE for the alfonsino fishery in BYX 2 and BYX 3 from 1990 to 2023

New Zealand Fisheries Assessment Report 2025/35

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Plain language summary

Alfonsino stocks in the Quota Management System include two related species, but most of the catch is of splendid alfonsio, *Beryx splendens*, a species that occurs globally but with poorly understood population dynamics.

The New Zealand alfonsino fishery occurs off the southern east coast of the North Island, and on the eastern Chatham Rise, north and south-east of the Chatham Islands. Alfonsino is caught by a mix of bottom and midwater trawling.

Analyses of commercial catch rates have demonstrated that alfonsino abundance trends are different in the four main areas of the fishery. The reasons for the differing trends are not well understood. More extensive biological sampling, aimed at monitoring the age structure of alfonsino in the different areas over time, is recommended.

EXECUTIVE SUMMARY

Middleton, D.A.J.[1]; Tornquist, M.[2]; Neubauer, P.[2]; Hill-Moana, T.[2] (2025). Characterisation and CPUE for the alfonsino fishery in BYX 2 and BYX 3 from 1990 to 2023.

***New Zealand Fisheries Assessment Report 2025/35*. 246 p.**

In New Zealand, the Quota Management System stocks of alfonsino include both *Beryx splendens* and *B. decadactylus*. However, *B. splendens* makes up the great majority of the catch. *Beryx* species, including *B. splendens*, are widely distributed in the world's oceans, but their population biology is poorly known.

The New Zealand alfonsino fishery became established in the mid 1980s, initially off the southern east coast of the North Island and later on the eastern Chatham Rise. These areas make up the key BYX 2 and BYX 3 fisheries, although alfonsino is caught in smaller volumes widely around New Zealand. Alfonsino is fished by both bottom and midwater trawling and the main fishery areas are often associated with bathymetric features. In this report, spatial density clustering was used to delimit the key areas of the fishery; the areas identified were then used as the spatial strata in analyses of catch per unit effort (CPUE).

The CPUE modelling undertaken was assisted by using a dataset encompassing effort from BYX 2 and BYX 3; in particular this allowed for covariates, including vessel coefficients, to be estimated using a larger dataset from across the fishery. The resulting model had improved diagnostics compared with models using data from smaller areas. However, there was evidence that the temporal trends in CPUE differed between areas. Groups of neighbouring areas were amalgamated into four key fishery regions: a northern and southern area off the North Island southern east coast, and areas to the north and south-east of the Chatham Islands. These areas had differing temporal trends in CPUE and it was not possible to propose an abundance index that was suitable for stock-level monitoring.

The population structure and dynamics of alfonsino is not well understood; most of the directed research on alfonsino in New Zealand was carried out in the early 1990s and the limited sampling of catches since then allows for little new insight. Alfonsino is known to have a long (~1 year) pelagic larval stage with much more limited movement of adult fish after settlement. Nevertheless, there is evidence of size structuring with depth, different age structures on different fishing grounds, and differential growth by sex. It is unclear, however, if the differing trends in the main areas of the fishery arise due to differential recruitment driven by varying oceanic drivers, or as a result of processes—including varying fishing pressure— acting on the recruited populations.

Although CPUE analyses of commercial fishing effort appear to provide a reasonable approach to monitoring regional trends, extensive biological sampling and otolith ageing to provide spatially resolved age frequency distributions over time, will be required to better understand the dynamics of alfonsino populations and develop a fuller stock monitoring approach.

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1. INTRODUCTION

Alfonsino (*Beryx spp.*) is found widely throughout the world's tropical and temperate oceans (Shotton 2016); it is found along the European and African coasts, around oceanic islands of the Atlantic Ocean and in the Indian Ocean, in the northern Tasman Sea, along the Pacific coast of the Japanese Archipelago, the Southern Emperor and Northern Hawaiian ridges and westward towards Chile. Alfonsino fisheries are located around the Azores, in the Southeast Atlantic, the Southwest Indian Ocean, off Australia and New Zealand, on the Southern Emperor seamounts and in the southern area of the Northern Hawaiian Ridge. They were previously also fished around the Juan Fernández Archipelago in the Eastern Pacific.

In New Zealand, alfonsino (BYX; *Beryx splendens, B. decadactylus*) was introduced to the Quota Management System (QMS) on 01 October 1986, with six QMS stocks defined (Figure 1). Although the BYX 1 Total Allowable Commercial Catch (TACC) was increased on 1 October 2001 under the Adaptive Management Programme (Table 1; Fisheries New Zealand 2024), and some larger catches were recorded in that area in the early 2000s, it is really only BYX 2 and BYX 3 that have well-developed alfonsino fisheries (Figure 2). While the QMS stocks include both *Beryx splendens* and *B. decadactylus*, also known as red bream, Horn (1988) considered that the commercial catch was almost exclusively *B. splendens*. Catch sampling programmes in the late 1990s and early 2000s (for example Blackwell et al. 2002) did not explicitly address the species mix, but make no mention of encountering *B. decadactylus*. In this report, alfonsino catches are assumed to be exclusively *B. splendens*.

Alfonsino larvae may have a pelagic phase of up to a year (Shotton 2016). Analyses of *Beryx splendens* mitochondrial DNA demonstrated a population subdivision between the Atlantic and Indo-Pacific Oceans and suggested that global oceanic currents are important in the distribution of larvae (Lévy-Hartmann et al. 2011). Stock structure of alfonsino in New Zealand is not known. The BYX 2 and BYX 3 fisheries may be part of the same biological stock, and potentially part of a wider southwest Pacific stock.

Horn (1988) indicated that alfonsino was virtually unfished in New Zealand prior to 1983 when a fishery began developing off the Wairarapa coast (BYX 2), although Horn & Massey (1989) noted that foreign commercial vessels and research vessels had been catching alfonsino prior to this, especially on the Chatham Rise. Declines in catch per unit effort (CPUE) on the various Wairarapa fishing grounds led to concern about the long-term sustainability of the developing fishery (Horn 1988). A subsequent research programme (Horn & Massey 1989) found it challenging to resolve the dynamics of the population; regular sampling over a year suggested that fish stayed on the same grounds rather than moving between the areas. However, some age-specific migration was thought to occur. Monitoring of macroscopic maturity stages and gonadosomatic indices indicated that alfonsino spawing may occur from July to August, but not on the fishing grounds. Horn & Massey (1989) hypothesised that alfonsino may grow off the east coast North Island until they are near maturity then migrate elsewhere to reproduce. After considering and testing a range of techniques for monitoring alfonsino abundance, Horn & Massey (1989) concluded that analysis of CPUE from the commercial fishery was the most useful approach.

Stocker & Blackwell (1991) found that the decline in alfonsino CPUE in BYX 2 calculated over all areas was less than previously estimated by averaging across the indices from individual grounds; a stock reduction analysis, and various yield estimates, led to the conclusion that the TAC and landings were sustainable. A subsequent standardised CPUE analysis (Langley 1995) found differences in catch rates between fishing grounds, but no consistent trend in CPUE during the early 1990s. However, Langley (1995) noted that neither tow duration or searching time were accounted for in the CPUE model and that the resulting indices were unlikely to be related to abundance.

Blackwell (2000) updated CPUE indices for BYX 2 to 1998; he suggested that daily CPUE indices, with a covariate for the number of tows, were preferred over tow-level indices as these accounted for searching time and provided a better fit to the data. Abundance was considered to have been stable since the early 1990s, following the initial development of the fishery. However, the analysis was considered uncertain,

and was not accepted as an index of abundance by the Inshore Working Group (Fisheries New Zealand 2024).

CPUE in BYX 3 was first investigated by Langley & Walker (2002a) for the 1996 to 2000 fishing years. All models explored were considered to be limited by the small data set, with high variation in the observed catch rates, and changes in the distribution of fishing effort over the study period. No sytematic trend in CPUE was evident but the indices were not considered to be reliable indices of abundance for either the East Chathams fishery or the wider BYX 3 stock. Ongoing monitoring of CPUE, and refinements to methods, were recommended, together with biological sampling of the catches (Langley & Walker 2002b).

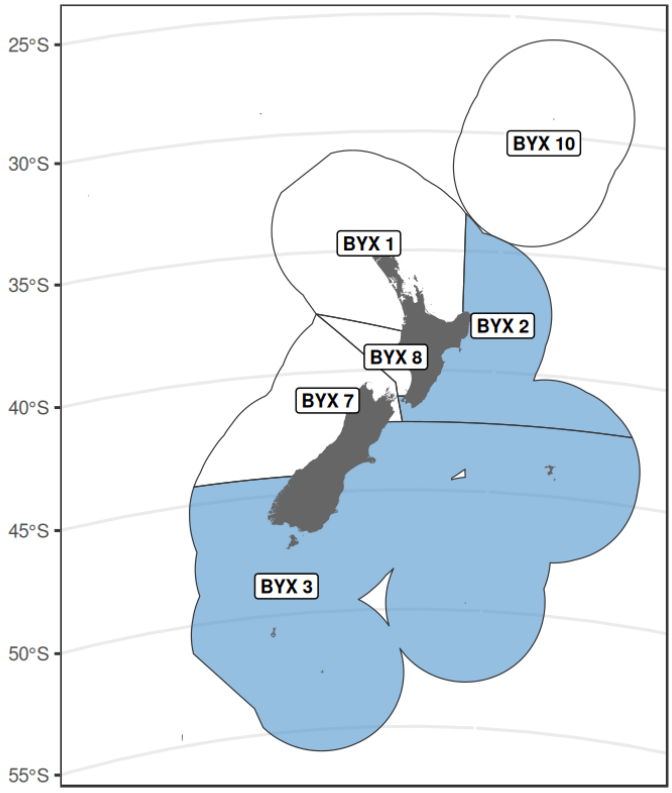

Figure 1: Quota Management Areas for alfonsino with BYX 2 and BYX 3 highlighted.

Table 1: Total Allowable Catch (TAC), Total Allowable Commercial Catch (TACC), and allowances (all tonnes) for BYX 1, BYX 2, BYX 3, BYX 7, BYX 8 and BYX 10, as at 1 October 2024.

			Allowances		
Stock	TAC	TACC	Customary	Recreational	Other mortality
BYX 1	304	300.0	2	2	-
BYX 2	-	1 574.8	-	-	-
BYX 3	-	1 010.4	-	-	-
BYX 7	-	80.5	-	-	-
BYX 8	-	20.0	-	-	-
BYX 10	-	10.0	-	-	-

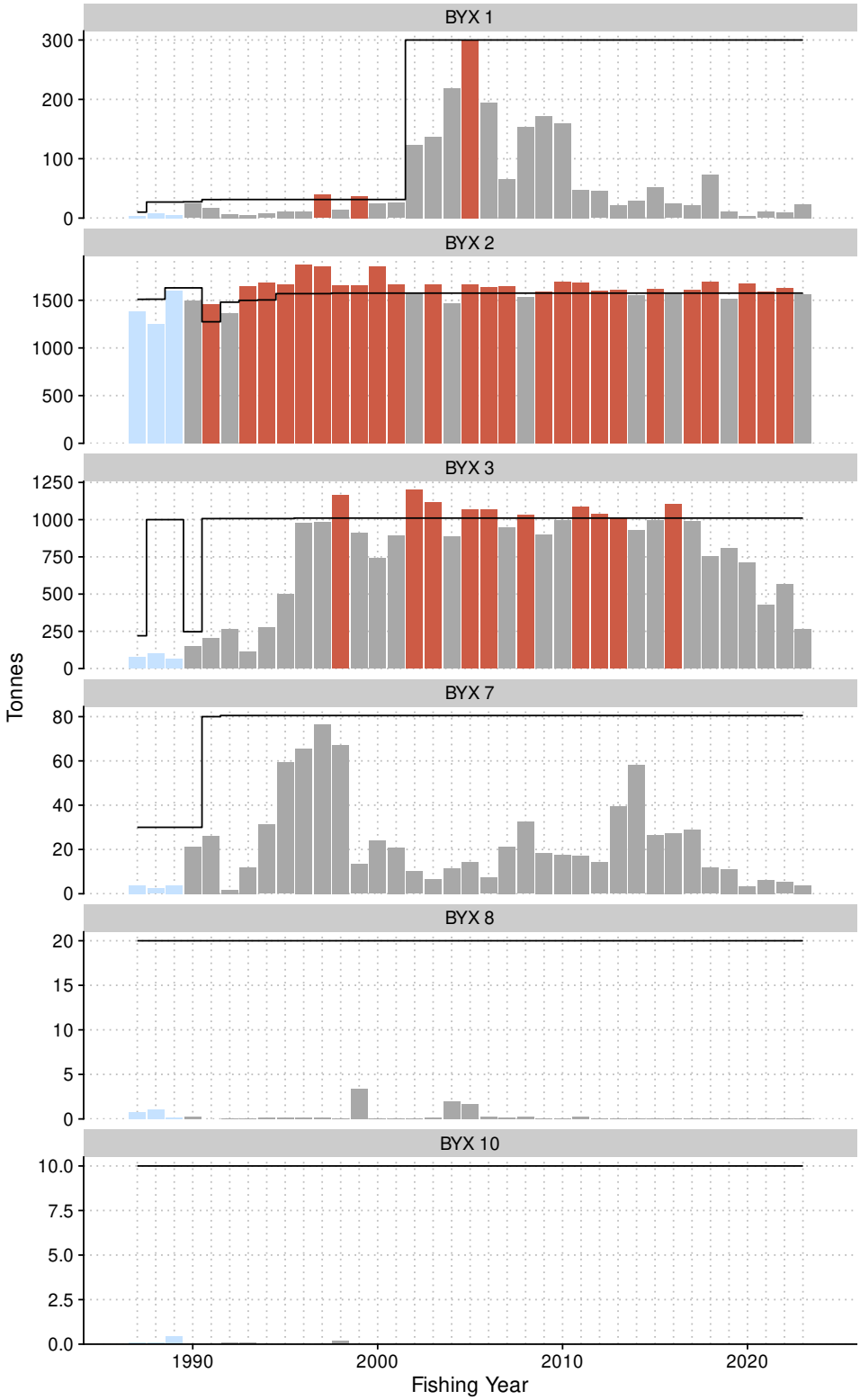

Figure 2: Total Allowable Commercial Catch (TACC; black line) and Monthly Harvest Return/Quota Management Report totals (bars) for BYX 1, BYX 2, BYX 3, BYX 7, BYX 8 and BYX 10 from 1990 to 2023. Years where the TACC was exceeded are highlighted in red. Catches prior to 1990 are shown in blue using the information compiled in the Fisheries Assessment Plenary Report (Fisheries New Zealand 2024). Tabulated data are provided in Table B.1.

A characterisation of all alfonsino fisheries to 2010 was provided by MacGibbon (2013). Standardised CPUE indices for BYX 2 showed large interannual variation and no trend. The geographical complexity of the fishery, and changes in the fleet over time, were considered to compromise the use of the indices for monitoring alfonsino abundance. An index for BYX 3 was rejected by the Middle Depths Working Group due to a small dataset (just one vessel from 2007–2010) and the spatial complexity of the fishery. Fine scale (feature-level) CPUE analyses were recommended together with catch sampling. MacGibbon (2015) updated the characterisation of alfonsino fisheries to the 2014 fishing year, but did not extend the previous CPUE analyses, or consider alternative CPUE models.

At present the status of all alfonsino stocks in New Zealand is considered to be unknown. In response to catches of smaller alfonsino in BYX 3, a catch limit agreement between the four major quota owners was introduced from the 2021 fishing year. This has involved transferring 50% of available ACE to Commercial Fisheries Services Ltd. The annual amounts shelved have varied between 450 t to 550 t from 2021–2024 due to ACE carry forward provisions Fisheries New Zealand (2024).

The relationship between the trawl fisheries for alfonsino and bluenose, *Hyperoglyphe antarctica*, and the amount of bluenose bycatch taken when targeting alfonsino has been identified as a particular issue affecting the operation of the alfonsino fisheries in New Zealand (Horn 1988, Langley & Walker 2002b).

This report provides an updated characterisation of the BYX 2 and BYX 3 fisheries to the 2023 fishing year, investigates the fine-scale spatial structure of the alfonsino fisheries with the aim of identifying the consistently fished ‘features’, and explores the use of the resulting spatial strata in new CPUE analyses.

2. METHODS

Extracts (report logs 13159, 16037) 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 F.

2.1 Terminology

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

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

2.2 Data sources

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

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

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

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

Landings and disposals provide data on the catches of all stocks, generally at the fishing trip resolution, with quantities verified (where practicable; e.g., when landed) by weighing. Under the Electronic Reporting regime introduced by the Fisheries (Reporting) Regulations 2017, these data provide a comprehensive record of catches per trip, with the fate of those catches indicated by a destination code (Table 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*.

The trip-based approach allocates the catches of BYX from a trip to the fishing event records from the trip using the hierarchical method of Starr (2007). If alfonsino was 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 alfonsino 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).

However, in fisheries where there is significant use of intermediate destinations, the trip-based approach breaks down because catches may no longer be recorded in the same trip as the fishing effort that gave rise to those catches. In these cases, we instead calculate the annual ratio of summed catches to summed estimated catch for each vessel and species, and scale the estimated catch of the species for each fishing event within the year by this ratio. In this report, we employed this approach for trips in BYX 3 where the modal fishing method was BT or MW .

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 BYX 2 and BYX 3 and extracting the associated catch and effort data for fishing events within the BYX 2 and BYX 3 Quota Management Areas (Figure 1). Fishing events were selected based on start position (where available) or statistical area. 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).

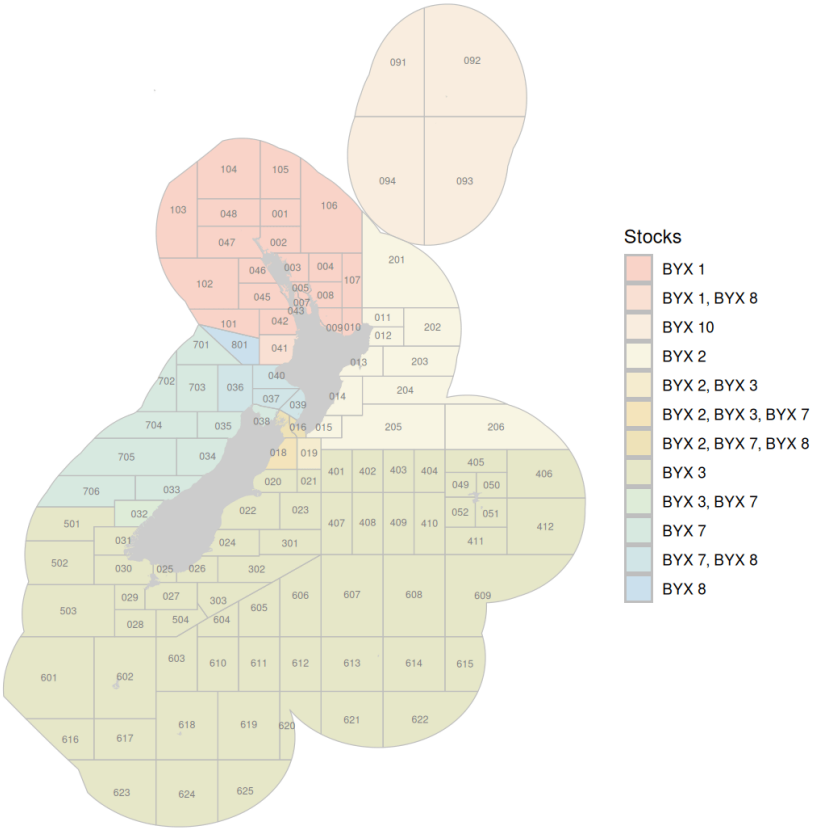

Figure 3: Statistical Areas that intersect the BYX 1, BYX 2, BYX 3, BYX 7, BYX 8 and BYX 10 Quota Management Areas.

2.6 Identifying spatial clusters of fishing effort

Density based clustering (dbscan; Hahsler et al. 2019) of tow start locations was used to identify spatial clusters in the fishing event data for trips that had catches of alfonsino from BYX 2 or BYX 3. All fishing events from these trips were included in the cluster analysis, whether or not alfonsino was targeted or caught, so long as the event reported a start latitude/longitude, and the trip included estimated catches of alfonsino. The dbscan algorithm uses the concept of the ε-neighbourhood (epsilon neighbourhood) of a data point to identify the set of points within a specified radius, ε, around a data point p.

The dbscan algorithm requires two parameters:

- ε, the size (radius) of the ε-neighbourhood (here measured in metres); and
- *minPts*, the minimum number of points required in the ε-neighbourhood for a point to qualify as a core point.

Points are then classified as:

- **core points**, if the number of points, $N_\varepsilon(p)$, in their ε-neighbourhood is greater than or equal to the minimum threshold, *minPts*;
- **border points**, if they are in the neighbourhood of a core point but do not meet the definition of a core point; or
- **noise points** otherwise.

Points are assigned to a cluster if they qualify as core or border points; noise points are not assigned to a cluster.

The parameters used for the dbscan algorithm were selected after inspecting the resulting spatial clustering for a range of parameter choices and considering the clustering of tows in relation to bathymetric features. Different values were chosen for the northern and southern parts of the area, with the division between the north and south areas taken to be –42.1°S.

For reporting purposes, the concave hull that encloses the tow locations assigned to a cluster was plotted, using a concavity parameter of 0.8 to limit the detail of the polygon border.

2.7 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 BYX 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 in the dataset (`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.

2.8 Maximum-likelihood CPUE modelling

Two generalised linear models (GLMs) were fitted to the core vessel datasets: a binomial GLM was developed for the probability that a record had a non-zero reported catch of alfonsino, and a second GLM was developed for the magnitude of alfonsino catch in the subset of records with a non-zero catch. For the positive-catch GLM the dependent variable was the log of catch per record; positive catch models were fitted with alternative error distributions (lognormal, gamma or Weibull) and the preferred distribution chosen after considering standard diagnostics.

The binomial and positive catch GLMs were offered the same explanatory variables, but model selection was carried out separately. Forward stepwise selection of model terms was carried out using the Akaike Information Criterion (AIC). Additionally, terms were only retained in the final model if they increased the deviance explained by at least 1%. Fishing year was forced as the first variable in each GLM and year effects were extracted as canonical coefficients so that confidence bounds could be calculated for each year (Francis 1999). The impact of the explanatory variables included in the binomial and positive catch GLMs is explored using the approaches of Bentley et al. (2012); this includes presenting step plots and coefficient-distribution-influence (CDI) plots.

The two indices (i.e., the 'binomial index' and the 'positive catch index') were combined into a single 'combined index' by multiplying the standardised probability of catch and the standardised magnitude of catch (Vignaux 1994).

3. FISHERY CHARACTERISATION

The majority of alfonsino landings have been made directly to a Licensed Fish Receiver (LFR), although some landings from BYX 3 in the early 1990s were transported directly out of the EEZ (Figure 4). There was a reasonable correspondence between annual MHR and landings totals for both stocks.

Alfonsino landings have generally been a mix of green (unprocessed fish) and dressed product, with green fish tending to dominate the landings from BYX 2 and the mix of states from BYX 3 showing greater inter-annual variation (Figure 5). The conversion factor for dressed alfonsino increase in the late 1990s (Figure 6), with a slight adjustment in the total catches prior to this change evident in Figure 4 as a result.

There is a good correspondence between total catches and catches that can be allocated to fishing events (Figure 7).

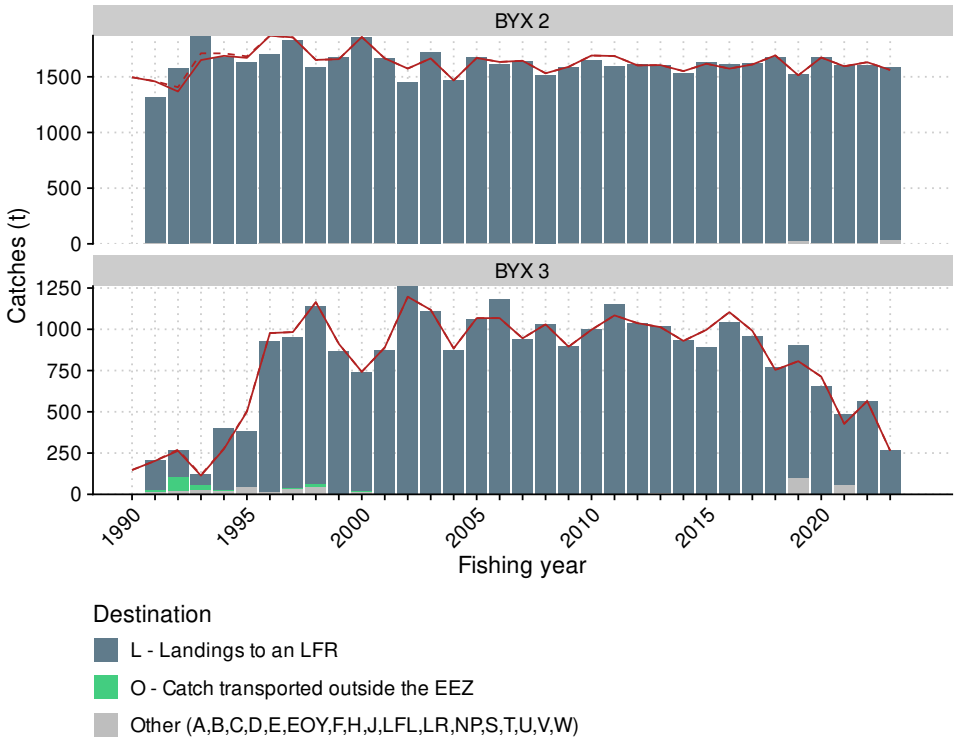

Figure 4: Catches of alfonsino by destination (bars), compared with Monthly Harvest Return / Quota Management Report (MHR/QMR) totals (line), for Quota Management Areas BYX 2 and BYX 3. The dashed line illustrates the MHR/QMR totals adjusted by the annual ratio between the originally reported landings and the landings adjusted to the current conversion factor. Destination codes are defined in Table 2 and tabulated catches are given in Appendix B.

Figure 5: Product state of alfonsino landings from Quota Management Areas BYX 2 and BYX 3. Catches are tabulated in Appendix B, and product state codes are defined in the glossary Table F.1.

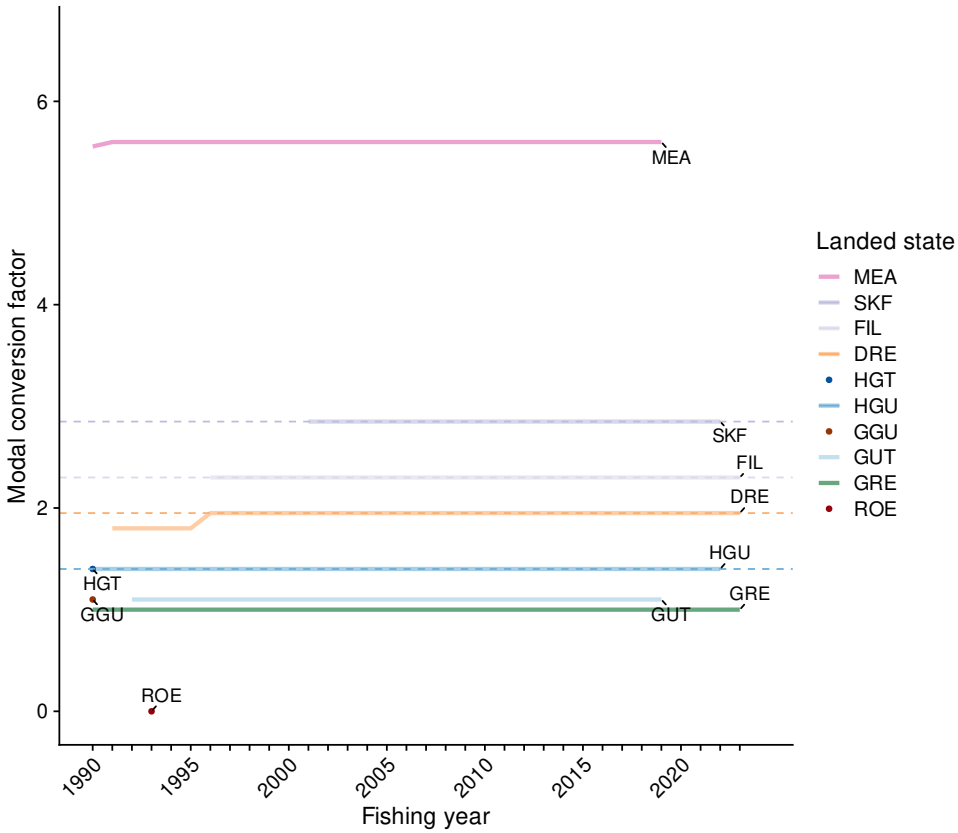

Figure 6: The modal annual conversion factor reported for the product states used in BYX 2 and BYX 3 catches. The current statutory conversion factor is indicated by a dashed line for states where a species-specific value is defined. Tabulated results are provided in Table B.8, and landed state codes are defined in the glossary Table F.1.

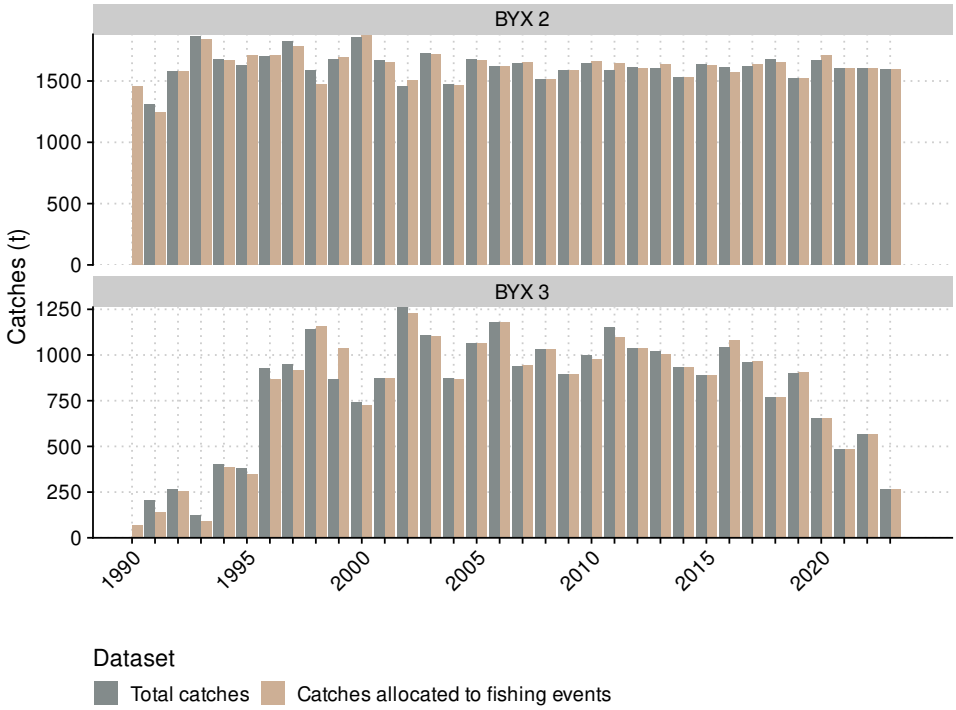

Figure 7: Total catches (t) of alfonsino from BYX 2 and BYX 3 in comparison with catches allocated to fishing events in the characterisation dataset.

3.1 The BYX 2 Quota Management Area

A high proportion of the catches from BYX 2 have come from trips with estimated catches of alfonsino, allowing catches to be pro-rated to fishing events based on estimated catches (Figure 8a). Estimated catches typically represent at least 90% of the total, so limited scaling is required (Figure 8b). The proportion of the catch included in daily processing data has varied over time (from 0% to 90%; Figure 8a,b), presumably as a result of changes in the key vessels in the fishery.

Estimated catches of alfonsino occur on an average of 25% of events (Figure 8c) and around 40% of days (Figure 8d) on trips with catches of BYX 2. There are indications of a slight increase in these proportions over the period from the late 1990s to 2023.

The bulk of alfonsino catches from BYX 2 are reported via the tow-resolution trawl forms, the TCEPR form during 1990–2017, then the ERS from 2018 (Figure 9). There is a small amount of alfonsino catch reported from lining and netting effort.

Catches are split between bottom and midwater trawling, with a slight predominance of midwater trawling over the entire time series, but a generally increased proportion from bottom trawling after 2005 (Figure 10, Table B.2). During 2016 to 2018 between 37% and 52% of the midwater trawl catch was taken using Precision Midwater Trawls (PRM) rather than conventional gear (MW). Bottom longline catches have always been a minor component of the BYX 2 catches, and have declined in volume after the mid 2010s.

Midwater trawl catches of alfonsino in BYX 2 have predominantly come from target fishing, with bycatch in hoki target effort representing a key secondary fishery (Figure 11). During the 1990s, alfonsino catches by bottom trawl were from a mix of orange roughy, hoki, alfonsino, cardinalfish, bluenose and gemfish target effort. From the mid 2000s, alfonino target catches have dominated, with ongoing, but reducing, bycatch from hoki and cardinalfish target effort. Bottom longline catches of alfonsino have almost exclusively been bycatch from bluenose target events.

When alfonsino was targeted it was generally the top ranked species in the reported estimated catches (Figure 12); as bycatch, alfonsino had an average reporting rank of around three when reporting was on the TCEPR form, with the average range increasing when the ERS was introduced, probably due to the reporting of more species per event.

Effort reporting for bottom and midwater trawling was similar on the TCEPR form and via the ERS (Figure 13). Trawling reported on the CELR or TCER forms showed somewhat lower effort, likely reflecting the smaller vessels using these forms, and decreasing over time in the case of midwater trawling. Very high daily mean fishing events in the late 1990s are evidence of recording errors in the bottom longline effort reported on the CELR form, probably reflecting a transposition of hooks and events.

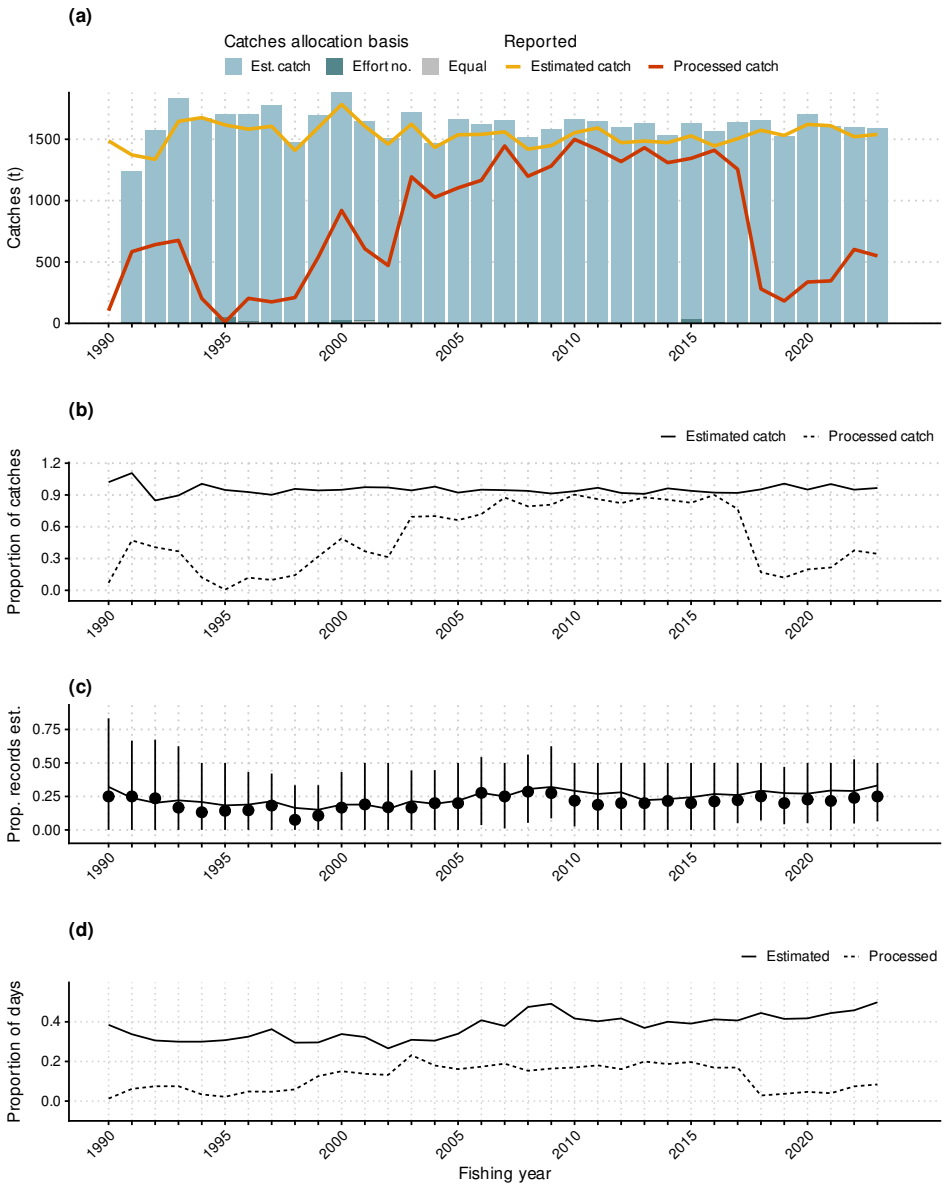

Figure 8: (a) bars: alfonsino catches allocated to fishing events in the BYX 2 QMA with allocation method indicated by fill colour (see Section 2.3); lines: total estimated and processed catch of BYX; (b) the proportion of BYX 2 catches included in estimated and processed catch data; (c) the proportion of fishing event records with an estimated catch of BYX, 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 BYX.

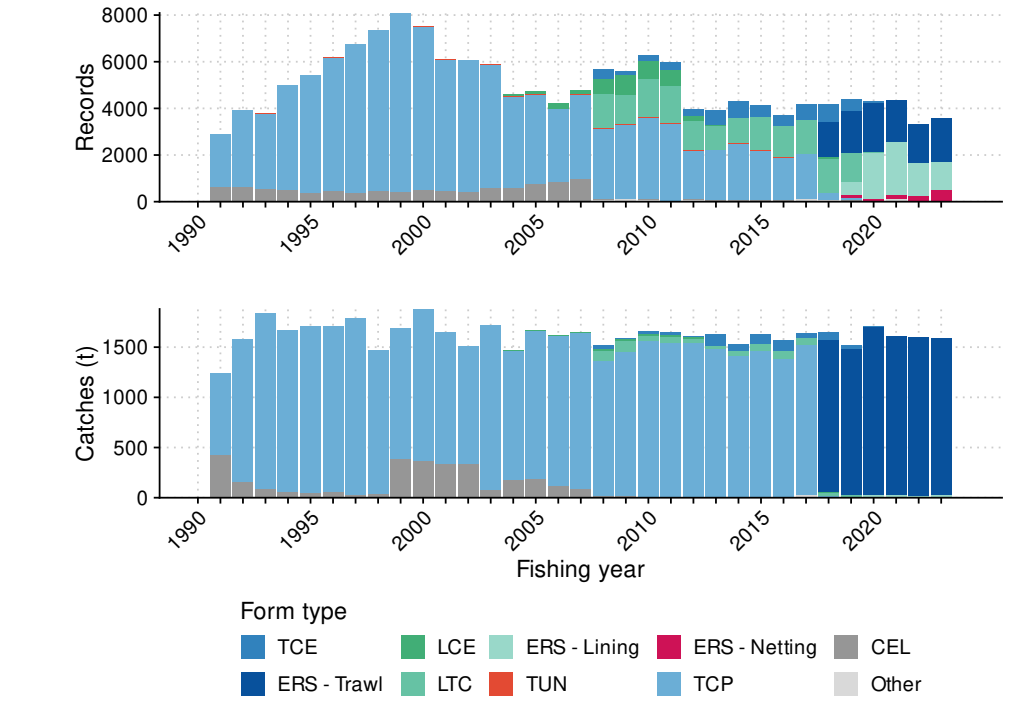

Figure 9: Reporting forms used on trips catching alfonsino within the BYX 2 Quota Management Area, in terms of fishing event records and catches. Tabulated results are available in Appendix B. Form types grouped as Other include: ERS - Other Lining, HTC, NCE. A list of the main form type codes is included in the glossary Table F.2.

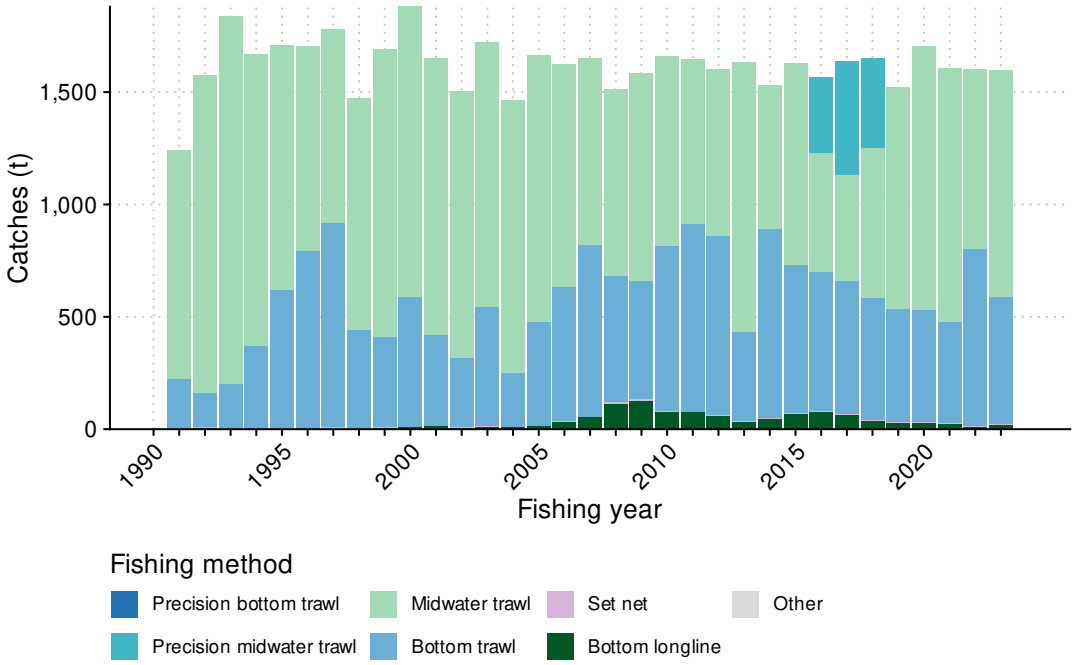

Figure 10: Catches of alfonsino by fishing method, for events within the BYX 2 Quota Management Area. Methods grouped as Other include: DL, HL, PSH, SLL, T, TL. Tabulated results are provided in Appendix B, and a list of the main fishing method codes is included in the glossary Table F.3.

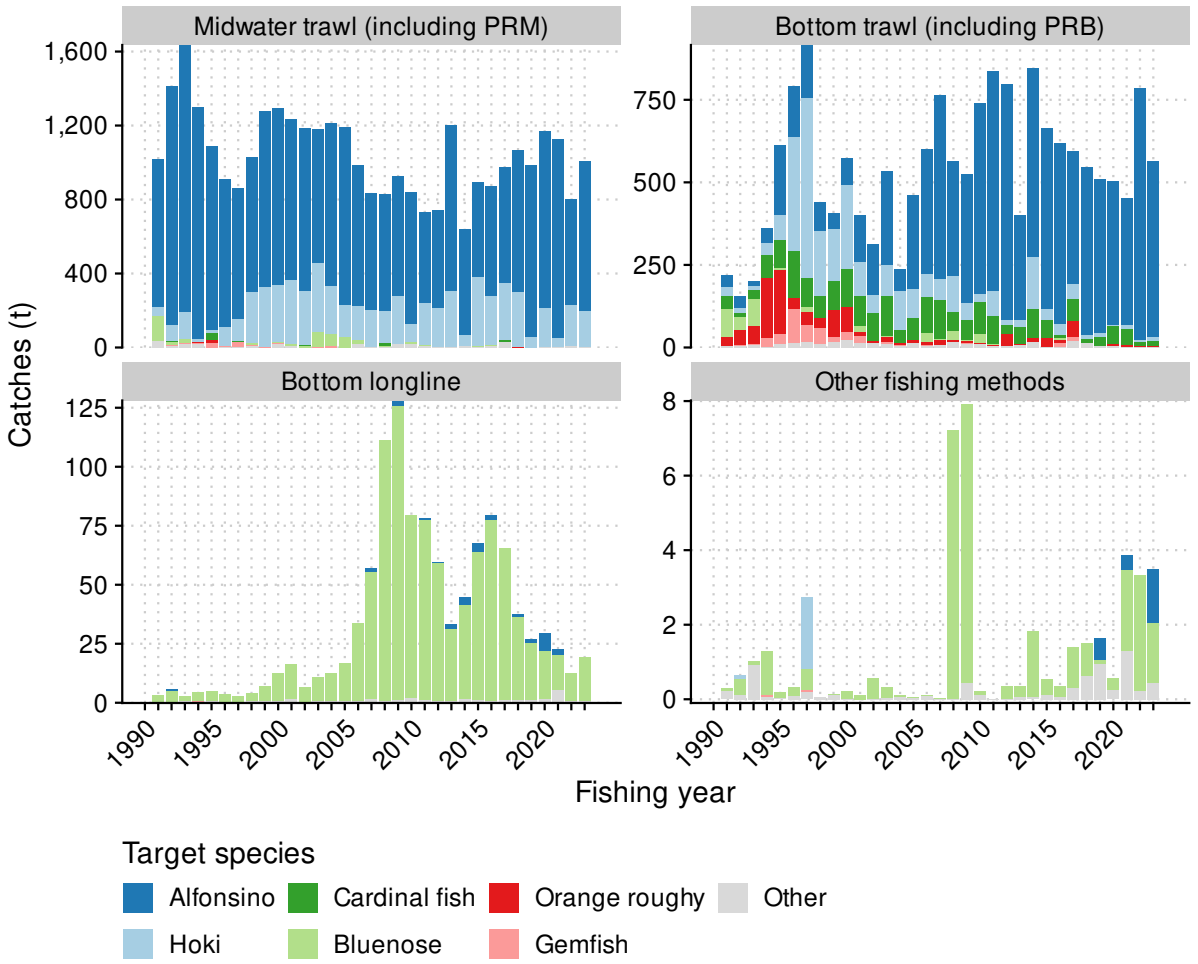

Figure 11: Catches of alfonsino by fishing method and declared target species, for events within the BYX 2 Quota Management Area. Precision bottom trawl (PRB) catches are included with conventional bottom trawl (BT) catches, and precision midwater trawl (PRM) catches are included with conventional midwater trawl (MW) catches. Fishing methods grouped as Other include: DL, HL, PSH, SLL, SN, T, TL. Species grouped as Other include target species with less than 5% of the alfonsino catch within the BYX 2 Quota Management Area in a fishing year.

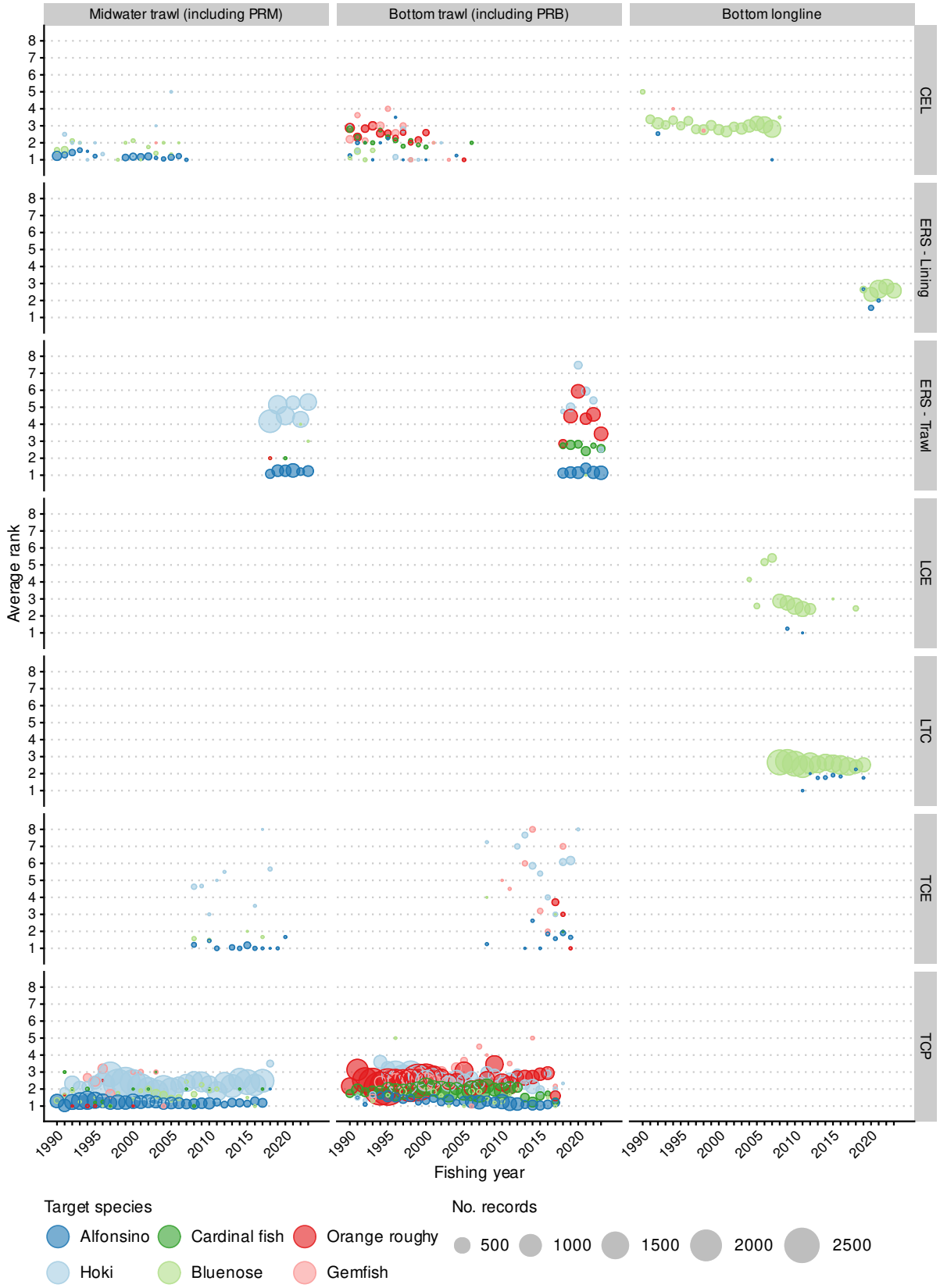

Figure 12: Average rank of alfonsino in the estimated catch, by fishing method, form type and declared target species, for events with estimated catches within the BYX 2 Quota Management Area. The area of the circles scales with the number of records.

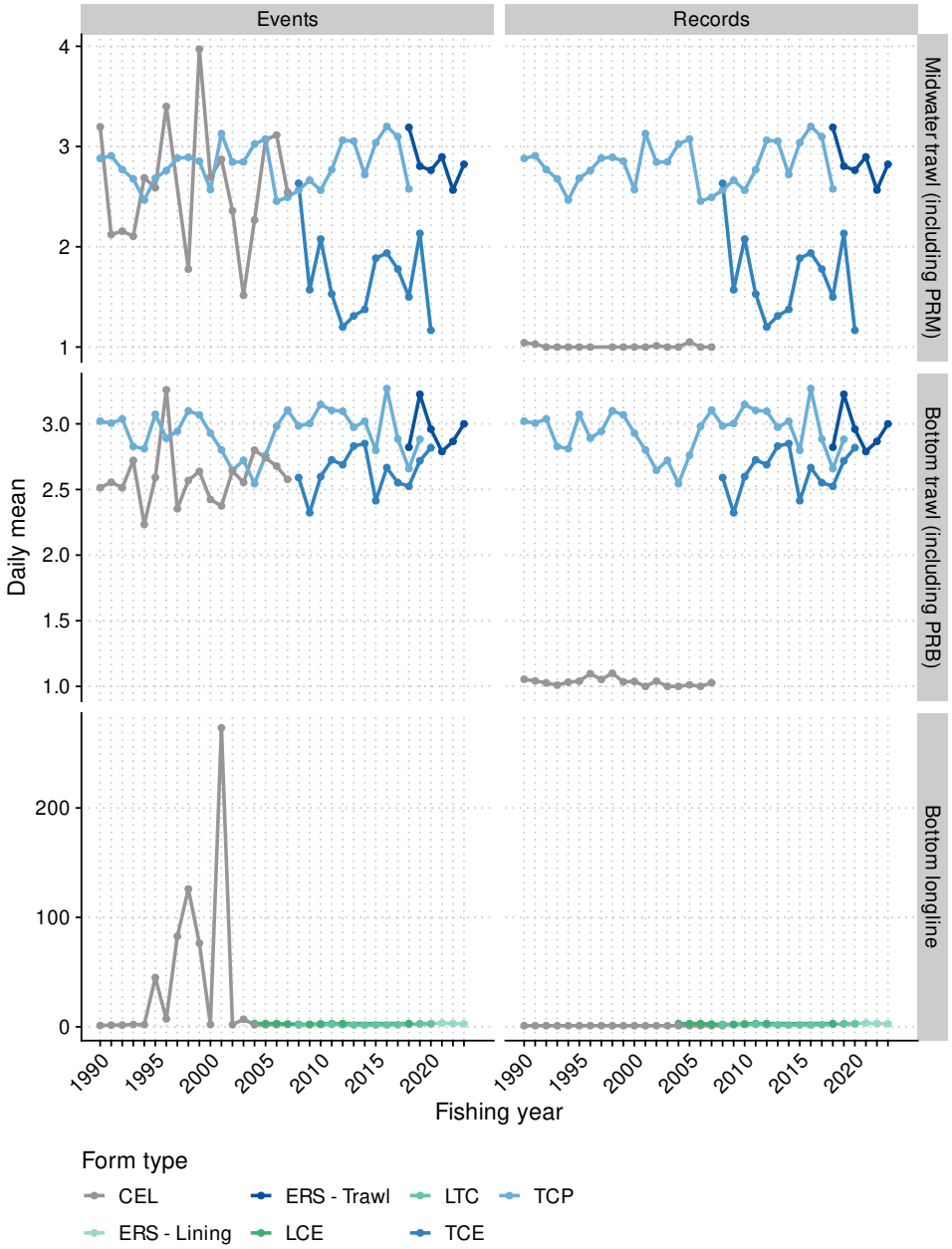

Figure 13: The mean number of fishing events and data records per vessel-day, by fishing method and reporting form, for effort within the BYX 2 QMA on trips landing catch from BYX 2. Data are included for years where a form was used on at least five vessel-days.

3.2 The BYX 3 Quota Management Area

Reporting patterns in BYX 3 are similar to those seen in BYX 2. Other than a couple of years in the mid 1990s, most catches of alfonsino have come from trips with estimated catches (Figure 14a). Estimated catches typically represent at least 90% of the total, so limited scaling is required (Figure 14b). As found in BYX 2, the proportion of the catch included in daily processing data has varied over time (from 0% to 90%; Figure 14a,b), reflecting changes in the fleet composition.

Estimated catches of alfonsino occurred less frequently in BYX 3 with an average of less than 10% of events (Figure 14c) and around 10% of days (Figure 14d) having estimated catches, from trips with catches of BYX 3.

As in BYX 2, the bulk of alfonsino catches from BYX 3 are reported via the tow-resolution trawl forms, the TCEPR form during 1990–2017, then the ERS from 2018 (Figure 15). However, in contrast to BYX 2, there has been a substantial change in the trawl types used in the BYX 3 fishery with bottom trawling dominating from the development of the fishery in the mid 1990s to 2005, then a gradual increase in the proportion of the catch taken by midwater trawling in the period to 2018, with midwater trawling dominating during 2019–2023 (Figure 16, Table B.3). Catches by other methods have been insignificant.

Until the mid 1990s, the bottom trawl catches of alfonsino were bycatch, predominantly in the orange roughy and ling fisheries (Figure 17). However, target alfonsino fishing has taken the majority of the BYX 3 catch since then.

Consistent with the BYX 2 fishery, alfonsino was generally the top ranked species in the estimated catch when it was targeted, and had an average rank around three as bycatch, for events reported on the TCEPR form, with average rank lower for effort reported via the ERS (Figure 18).

There are no indications that effort reporting changed as a result of the transition to the ERS, but the average number of tows per day decreased during 1995–2005 for both trawl methods (Figure 19). Daily effort stabilised at just over two tows per day in the midwater trawl fishery after 2005, but continued to reduce in the bottom trawl fishery.

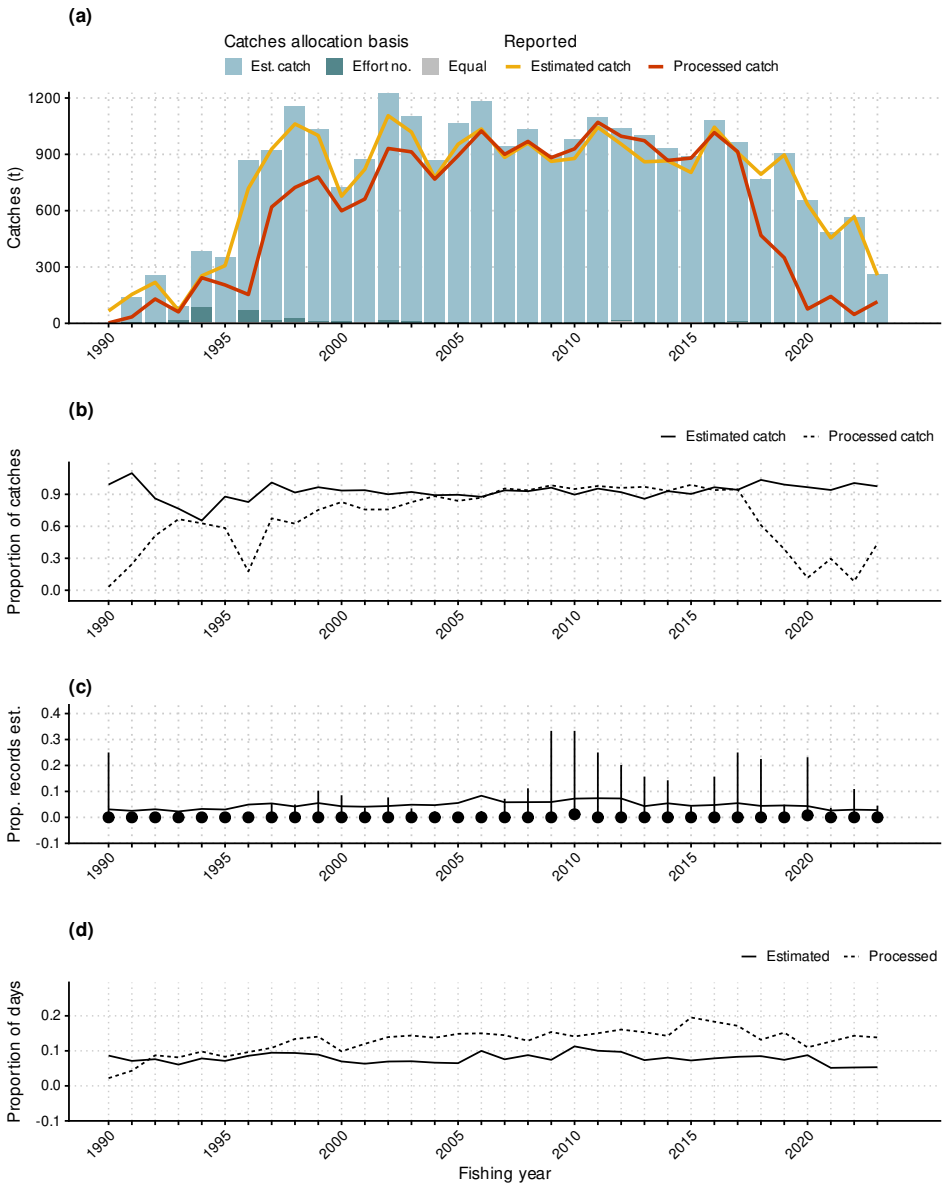

Figure 14: (a) bars: alfonsino catches allocated to fishing events in the BYX 3 QMA with allocation method indicated by fill colour (see Section 2.3); lines: total estimated and processed catch of BYX; (b) the proportion of BYX 3 catches included in estimated and processed catch data; (c) the proportion of fishing event records with an estimated catch of BYX, 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 BYX.

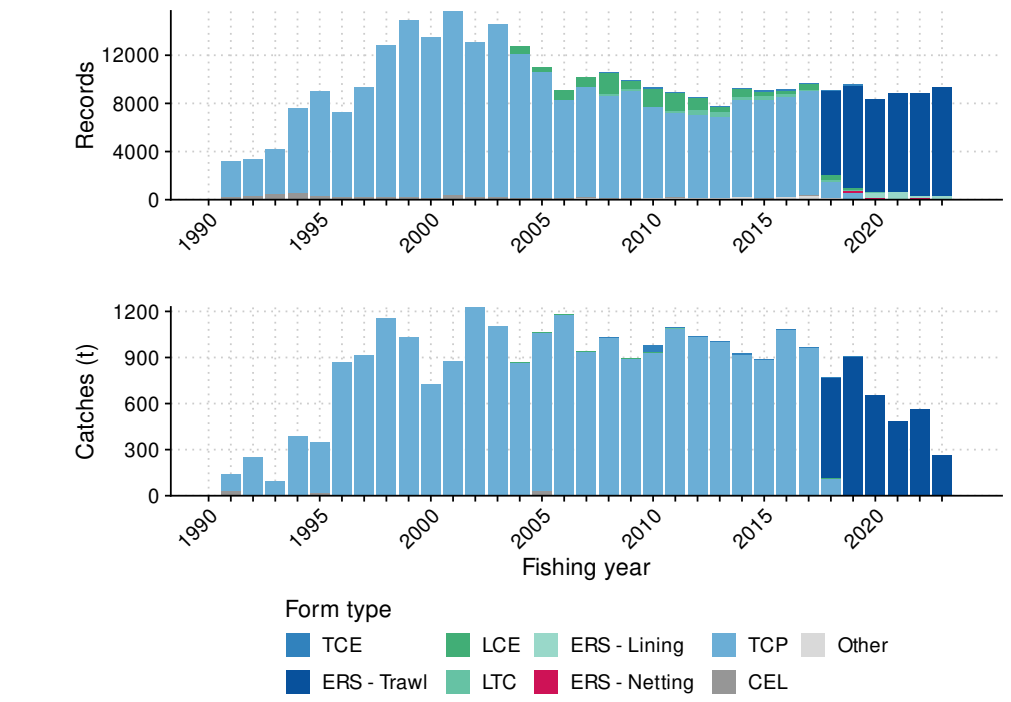

Figure 15: Reporting forms used on trips catching alfonsino within the BYX 3 Quota Management Area, in terms of fishing event records and catches. Tabulated results are available in Appendix B. Form types grouped as Other include: ERS - Potting, HTC, NCE. A list of the main form type codes is included in the glossary Table F.2.

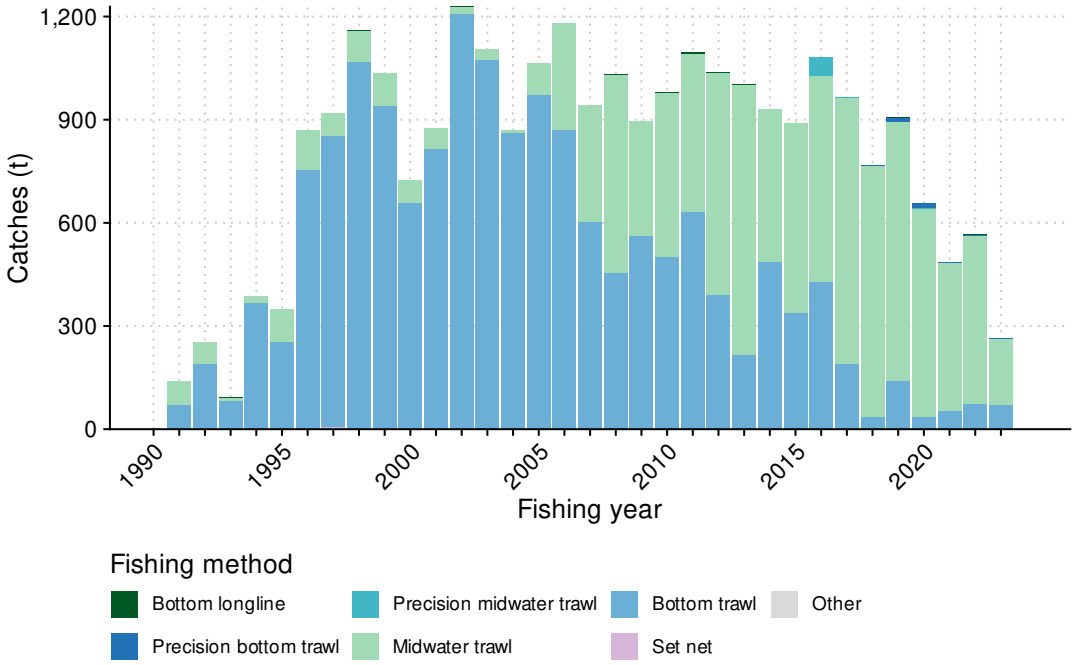

Figure 16: Catches of alfonsino by fishing method, for events within the BYX 3 Quota Management Area. Methods grouped as Other include: CP, DL, DS, HL, PL, POT, PSH, RLP, T. Tabulated results are provided in Appendix B, and a list of the main fishing method codes is included in the glossary Table F.3.

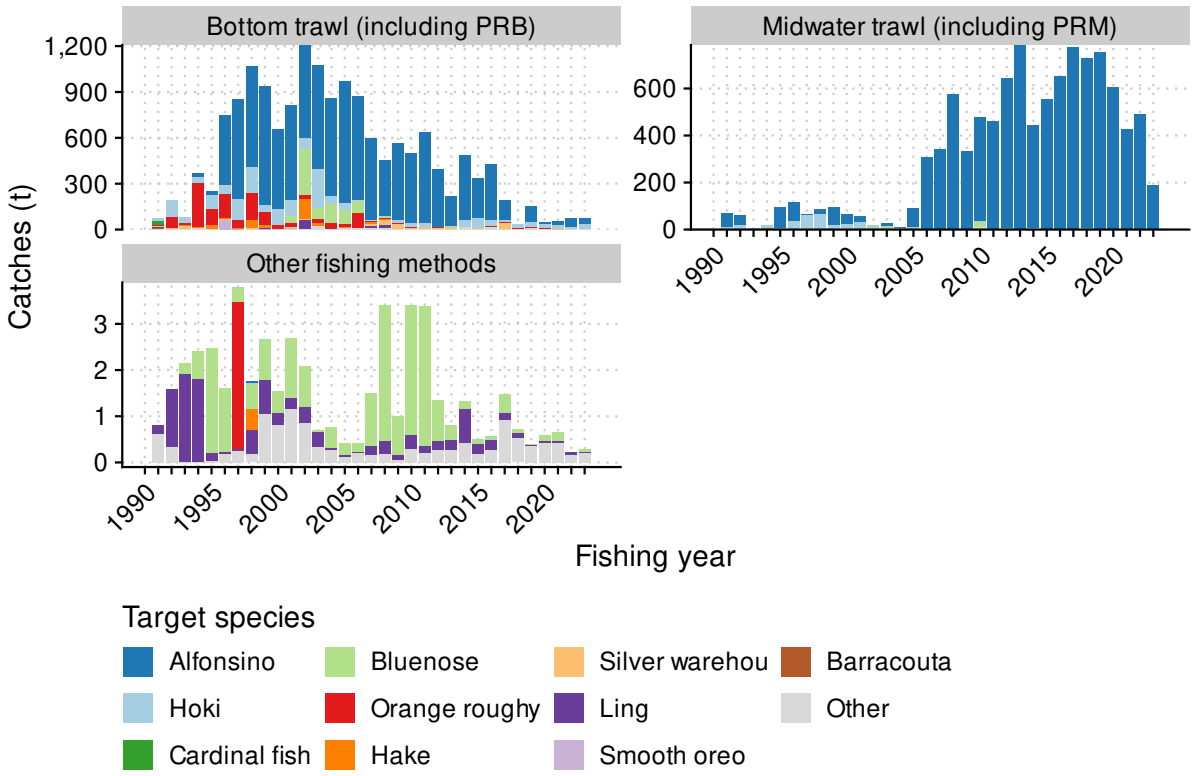

Figure 17: Catches of alfonsino by fishing method and declared target species, for events within the BYX 3 Quota Management Area. Precision bottom trawl (PRB) catches are included with conventional bottom trawl (BT) catches, and precision midwater trawl (PRM) catches are included with conventional midwater trawl (MW) catches. Fishing methods grouped as Other include: BLL, CP, DL, DS, HL, PL, POT, PSH, RLP, SN, T. Species grouped as Other include target species with less than 5% of the alfonsino catch within the BYX 3 Quota Management Area in a fishing year.

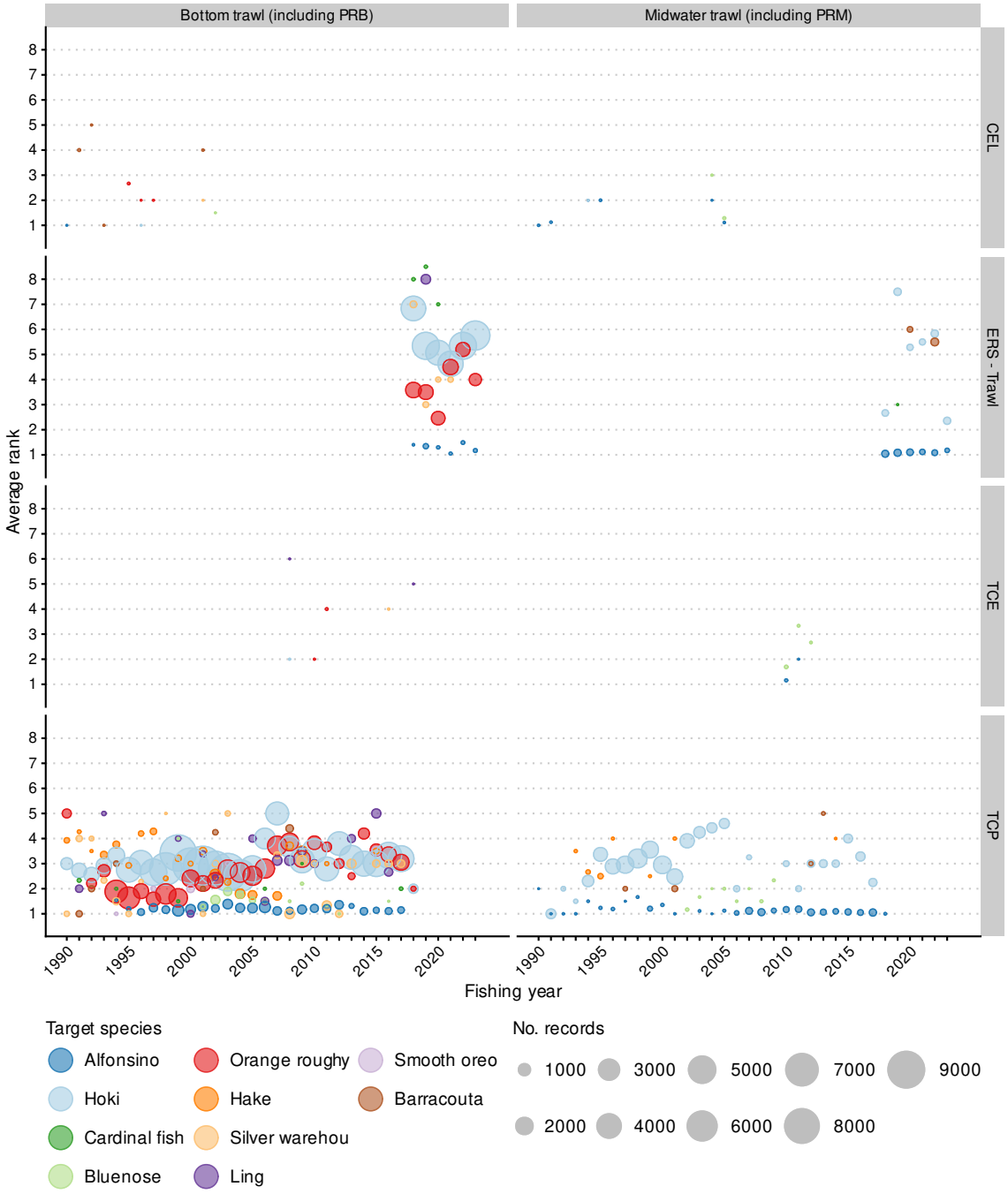

Figure 18: Average rank of alfonsino in the estimated catch, by fishing method, form type and declared target species, for events with estimated catches within the BYX 3 Quota Management Area. The area of the circles scales with the number of records.

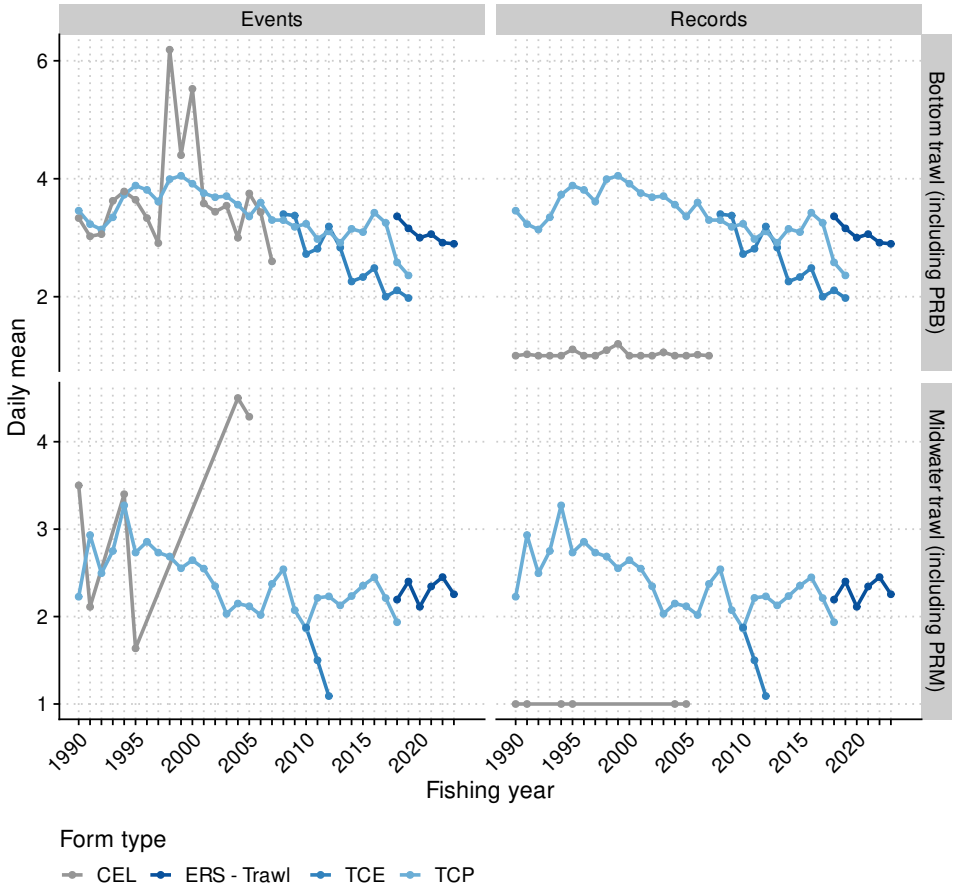

Figure 19: The mean number of fishing events and data records per vessel-day, by fishing method and reporting form, for effort within the BYX 3 QMA on trips landing catch from BYX 3. Data are included for years where a form was used on at least five vessel-days.

3.3 The midwater trawl (including PRM) fishery

Most midwater trawl catch in effort in BYX 2 and BYX 3 has been recorded with fine scale spatial information since 1993, although both areas had some years in the early 2000s where spatial information was missing for part of the catch (Figure 20).

Midwater trawl catches of alfonsino are recorded off the east coast of the North Island, from East Cape south to the Cook Strait, and along the north of the Chatham Rise round to the southeast of the Chatham Islands (Figure 21). The fishery has become more spatially concentrated over time (Figure 22). Alfonsino catches have also been reported from throughout the wider BYX 2 and BYX 3 QMAs, but the areas with significant catches are limited to the east coast North Island and Chatham Rise, with some areas supporting relatively consistent catches while others show considerable variation between years (Figure 23).

Target catches have occurred throughout the year in BYX 2 but, particularly since 2010, have tended to be focussed on the October–April period (Figure 24). In BYX 3, the timing of the fishery has varied, although June and July have always been months with limited target catch. BYX 3 catches have often been proportionally higher in September, potentially representing an end of fishing year process. In BYX 2, bycatch of alfonsino from hoki target effort is noticeably lower during June–August. Otherwise, bycatch of alfonsino tends to occur throughout the year (Figure 24). There is little indication of a seasonal pattern in catch rate in the target fisheries; however, in BYX 2 catch rates of alfonsino in the hoki fishery are lower during May–September (Figure 25).

A high proportion of the midwater trawl effort from trips that land alfonsino reports fishing quite close to the seabed (Figure 26). Industry representatives have indicated that typical midwater trawls for alfonsino involve fishing some distance off the seabed, but require an approach to the seabed at the end of the tow to assist in securing the fish within the trawl before hauling.

In both BYX 2 and BYX 3, the target midwater trawl effort for alfonsino is focussed in water depths of 250 m to 500 m (Figure 27), with target effort extending somewhat deeper in BYX 2. In other target fisheries, alfonsino is caught in both shallower and deeper depths but catch-weighted effort distributions indicate they are less likely to be caught shallower than 200 m and deeper than 600 m.

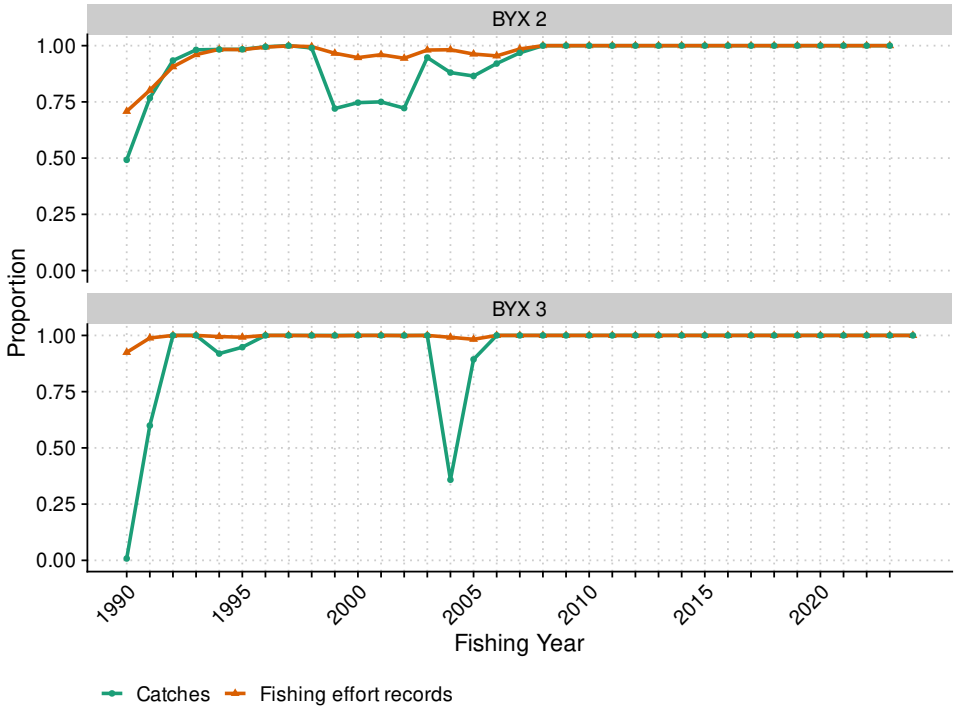

Figure 20: The proportion of records and catches reported with a latitude/longitude for the BYX 2 and BYX 3 midwater trawl (including PRM) fishery.

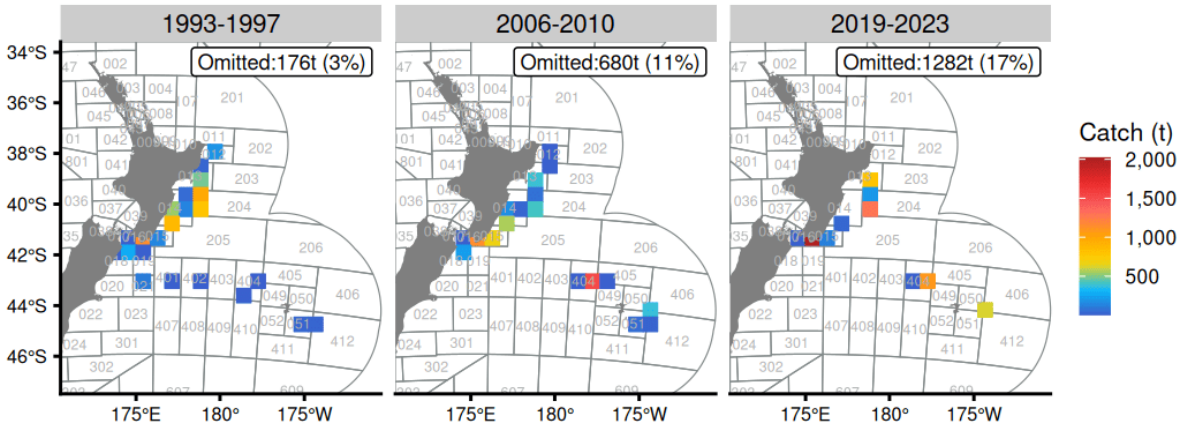

Figure 21: Catches (t) for the BYX 2 and BYX 3 midwater trawl (including PRM) fishery, for 5-year periods within the era during which at least 80% of catch was reported with spatial information. These plots use a 64 km grid and include records where catches were allocated in proportion to estimated catch. Cells with data from less than three vessels or permit holders are omitted; the quantity of catch affected is indicated on each panel.

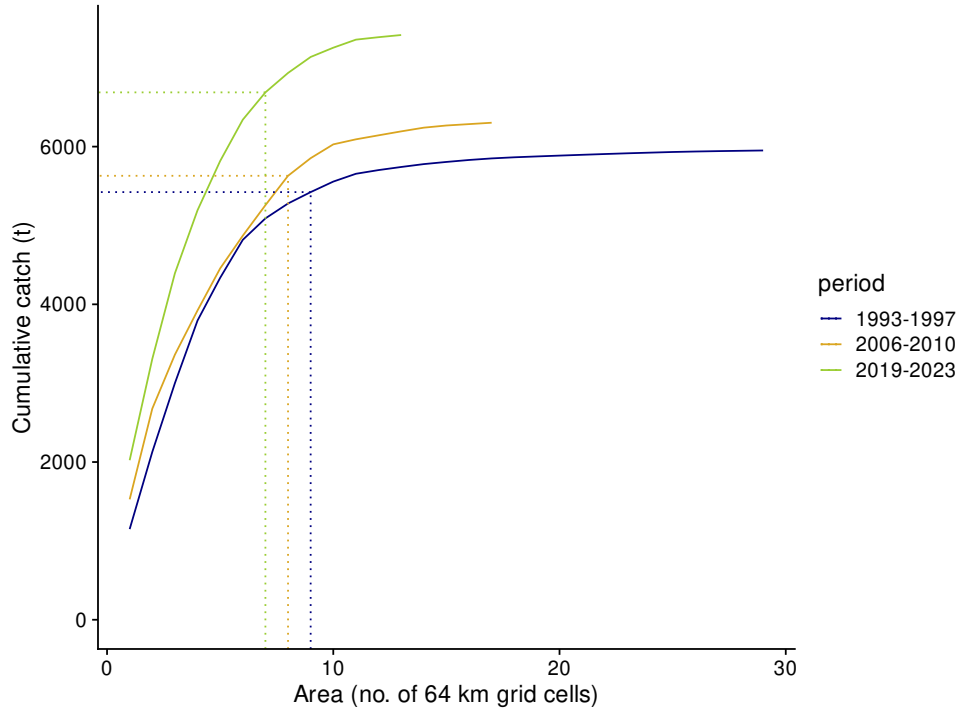

Figure 22: Cumulative BYX 2 and BYX 3 catch by area (grid cells) for the midwater trawl (including PRM) fishery, aggregated for the first, middle, and last 5-year period of reporting. Dotted lines indicate the 90th percentile for the first, middle, and last 5-year period of reporting.

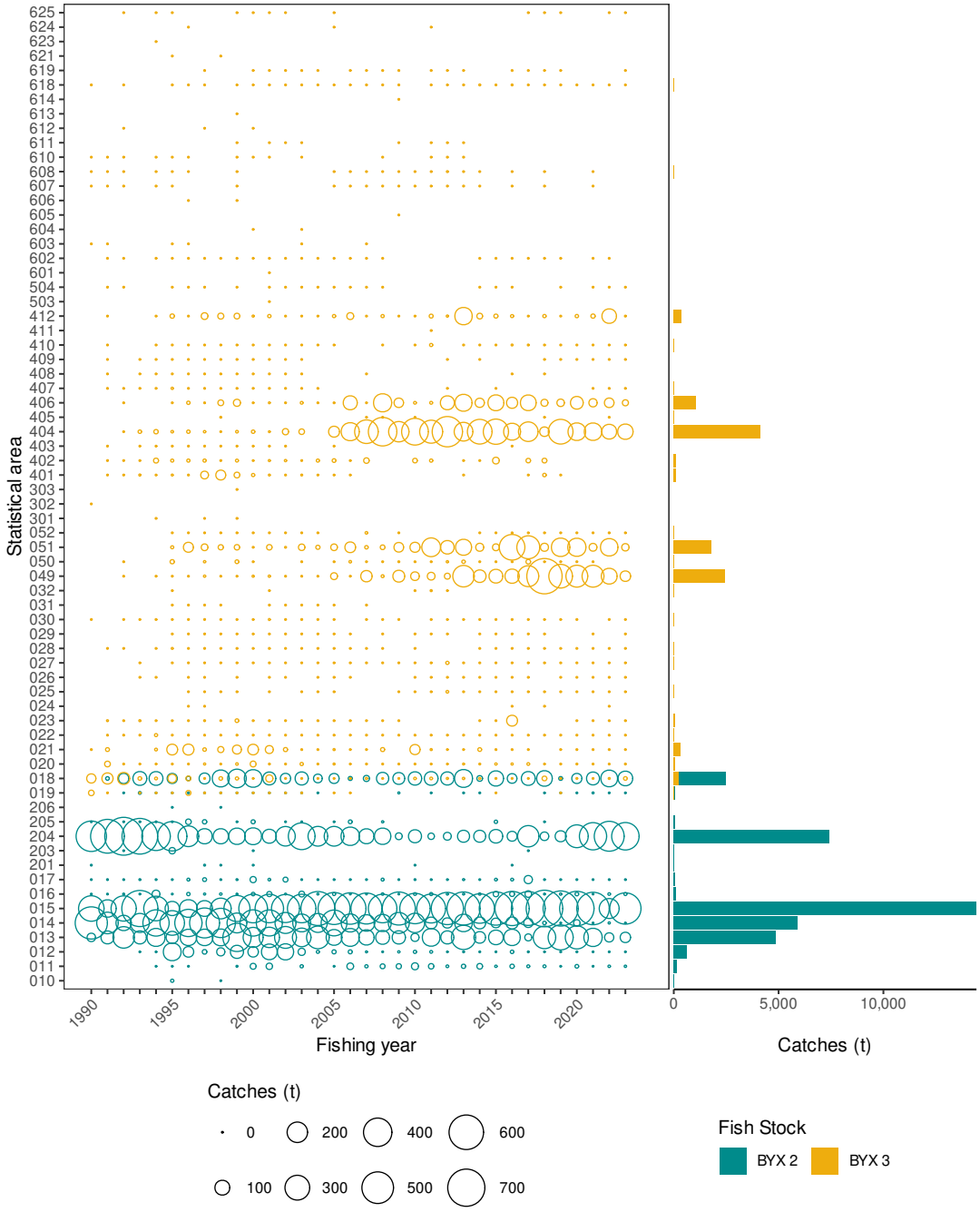

Figure 23: Annual BYX 2 and BYX 3 catches (t) by statistical area for the midwater trawl (including PRM) fishery. The circle size scales with the catches by statistical area. The bar plot (right) shows the total catches of BYX 2 and BYX 3 for each statistical area.

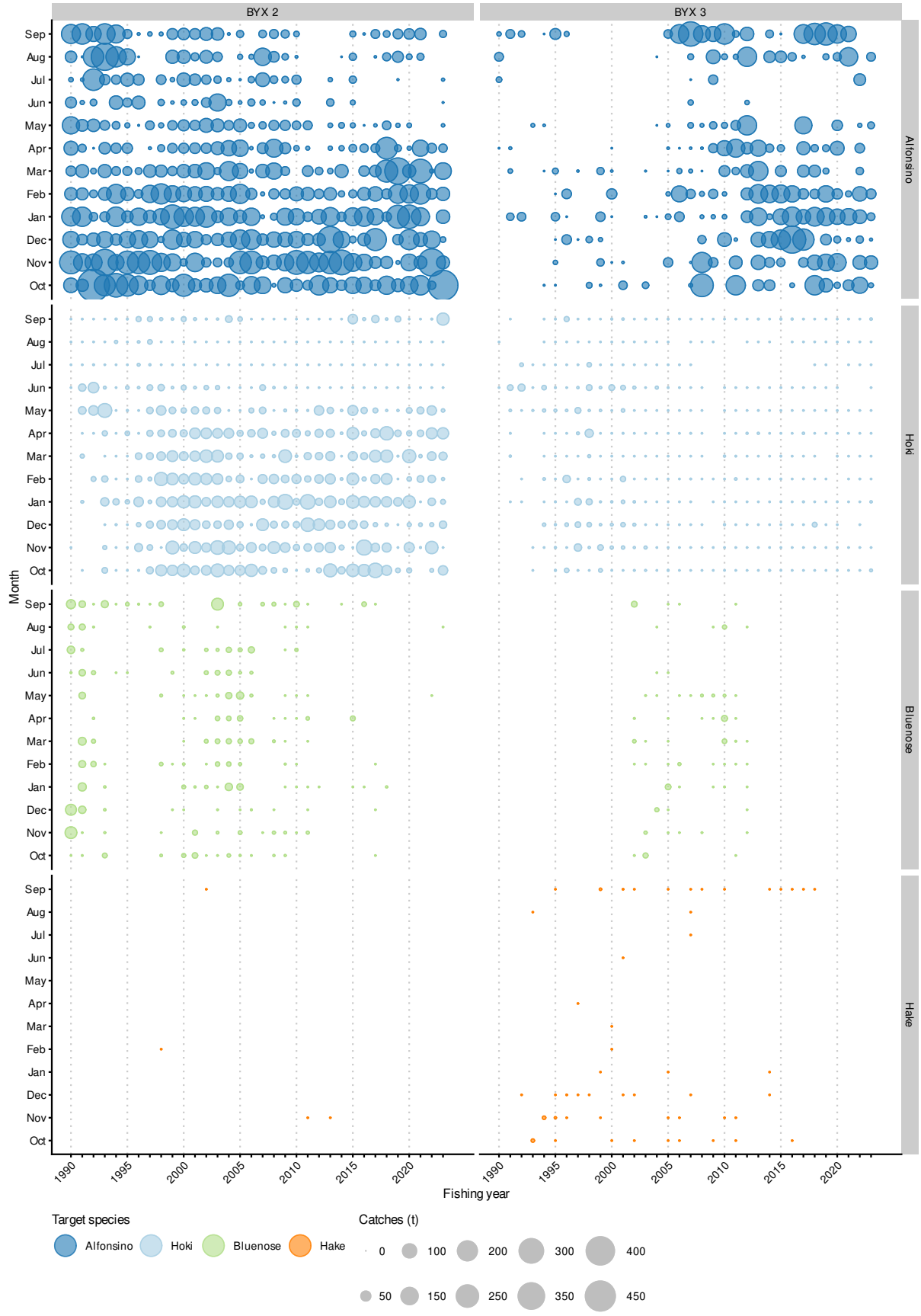

Figure 24: Seasonal distribution of BYX 2 and BYX 3 catches by month and fishing year for the midwater trawl (including PRM) target fisheries. The area of the circle scales with the monthly catches.

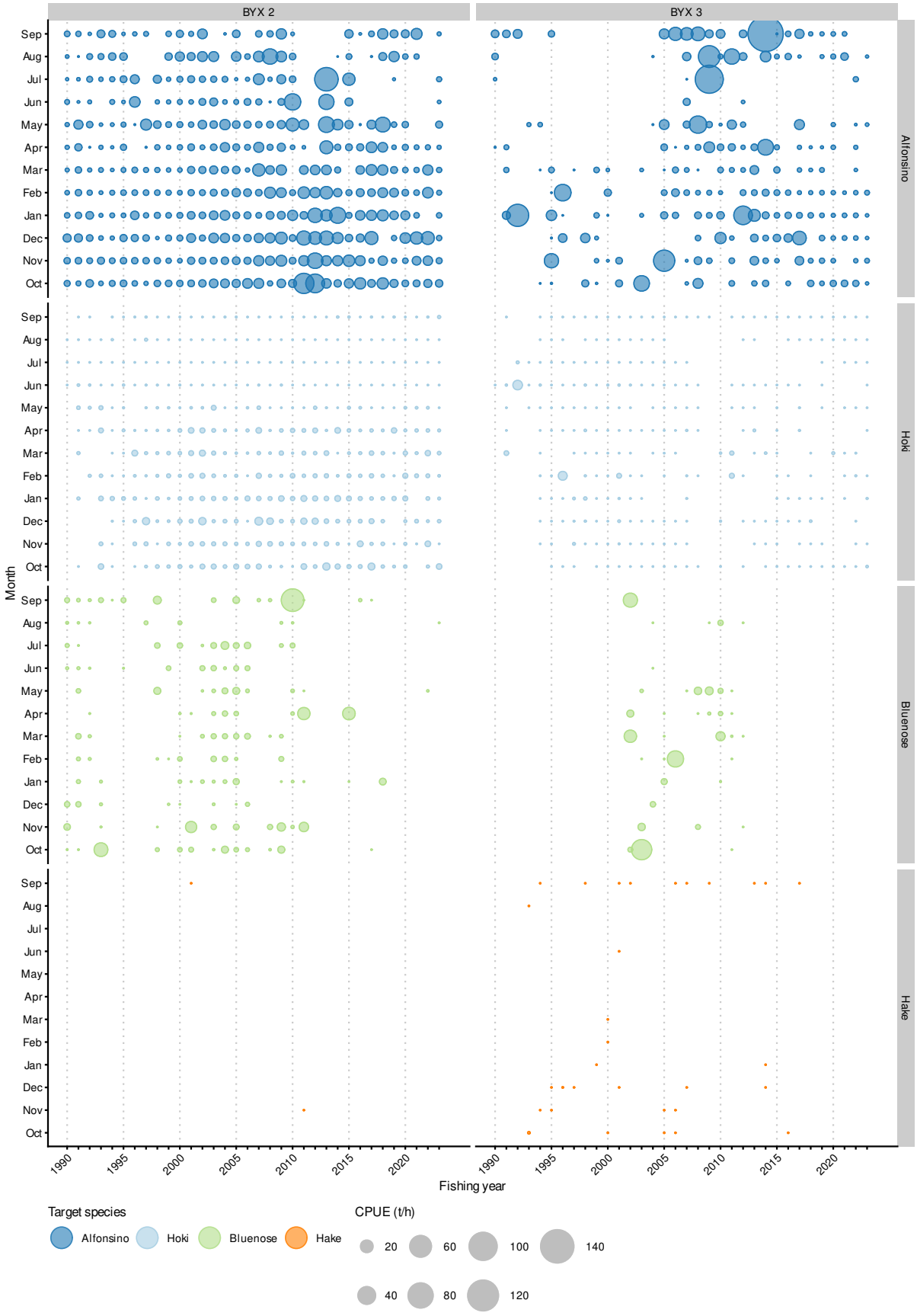

Figure 25: Seasonal distribution of BYX 2 and BYX 3 raw aggregate CPUE (t/h) by month and fishing year for the midwater trawl (including PRM) target fisheries. The area of the circle scales with the monthly raw aggregate CPUE (t/h).

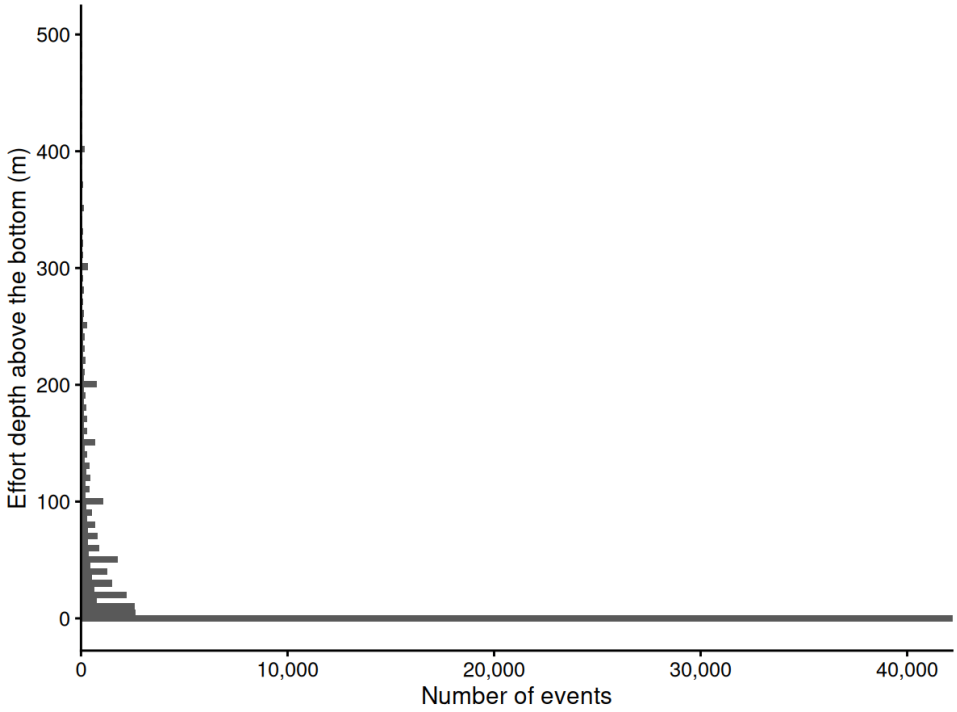

Figure 26: Distribution of the distance of fishing effort from the bottom for trips landing BYX 2 and BYX 3 from the midwater trawl (including PRM) fishery.

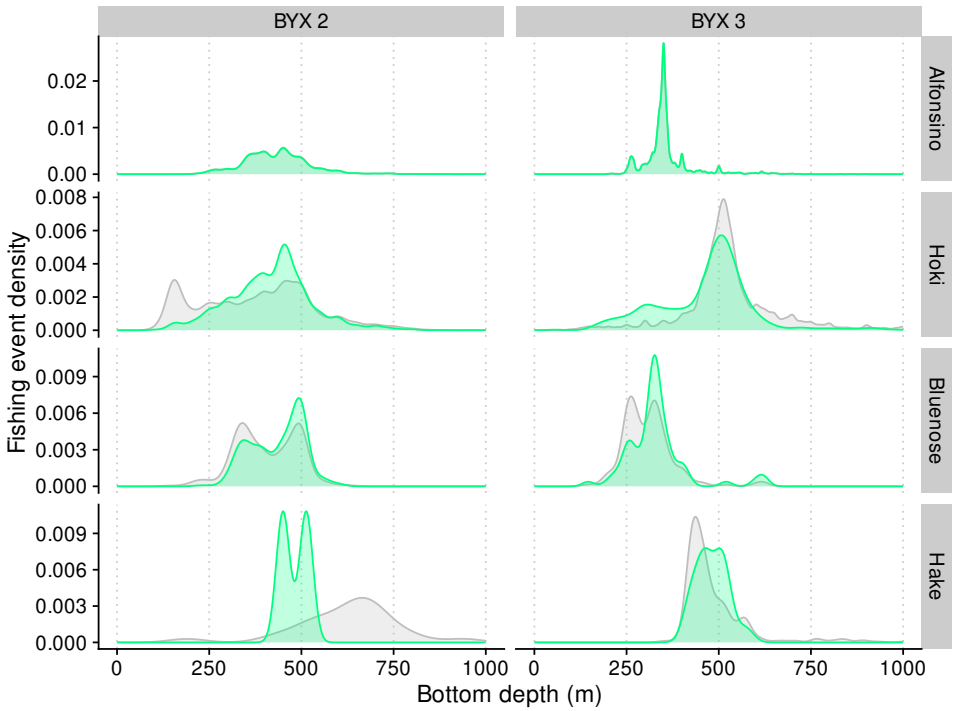

Figure 27: Effort depth distribution by target species for trips landing BYX 2 and BYX 3 from the midwater trawl (including PRM) fishery. Target species are included if they are represented in at least 30 events. Grey fill = total effort, green fill = positive effort (i.e., estimated catch > 0).

3.4 The bottom trawl (including PRB) fishery

Bottom trawl catch in effort in BYX 2 and BYX 3 has also been recorded with fine scale spatial information since the early 1990s (Figure 28). Bottom trawl catches occurred in the same general area as the midwater trawl fishery: off the southern east coast of the North Island, and along the north of the Chatham Rise round to the southeast of the Chatham Islands (Figure 29). The bottom trawl fishery has provided more continuous spatial coverage of this '*L*-shaped' region than the patchier midwater trawl fishery (Figure 21). However, bottom trawl catch rates show similar patchiness (Figure 30), and alfonsino target effort has focussed on these areas (Figure 31) with the wider spatial coverage of the bottom trawl fishery being largely attributable to hoki effort. As was the case with the midwater trawl fishery, the bottom trawl fishery has become more spatially concentrated over time (Figure 32).

Statistical area catch totals demonstrate that alfonsino bottom trawl catches have occurred throughout the wider BYX 2 and BYX 3 QMAs but, as with the midwater trawl fishery, the areas with significant catches are limited to the east coast North Island and Chatham Rise (Figure 33). In BYX 3, the transition from bottom trawling to midwater trawling (apparent in Figure 16) appears to have occurred in different areas at different times, with bottom trawling catches remaining consistently high in Statistical Area 051 until the mid 2010s, but dropping earlier in other areas on the eastern Chatham Rise. In BYX 2 there has been an increase in the catch taken in the offshore Statistical Area 204 in 2022 and 2023, and a reduction in the inshore areas, especially Statistical Area 015 (Figure 33).

The target bottom trawl for alfonsino shows a similar seasonal pattern to the midwater trawl fishery, with reduced catches in BYX 3 in June and July being the key feature (Figure 34) and with little indication of seasonality in unstandardised catch rates (Figure 35).

Target bottom trawling for alfonsino (Figure 36) has extended to somewhat deeper water depths than those fished by target midwater trawling (Figure 27); however, in both cases depths fished are predominantly from 250 m to 550 m. Deeper target fisheries, especially orange roughy and oreo effort, suggest that alfonsino abundance is usually lower beyond 750 m. There are some exceptions: the alfonsino catch-weighted distribution of oreo target effort in BYX 2 suggests alfonsino catches were greater in oreo tows between 850 m and 1000 m.

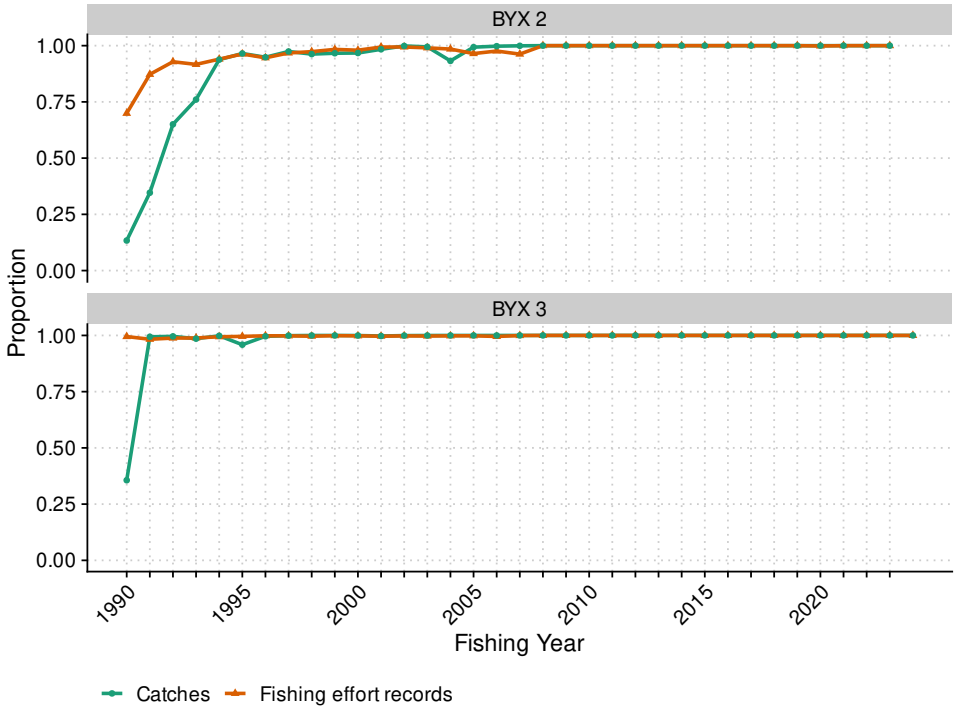

Figure 28: The proportion of records and catches reported with a latitude/longitude for the BYX 2 and BYX 3 bottom trawl (including PRB) fishery.

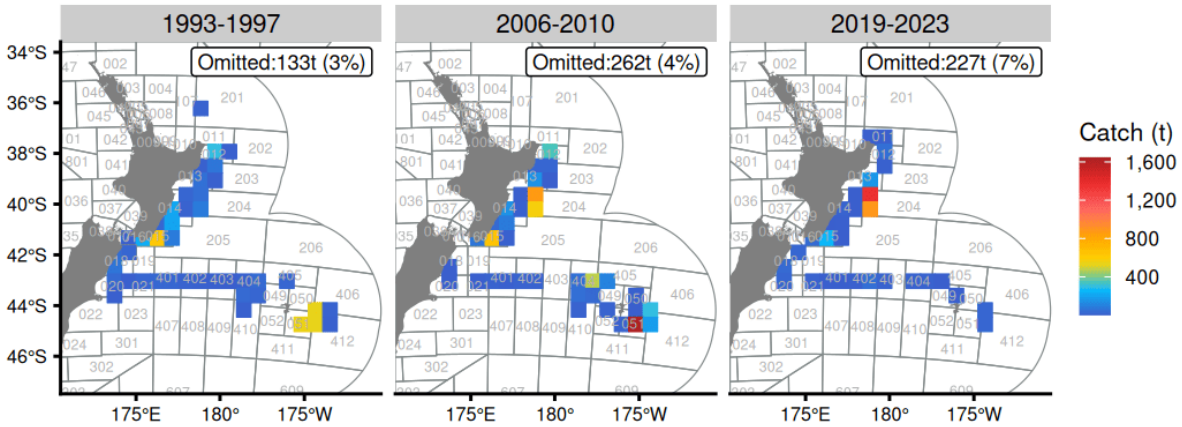

Figure 29: Catches (t) for the BYX 2 and BYX 3 bottom trawl (including PRB) fishery, for 5-year periods within the era during which at least 80% of catch was reported with spatial information. These plots use a 64 km grid and include records where catches were allocated in proportion to estimated catch. Cells with data from less than three vessels or permit holders are omitted; the quantity of catch affected is indicated on each panel.

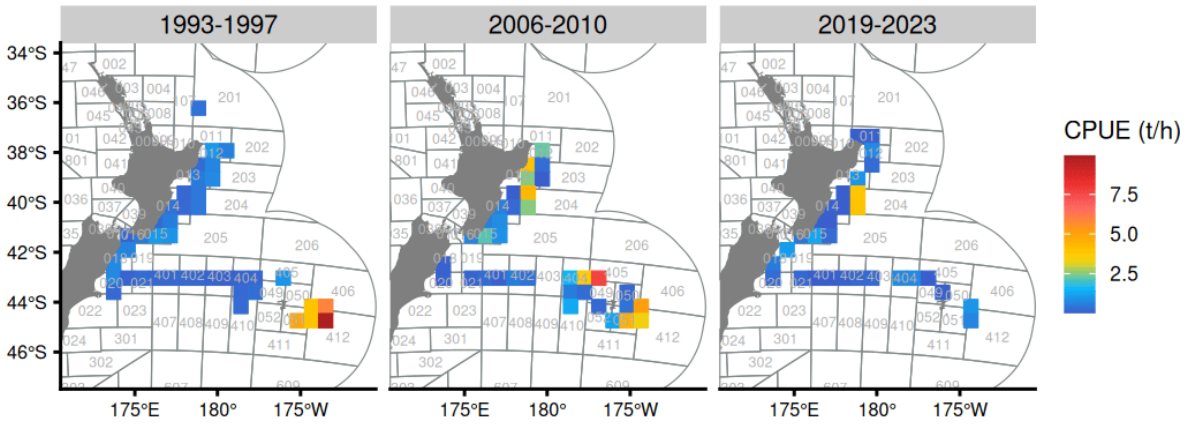

Figure 30: Raw aggregate CPUE (t/h) for the BYX 2 and BYX 3 bottom trawl (including PRB) fishery, for 5-year periods within the era during which at least 80% of catch was reported with spatial information. These plots use a 64 km grid and include records where catches were allocated in proportion to estimated catch. Cells with data from less than three vessels or permit holders are omitted.

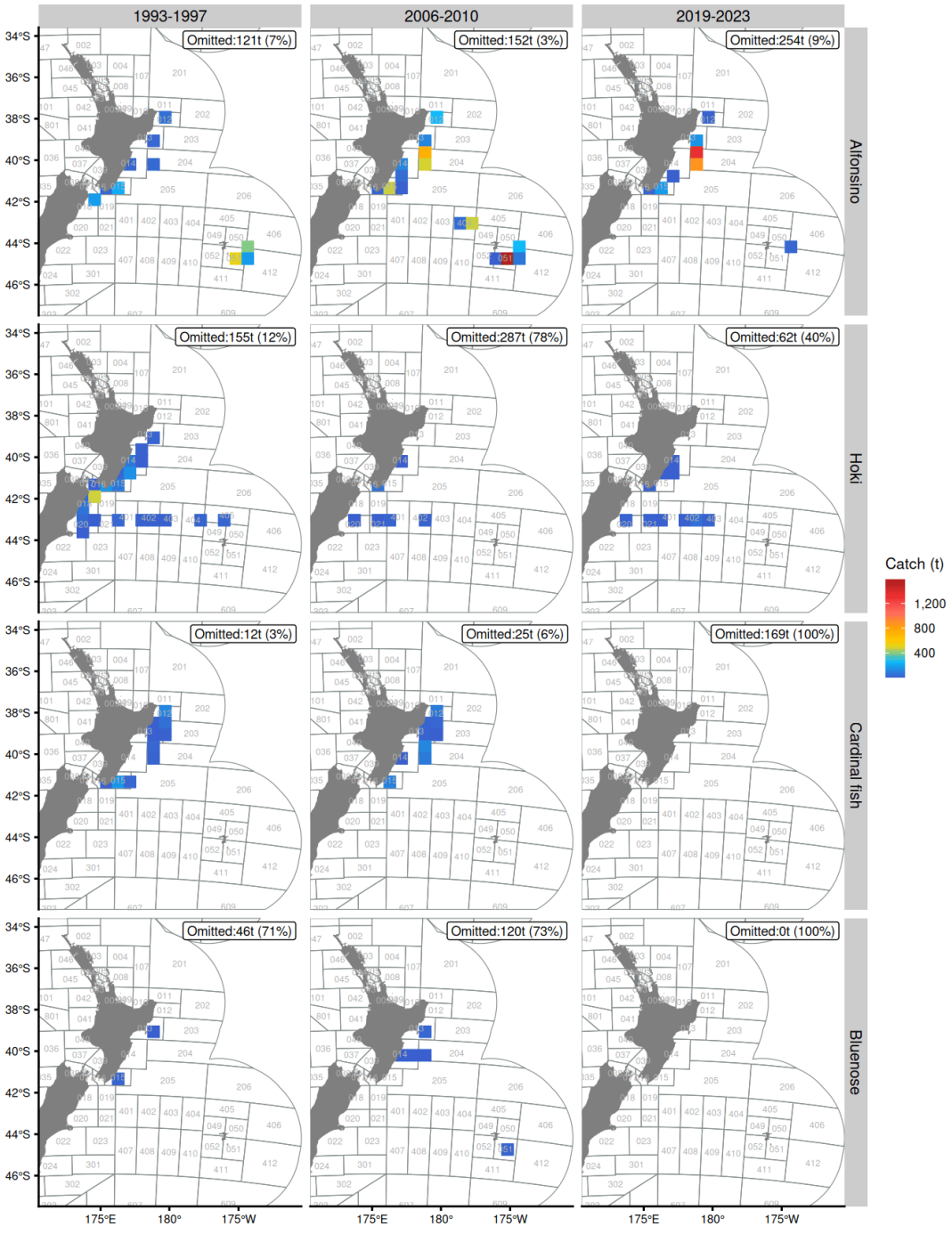

Figure 31: Catches of alfonsino from the bottom trawl (including PRB) fishery by key target species. These plots use a 64 km grid and include records where landings were allocated in proportion to estimated catch. Cells with data from less than three vessels or permit holders are omitted; the quantity of catch affected is indicated on each panel.

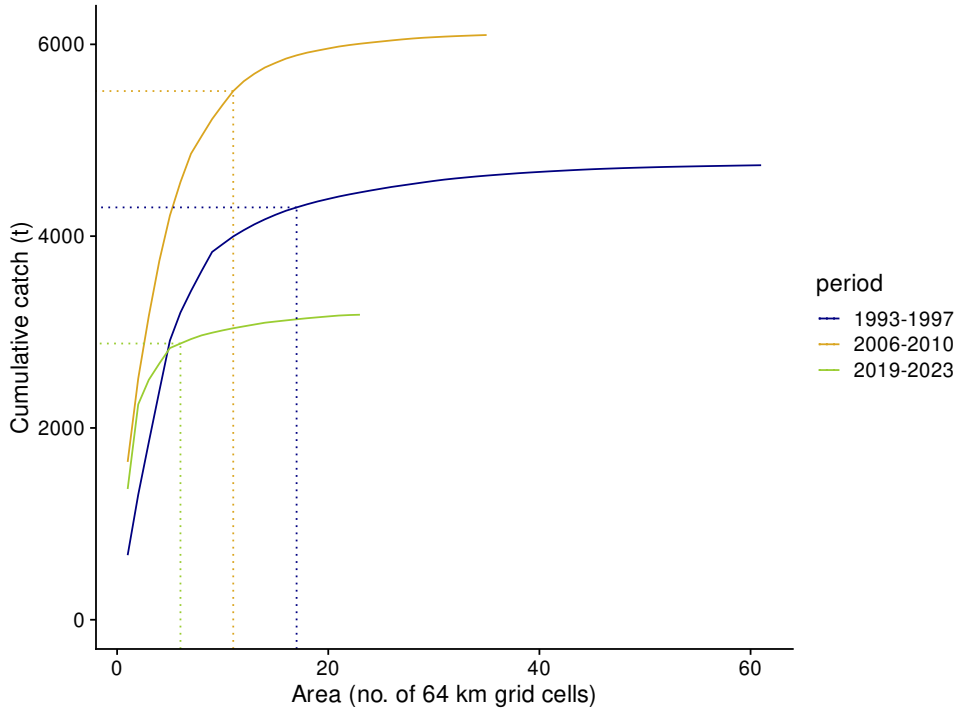

Figure 32: Cumulative BYX 2 and BYX 3 catch by area (grid cells) for the bottom trawl (including PRB) fishery, aggregated for the first, middle, and last 5-year period of reporting. Dotted lines indicate the 90th percentile for the first, middle, and last 5-year period of reporting.

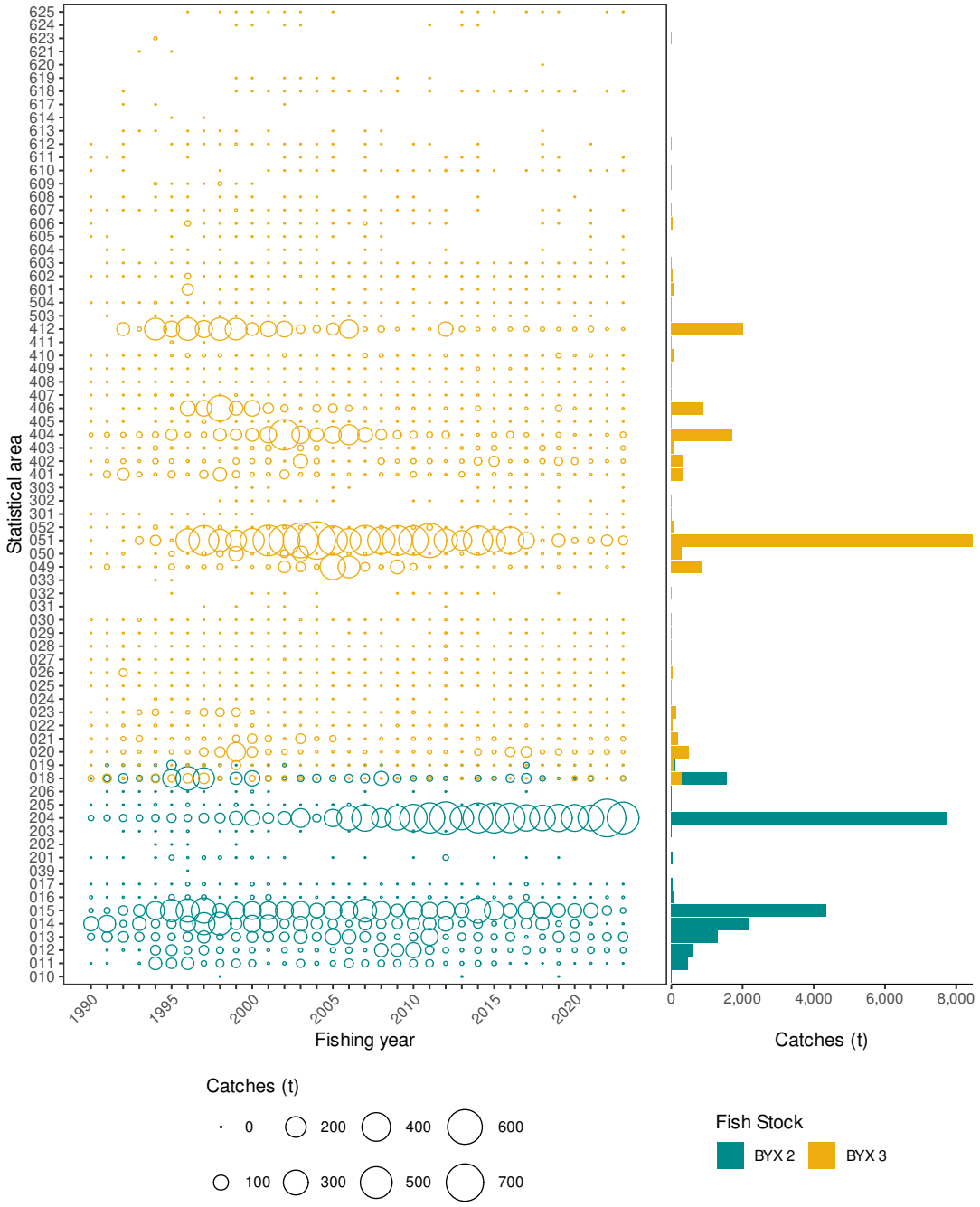

Figure 33: Annual BYX 2 and BYX 3 catches (t) by statistical area for the bottom trawl (including PRB) fishery. The circle size scales with the catches by statistical area. The bar plot (right) shows the total catches of BYX 2 and BYX 3 for each statistical area.

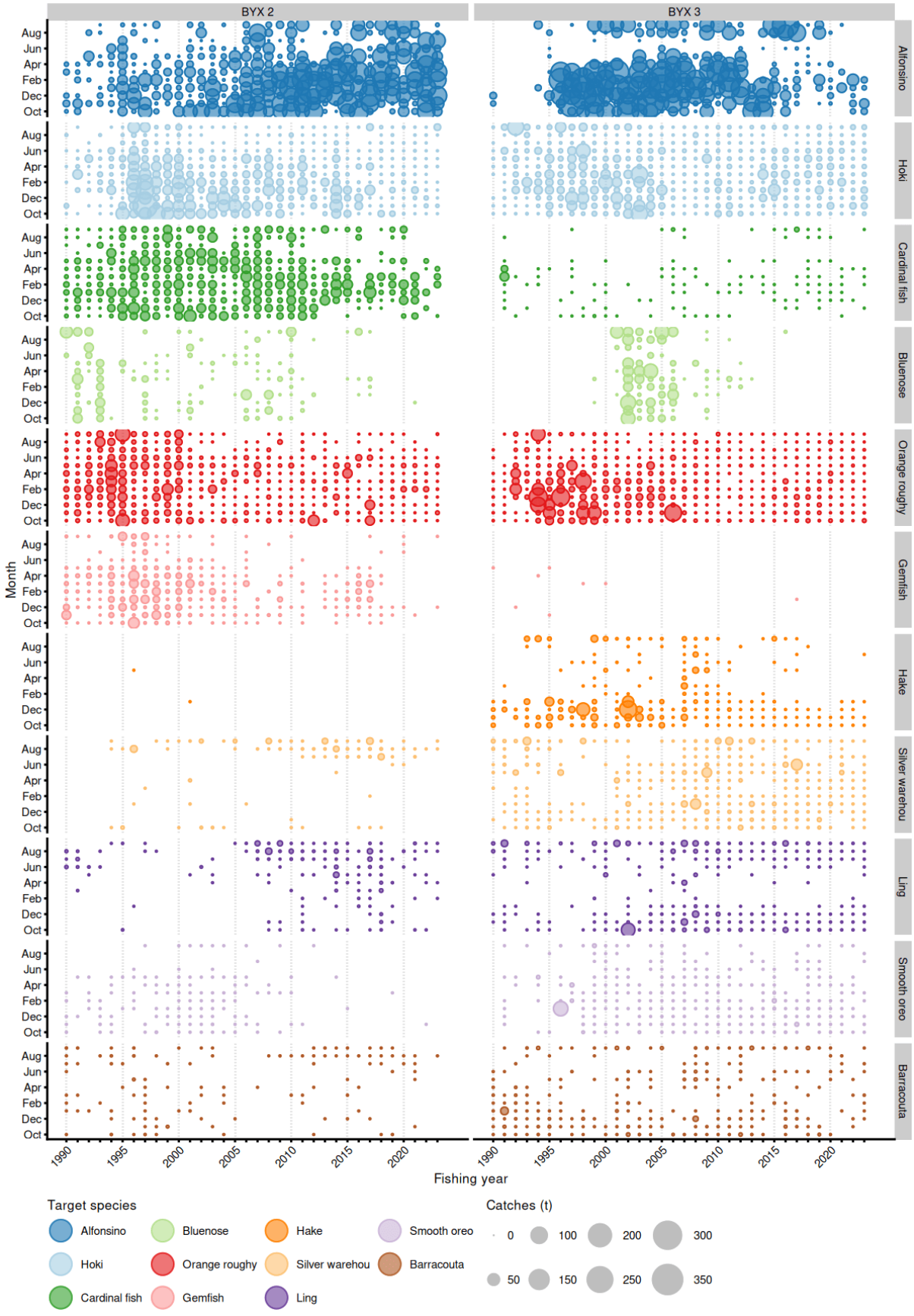

Figure 34: Seasonal distribution of BYX 2 and BYX 3 catches by month and fishing year for the bottom trawl (including PRB) target fisheries. The area of the circle scales with the monthly catches.

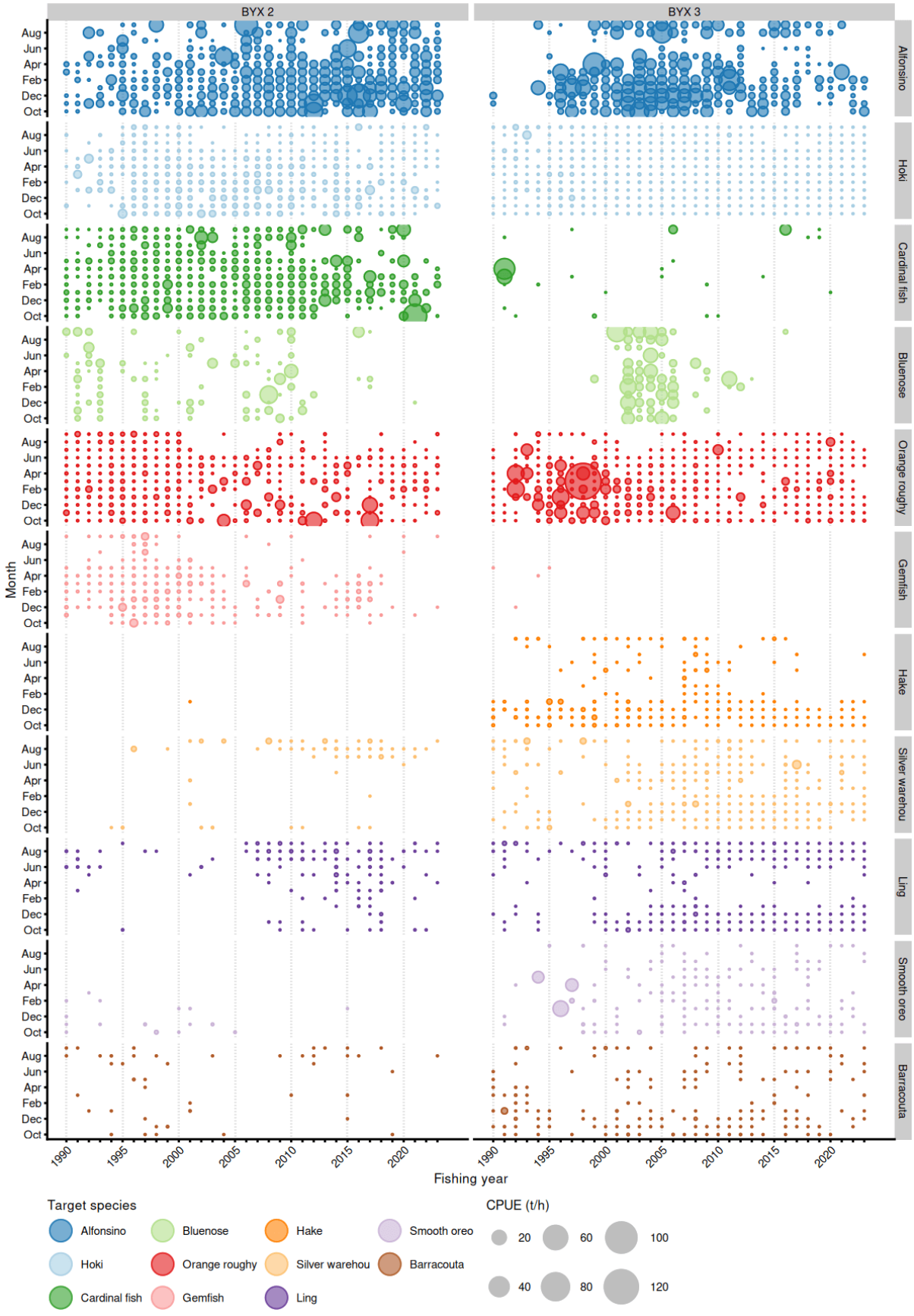

Figure 35: Seasonal distribution of BYX 2 and BYX 3 raw aggregate CPUE (t/h) by month and fishing year for the bottom trawl (including PRB) target fisheries. The area of the circle scales with the monthly raw aggregate CPUE (t/h).

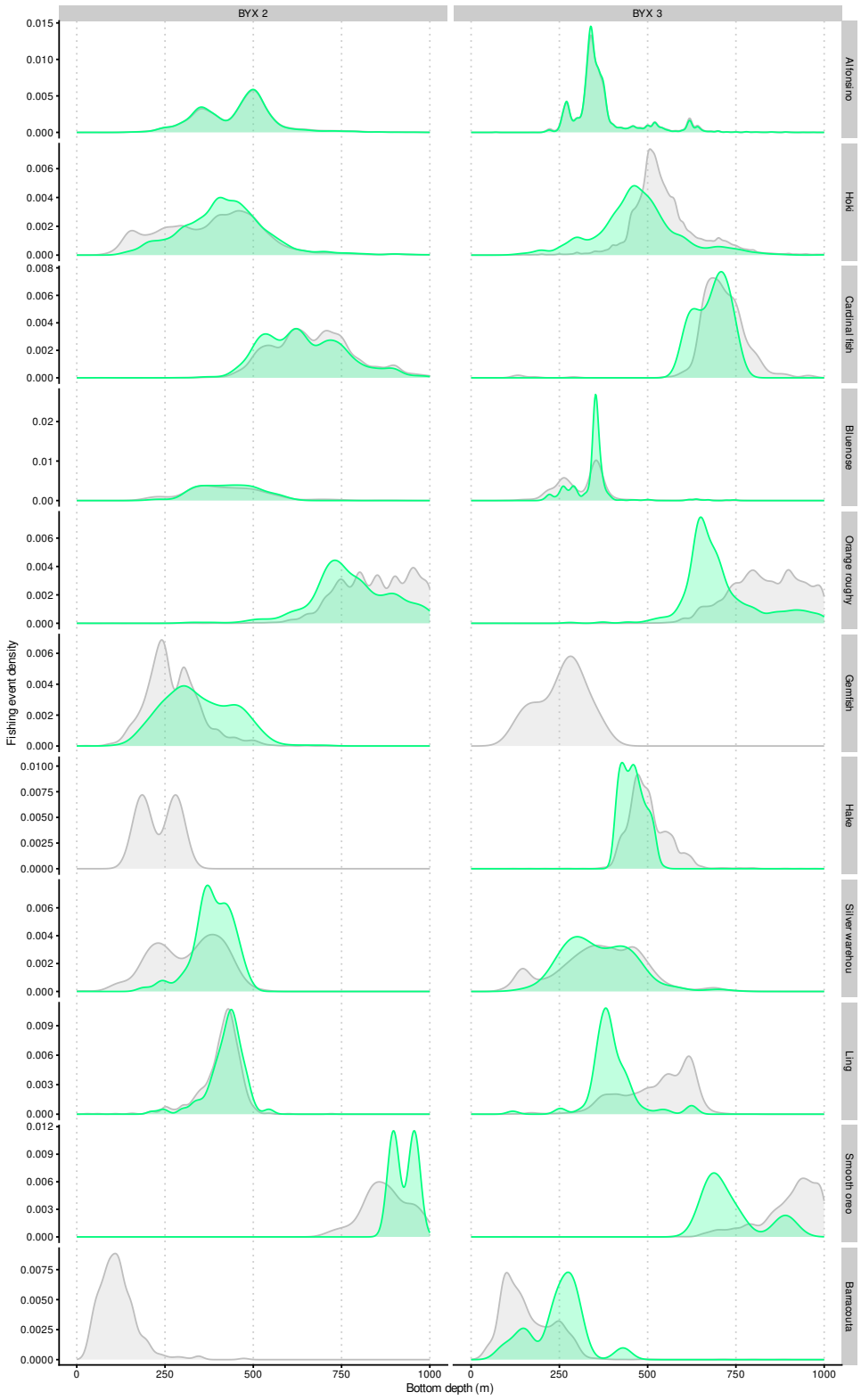

Figure 36: Effort depth distribution by target species for trips landing BYX 2 and BYX 3 from the bottom trawl (including PRB) fishery. Target species are included if they are represented in at least 30 events. Grey fill = total effort, green fill = positive effort (i.e., estimated catch > 0).

3.5 The bottom longline fishery

The bottom longline fisheries in BYX 2 and BYX 3 had limited spatial reporting until the late 2000s (Figure 37). The longline fishery has been largely limited to the southern east coast of the North Island (Figure 38) although alfonsino has been caught by longline throughout the QMAs (Figure 39).

There has been no particular seasonality in the bottom longline catch of alfonsino (Figure 40), which has been primarily a bycatch of bluenose target effort. The longline fisheries in both areas have operated from 250 m to 700 m with alfonsino caught throughout this range (Figure 41).

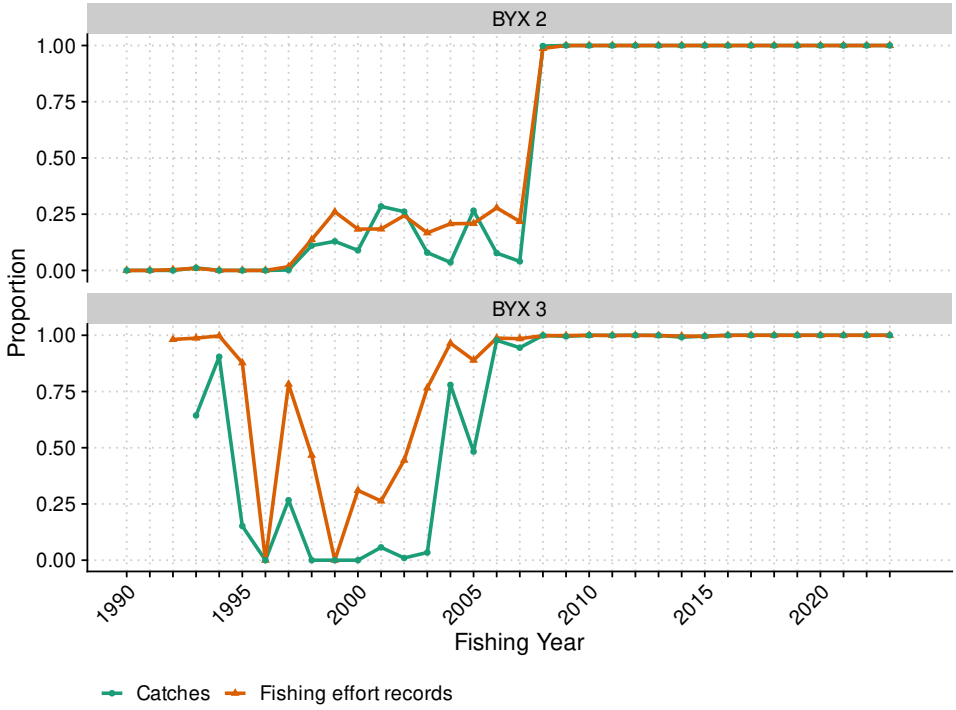

Figure 37: The proportion of records and catches reported with a latitude/longitude for the BYX 2 and BYX 3 bottom longline fishery.

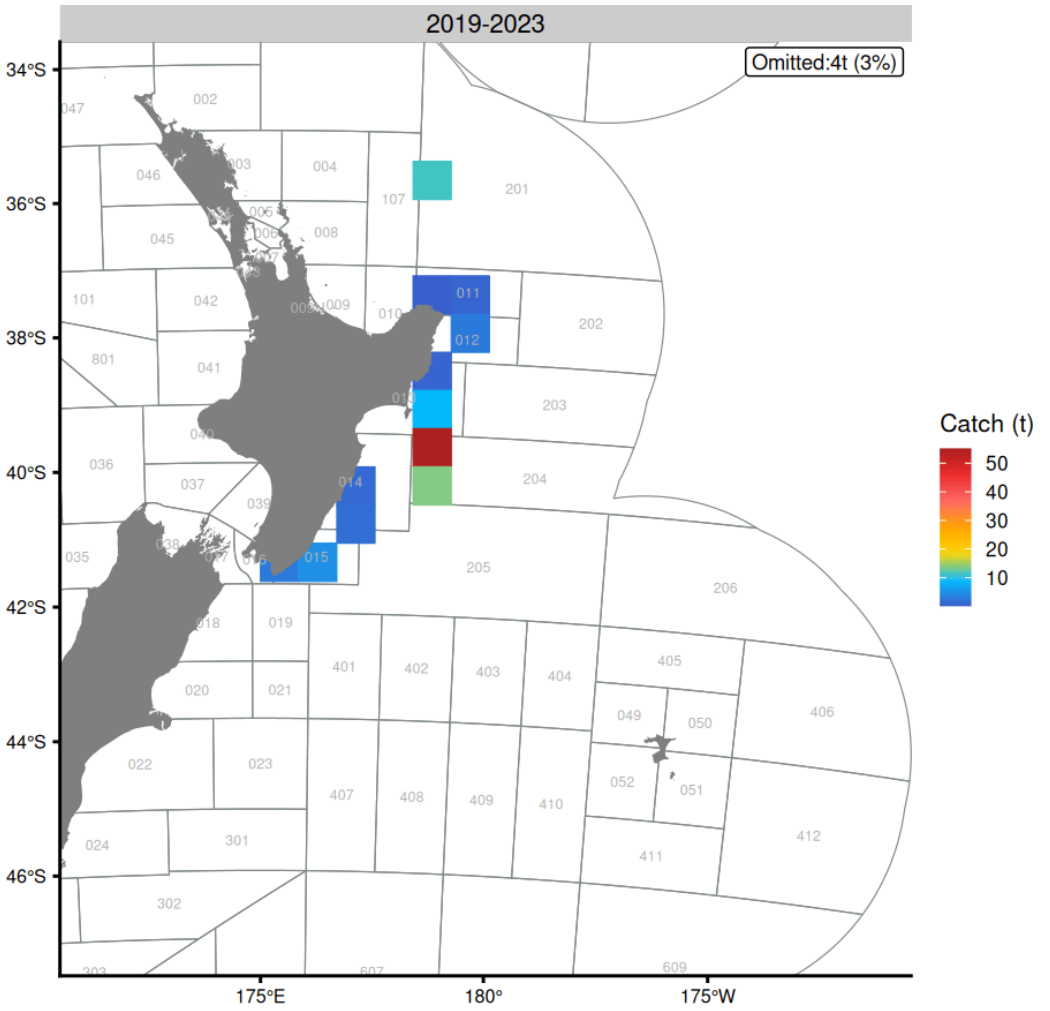

Figure 38: Catches (t) for the BYX 2 and BYX 3 bottom longline fishery, for 5-year periods within the era during which at least 80% of catch was reported with spatial information. These plots use a 64 km grid and include records where catches were allocated in proportion to estimated catch. Cells with data from less than three vessels or permit holders are omitted; the quantity of catch affected is indicated on each panel.

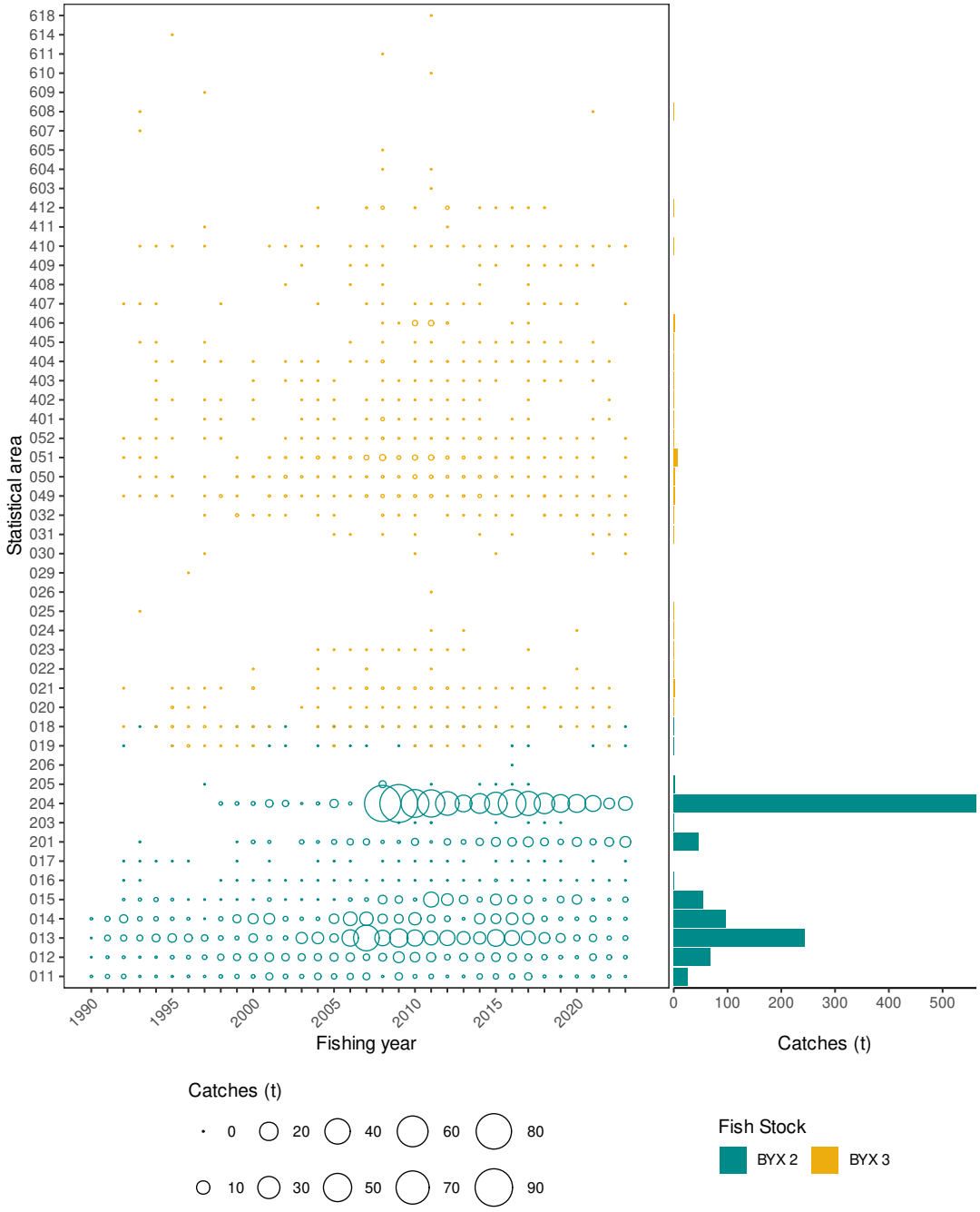

Figure 39: Annual BYX 2 and BYX 3 catches (t) by statistical area for the bottom longline fishery. The circle size scales with the catches by statistical area. The bar plot (right) shows the total catches of BYX 2 and BYX 3 for each statistical area.

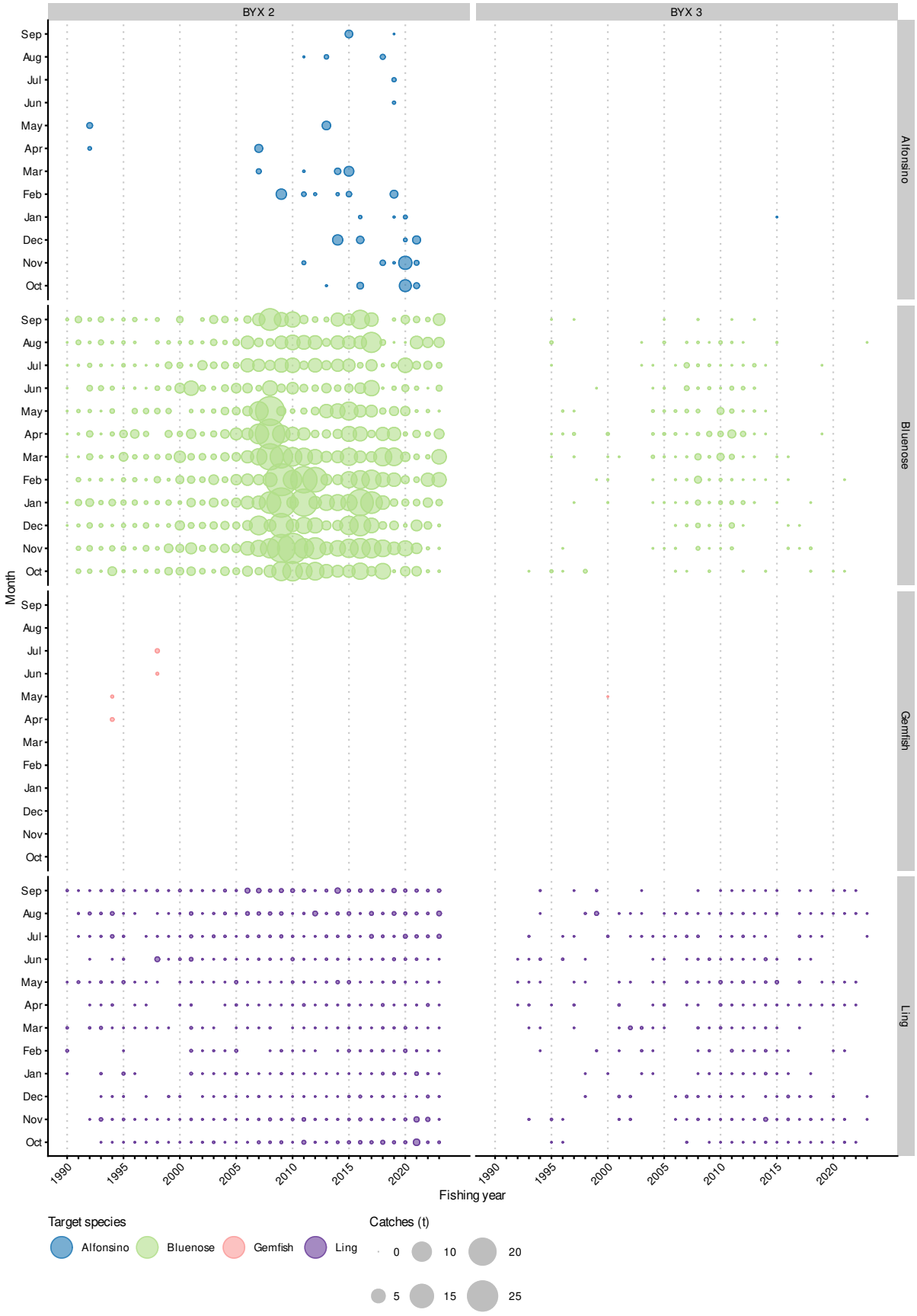

Figure 40: Seasonal distribution of BYX 2 and BYX 3 catches by month and fishing year for the bottom longline target fisheries. The area of the circle scales with the monthly catches.

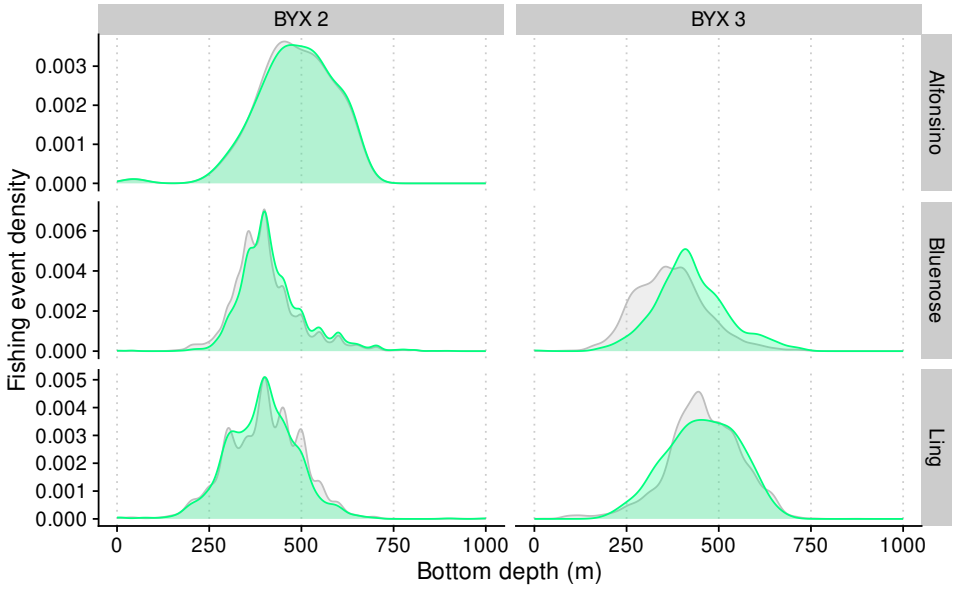

Figure 41: Effort depth distribution by target species for trips landing BYX 2 and BYX 3 from the bottom longline fishery. Target species are included if they are represented in at least 30 events. Grey fill = total effort, green fill = positive effort (i.e., estimated catch > 0).

3.6 Spatial clustering of effort

A final spatial clustering of fishing events from trips that landed alfonsino from BYX 2 and BYX 3 was selected after investigating the effect of varying the ε and *minPts* parameters of the dbscan algorithm. Different values were chosen for the northern and southern parts of the area (divided at –42.1°S); in the northern area ε was set at 2000 m and *minPts* at 10, while a ε of 10 000 m and *minPts* of 20 were used in the southern area. The resulting areas are illustrated in Figure 42. The areas are labelled by region (N and S) with the areas numbers increasing from north to south in the northern region and west to east in the southern region, based on area centroids.

The density-based clustering approach appeared to successful in providing a systematic, data-driven approach to identifying the spatial patterns within the fishery. Data summaries for each area identified are provided in Appendix C; these indicated that the alfonsino fishery has fished the identified areas consistently over time. In some, but not all, cases the areas were clearly associated with particular features of the local bathymetry. Particular areas were responsible for much of the alfonsino catch; catches had reduced from some features over time (generally secondary features, rather than those providing substantial parts of the catch) but there was little evidence of serial depletion.

While all effort from trips landing alfonsino was included in the spatial clustering analysis, not all of that effort was targeted at alfonsino. The modal target species for each area provides an indication of the areas where alfonsino was consistently targeted (Figure 43a); there is a good correspondence between the areas where alfonsino was the modal target species, and the areas that provided the highest catches of alfonsino during 1990–2023 (Figure 43b).

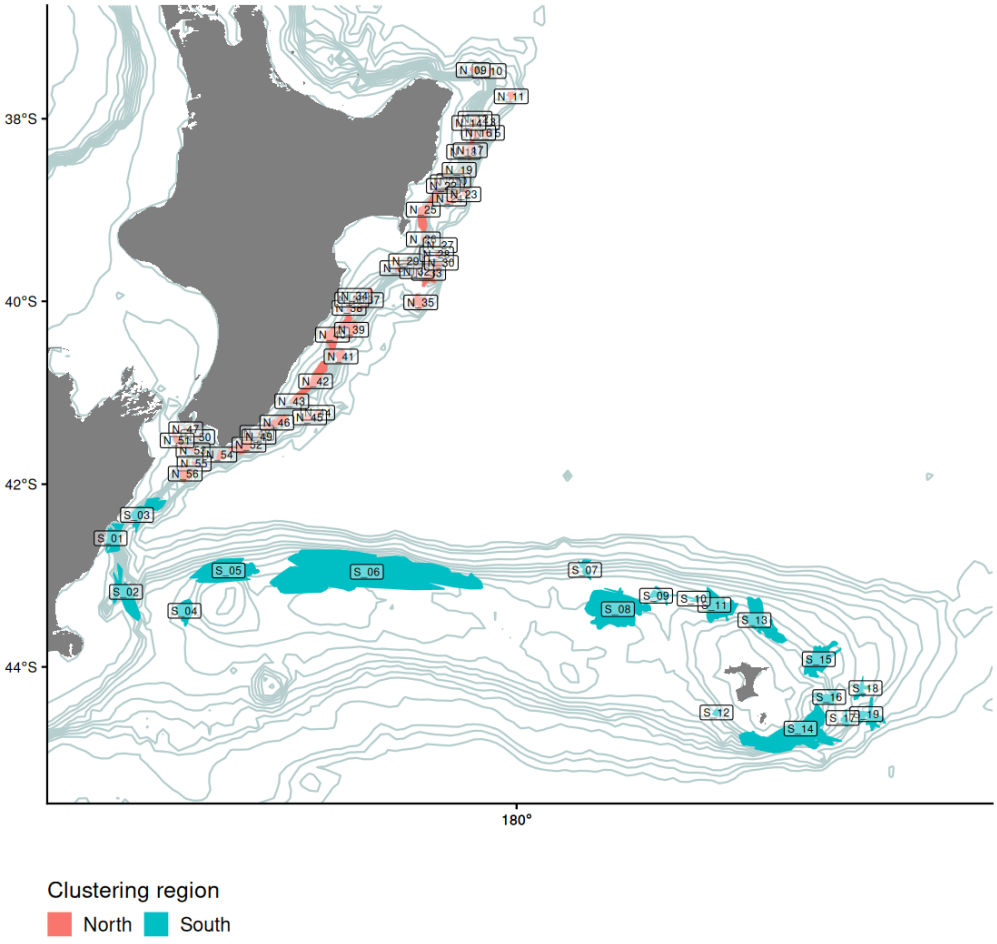

Figure 42: Regions used in clustering effort in the main BYX 2 and BYX 3 fishery area.

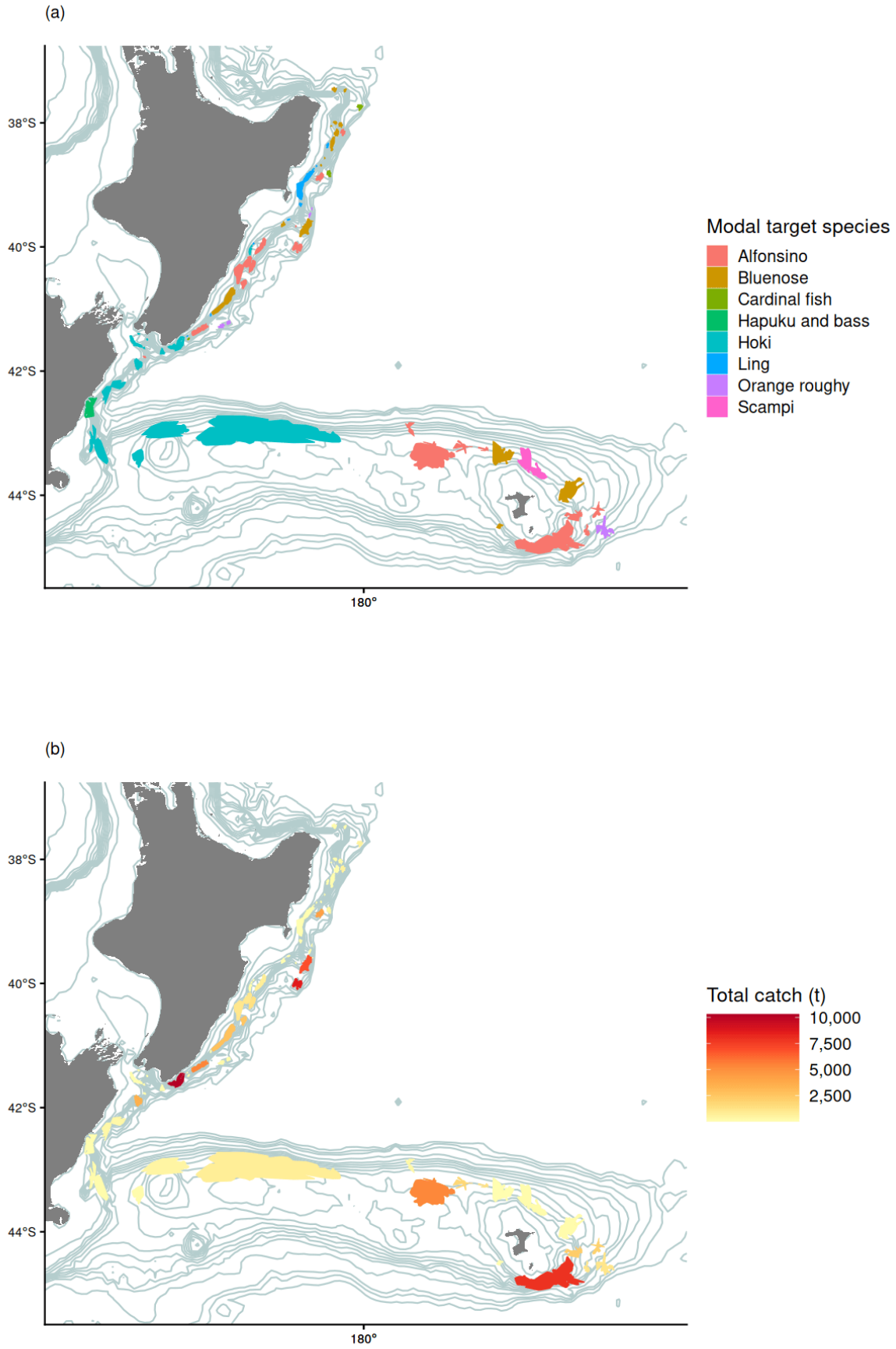

Figure 43: (a) Modal target species, and (b) total alfonsino catch (1990–2023) for effort clusters in the BYX 2 - BYX 3 region.

4. CATCH-PER-UNIT-EFFORT

A range of models for alfonsino catch per unit effort (CPUE) were investigated (Table 3). All but one model were event-resolution models focussed on the alfonsino target trawl fishery, with both midwater and bottom trawl effort included. In these cases, the areas identified by the spatial density clustering were used as the spatial strata in the model, in preference to statistical areas or other arbitrarily defined areas, in the expectation that this would provide the best opportunity for identifying whether there was a consistent trend in abundance across the region, or if trends differed at a fine spatial scale.

The other model investigated was for alfonsino bycatch in the hoki target trawl fisheries. The aim of this model was to investigate trends in abundance in areas, particularly the mid-Chatham Rise, where alfonsino were not typically targeted. In this case a trip-resolution model, with modal statistical area as the spatial covariate, was investigated.

Detailed diagnostics for the primary (BYX 2 BYX 3 event) model are discussed below; diagnostics for the other models are included in Appendix D.

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 D.

Series name	Data resolution	Response variable	Explanatory variable selection process	Core fleet years	Core fleet trips	Assumed error distribution
BYX 2 BYX 3 event	event	allockg_top5	Stepwise	5	3	Weibull
BYX 2 BYX 3 event (regions)	event	allockg_top5	Stepwise	5	3	Weibull
BYX WCR (HOK target) trip	trip	landkg	Stepwise	10	3	lognormal
BYX event (Chatham Rise - South East)	event	allockg_top5	Stepwise	5	3	Weibull
BYX event (Chatham Rise - North)	event	allockg_top5	Stepwise	5	3	Weibull
BYX event (East Coast - South)	event	allockg_top5	Stepwise	5	3	Weibull
BYX event (East Coast - North)	event	allockg_top5	Stepwise	5	3	Weibull

4.1 BYX 2 BYX 3 event

The initial BYX 2 and BYX 3 event resolution series is defined in Table 4. Data were selected from the statistical areas covering the main alfonsino fishery areas on the east coast of the North Island and the Chatham Rise. The selection included alfonsino-target bottom and midwater trawling, when reported using the event-resolution formats, and including use of the Precision Seafood Harvesting gear. The data were assigned to the final clusters (Figure 42) using the predict method provided by the dbscan package (Hahsler et al. 2019).

The core fleet selection required at least three trips per year, for a minimum of five years, for a vessel to be included in the dataset. This retained 89.6% of the catch while reducing the core fleet in the modelling dataset to 16 vessels (Figure 44). The dataset showed reasonable overlap; although fleet turnover was significant, there were three vessels with long term participation in the fishery (Figure 45). The annual effect of core fleet selection, and other data filters, on the data retained for modelling is summarised in Table 5; these included a rule that dropped any records that were not assigned to an area identified by the spatial clustering.

The modelling dataset (Table 6) comprised just three vessels in 1990, peaked at ten vessels in 2010, but reduced to four vessels in 2023. The amount of catch in the dataset varied substantially, from 320 t in 1990 to over 2000 t in the early 2010s. The proportion of tows catching alfonsino was always over 80%, and continuously over 90% from 2011. Virtually all records had catches allocated in proportion to estimated catches (Figure 46).

Stepwise selection for the binomial model, modelling the occurrence of positive catches, retained vessel, tow duration and area (Table 7). The effect of standardisation was small, but generally flattened the raw index: raising the index in the early part of the series (until the mid 2000s) and lowering it in the latter period (Figure 47). Vessel and area were responsible for most of the standardisation effect (Figure 48).

In general, the vessels that remained in the fleet to the 2020s had a higher probability of catching alfonsino resulting in increasing influence over time, with a notable increase in the early 2010s (Figure 49). There was an increasing probability of catching alfonsino with increasing tow duration (Figure 50); most target tows were short (less than 1.5 hours) although there was a greater proportion of longer tows in the early 1990s, with the right tail of the distribution increasing again from the mid 2000s. Fishing effort has been higher in the areas with higher probability of alfonsino catches (Figure 51); influence was highest at the start and end of the series, potentially reflecting development of the fishery in the 1990s, and a focus on core areas since the mid 2010s.

In the Weibull model for magnitude of the positive catches, method and month were selected alongside vessel and area, but fishing duration was not retained (Table 8). Diagnostics suggest the Weibull error distribution is acceptable (Figure 52), although the gamma distribution fits almost as well (Figure 53). The overall effect of standardisation on the annual indices was a flattening effect (Figure 54) that was more pronounced than that observed for the binomial model. Most of the standardisation was attributable to area and vessel, with method important at the beginning of the series (Figure 55).

The impact of area in the model for positive catches was similar to that seen in the binomial model, with influence higher in the early 1990s, decreasing to 2000, then increasing again after the mid 2010s (Figure 56). The changes in the fleet resulted in a stepwise change in influence in the positive catch model, rather than the more gradual change observed in the binomial model. Influence increased from 2002 to 2003, but stepped back down from 2021 to 2022 (Figure 57). Midwater trawling was associated with higher catches of alfonsino than bottom trawling, with influence decreasing in the early 1990s as target bottom trawling became established, and remaining relatively stable thereafter (Figure 58). Catch rates showed seasonality, with the lowest rates in April and May and highest rates from August to December (Figure 59). However, seasonal patterns in effort have varied little over the model period and there was no trend in influence.

Residual implied coefficients by area (Figure 60) suggest that the temporal changes in abundance differed between areas. For example, residual coefficients for areas N_33 and N_35 indicated a greater increase in abundance around 2010 than that of the overall series. Areas N_46 and S_14 both had residual coefficients that were generally below the overall series from the mid 2010s.

In general, the residual coefficients for bottom and midwater gear were consistent with the overall series (Figure 61) except during the early 1990s when the target fishery was dominated by midwater trawling. There was insufficient data to draw strong conclusions on the use of the Precision Midwater trawl as it was only used in the fishery for three years in the late 2010s.

The combined series closely resembled the positive catch series, with the binomial series only showing a slight increase over the period (Figure 62). Despite year to year variation, there were indications of some longer term trends (Table 9); however, because of the between-area differences, this cannot be interpreted as a stock level index of abundance.

Table 4: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the BYX 2 BYX 3 event CPUE series.

Series	BYX 2 BYX 3 event
QMS stock	BYX 2, BYX 3
Reporting forms	TCP, TCE, ERS - Trawl
Fishing methods	BT, PRB, MW, PRM
Target species	BYX
Statistical Areas	011, 012, 013, 014, 015, 016, 017, 018, 019, 020, 021, 202, 203, 204, 205, 401, 402, 403, 404, 405, 410, 049, 050, 051, 052, 406, 412
Period	1989-10-01, 2023-09-30
Resolution	Fishing event
Core fleet years	5
Core fleet trips	3
Default model	allockg_top5 ~ fyear + cluster + vessel_key + primary_method + month + ns(log(fishing_duration), 3) + ns(log(effort_height), 3) + ns(log(effort_depth), 3)
Stepwise selection	Yes
Positive catch distribution	Weibull

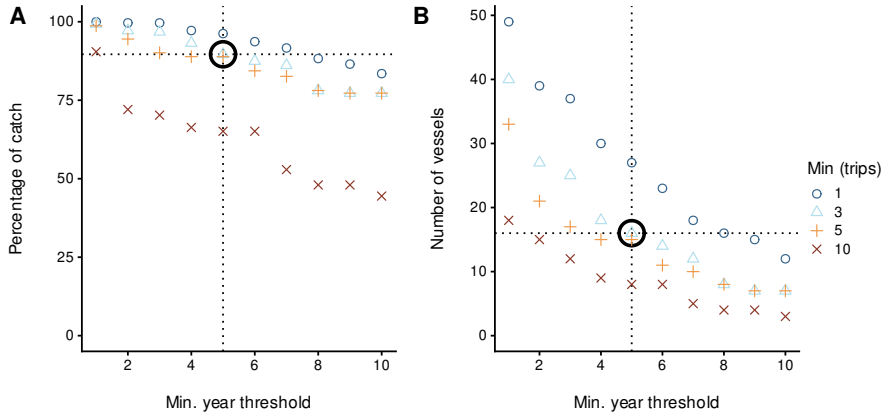

Figure 44: Percentage of catch and number of vessels for different core vessel selection criteria for the BYX 2 BYX 3 event CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

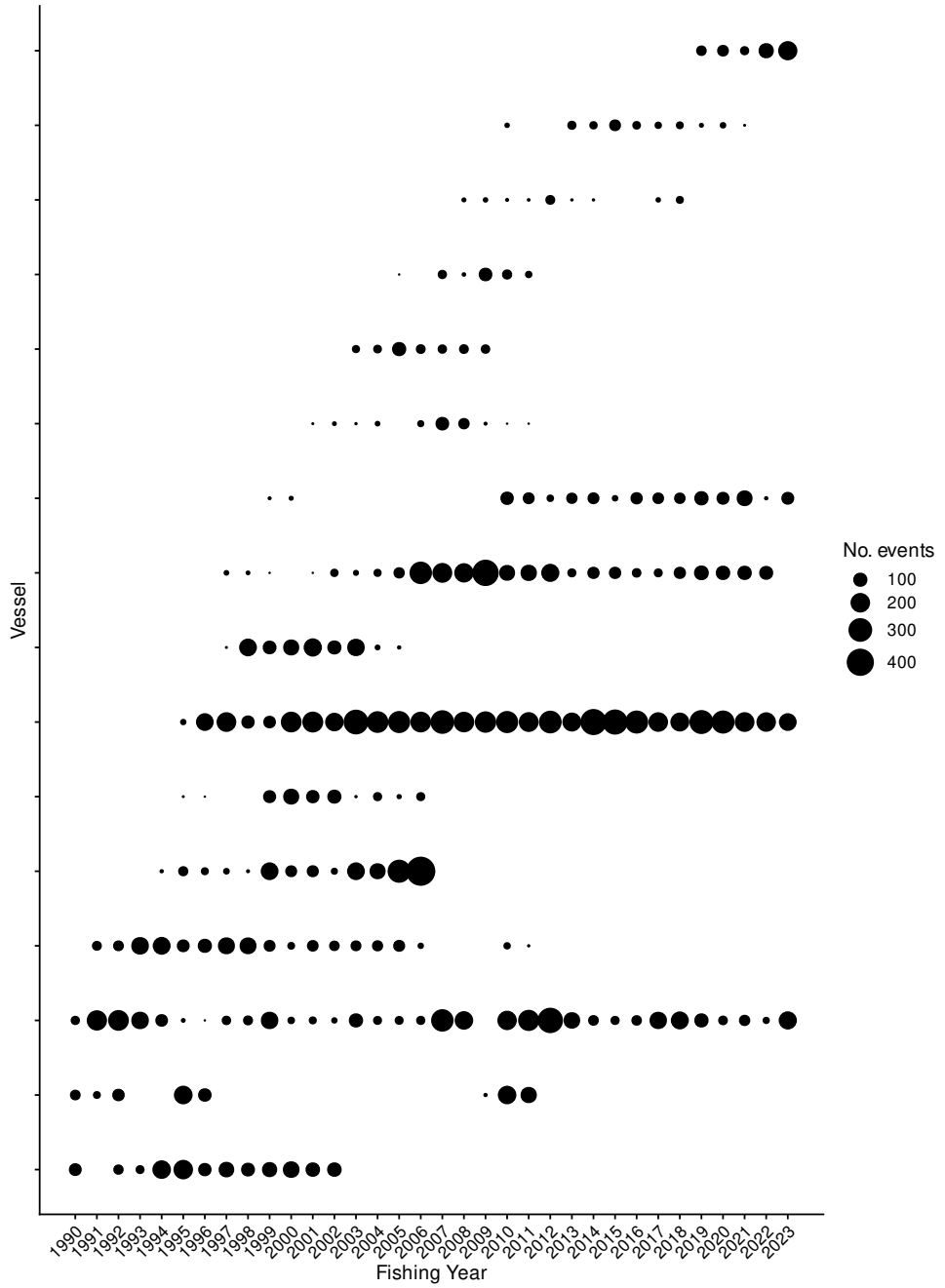

Figure 45: Number of events by fishing year for core vessels in the BYX 2 BYX 3 event series. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table 5: Summary of the BYX 2 BYX 3 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 2 pages)

Filter	1990	1991	1992	1993	1994	1995	1996	1997	1998
Ungroomed data	669 (100%) n: 335	749 (100%) n: 294	1260 (100%) n: 458	1444 (100%) n: 530	1332 (100%) n: 708	1307 (100%) n: 794	1503 (100%) n: 769	1500 (100%) n: 736	1540 (100%) n: 730
Fishing duration is not NA	669 (100%) n: 335	749 (100%) n: 294	1260 (100%) n: 458	1444 (100%) n: 530	1332 (100%) n: 708	1307 (100%) n: 794	1503 (100%) n: 769	1500 (100%) n: 736	1540 (100%) n: 730
Positive fishing duration	669 (100%) n: 335	749 (100%) n: 294	1260 (100%) n: 458	1444 (100%) n: 530	1332 (100%) n: 708	1307 (100%) n: 793	1502 (100%) n: 762	1500 (100%) n: 729	1540 (100%) n: 728
Duration under 12h	669 (100%) n: 335	739 (99%) n: 292	1260 (100%) n: 458	1416 (98%) n: 528	1332 (100%) n: 707	1304 (100%) n: 785	1498 (100%) n: 756	1472 (98%) n: 720	1534 (100%) n: 720
Headline under 60m	669 (100%) n: 335	739 (99%) n: 292	1260 (100%) n: 458	1416 (98%) n: 528	1332 (100%) n: 707	1294 (99%) n: 769	1467 (98%) n: 751	1450 (97%) n: 711	1457 (95%) n: 694
In a cluster	654 (98%) n: 330	739 (99%) n: 288	1241 (98%) n: 446	1380 (96%) n: 510	1271 (95%) n: 681	1256 (96%) n: 718	1436 (96%) n: 725	1419 (95%) n: 695	1396 (91%) n: 679
Core fleet selection	320 (48%) n: 173	739 (99%) n: 288	1195 (95%) n: 407	1126 (78%) n: 353	915 (69%) n: 428	971 (74%) n: 533	1148 (76%) n: 470	1082 (72%) n: 546	1149 (75%) n: 549

Filter	1999	2000	2001	2002	2003	2004	2005	2006	2007
Ungroomed data	1541 (100%) n: 1040	1269 (100%) n: 968	1352 (100%) n: 849	1329 (100%) n: 639	1602 (100%) n: 881	1430 (100%) n: 644	1942 (100%) n: 849	2045 (100%) n: 1139	2035 (100%) n: 1008
Fishing duration is not NA	1541 (100%) n: 1040	1269 (100%) n: 968	1352 (100%) n: 849	1329 (100%) n: 639	1602 (100%) n: 881	1430 (100%) n: 644	1942 (100%) n: 849	2045 (100%) n: 1139	2035 (100%) n: 1008
Positive fishing duration	1538 (100%) n: 1038	1269 (100%) n: 966	1341 (99%) n: 846	1326 (100%) n: 634	1602 (100%) n: 875	1430 (100%) n: 644	1942 (100%) n: 848	2045 (100%) n: 1139	2031 (100%) n: 1000
Duration under 12h	1535 (100%) n: 1030	1266 (100%) n: 959	1341 (99%) n: 846	1322 (99%) n: 631	1602 (100%) n: 875	1430 (100%) n: 644	1942 (100%) n: 848	2044 (100%) n: 1138	2031 (100%) n: 999
Headline under 60m	1492 (97%) n: 1011	1265 (100%) n: 953	1338 (99%) n: 845	1322 (99%) n: 631	1602 (100%) n: 875	1420 (99%) n: 637	1942 (100%) n: 848	2044 (100%) n: 1138	2031 (100%) n: 999
In a cluster	1437 (93%) n: 969	1232 (97%) n: 929	1310 (97%) n: 830	1313 (99%) n: 624	1588 (99%) n: 867	1415 (99%) n: 631	1939 (100%) n: 844	2035 (99%) n: 1127	2025 (100%) n: 991
Core fleet selection	1246 (81%) n: 764	1110 (87%) n: 755	1220 (90%) n: 762	1278 (96%) n: 609	1503 (94%) n: 853	1374 (96%) n: 601	1909 (98%) n: 824	2015 (99%) n: 1111	1979 (97%) n: 940

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	1926 (100%) n: 796	1867 (100%) n: 838	2252 (100%) n: 1072	2185 (100%) n: 883	2253 (100%) n: 873	2187 (100%) n: 480	2008 (100%) n: 653	1976 (100%) n: 617	2136 (100%) n: 590
Fishing duration is not NA	1926 (100%) n: 796	1867 (100%) n: 838	2252 (100%) n: 1072	2185 (100%) n: 883	2253 (100%) n: 873	2187 (100%) n: 480	2008 (100%) n: 653	1976 (100%) n: 617	2136 (100%) n: 590
Positive fishing duration	1905 (99%) n: 792	1855 (99%) n: 829	2252 (100%) n: 1070	2182 (100%) n: 880	2250 (100%) n: 870	2187 (100%) n: 479	2008 (100%) n: 652	1976 (100%) n: 617	2136 (100%) n: 590
Duration under 12h	1903 (99%) n: 791	1855 (99%) n: 829	2252 (100%) n: 1070	2182 (100%) n: 879	2250 (100%) n: 870	2187 (100%) n: 479	2008 (100%) n: 652	1961 (99%) n: 616	2136 (100%) n: 590
Headline under 60m	1903 (99%) n: 791	1854 (99%) n: 828	2245 (100%) n: 1067	2182 (100%) n: 878	2250 (100%) n: 870	2187 (100%) n: 479	2008 (100%) n: 652	1961 (99%) n: 616	2126 (100%) n: 588
In a cluster	1877 (97%) n: 779	1853 (99%) n: 827	2240 (99%) n: 1059	2133 (98%) n: 869	2247 (100%) n: 862	2184 (100%) n: 476	1980 (99%) n: 643	1953 (99%) n: 613	2126 (100%) n: 587
Core fleet selection	1796 (93%) n: 718	1749 (94%) n: 772	1960 (87%) n: 939	2005 (92%) n: 810	2222 (99%) n: 858	2151 (98%) n: 466	1847 (92%) n: 595	1652 (84%) n: 535	1714 (80%) n: 482

Filter	2017	2018	2019	2020	2021	2022	2023
Ungroomed data	1894 (100%) n: 645	2005 (100%) n: 595	2141 (100%) n: 757	2075 (100%) n: 704	1853 (100%) n: 611	1882 (100%) n: 512	1569 (100%) n: 624
Fishing duration is not NA	1894 (100%) n: 645	2005 (100%) n: 595	2141 (100%) n: 757	2075 (100%) n: 704	1853 (100%) n: 610	1882 (100%) n: 512	1569 (100%) n: 624
Positive fishing duration	1894 (100%) n: 645	2005 (100%) n: 595	2141 (100%) n: 754	2075 (100%) n: 702	1853 (100%) n: 608	1882 (100%) n: 512	1569 (100%) n: 623
Duration under 12h	1894 (100%) n: 644	2005 (100%) n: 595	2137 (100%) n: 752	2074 (100%) n: 701	1853 (100%) n: 608	1882 (100%) n: 512	1569 (100%) n: 623
Headline under 60m	1894 (100%) n: 644	2005 (100%) n: 595	2125 (99%) n: 749	2048 (99%) n: 698	1853 (100%) n: 608	1882 (100%) n: 512	1569 (100%) n: 623
In a cluster	1874 (99%) n: 634	1991 (99%) n: 587	2122 (99%) n: 746	2048 (99%) n: 695	1841 (99%) n: 604	1882 (100%) n: 512	1569 (100%) n: 621
Core fleet selection	1492 (79%) n: 490	1837 (92%) n: 544	1982 (93%) n: 679	1810 (87%) n: 595	1655 (89%) n: 534	1433 (76%) n: 440	1499 (96%) n: 606

Table 6: Summary of the BYX 2 BYX 3 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 alfonsino.

Fishing year	Vessels	Trips	Records	Hours	Catch (t)	Records caught
1990	3	11	173	154.93	319.68	81.50
1991	3	24	288	149.17	738.61	95.49
1992	4	43	407	364.50	1 194.78	81.08
1993	3	53	353	386.62	1 126.03	90.65
1994	4	59	428	426.30	915.05	89.49
1995	7	86	533	402.38	970.78	81.80
1996	7	67	470	265.35	1 148.07	88.72
1997	7	61	546	340.82	1 082.48	86.45
1998	7	65	549	425.18	1 148.84	83.97
1999	9	73	764	429.73	1 245.78	83.77
2000	8	77	755	391.83	1 110.37	85.96
2001	9	75	762	331.50	1 220.01	80.58
2002	9	94	609	284.03	1 278.38	80.30
2003	9	88	853	310.47	1 502.94	86.05
2004	9	86	601	249.15	1 374.33	89.02
2005	9	95	824	382.43	1 909.44	89.20
2006	8	86	1 111	445.38	2 014.94	84.97
2007	6	93	940	450.62	1 979.08	85.32
2008	7	84	718	386.22	1 795.81	90.11
2009	7	87	772	368.55	1 749.19	92.36
2010	10	81	939	507.80	1 959.67	87.11
2011	9	62	810	451.05	2 005.00	92.35
2012	5	53	858	634.13	2 221.64	91.84
2013	6	57	466	354.32	2 150.80	93.35
2014	6	67	595	409.43	1 846.92	94.96
2015	5	61	535	386.60	1 652.03	93.27
2016	5	72	482	384.57	1 714.23	95.64
2017	6	82	490	383.32	1 492.04	92.45
2018	6	73	544	646.95	1 836.89	96.51
2019	6	63	679	739.47	1 981.88	97.64
2020	6	60	595	813.83	1 810.11	95.63
2021	6	49	534	651.05	1 655.32	96.82
2022	5	40	440	563.00	1 433.47	98.18
2023	4	45	606	762.40	1 498.68	95.21

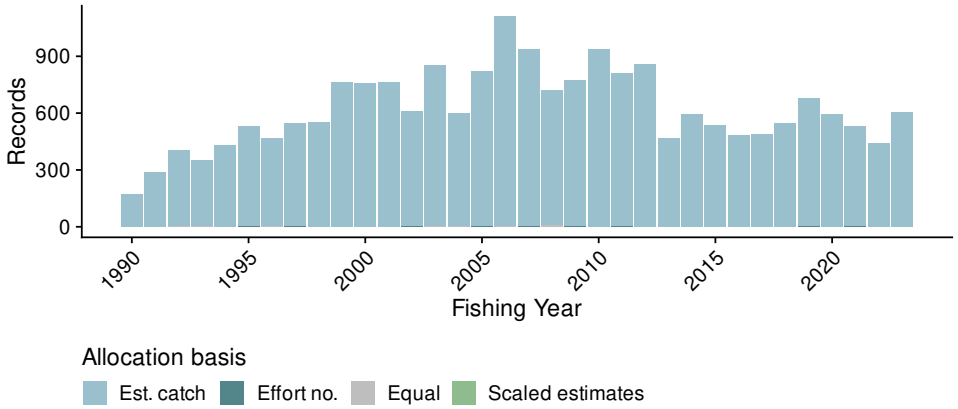

Figure 46: Allocation basis for attributing landings to records in the BYX 2 BYX 3 event catch-per-unit-effort dataset. Allocation basis is in terms of estimated catch, effort number, and/or equal.

Table 7: Summary of stepwise selection for occurrence of positive catch in the BYX 2 BYX 3 event series. 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	32	13 511	4.4	4.4	*
+ vessel_key	15	13 033	8.0	3.6	*
+ ns(log(fishing_duration), 3)	3	12 608	11.1	3.1	*
+ cluster	40	12 347	13.5	2.4	*
+ ns(log(effort_depth), 3)	3	12 248	14.2	0.7	
+ ns(log(effort_height), 3)	3	12 243	14.3	0.1	

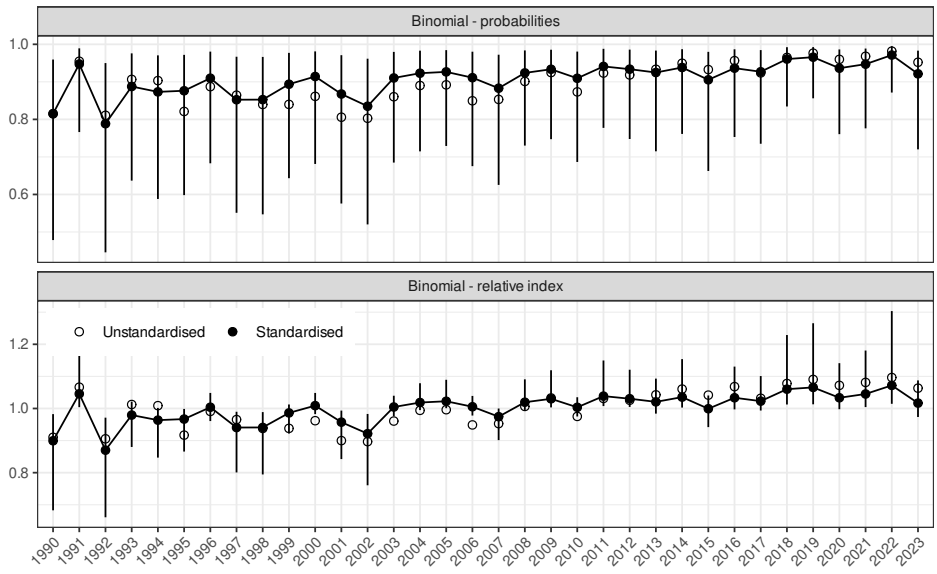

Figure 47: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the BYX 2 BYX 3 event dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

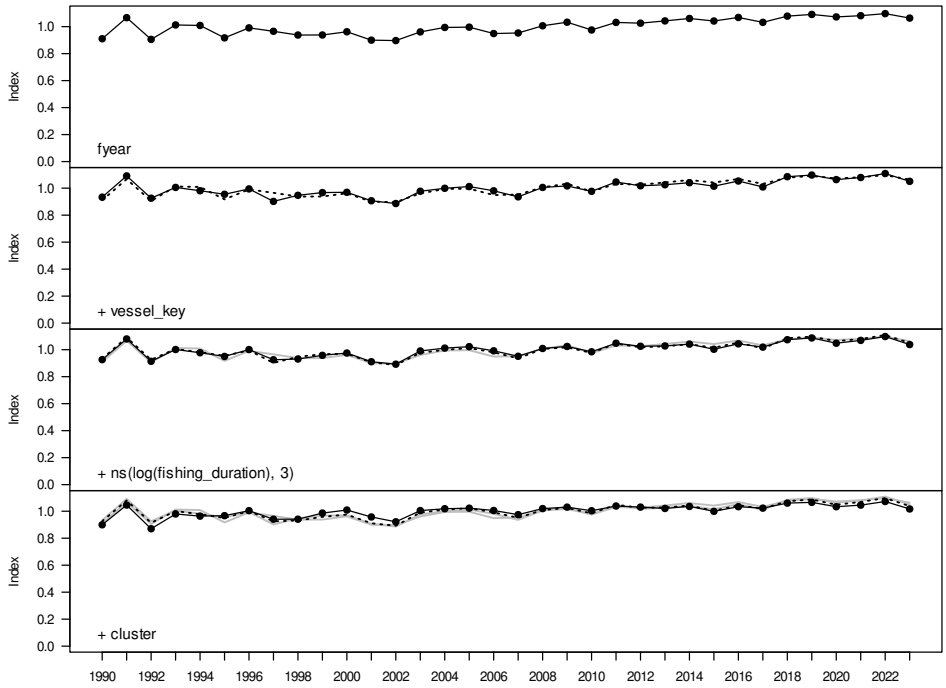

Figure 48: Step plot for occurrence of catch in the BYX 2 BYX 3 event dataset.

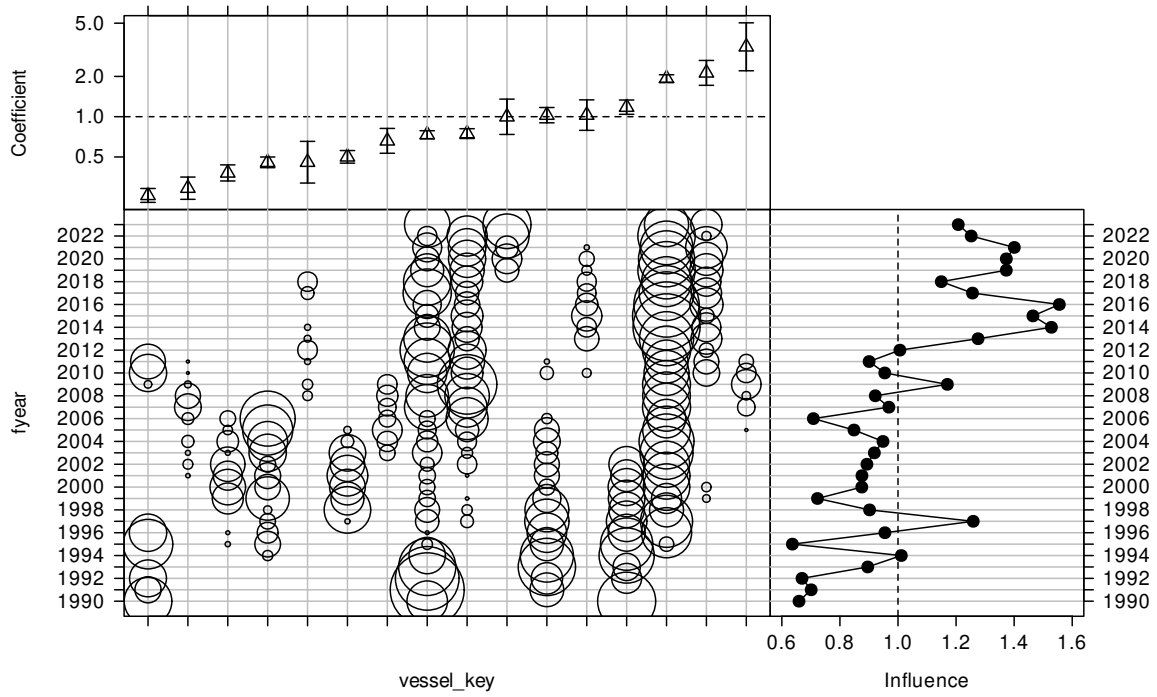

Figure 49: CDI plot for vessel key for the occurrence of positive catch in the BYX 2 BYX 3 event catch-per-unit-effort dataset.

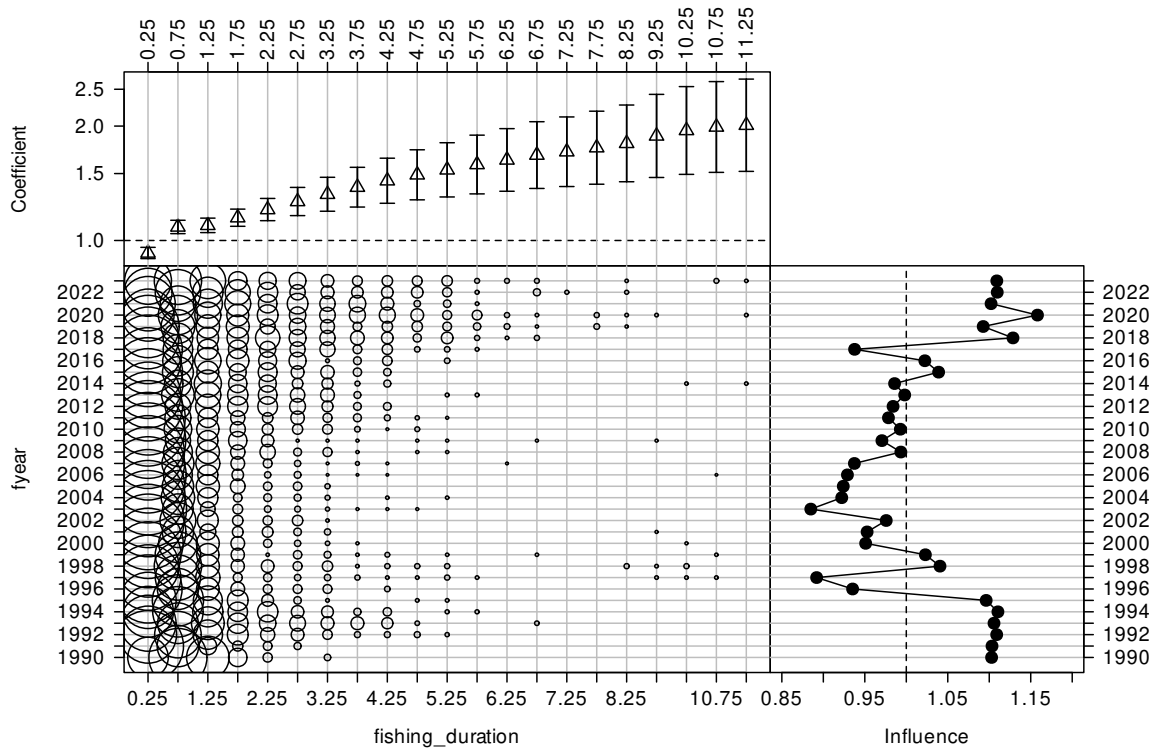

Figure 50: CDI plot for fishing duration (h) for the occurrence of positive catch in the BYX 2 BYX 3 event catch-per-unit-effort dataset.

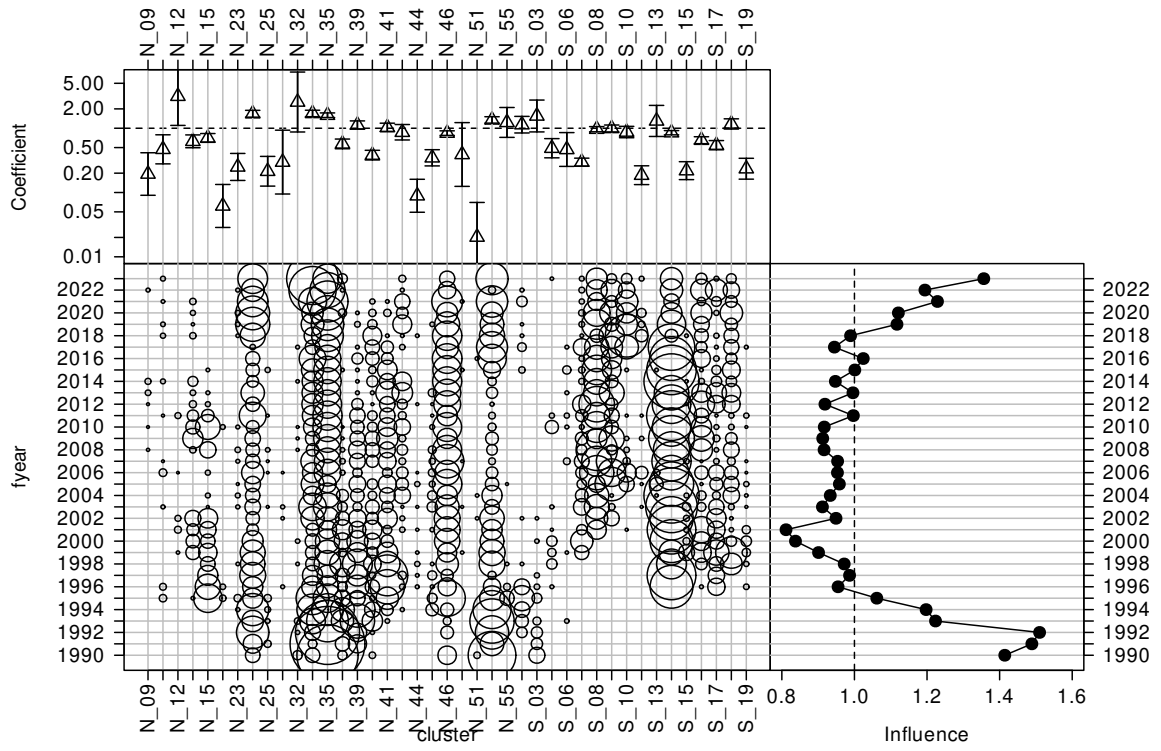

Figure 51: CDI plot for cluster for the occurrence of positive catch in the BYX 2 BYX 3 event catch-per-unit-effort dataset.

Table 8: Summary of stepwise selection for the Weibull model for positive catches in the BYX 2 BYX 3 event series. 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	35	328 781	2.5	2.5	*
+ cluster	40	327 727	7.6	5.2	*
+ vessel_key	15	326 821	11.9	4.3	*
+ primary_method	2	326 453	13.6	1.7	*
+ month	11	326 254	14.6	1.0	*
+ ns(log(fishing_duration), 3)	3	326 209	14.8	0.2	
+ ns(log(effort_depth), 3)	3	326 209	14.9	0.0	

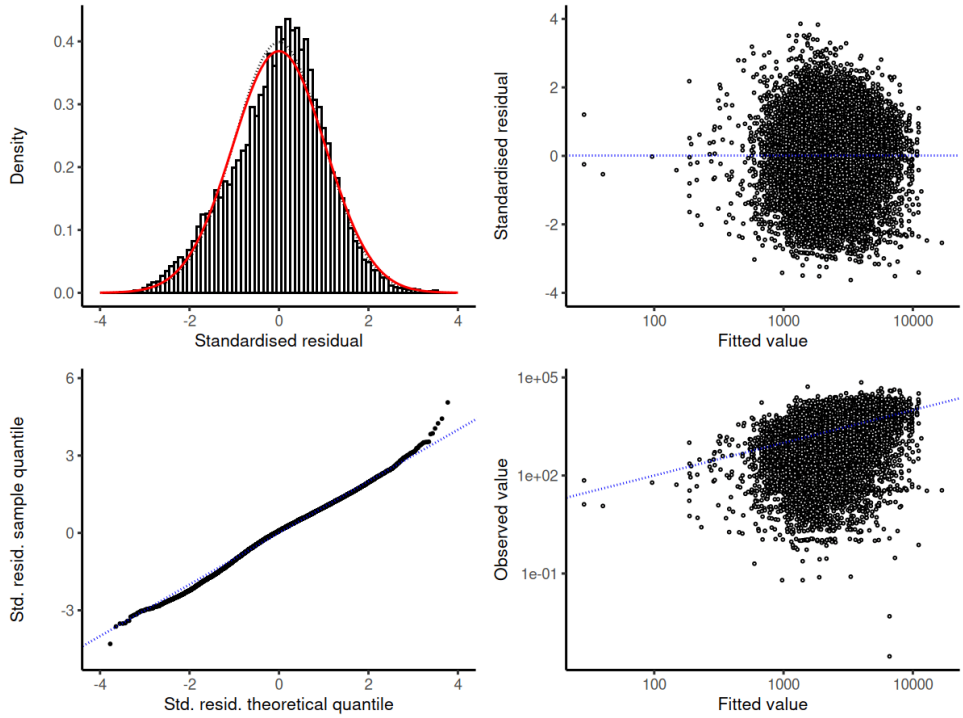

Figure 52: Diagnostic plots for the selected Weibull model for positive catches in the BYX 2 BYX 3 event dataset.

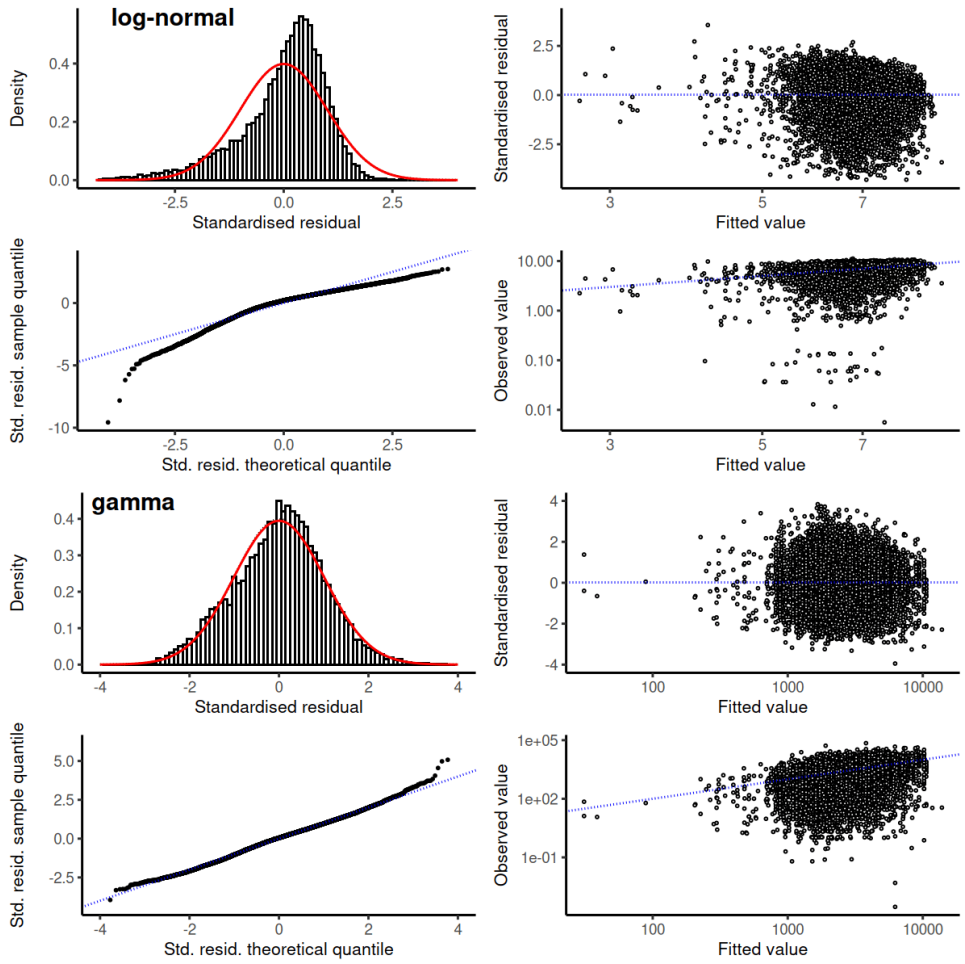

Figure 53: Diagnostic plots for the alternative log-normal and gamma models considered for positive catches in the BYX 2 BYX 3 event dataset.

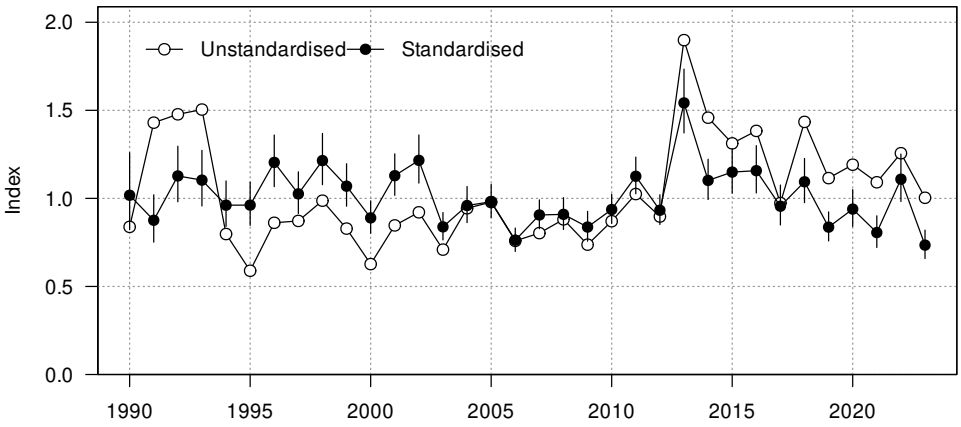

Figure 54: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch using the Weibull model for the BYX 2 BYX 3 event dataset.

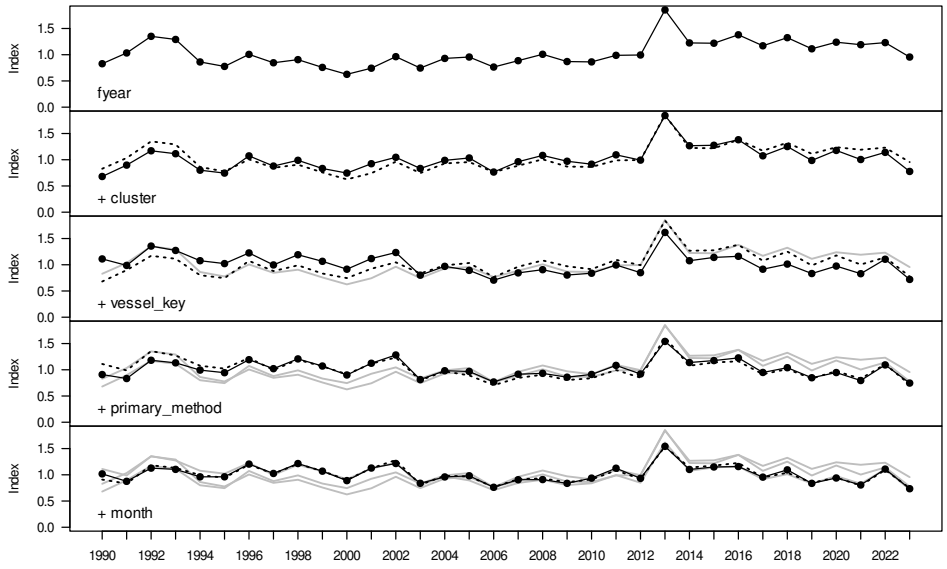

Figure 55: Changes to the BYX 2 BYX 3 event positive catch index as terms are successively entered into the Weibull model.

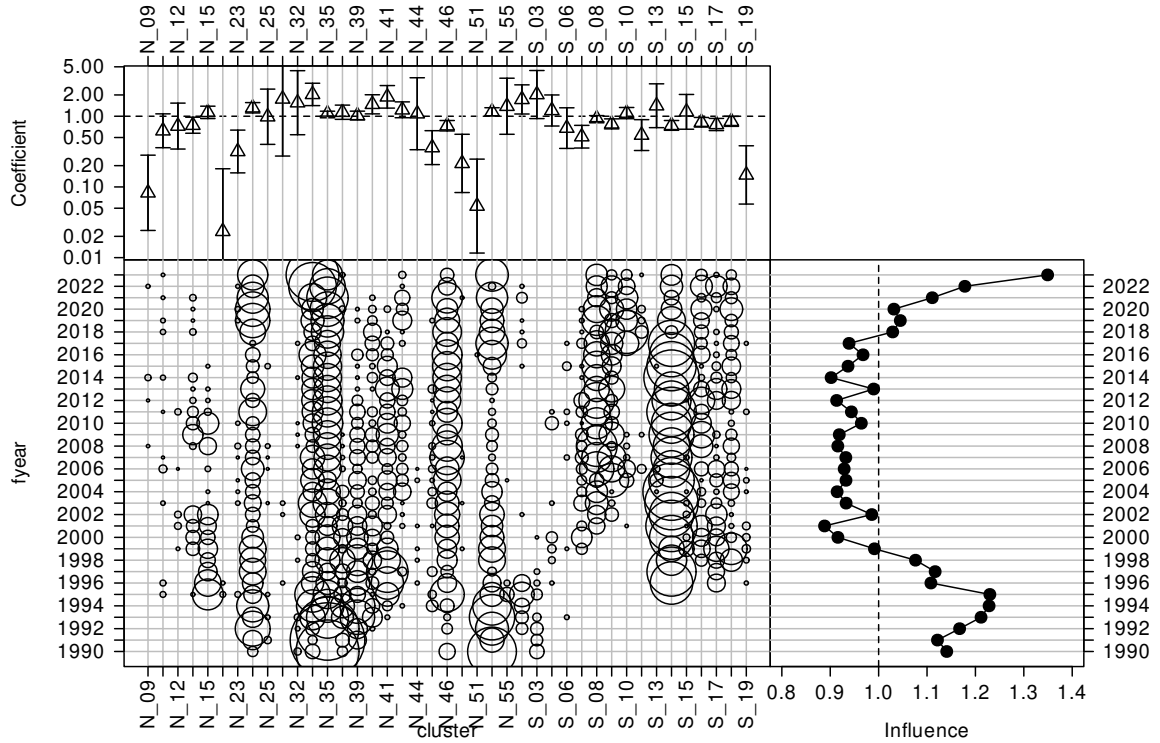

Figure 56: CDI plot for cluster for the Weibull model of positive catches in the BYX 2 BYX 3 event catch-per-unit-effort dataset.

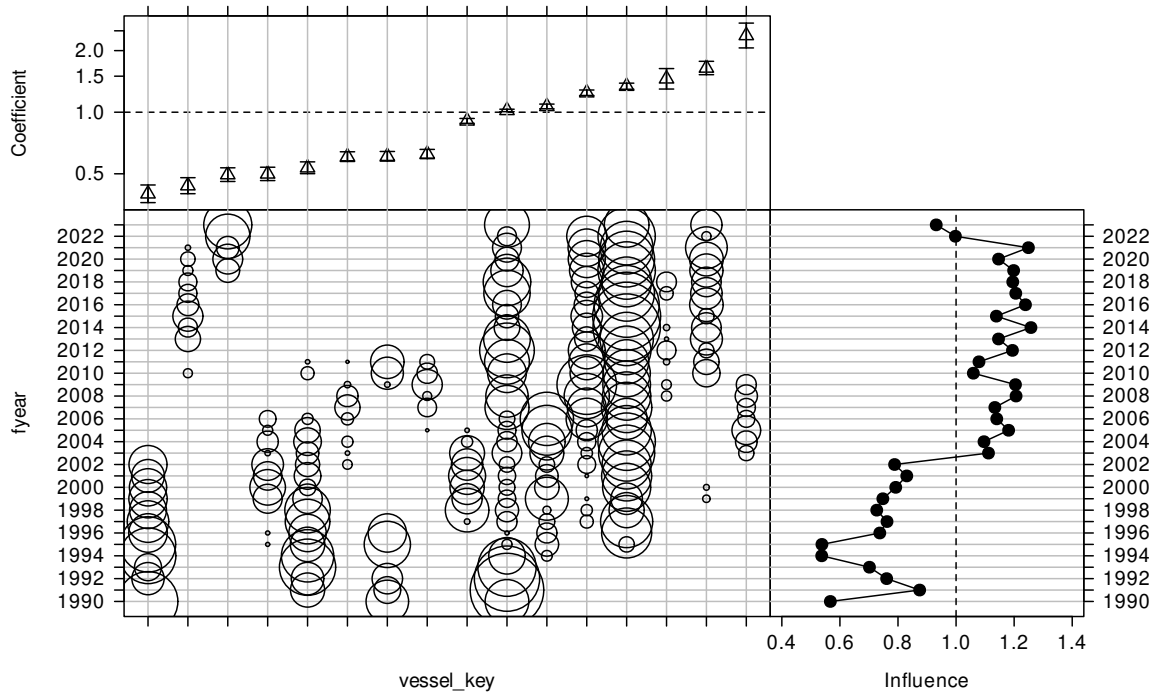

Figure 57: CDI plot for vessel key for the Weibull model of positive catches in the BYX 2 BYX 3 event catch-per-unit-effort dataset.

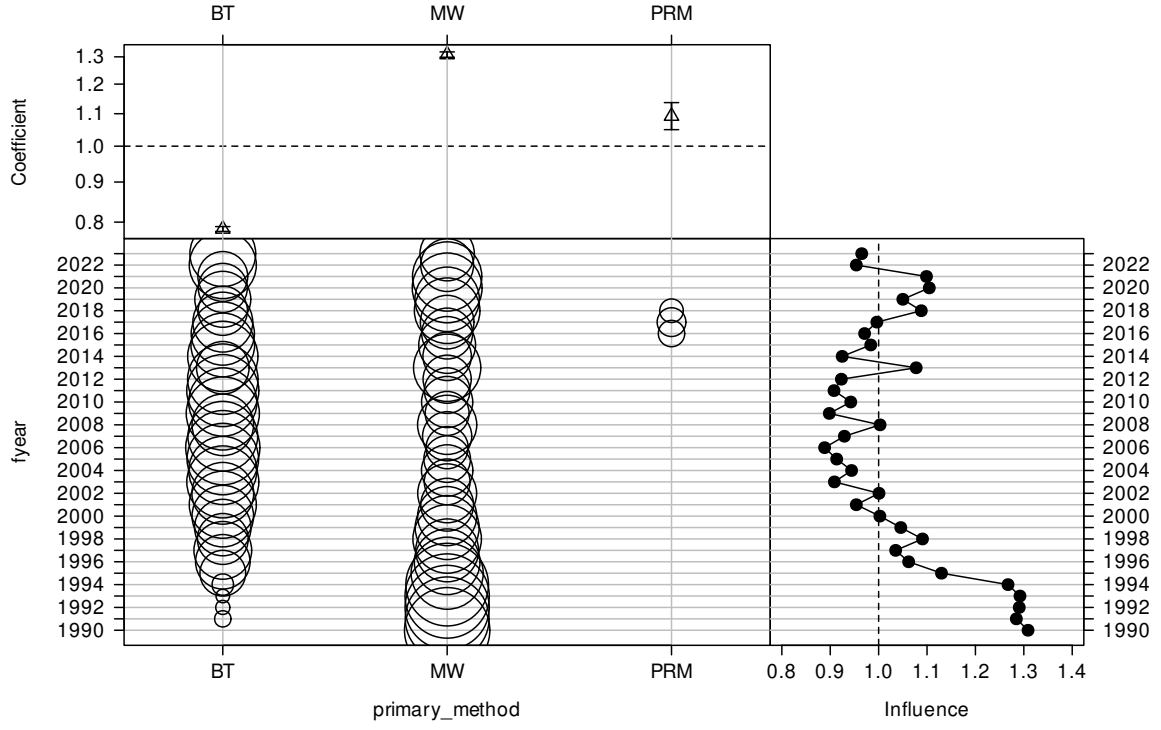

Figure 58: CDI plot for primary method for the Weibull model of positive catches in the BYX 2 BYX 3 event catch-per-unit-effort dataset.

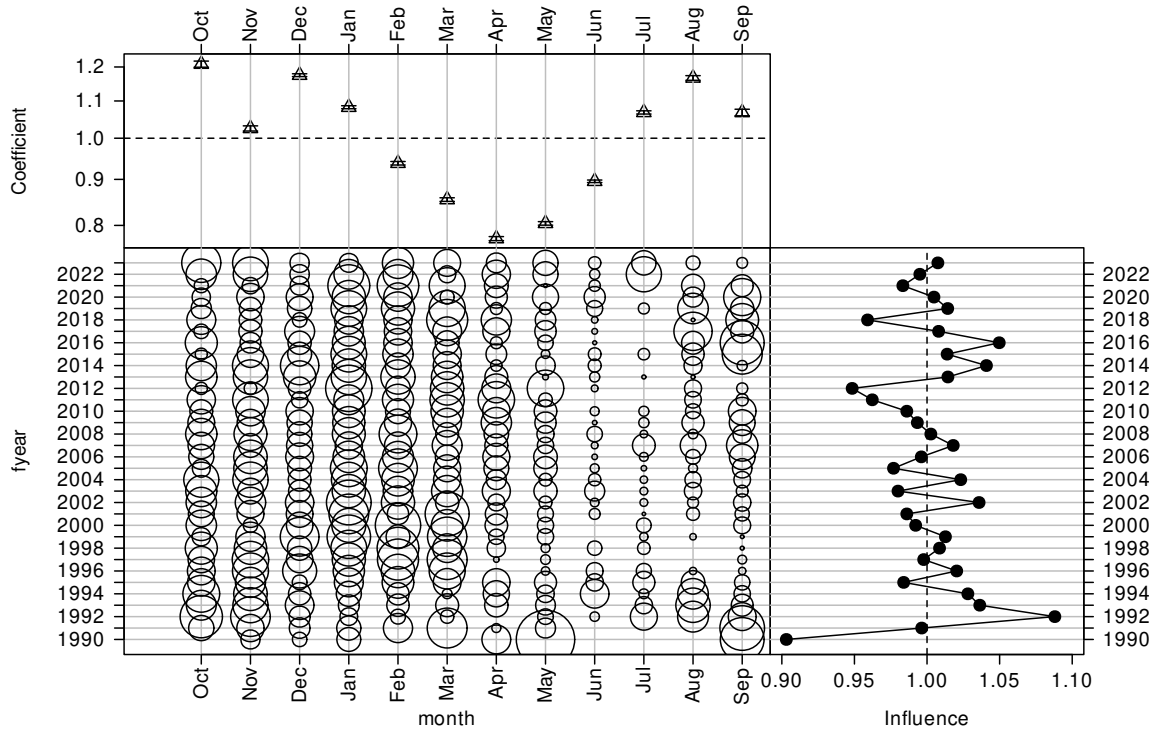

Figure 59: CDI plot for month for the Weibull model of positive catches in the BYX 2 BYX 3 event catch-per-unit-effort dataset.

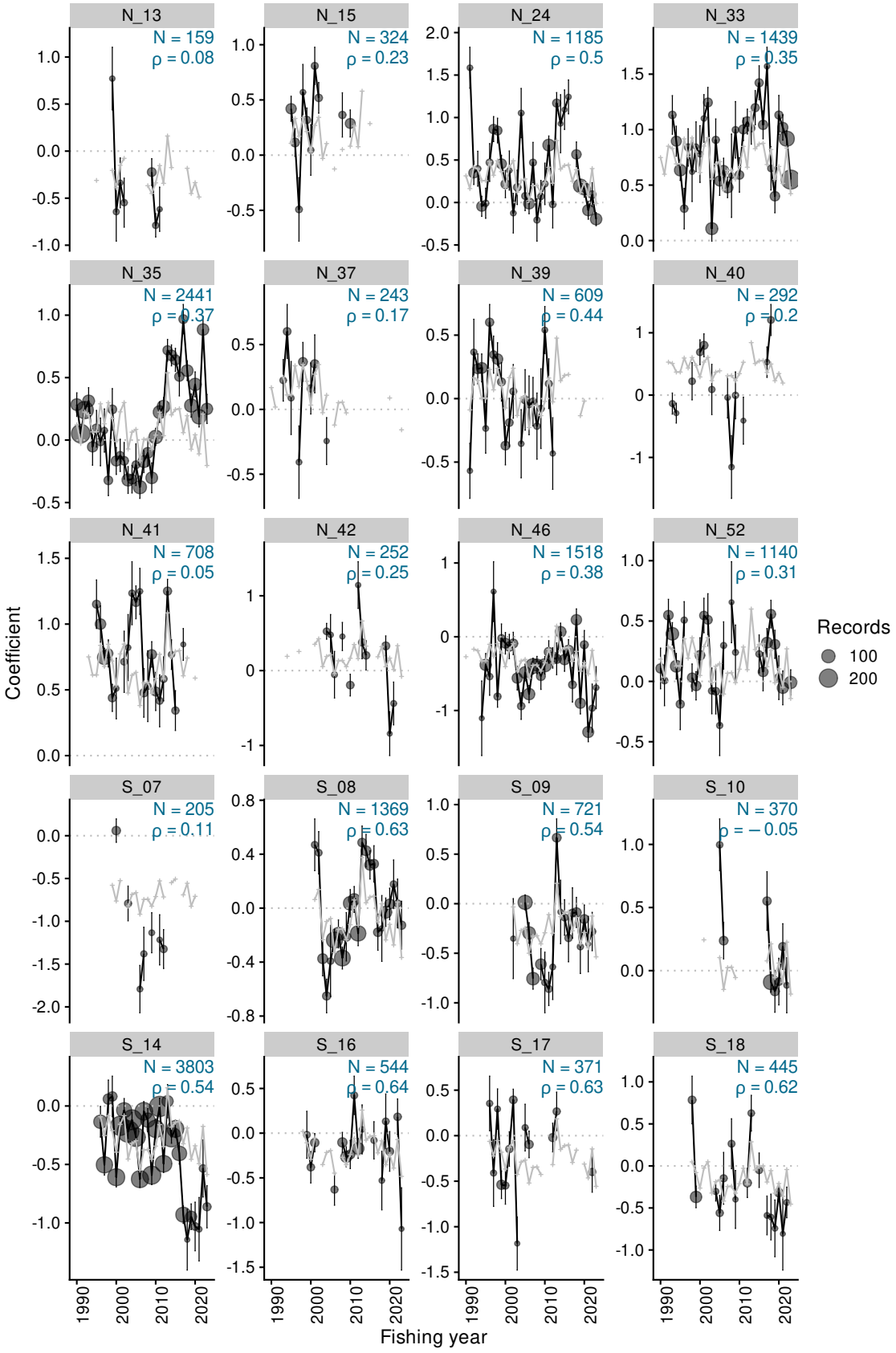

Figure 60: Residual implied coefficients for area-year in the Weibull positive catch model for the BYX 2 BYX 3 event dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 10 data points in an area-year stratum. The light grey line and points indicate the overall year indices; these are only plotted where there are data in a stratum. Areas with less than 100 events are not plotted.

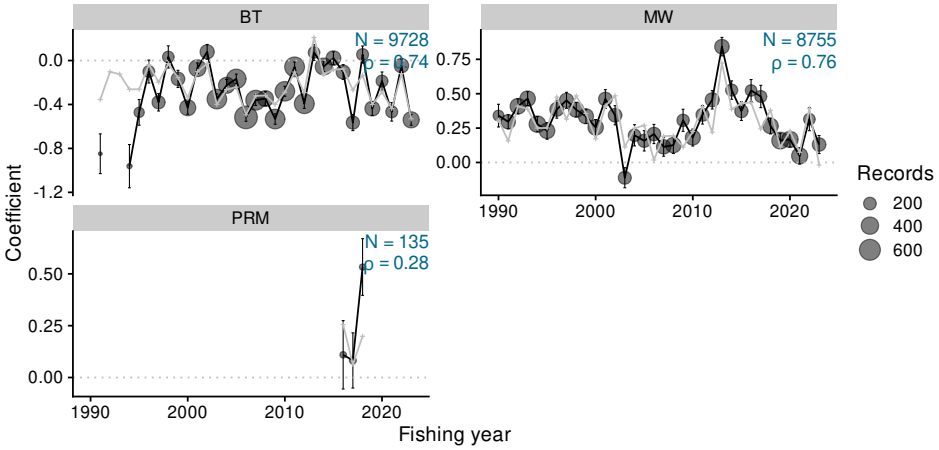

Figure 61: Residual implied coefficients for primary method-year in the Weibull positive catch model for the BYX 2 BYX 3 event dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 10 data points in a method-year stratum. The light grey line and points indicate the overall year indices; these are only plotted where there are data in a stratum.

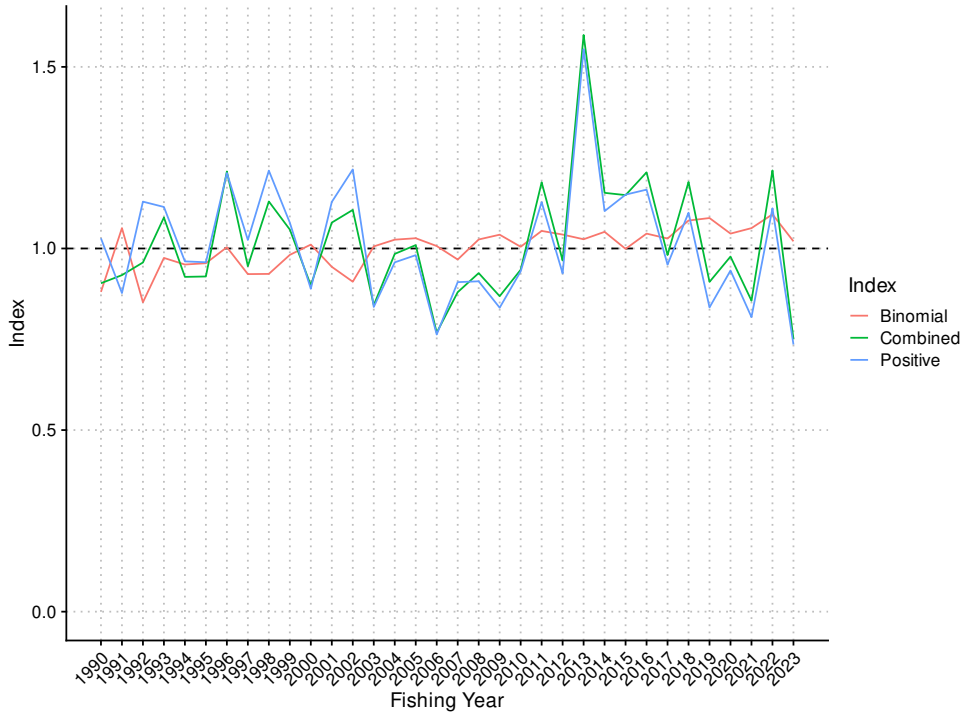

Figure 62: Standardised indices for the BYX 2 BYX 3 event dataset.

Table 9: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in BYX 2 BYX 3 event.

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
1990	0.881	0.081	0.666	0.983	0.904	0.127	0.647	1.145	1.028	0.112	0.823	1.262
1991	1.056	0.047	1.004	1.189	0.927	0.088	0.783	1.127	0.877	0.069	0.752	1.021
1992	0.852	0.086	0.635	0.972	0.961	0.118	0.704	1.167	1.129	0.076	0.991	1.287
1993	0.974	0.035	0.884	1.020	1.085	0.087	0.914	1.255	1.114	0.080	0.961	1.275
1994	0.956	0.041	0.839	1.002	0.922	0.073	0.783	1.070	0.964	0.064	0.852	1.101
1995	0.959	0.035	0.860	0.998	0.923	0.066	0.794	1.055	0.962	0.059	0.847	1.079
1996	1.003	0.024	0.956	1.049	1.212	0.080	1.064	1.378	1.208	0.078	1.069	1.373
1997	0.929	0.049	0.796	0.989	0.951	0.081	0.783	1.101	1.023	0.059	0.912	1.142
1998	0.930	0.047	0.805	0.990	1.129	0.093	0.940	1.305	1.214	0.075	1.068	1.362
1999	0.982	0.024	0.919	1.012	1.052	0.066	0.923	1.182	1.071	0.063	0.947	1.193
2000	1.011	0.019	0.979	1.054	0.899	0.051	0.803	1.003	0.889	0.045	0.803	0.981
2001	0.949	0.038	0.846	0.993	1.071	0.071	0.924	1.200	1.128	0.058	1.018	1.244
2002	0.909	0.061	0.743	0.984	1.106	0.102	0.884	1.285	1.218	0.069	1.092	1.361
2003	1.006	0.018	0.974	1.044	0.844	0.042	0.765	0.928	0.839	0.040	0.761	0.917
2004	1.024	0.024	0.994	1.087	0.985	0.058	0.878	1.104	0.962	0.049	0.866	1.059
2005	1.028	0.024	1.002	1.094	1.009	0.056	0.909	1.127	0.982	0.049	0.891	1.084
2006	1.007	0.016	0.980	1.044	0.768	0.034	0.704	0.838	0.763	0.032	0.701	0.827
2007	0.970	0.027	0.891	0.999	0.880	0.049	0.783	0.974	0.907	0.040	0.830	0.988
2008	1.025	0.023	0.997	1.089	0.932	0.051	0.840	1.039	0.910	0.044	0.826	0.998
2009	1.038	0.030	1.004	1.123	0.869	0.050	0.780	0.975	0.837	0.040	0.762	0.919
2010	1.005	0.019	0.966	1.042	0.941	0.044	0.859	1.030	0.937	0.042	0.858	1.024
2011	1.048	0.036	1.007	1.149	1.182	0.069	1.054	1.324	1.128	0.054	1.020	1.231
2012	1.038	0.028	1.005	1.113	0.967	0.052	0.875	1.078	0.931	0.042	0.852	1.017
2013	1.025	0.032	0.982	1.108	1.588	0.103	1.408	1.811	1.549	0.091	1.385	1.741
2014	1.046	0.040	1.004	1.159	1.153	0.073	1.028	1.316	1.103	0.058	0.994	1.220
2015	0.999	0.027	0.938	1.043	1.147	0.072	1.008	1.291	1.148	0.062	1.033	1.276
2016	1.041	0.038	1.000	1.149	1.210	0.081	1.062	1.381	1.162	0.067	1.037	1.302
2017	1.027	0.028	0.994	1.103	0.982	0.063	0.871	1.119	0.956	0.054	0.857	1.070
2018	1.077	0.057	1.012	1.233	1.183	0.094	1.027	1.396	1.099	0.062	0.979	1.222
2019	1.084	0.064	1.013	1.265	0.908	0.070	0.794	1.069	0.838	0.039	0.760	0.912
2020	1.041	0.036	1.001	1.144	0.978	0.066	0.860	1.118	0.939	0.054	0.837	1.047
2021	1.056	0.044	1.006	1.177	0.856	0.059	0.755	0.984	0.811	0.045	0.724	0.902
2022	1.094	0.075	1.013	1.307	1.215	0.110	1.043	1.476	1.111	0.065	0.994	1.249
2023	1.020	0.031	0.971	1.092	0.750	0.048	0.659	0.849	0.736	0.039	0.663	0.817

4.2 Spatial variation in CPUE trends

Although the residual implied coefficients for the different areas in the BYX 2 and BYX 3 event resolution model clearly indicated differing trends between areas (Figure 60), broad scale patterns in the abundance trends across the region were difficult to discern. While some similarities were evident in the trends of adjacent and nearby areas, the number of areas involved and the varying levels of effort between areas made comparisons difficult.

In Figure 63 the time series of residual implied coefficients by area from the BYX 2 and BYX 3 event resolution model are overlaid, with the lines coloured such that areas that are spatially adjacent have similar line colours. This provides a somewhat clearer picture of the differing trends by area, and supports the interpretation that areas that are spatially adjacent have more similar trends than those seen in more distant areas.

To further investigate the difference in trends in abundance in different parts of the alfonsino fishery, the areas identified by the cluster analysis were manually grouped into four regional groupings (Figure 64). The areas assigned to groups were the key areas in terms of alfonsino catch volume (Figure 43), and the groupings were defined based on spatial proximity and similarity in trends from the initial CPUE model (Figure 63). These regional groupings were then used as the spatial strata in a second CPUE analysis (BYX 2 BYX 3 event (regions)) where the regions were offered as the spatial strata, rather than each area identified by the cluster analysis.

Detailed diagnostics for the BYX 2 BYX 3 event (regions) model are provided in Appendix D. The dataset and resulting model were similar to the all-areas model (BYX 2 and BYX 3 event) except that fishing depth was selected in the occurrence model rather than region, and net height was selected instead of month and method in the positive catch model. Region was selected in the positive catch model and indicates that catch rates tended to be higher in the east coast regions than the Chatham Rise regions (Figure D.15). The four regions all showed departures from the overall model trend, but in different ways and at different times (Figure D.16).

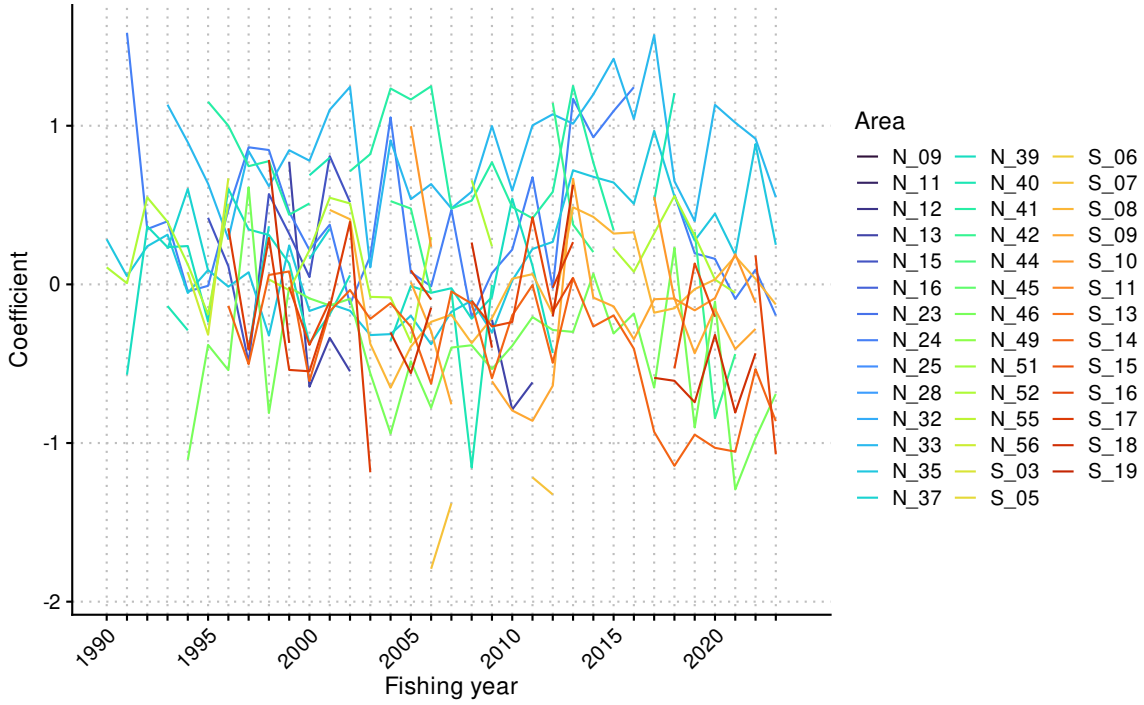

Figure 63: Overlap of residual implied coefficients for area-year in the Weibull positive catch model for the BYX 2 BYX 3 event dataset. The mean residual is plotted for years where an area has at least 10 fishing events.

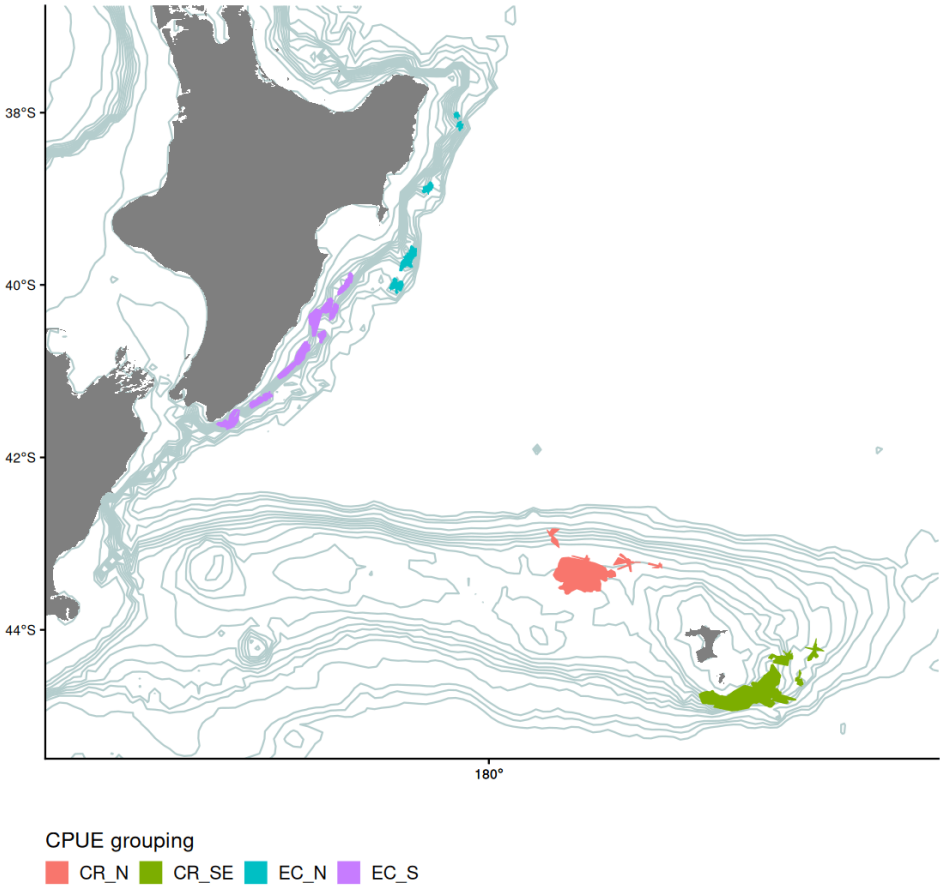

Figure 64: Groupings of fishery areas identified by density-based clustering of fishing events from trips landing BYX 2 and BYX 3. The groups include the key areas in terms of alfonsino catches, and group spatially close areas that had generally similar trends in residual implied coefficients from the BYX 2 and BYX 3 event resolution model. The clusters were labelled by general region: CR_N = Chatham Rise north, CR_SE = Chatham Rise south-east, EC_N = east coast north, and EC_S = east coast south.

Overlaid residual implied coefficients, by region, from the BYX 2 BYX 3 event (regions) model (Figure 65) indicate that, at times, the regions can have similar general trends in abundance, but that on other occasions the temporal trends diverge. As a result, it is unrealistic to consider that the overall trend from the model provides a stock level indication of alfonsino abundance.

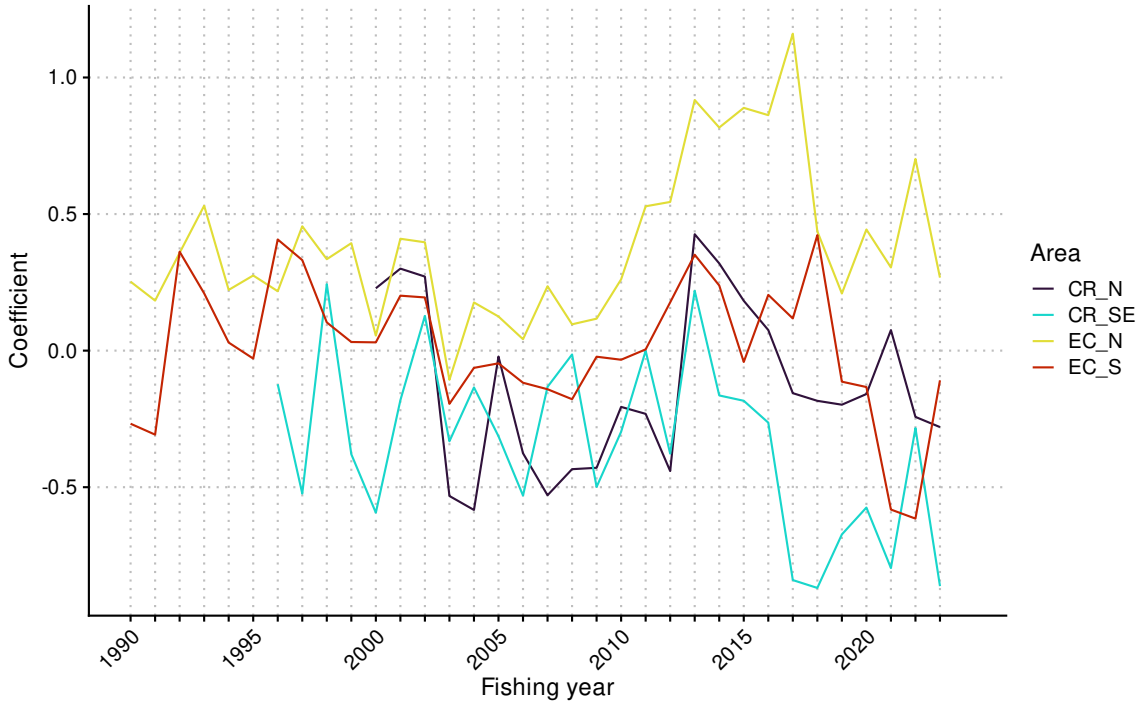

Figure 65: Overlap of residual implied coefficients for area-year in the Weibull positive catch model for the BYX 2 BYX 3 event (regions) dataset. The mean residual is plotted for years where an area has at least 10 fishing events.

4.3 Additional CPUE analyses

The key regions in the alfonsino fishery are spatially separated (Figure 64). Most of the trawl effort from trips landing BYX 2 and BYX 3 in eastern Cook Strait and on the western Chatham Rise is targeted at hoki (Figure 43a). To investigate alfonsino abundance in this area, a CPUE analysis was carried out for alfonsino caught by the hoki target trawl fishery on south-east coast of the North Island, north-east coast of the South Island, and north-western Chatham Rise (Table D.7). Because alfonsino catches were relatively infrequent in this fishery, a trip level analysis was carried out. Details and diagnostics are provided in Appendix D.

Alfonsino catches occurred in different regions of the hoki fishery at different times. Statistical Area 016, the eastern Cook Strait, had the most consistent catches although CPUE trends in Statistical Areas 015 and 018 were similar, for periods with catches (Figure D.38). However, from 2018 to 2023, most catches of alfonsino were from Statistical Area 017. Effort in the hoki fishery showed a significant shift from Statistical Area 016 to 017 in this period (Figure D.29) and, with the relative rarity of alfonsino bycatch, is difficult to disentangle spatial changes in the distribution of alfonsino from the impacts of changes in hoki fishery effort. There is also a substantial effect of standardisation, particularly on the positive catch series; much of the standardisation effect is attributable to modal month, but the fitted seasonal trend (Figure D.34) does not match that seen in the target fishery model (Figure 59).

The final four CPUE analyses (Table 3, Appendix D) were separate analyses for each of the four broad regions within the BYX 2 and BYX 3 fishery (Figure 64). The primary purpose of these analyses was to facilitate further evaluation of the consistency in CPUE trend between areas within a region.

A side effect of the region level models was highlighting that the number of vessels involved in the fishery at the regional level could be quite limited, especially after applying core fleet selection rules. For example, only four vessels are retained in the BYX event (Chatham Rise - South East) dataset (Figure D.43). However, examining effort patterns by vessel and region using the dataset for the BYX

2 BYX 3 event (regions) model (Figure 66) provides reassurance that key vessels fished in all regions, limiting the potential for vessel and region effects to be confounded and highlighting the value of a multi-region model.

The individual region models each had data limitations or poor diagnostics that would require further investigation in the event that they were being considered for use as abundance series. In all cases, however, the residual implied coefficients for the spatial clustering based areas within each region (Figure D.55, Figure D.74, Figure D.92, Figure D.113) were more consistent with the main regional trend than was in case in the wide area model (BYX 2 BYX 3 event), lending support to the conclusion that the abundance trends are generally consistent within the four main regions.

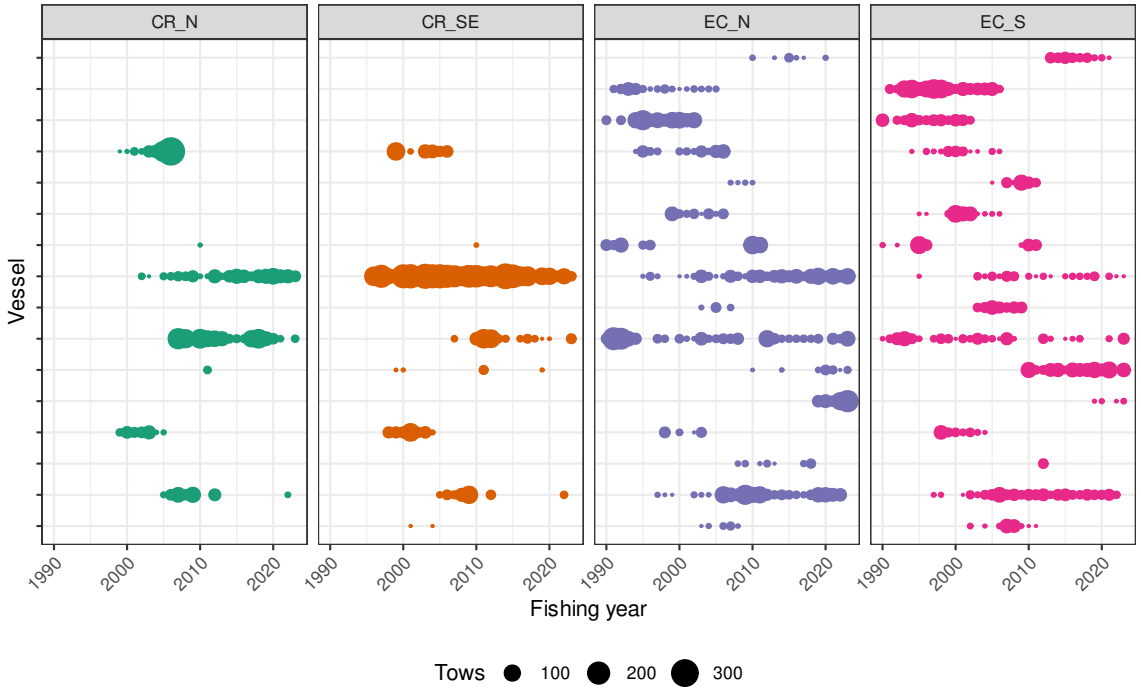

Figure 66: Number of tows by fishing year for core vessels in the BYX 2 BYX 3 event (regions) series, by region. The area of the circles is proportional to the number of tows undertaken by a vessel in a fishing year.

5. CATCH COMPOSITION

An understanding of the size and age composition of alfonsino in the different regions, and how these change over time, is required in order to interpret the differing trends in abundance. Two sources of size composition data are available: observer sampling and fish grade data.

5.1 Observer length-frequency data

Observer information on alfonsino may be recorded under the generic BYX code, or using the species specific codes (BYS = *Beryx splendens*; BYD = *B. decadactylus*). Length data are available for the bottom and midwater trawl fisheries off the North Island east coast and from the Chatham Rise, with a small number of measurements from other areas and methods (Table 10, Figure 67). However, while the aggregate number of length measurements from these key fisheries is reasonably large, this represents the total from three decades of data collection so fine scale spatial and temporal analyses will not be feasible.

The species codes used in recording the fish with length measurements are summarised in Table 11. Most length measurements were recorded with a species specific code, and these data support the assumption that the vast majority of the alfonsino catch is of *B. splendens* with *B. decadactylus* only rarely encountered. Only the length data for *B. splendens* are considered below.

The aggregate length data from observer sampling (Figure 68, Figure 69) indicate that the modal size of alfonsino caught in the New Zealand fishery is 30 cm to 35 cm. The bottom trawl fisheries appear to catch more fish over 40 cm than the midwater trawl fisheries, with the difference especially evident in samples from the Chatham Rise (the SOE area). The larger fish in the samples (over 45 cm) are almost exclusively female, consistent with the differential growth reported by Stocker & Blackwell (1991), and more females than males were sampled overall.

Length samples are available from a range of target bottom trawl fisheries (Figure 70, Figure 71, and noting that alfonsino targeting may be recorded with either BYX or BYS as the target species code). When alfonsino have been sampled from orange roughy target tows, these have generally been larger fish (predominantly 40 cm to 50 cm) that are rarely encountered in bycatch in the shallower hoki and hake target fisheries. The smallest alfonsino encountered have been 18 cm to 24 cm, sampled in both alfonsino and silver warehou tows. Fewer different midwater target fisheries have been sampled (Figure 72, Figure 73), with alfonsino from hoki target midwater fishing showing a similar size distribution to that from alfonsino target tows.

The annual representativeness of observer sampling from the bottom and midwater trawl fisheries is illustrated by month and latitude in Appendix E. In both fisheries, sampling has been patchy and is not representative of the fishery.

Annual length frequency distributions, by observer fisheries management area, for alfonsino caught by bottom trawl (Figure 74) demonstrate that alfonsino has been sampled from a range of fisheries, although some time periods have annual samples from the target fishery. The size distribution of alfonsino in the samples can vary substantially from year to year but, given the small number of samples, the unrepresentative sampling, and spatial complexity of the fishery it is not possible to reliably separate the contributions of temporal change and sampling variation to these differences. Sampling of midwater fishing events has been more consistently from the alfonsino target fishery (Figure 75), but otherwise the same caveats apply.

Table 10: Length-frequency samples of alfonsino by area and method, sampled by the Observer Programme from fishing years 1994 to 2023. Observer Fisheries Management Area (FMA) codes and method codes are defined in the glossary.

QMA	Observer FMA	Method	Sampled events	Number of fish
BYX 2	CEE	BLL	13	181
BYX 2	CEE	BT	132	7 192
BYX 2	CEE	MW	99	6 523
BYX 2	CEE	PRM	3	140
BYX 3	SEC	BT	23	119
BYX 3	SEC	MW	3	50
BYX 3	SEC	PRB	2	50
BYX 3	SEC	TWL	1	3
BYX 3	SOE	BLL	1	1
BYX 3	SOE	BT	211	8 059
BYX 3	SOE	MW	109	4 964
BYX 3	SOE	PRB	1	25
BYX 3	SOU	BT	2	15

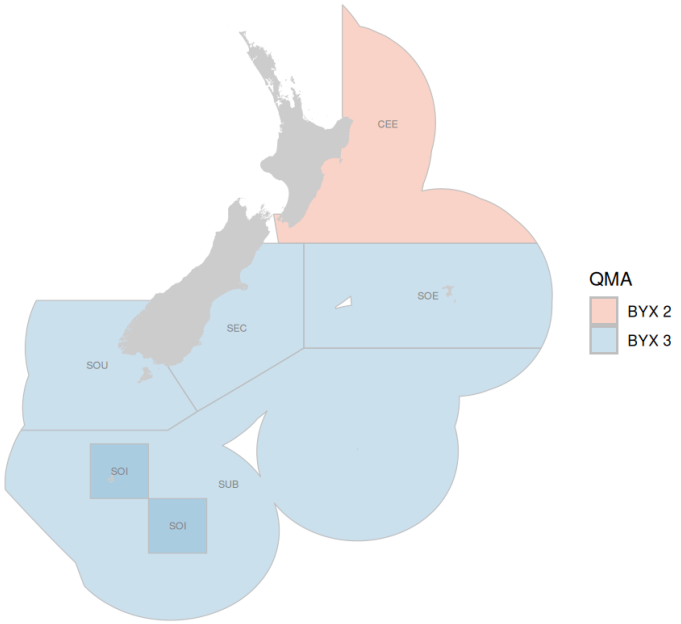

Figure 67: Observer Fisheries Management Areas in relation to the Quota Management Areas (QMA) for alfonsino.

Table 11: Length-frequency samples of alfonsino by species code, sampled by the Observer Programme from fishing years 1994 to 2023

Species code recorded	Number of fish
BYD	160
BYS	27 134
BYX	28

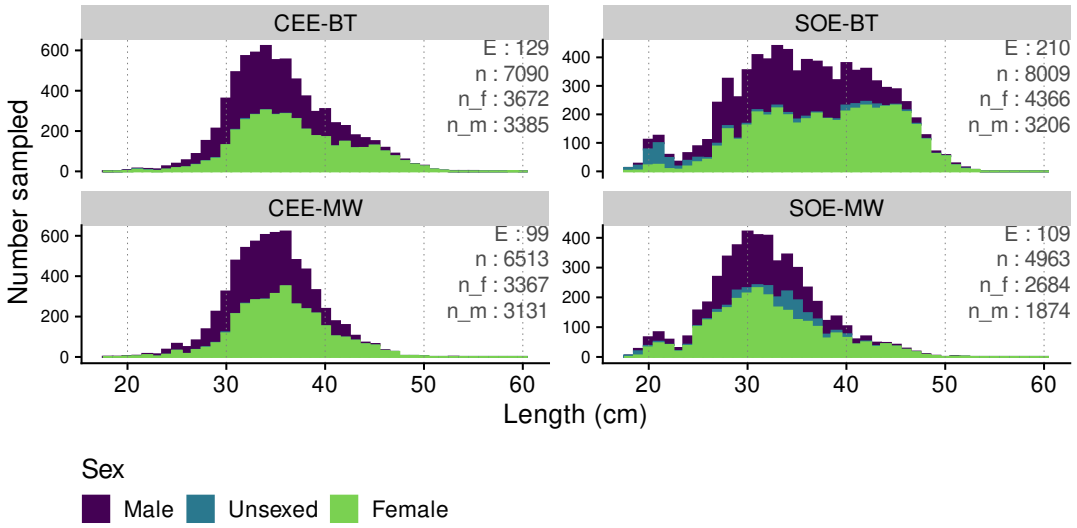

Figure 68: Length-frequency distributions of alfonsino for the CEE, SOE areas by fishing method, with sex indicated by stacked bars. Annotations indicate the number of unique sampling events (E) and sampled number of fish (n) for each area-method. Only area-methods with at least 200 fish measurements are included. The observer area codes are defined in the glossary.

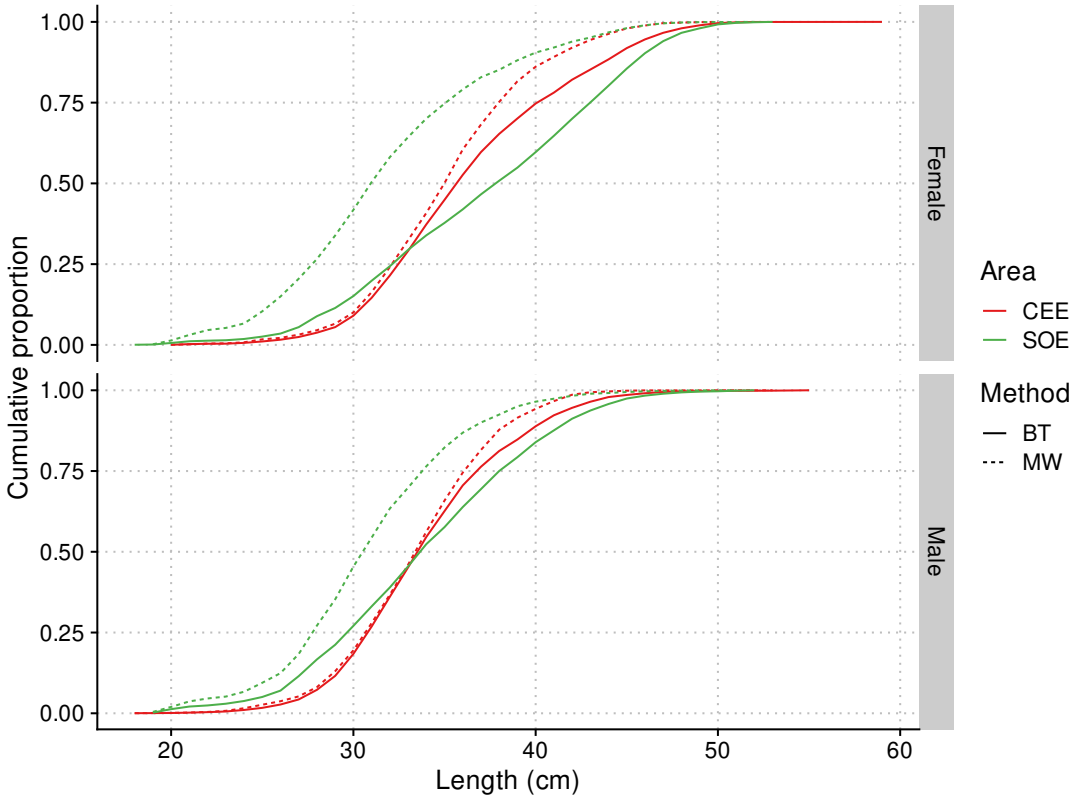

Figure 69: Cumulative length-frequency distributions of alfonsino for the CEE, SOE area by fishing method, using raw, unscaled observer samples.

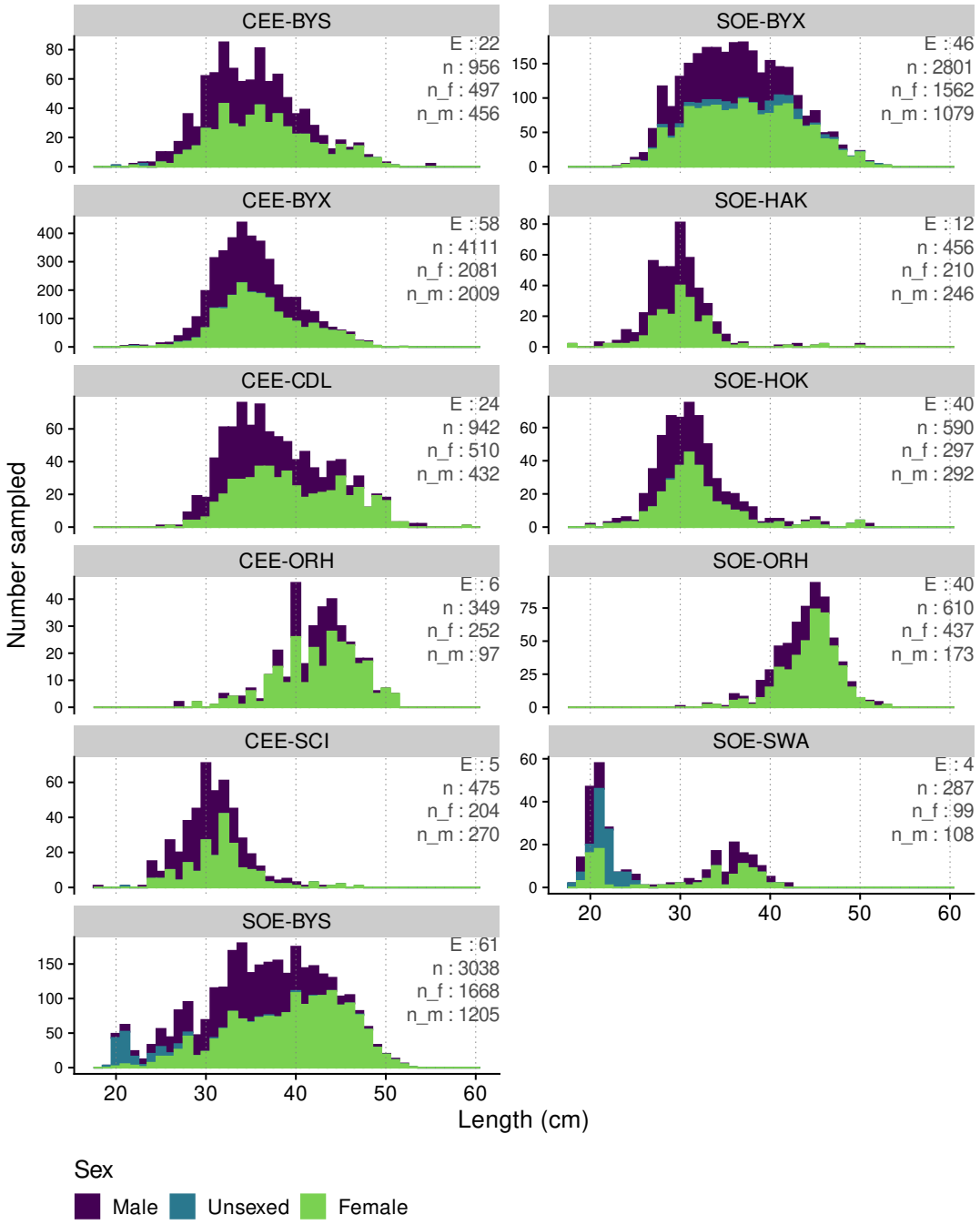

Figure 70: Length-frequency distributions for alfonsino caught in the bottom trawl fishery, by area, target species, and sex (stacked bars). Annotations indicate the number of unique sampling events (E) and sampled number of fish (n) for each area-target and sex. Only area-targets with at least 200 fish measurements are included. Observer area codes are defined in the glossary.

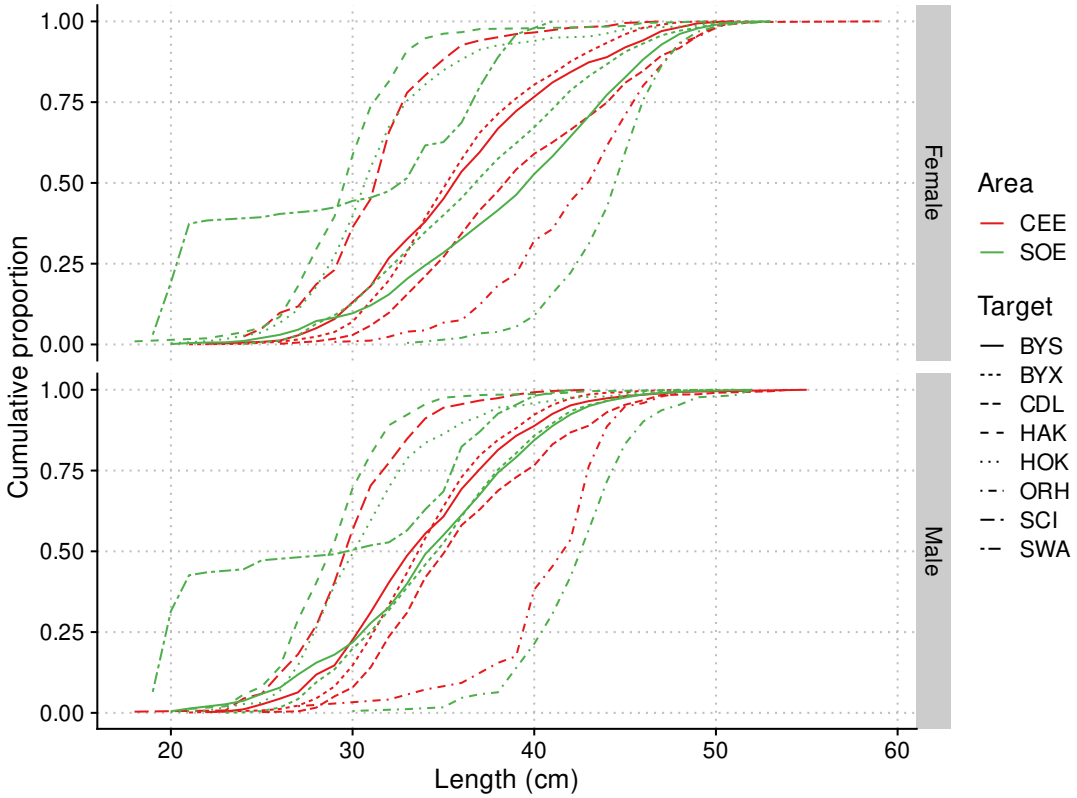

Figure 71: Cumulative length-frequency distributions for alfonsino caught in the bottom trawl fishery, by area and target species. Only area-targets with at least 200 fish measurements are included. Observer area codes are defined in the glossary.

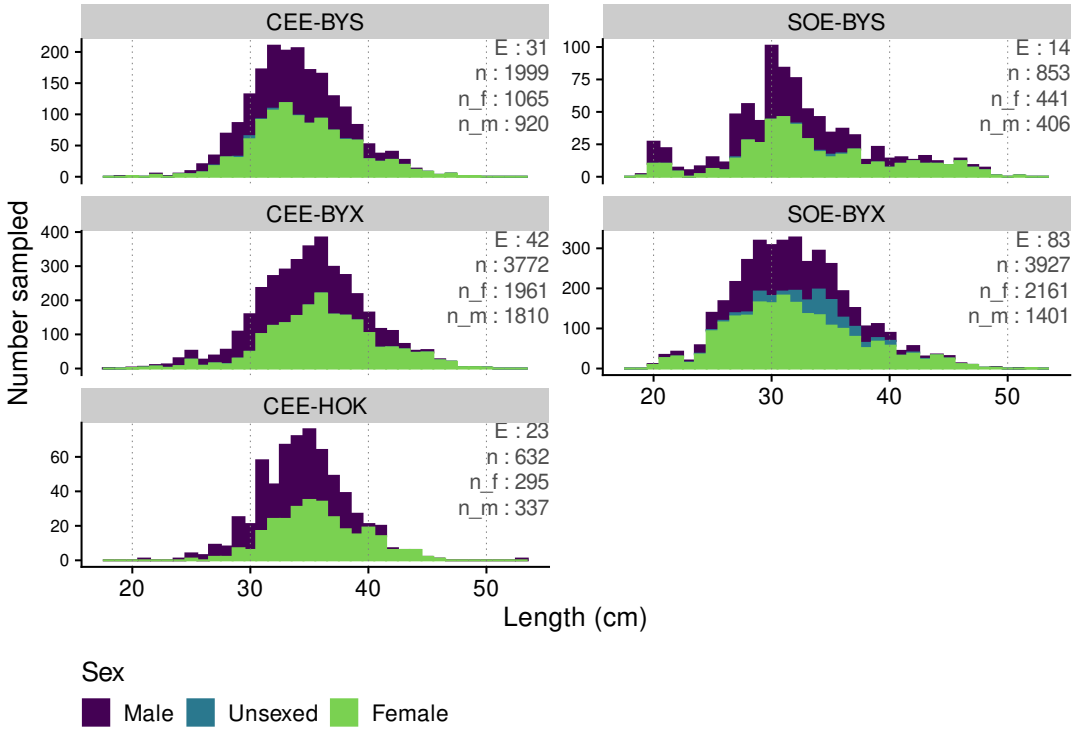

Figure 72: Length-frequency distributions for alfonsino caught in the midwater trawl fishery, by area, target species, and sex (stacked bars). Annotations indicate the number of unique sampling events (E) and sampled number of fish (n) for each area-target and sex. Only area-targets with at least 200 fish measurements are included. Observer area codes are defined in the glossary.

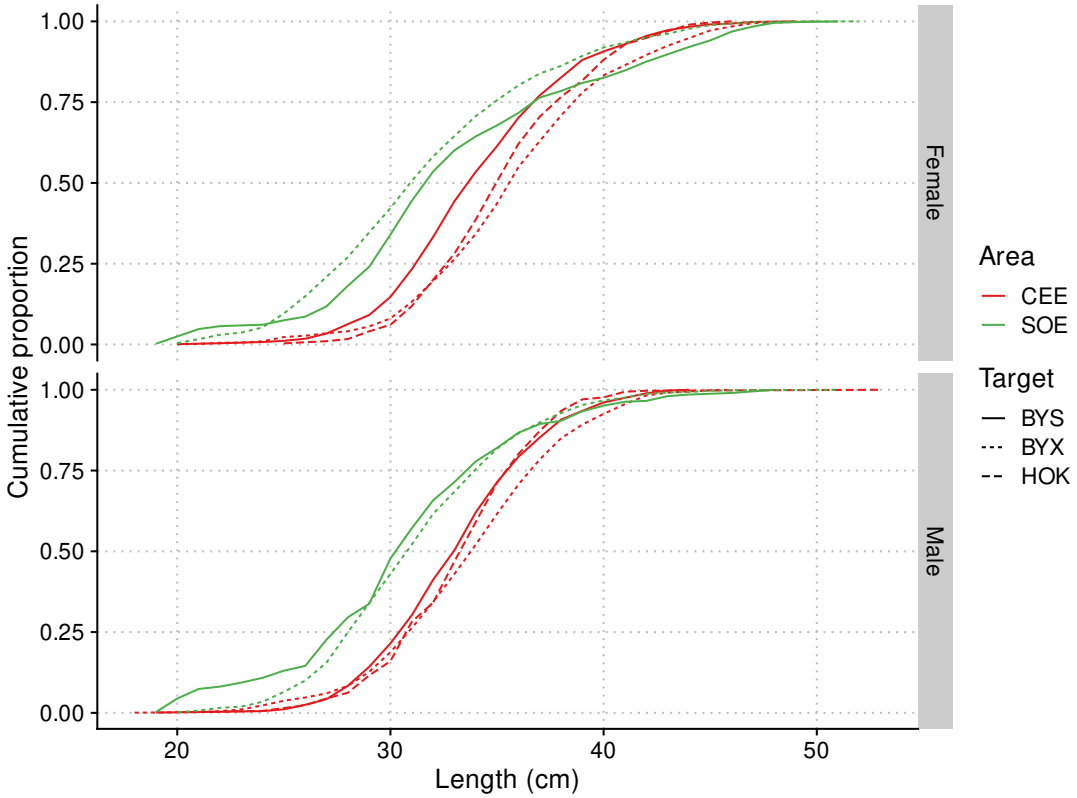

Figure 73: Cumulative length-frequency distributions for alfonsino caught in the midwater trawl fishery, by area and target species. Only area-targets with at least 200 fish measurements are included. Observer area codes are defined in the glossary.

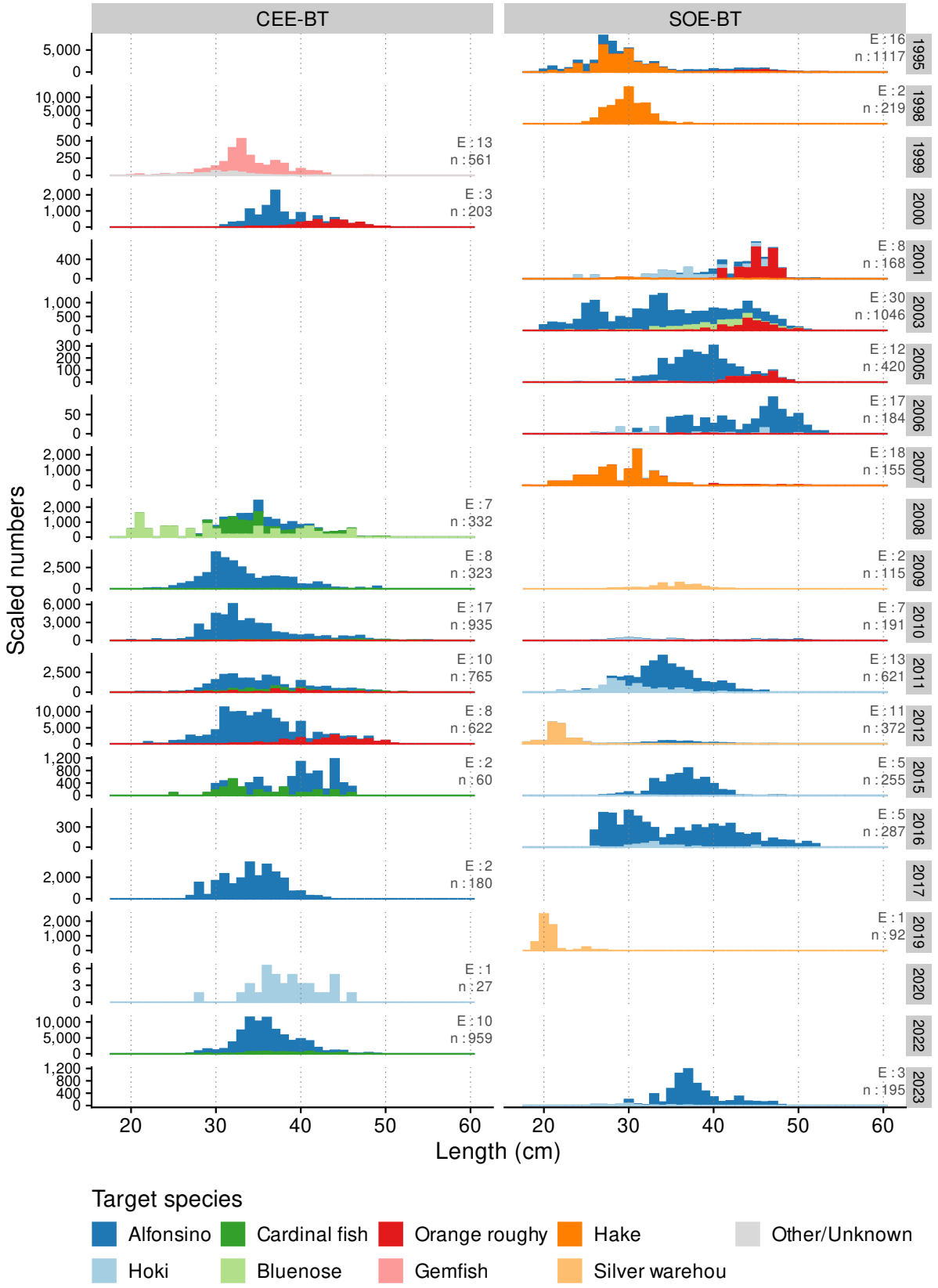

Figure 74: Length-frequency distributions for alfonsino caught in the bottom trawl fishery, by area, fishing year, and target species (stacked bars). Annotations indicate the number of unique sampling events (E) and sampled number of fish (n) for each area, target and year. Sampled numbers are scaled to the catch weight in each sampled event. Observer area codes are defined in the glossary. The Other grouping includes both minor target species and events where the target species was not recorded.

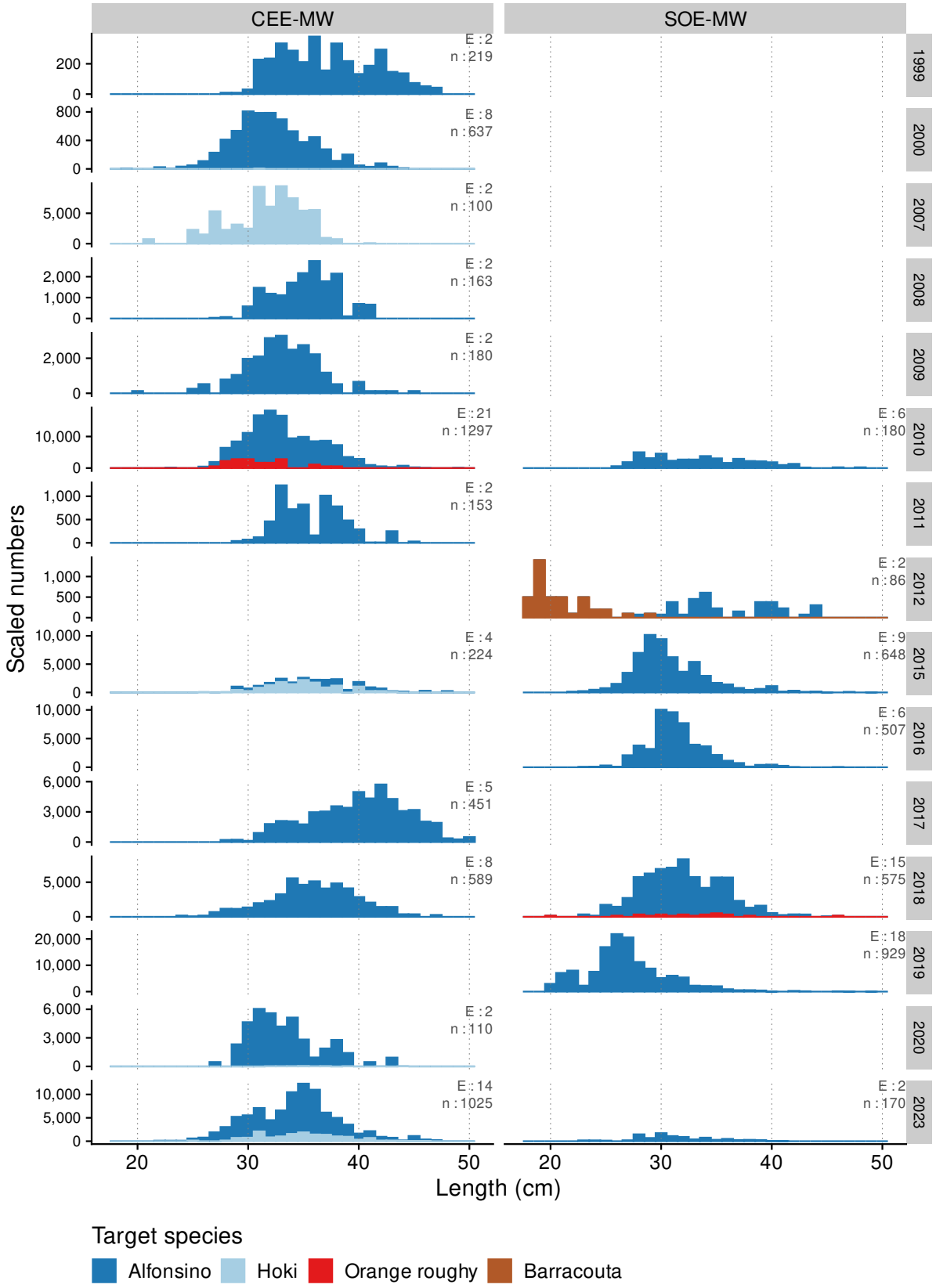

Figure 75: Length-frequency distributions for alfonsino caught in the midwater trawl fishery, by area, fishing year, and target species (stacked bars). Annotations indicate the number of unique sampling events (E) and sampled number of fish (n) for each area, target and year. Sampled numbers are scaled to the catch weight in each sampled event. Observer area codes are defined in the glossary.

5.2 Commercial grade data

Commercial grade data, where fish are packed by size class, provide another source of information on the size composition of the alfonsino catch. Grade information is available from at least two of the main operators in the alfonsino fishery but, here, the exploration of these data focusses on the more extensive dataset provided by one operator that included data from 2008 to 2022.

The grading categories used in these data are listed in Table 12, together with the total greenweight in the dataset by stock and landed state. For each grade a reference weight was calculated as the midpoint of the grade weight range, after applying the conversion factor for the processed state. An indicative fish length range for each grade can also be estimated, based on the established length-weight relationships tabulated by Fisheries New Zealand (2024); these differ slightly between BYX 2 and BYX 3, so size ranges are indicated for both sets of parameters.

These size ranges can be also expressed as approximate age ranges, based on the growth curves reported by (Fisheries New Zealand 2024; see Figure 76). This suggests that the smallest size grade of alfonsino includes fish age 3 to 4; Massey & Horn (1990) estimated that full recruitment to the commercial fishery occurred at age 5 in the Palliser Bank fishery off the east coast of the North Island. Based on this growth curve, the other grades would have fish at 4–7 years, 7–9 years, 9–13 years, and 14+ years. This suggests that the progression of stronger and weaker year classes will potentially be evident in the grade data.

Table 12: Total greenweight (tonnes) of alfonsino by stock, processed state, and grade, for daily processed grade data from 2008 to 2022. Grades refer to piece weights. A reference fish weight is given for each grade based on the midpoint of the grade weight and the regulated conversion factor. Indicative fish size ranges for the grade are calculated using the length-weight relationships provided by Fisheries New Zealand (2024).

				Approximate length		
Stock	State	Grade specification	Ref. wt (g)	BYX 2 params	BYX 3 params	Greenweight (t)
BYX2	DRE	200 to 300g	487.5	25.3 to 29cm	26 to 29.7cm	90.5
BYX2	DRE	300 to 500g	780.0	29 to 34.3cm	29.7 to 35.1cm	881.3
BYX2	DRE	500 to 700g	1 170.0	34.3 to 38.4cm	35.1 to 39.2cm	556.6
BYX2	DRE	700 to 1000g	1 657.5	38.4 to 43.2cm	39.2 to 44cm	220.2
BYX2	DRE	1000 to 1500g	2 437.5	43.2 to 49.4cm	44 to 50.3cm	66.6
BYX2	DRE		-			288.2
BYX2	GRE	100 to 200g	150.0	16.1 to 20.3cm	16.6 to 20.9cm	0.2
BYX2	GRE	200 to 400g	300.0	20.3 to 25.6cm	20.9 to 26.2cm	1.9
BYX2	GRE		-			0.0
BYX2	HDS		-			0.0
BYX3	DRE	200 to 300g	487.5	25.3 to 29cm	26 to 29.7cm	195.4
BYX3	DRE	300 to 500g	780.0	29 to 34.3cm	29.7 to 35.1cm	371.9
BYX3	DRE	500 to 700g	1 170.0	34.3 to 38.4cm	35.1 to 39.2cm	181.9
BYX3	DRE	700 to 1000g	1 657.5	38.4 to 43.2cm	39.2 to 44cm	106.8
BYX3	DRE	1000 to 1500g	2 437.5	43.2 to 49.4cm	44 to 50.3cm	41.8
BYX3	DRE		-			251.6
BYX3	GRE	100 to 200g	150.0	16.1 to 20.3cm	16.6 to 20.9cm	1.4
BYX3	GRE	200 to 400g	300.0	20.3 to 25.6cm	20.9 to 26.2cm	2.7
BYX3	GRE	400 to 800g	600.0	25.6 to 32.2cm	26.2 to 32.9cm	0.0
BYX3	GRE	500 to 800g	650.0	27.5 to 32.2cm	28.2 to 32.9cm	10.1
BYX3	GRE	800 to 1100g	950.0	32.2 to 35.7cm	32.9 to 36.5cm	5.7
BYX3	GRE	1100 to 1500g	1 300.0	35.7 to 39.6cm	36.5 to 40.4cm	7.8
BYX3	HDS		-			0.0

Grade data are available either at the trip level, for 'fresher' vessels where the catch is packed ashore, or on a daily basis from vessels that process at sea. Here the focus was on the daily processing data because these can be linked to catch locations at a finer scale (i.e., to the day's fishing rather than to a whole trip's activity). The daily processing information was associated either with the daily average location of the tows conducted that caught alfonsino, or to a single tow if only one tow on the day caught alfonsino (Figure 77). The linked locations were then classified to indicate whether or not they fell within the boundaries of one of the areas identified by the cluster analysis of fishing effort (Figure 42, Figure 78).

The daily grading dataset (noting this is limited to one operator for exploratory purposes) represents 15% to 25% of the catch in approximately half of the years from 2008 to 2022 (Figure 79). However, there are periods (e.g., 2018–2021) where the proportion is much lower; this is due to an increased proportion of the operator's catch being taken by fresher vessels in this period. For comparison, the proportion of the catch with observer length samples is lower, although in most years observers were present on vessels when 15% to 20% of the catch was taken (Figure 79).

The annual proportions of the alfonsino catch by grade, based on the daily grading dataset, is illustrated for the areas identified in the spatial cluster analysis (Figure 80), and for the four main fishery regions (Figure 81). The dataset does not provide information from all areas, or regions, in all years. For the East Coast - South (EC_S) region the bulk of the catch is from two size grades in most years. In the two Chatham Rise areas, fish were present in a wider range of sizes and there are hints of size progression (for example, there are small fish in the CR_N region in 2009 and 2010, and larger fish in 2015 and 2016), potentially indicating intermittent recruitment and subsequent growth of resident fish, but intervening years without data make such interpretations somewhat speculative.

Given the limited coverage of the areas by the daily grading data, an initial exploration was made of the potential use of trip level grading data from fresher vessels. These are known to be available in electronic format from two operators in the fishery. Trips by vessels landing to these operators were characterised to evaluate the extent to which vessels fish one or many areas or regions on a trip. Some trips that targeted alfonsino fished in a single area, but the majority of trips fished in more than one area (Figure 82). Just under half of the trips with alfonsino target fishing fished in only one of the four main fishery regions. Unfortunately the trips that had a more limited spatial extent when targeting alfonsino were less likely to be made by one of the operators that is known to maintain trip-level grade data in an electronic format.

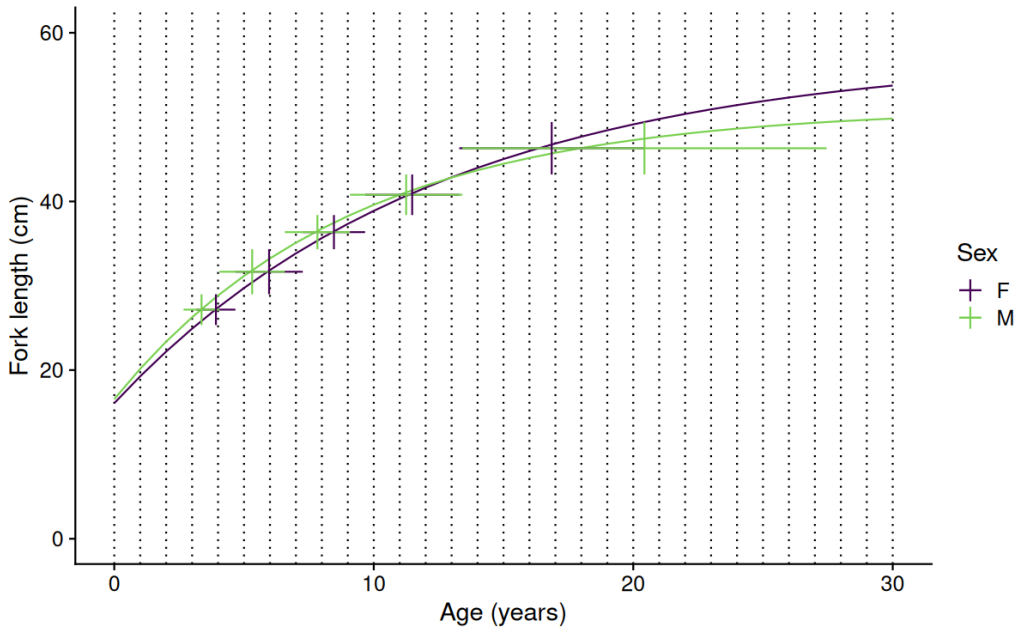

Figure 76: Alfonsino size at age from fitted growth curves (Fisheries New Zealand 2024), with the approximate size and age ranges indicated for the main grades of dressed fish.

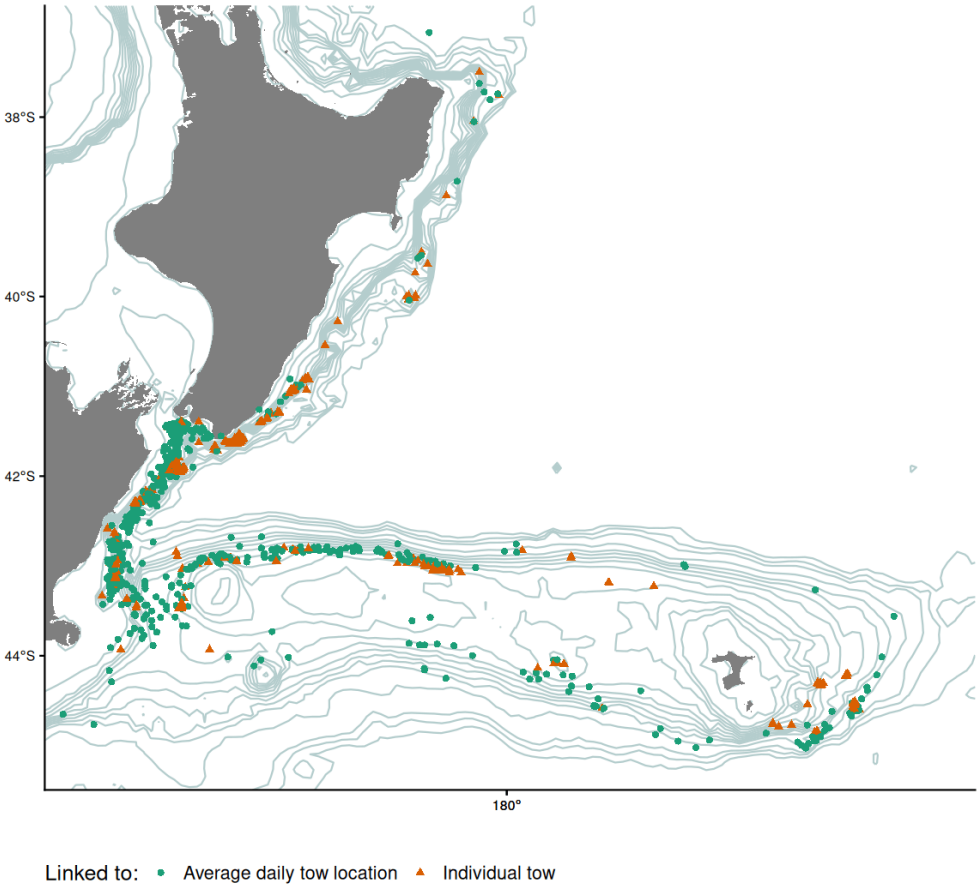

Figure 77: Locations assigned to grade data, classified according to whether the data was matched to an individual tow or a daily average position.

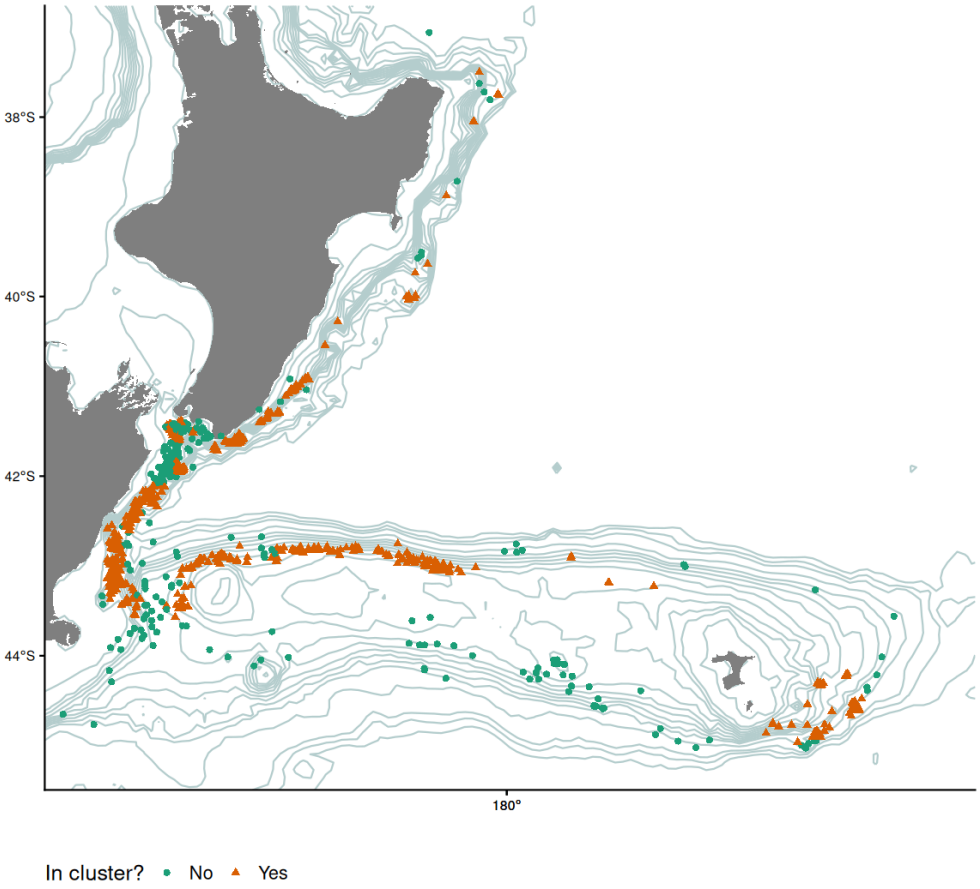

Figure 78: Locations assigned to grade data, classified according to whether the position was included in a cluster identified using the characterisation dataset.

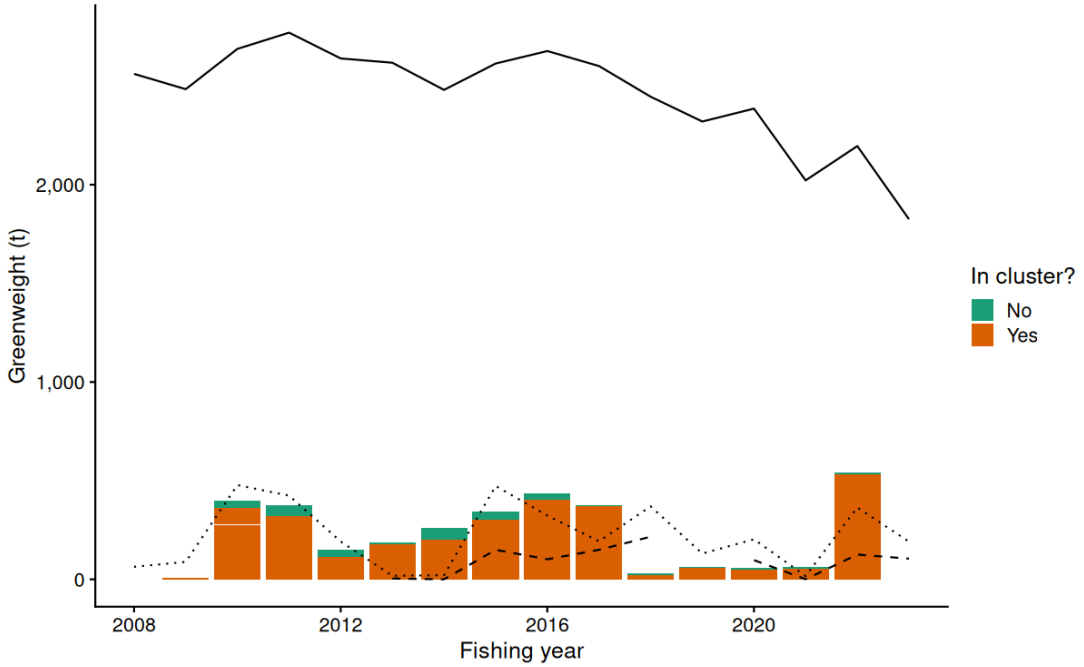

Figure 79: Bars: volume of alfonsino daily grade data available, by fishing year, in the single operator dataset; solid line: total catch from BYX 2 and BYX 3; dashed line: alfonsino catch from tows with observer length sampling; dotted line: alfonsino catch from all observed tows.

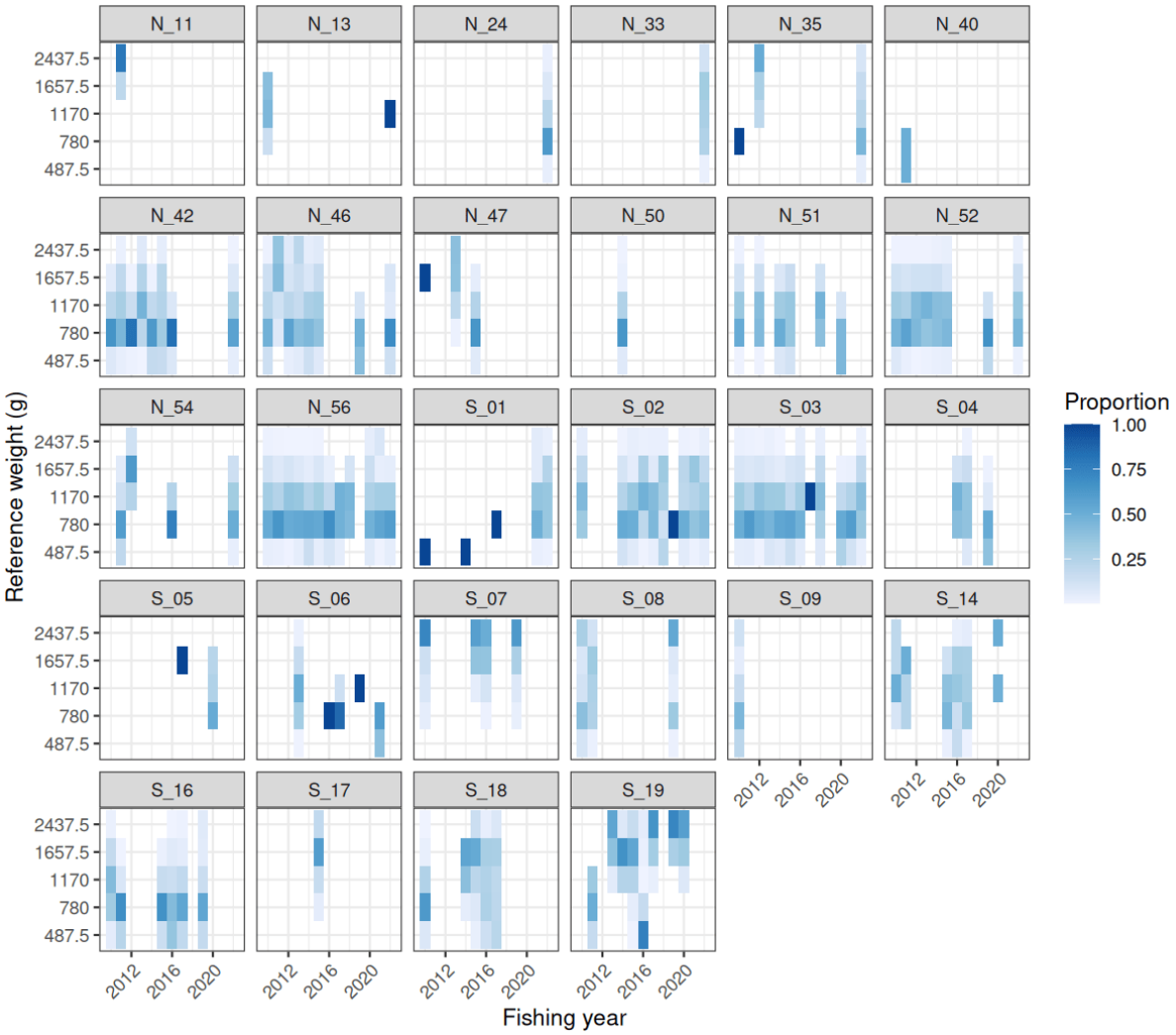

Figure 80: Proportion in grade by cluster.

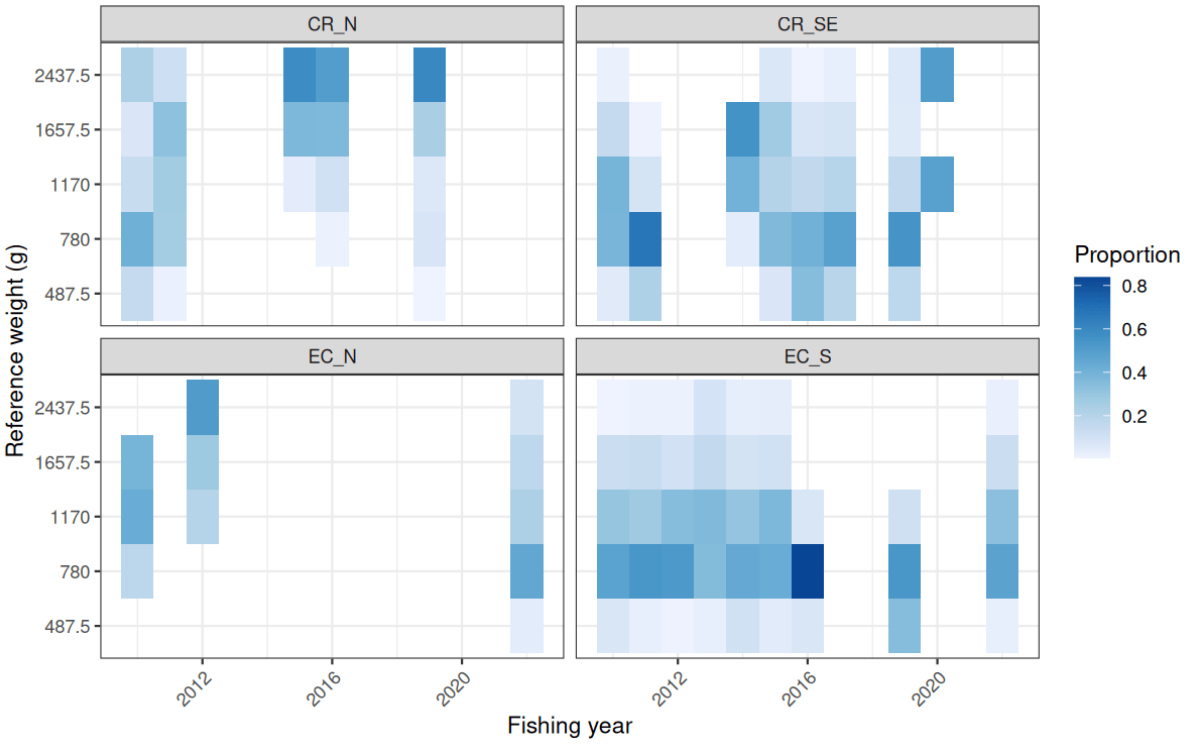

Figure 81: Proportion in grade by region.

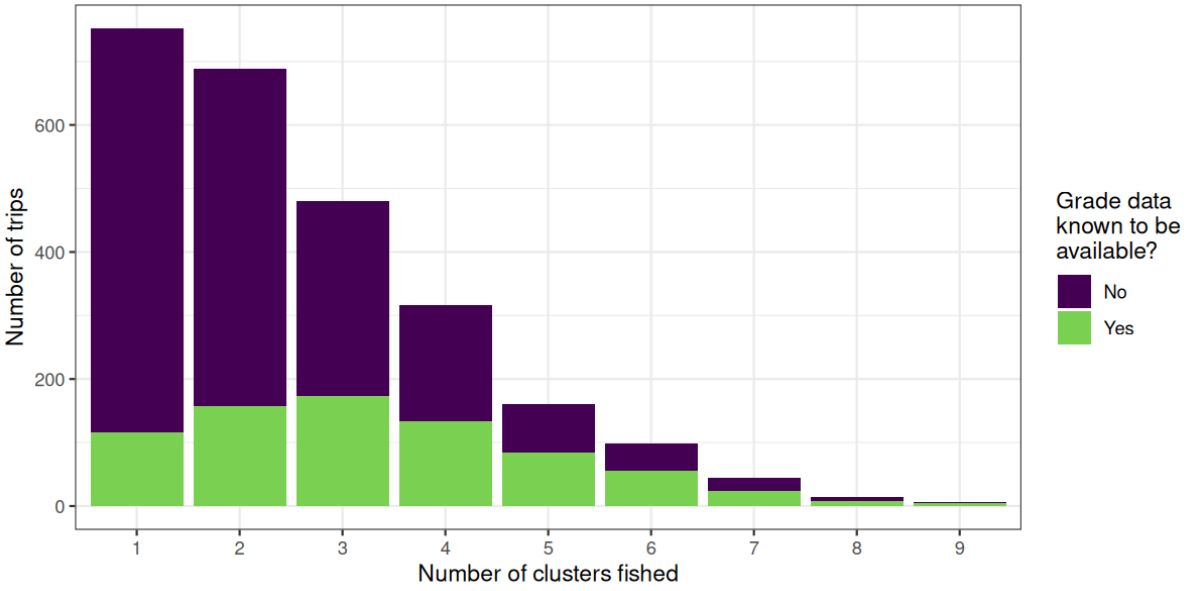

Figure 82: The number of areas (from the spatial clustering analysis) fished per trip, with trips classified according to whether or not it landed to an operator that is currently known to be able to provide trip level grade data for alfonsino in an electronic format.

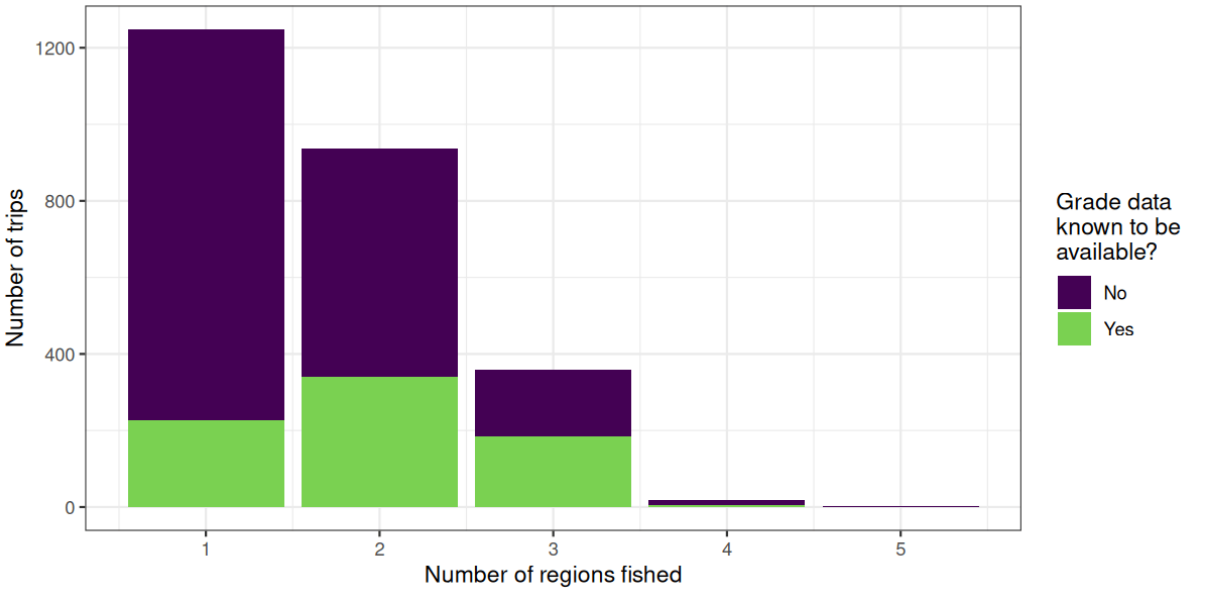

Figure 83: The number of regions fished per trip, with trips classified according to whether or not it landed to an operator that is currently known to be able to provide trip level grade data for alfonsino in an electronic format. Any fishing outside of the four key regions was allocated to an Other region.

6. DISCUSSION

This report has evaluated a range of information in order to characterise the alfonsino fishery, understand the stock structure, and consider how to monitor the stock.

The use of spatial clustering of fishing event locations was successful in providing coherent strata for summarising the activity in the fishery. Vessels that landed alfonsino from BYX 2 and BYX 3 were involved in a range of target fisheries, and the cluster analysis assisted in highlighting the particular areas that were most important for alfonsino target fishing. The alfonsino fishery has evolved since it became established in the 1980s, in particular the development of target fisheries on eastern Chatham Rise in addition to the areas fished initially on the east coast of the North Island. Demonstrating that the fishery has subsequently tended to fish the same areas, rather than moving to new areas every few years, has been important in recognising that the fishery has an established spatial footprint and is not simply following a process of serially depleting the biomass in newly found areas of alfonsino abundance.

The spatial cluster analysis has also provided an appropriate means of establishing spatial strata for use in CPUE analyses. Statistical Areas, or other arbitarily defined areas, risk masking within-area differences that are particularly relevant for "feature-based" fisheries, such as alfonsino. While the decisions about the particular parameters to use in the spatial clustering algorithm still require a judgement to be made, the areas can be evaluated with respect to the underlying bathymetry and fishing activity patterns to ensure that the resulting areas are indeed spatially discrete. Because the clustering of fishing effort was applied to all fishing events from trips that landed alfonsino from BYX 2 and BYX 3, many of the areas identified were peripheral to the target fishery for alfonsino. Furthermore, the exploratory CPUE analyses indicated that abundance trends were more similar in nearby areas than between more distant areas. As a result, amalgamating adjacent areas has allowed the identification of four key regions in the BYX 2 and BYX 3 alfonsino fishery, with a region-level CPUE analysis indicating that abundance trends differ between these regions.

The alfonsino fleet is small, but the vessels involved have tended to fish a range of areas rather than just one of the four regions. As a consequence, a CPUE model fitted to all regions simultaneously performed better than models fitted to the areas separately. The larger dataset, and the opportunity to estimate vessel coefficients based on their wider activity, provided a model with better diagnostics than any of the regional models. This implies that the best indication of regional level abundance trends is provided by the residual coefficients by area from the multi-region model, rather than the annual indices from the individual region models. These residual coefficients are only provided for the positive catch model in the multi-regional analysis, but this is likely to be adequate—at present—because there is only a minor trend in the binomial model for the occurrence of positive catches.

The CPUE standardisation models considered here are based on data that provide the potential to estimate seasonal and spatial differences in catch rates, the relative performance of different vessels, and of different gears and net openings. However, one recent influence on the alfonsino fishery has been the need to avoid bluenose bycatch, as a consequence of reductions in the catch limits for bluenose throughout New Zealand. To the extent that bluenose catch avoidance involves changes in the areas fished, or changes in fishing depths and net openings captured in the tow by tow data, the CPUE standardisation should account for these changes. However, where bluenose avoidance involves gear modification (for example, to facilitate the escape of bluenose from trawls), or behavioural changes in how tows are carried out, it is unlikely that these will be adequately accounted for.

The apparently differing trends in alfonsino abundance at the regional level highlight the importance of understanding the stock structure and dynamics. Biological sampling data from the fishery are limited. Nevertheless, these data provide evidence of depth stratification by size, with small alfonsino being encountered in shallower target fisheries (e.g., silver warehou target trawling) and larger fish dominating the alfonsino bycatch in the deeper orange roughy fishery. The observer data also indicate that the largest alfonsino encountered are almost exclusively female, consistent with the differential growth indicated by Massey & Horn (1990), and that females are generally more prevalent in the catch.

Taking into account the long pelagic larval stage of alfonsino, Horn & Massey (1989) suggested that alfonsino in New Zealand waters could form part of an oceanic eddy population where the east coast of the North Island represents a non-reproductive 'vegetative' zone where fish grow to maturity before leaving for a reproductive area elsewhere. Surface currents flow generally southwards on the North Island east coast, and eastwards along the north of the Chatham Rise, before encountering a northwards flow to the east of the Chatham Rise (Figure 84). Shotton (2016) notes that catches of alfonsino have been reported from the Louisville Ridge, visible in Figure 84 to the east of New Zealand, although alfonsino have only been targeted infrequently with the main fishery in the area focussed on orange roughy (Clark 2008).

Some northward surface current flow is also apparent from the mid Chatham Rise, around 179°E; this represents the eastern boundary of the Wairarapa Eddy (Chiswell 2003). Smith & Paul (2000) suggest that it is possible that the BYX 2 population of alfonsino could be confined to this eddy system, with BYX 3 potentially confined to a second eddy system lying further east.

In general, Smith & Paul (2000) consider that there are two potential stock models for alfonsino: a single stock with extensive larval dispersal but little adult movement, at least between the east coast of the North Island and the Chatham Rise fishery, or two stocks with larvae confined to separate gyre systems and little adult movement. They suggested that stock discrimination based on parasites or morphometrics may be suitable for further investigation of stock dynamics, with tagging, otolith microchemistry, genetics and life history traits considered unsuitable. Although the results of Massey & Horn (1990) were described, Smith & Paul (2000) do not discuss the potential benefits of comparing age distributions—spatially and over time—in further understanding the structure and dynamics of alfonsino in New Zealand, an approach that is also likely to provide data useful in future stock assessments.

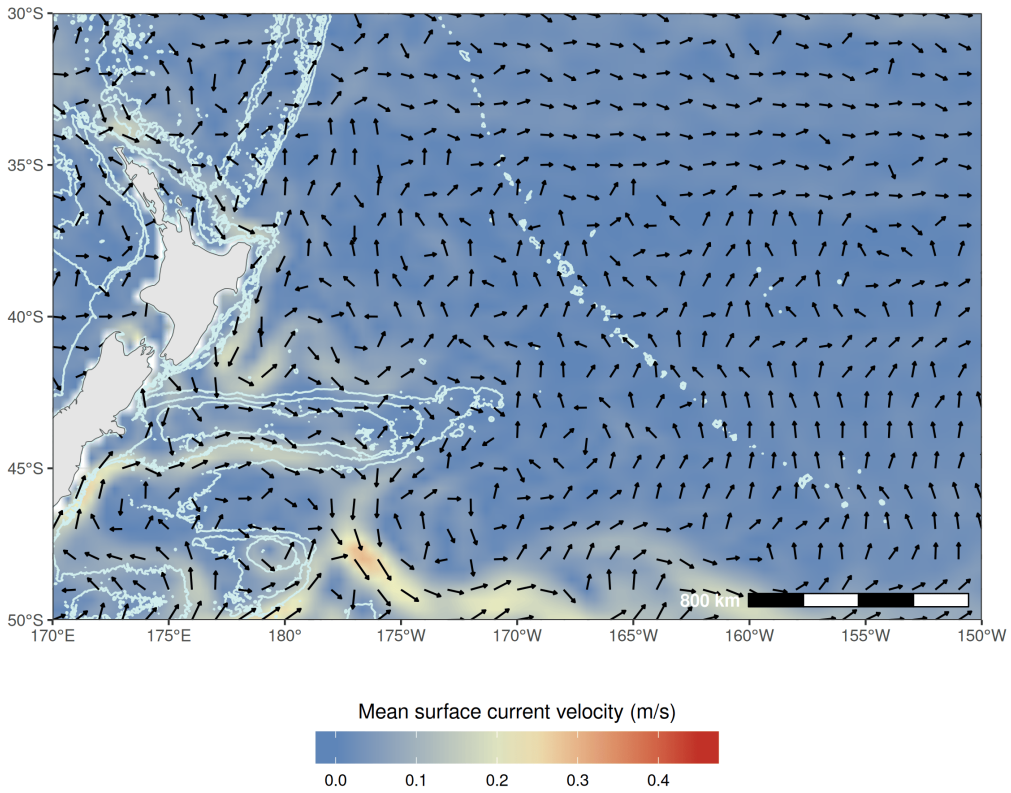

Figure 84: Bathymetry and OSCAR (Dohan 2021) surface current data for the area including and surrounding the BYX 2 and BYX 3 fishery. Average current speed in metres per second is shown via the colour scale while average current direction, and relative velocity, is indicated by the arrows.

Massey & Horn (1990) investigated the validity of the otolith zone counts used for ageing alfonsino by following the marginal index of otoliths, defined as the distance from the outer edge of the last hyaline ring to the otolith edge divided by the width of the last complete opaque and hyaline ring, over the course of a year. In each area studied, the marginal index dropped from June to December, and this was interpreted as supporting the interpretation that one opaque and one hyaline zone was laid down in alfonsino otoliths each year. Most otoliths were read whole, although some were ground to provide thinner sections.

Fish older than 15 years of age were rare in the samples studied by Massey & Horn (1990). An initial study of bomb radiocarbon ageing, using twelve alfonsino otoliths from the Indian Ocean, has suggested that whole otolith ageing may underestimate the age of fish older than 10 years (Andrews 2023). Use of transverse sections for zone counts from larger otoliths, together with further comparisons between fine scale ring counts and bomb radiocarbon data, has been recommended. The initial sample had one fish with an initial estimated age of 25 years, but where the otolith mass and bomb radiocarbon signal suggested an age around 70 years. Subsequent reading of fine scale zones in an otolith section suggested an age of 61 years.

6.1 Future research

Although the CPUE analyses reported here provide an indication of stock abundance trends for different parts of the New Zealand alfonsino fishery (noting the caveats around bluenose bycatch avoidance), they do not yet provide a tool for stock-level abundance monitoring, with associated targets and limits. A better understanding of stock structure and dynamics is required to assist in interpreting the differing regional trends in alfonsino CPUE. Although MacGibbon (2015) suggested exploring the use of total mortality (Z) estimates for assessing alfonsino stock status, Horn & Massey (1989) previously advised against estimating mortality rates from age data due to the likelihood that age distributions from the key east coast North Island fisheries were influenced by age-specific migration.

Unfortunately there has been little advancement in understanding of alfonsino biology in New Zealand since the early 1990s (Horn & Massey 1989, Massey & Horn 1990) despite a review of potential approaches for understanding stock structure in the late 1990s (Smith & Paul 2000). Some biological sampling by Fisheries New Zealand observers has occurred, but has not provided representative data from the fishery.

As a result, the Deepwater Working group agreed:

- that comprehensive biological sampling of the alfonsino fishery should be undertaken to interpret varying abundance trends and understand stock structure over the fishery. Shore based sampling may be adequate as long as the process allows data to be collected at an appropriate spatial scale (i.e., cluster area or region);
- revisiting ageing protocols for alfonsino taking into account the results of the bomb radiocarbon study contracted by SIOFA; and
- reviewing the collection of biological data and otoliths from alfonsino to ensure that these assist in developing a better understanding of alfonsino population structure.

7. ACKNOWLEDGEMENTS

This work was funded by alfonsino quota owners via the Inshore Council of Seafood New Zealand. Access to commercial catch, effort and landings data, and data collected by observers, was provided by Fisheries New Zealand. Sealord and Talleys provided commercial grading data. The Deepwater Working Group provided periodic review of the work presented here, and constructive suggestions that have improved the final outputs. Discussions of alfonsino fisheries in the Indian Ocean with Alistair Dunn, Steve Brouwer and Charles Heaphy were also helpful.

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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

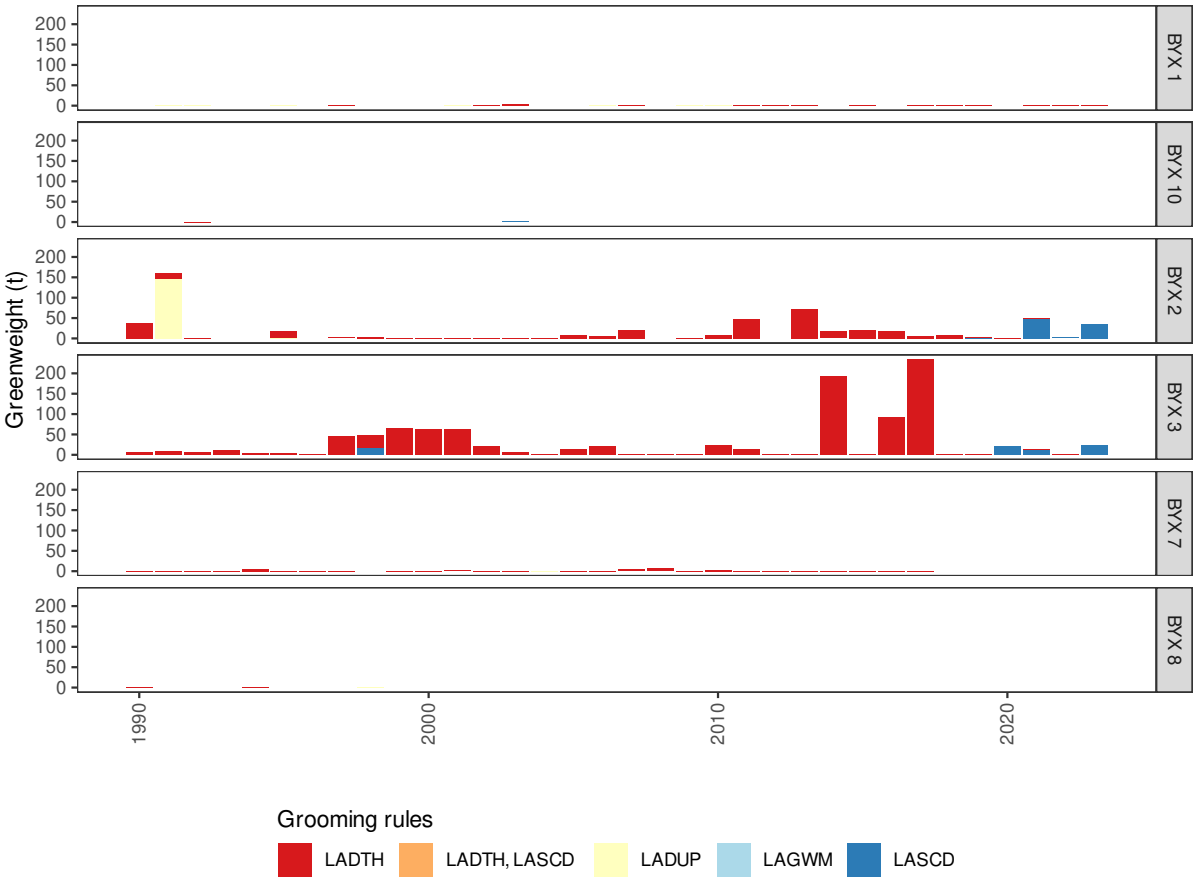

Figure A.1: The quantity of landings dropped, with the relevant grooming rules indicated, by stock and fishing year.

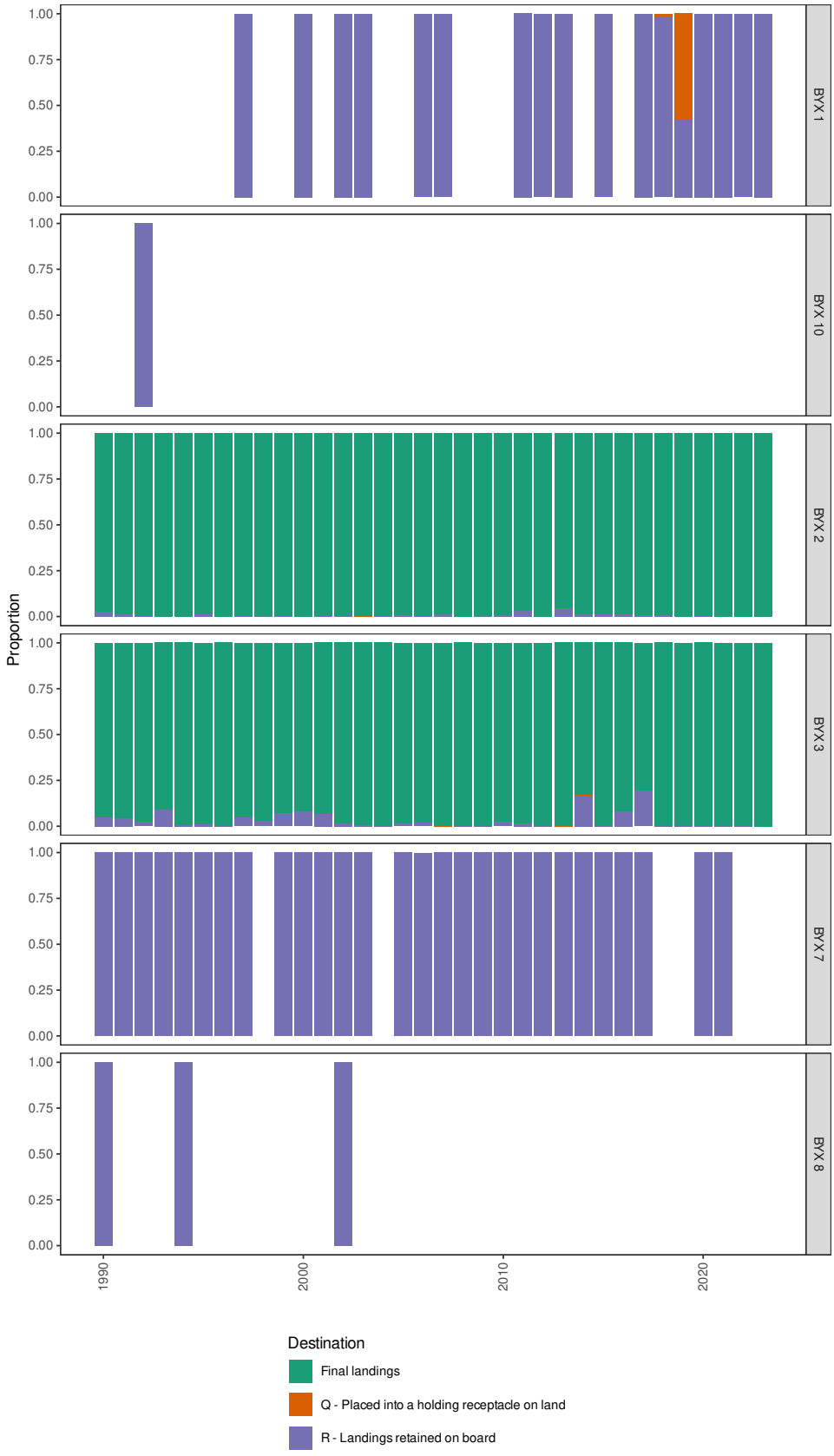

Figure A.2: The proportion of total (final and non-final) landings that are initially to non-final destinations, by stock and fishing year.

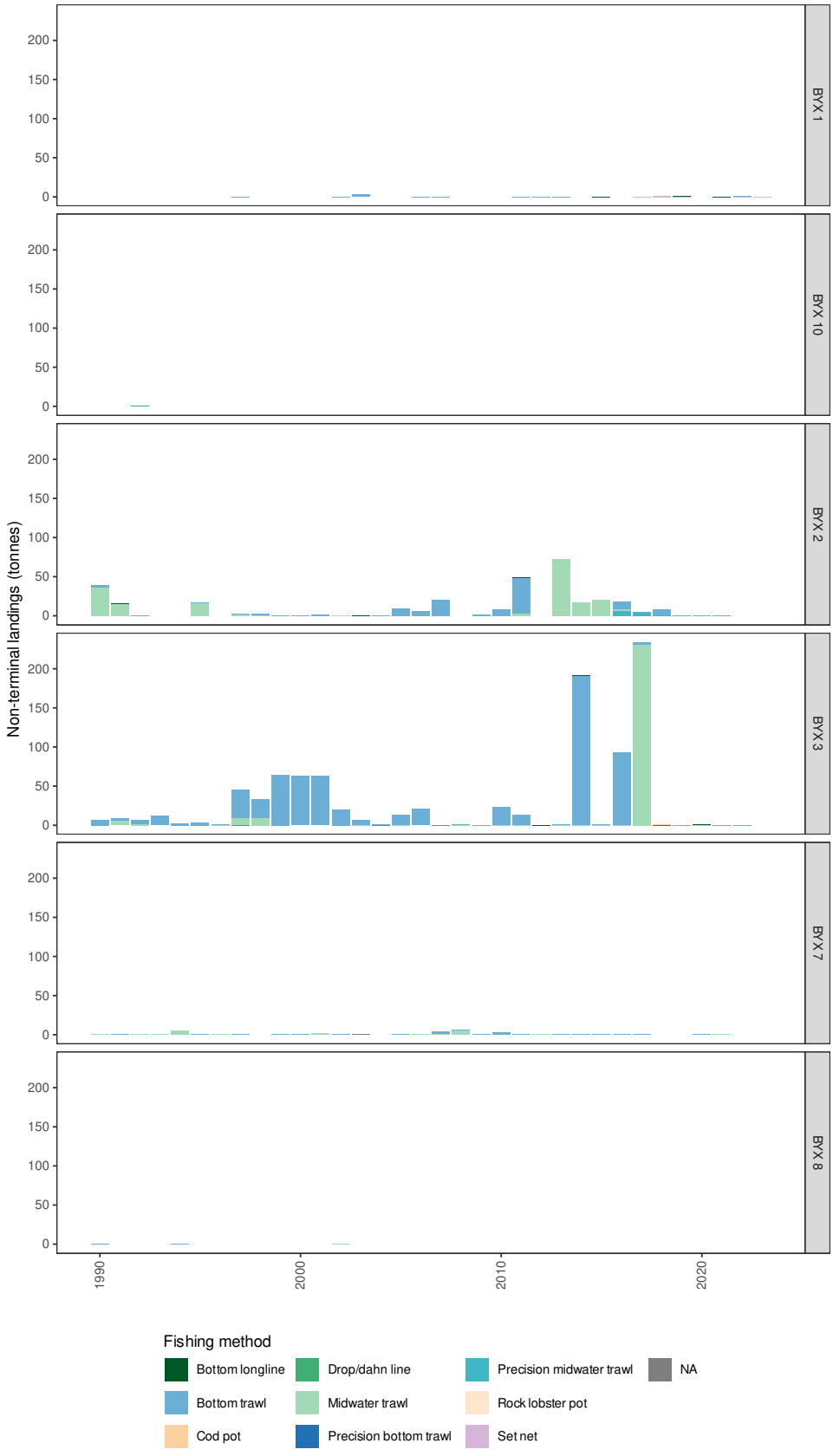

Figure A.3: The quantity of non-final landings, by stock, fishing year, and the modal fishing method used on the trip.

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
BYX 1	2003	1	14.5	0.1450
BYX 1	2010	1	10.0	0.1000
BYX 1	2011	1	18.0	0.1800
BYX 1	2019	1	150.0	1.5000
BYX 2	1996	1	105 222.0	1 052.2200
BYX 2	2011	3	34 538.0	98.0636
BYX 2	2015	1	1 160.0	11.6000
BYX 2	2016	1	866.0	8.6600

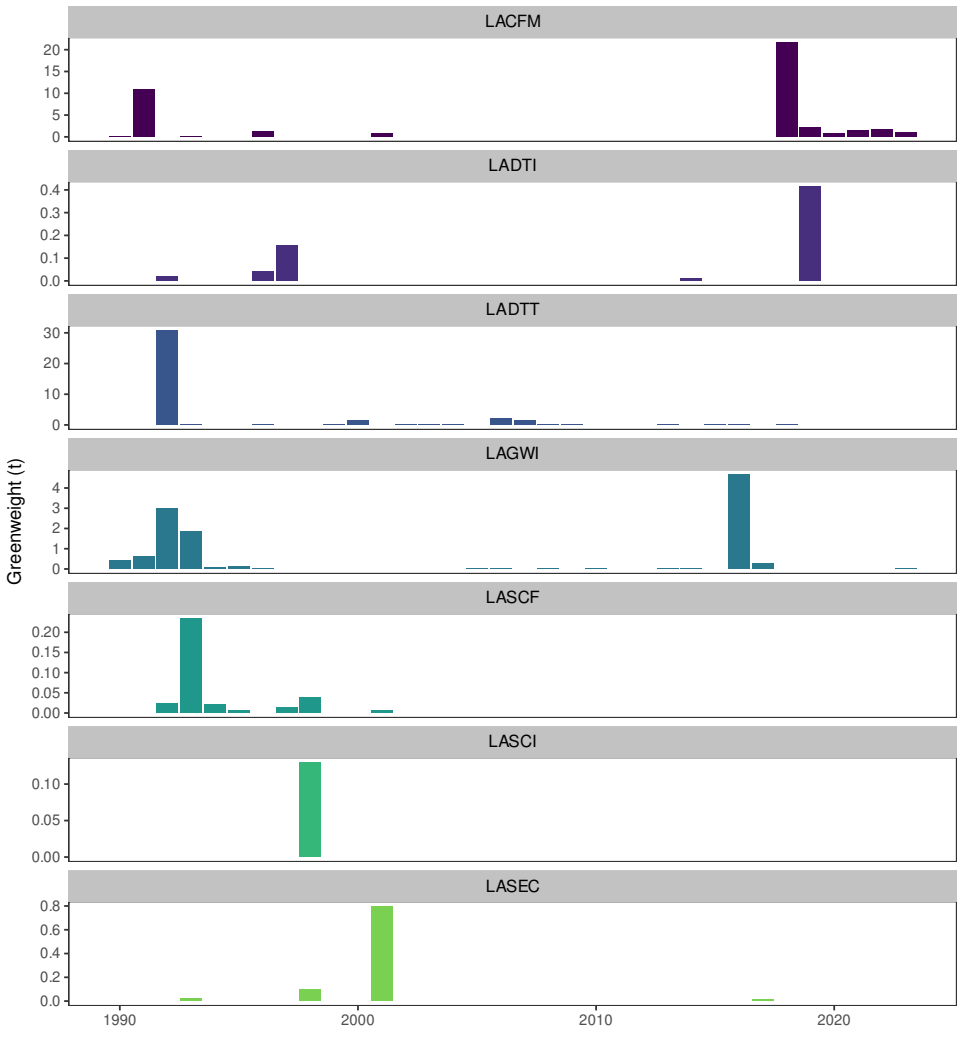

Figure A.4: The quantity of landings flagged by the grooming rules, or where fixes were applied to fields other than the landed greenweight. Note that some landing events may be affected by multiple rules.

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

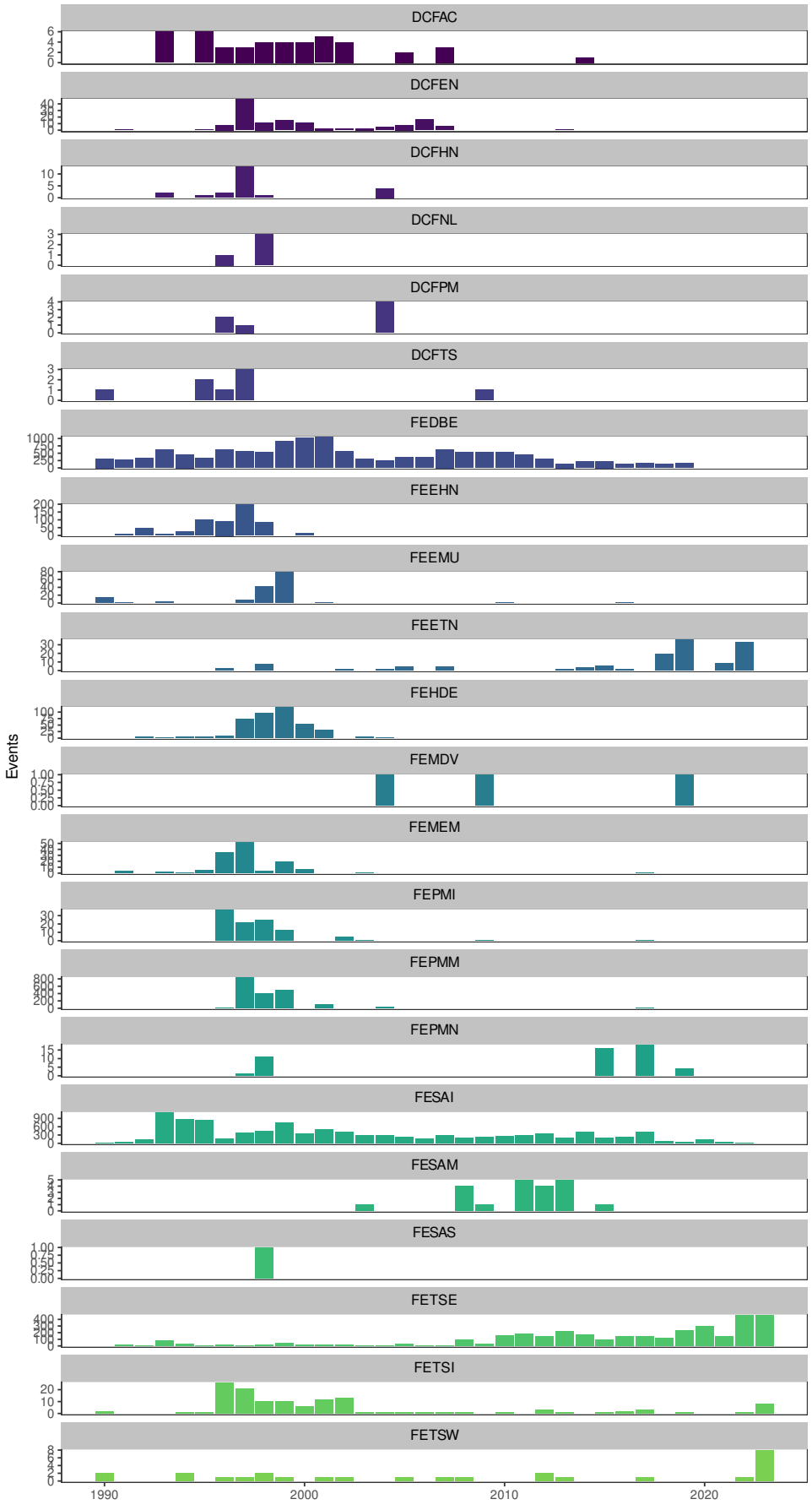

Figure A.5: The number of fishing events flagged or fixed by the grooming rules. Note that some events may be affected by multiple rules.

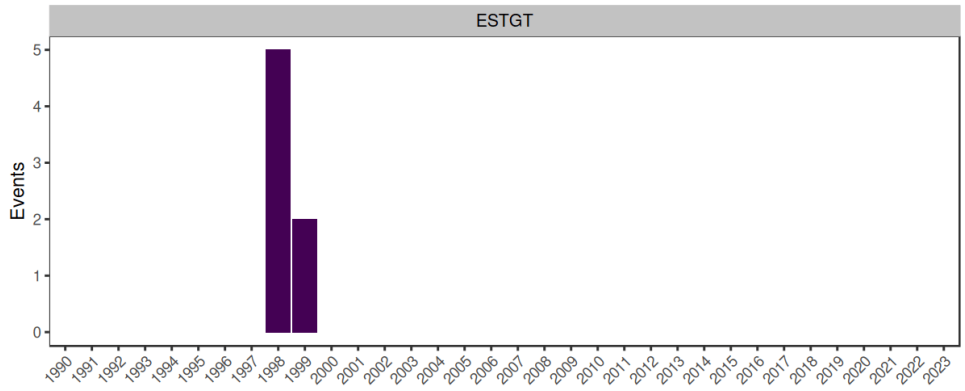

Figure A.6: The number of fishing events where the estimated catch of alfonsino was flagged or fixed by the grooming rules. Note that some events may be affected by multiple rules.

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 BYX 1, BYX 2, BYX 3, BYX 7, BYX 8 and BYX 10 from 1990 to 2023.

Fishing year	BYX 1		BYX 10		BYX 2		BYX 3		BYX 7		BYX 8	
	TACC	MHR/QMR	TACC	MHR/QMR	TACC	MHR/QMR	TACC	MHR/QMR	TACC	MHR/QMR	TACC	MHR/QMR
1990	27.40	24.08	10.00	-	1 630.00	1 495.82	247.20	147.31	30.00	21.18	20.00	0.27
1991	31.20	16.93	10.00	-	1 274.30	1 458.74	1 006.90	202.35	80.00	26.25	20.00	-
1992	31.30	6.67	10.00	0.07	1 480.00	1 368.02	1 007.20	263.76	80.50	1.69	20.00	0.06
1993	31.30	5.01	10.00	0.08	1 499.00	1 650.20	1 007.20	113.20	80.50	11.98	20.00	0.05
1994	31.30	7.25	10.00	-	1 503.50	1 688.22	1 007.20	274.62	80.50	31.16	20.00	0.15
1995	31.30	11.48	10.00	-	1 569.20	1 669.96	1 007.20	500.76	80.50	59.26	20.00	0.13
1996	31.30	10.71	10.00	-	1 569.20	1 868.81	1 010.40	976.93	80.50	65.68	20.00	0.11
1997	31.30	39.25	10.00	0.01	1 569.20	1 854.12	1 010.40	983.12	80.50	76.54	20.00	0.12
1998	31.30	14.42	10.00	0.15	1 574.80	1 651.74	1 010.40	1 164.21	80.50	67.30	20.00	0.10
1999	31.30	37.16	10.00	-	1 574.80	1 658.43	1 010.40	911.90	80.50	13.27	20.00	3.42
2000	31.30	24.50	10.00	-	1 574.80	1 856.88	1 010.40	742.54	80.50	23.91	20.00	0.04
2001	31.30	25.42	10.00	-	1 574.80	1 665.42	1 010.40	889.68	80.50	20.80	20.00	0.01
2002	300.00	123.19	10.00	-	1 574.80	1 573.91	1 010.40	1 197.00	80.50	10.08	20.00	0.03
2003	300.00	136.97	10.00	-	1 574.80	1 665.15	1 010.40	1 117.86	80.50	6.73	20.00	0.11
2004	300.00	218.55	10.00	-	1 574.80	1 467.91	1 010.40	884.02	80.50	11.41	20.00	1.98
2005	300.00	300.23	10.00	-	1 574.80	1 668.85	1 010.40	1 067.45	80.50	14.30	20.00	1.70
2006	300.00	194.95	10.00	-	1 574.80	1 633.35	1 010.40	1 067.66	80.50	7.20	20.00	0.21
2007	300.00	66.15	10.00	-	1 574.80	1 643.86	1 010.40	945.21	80.50	21.34	20.00	0.18
2008	300.00	154.01	10.00	-	1 574.80	1 531.52	1 010.40	1 030.02	80.50	32.48	20.00	0.24
2009	300.00	172.40	10.00	-	1 574.80	1 589.49	1 010.40	894.58	80.50	18.48	20.00	0.04
2010	300.00	159.19	10.00	-	1 574.80	1 691.11	1 010.40	997.20	80.50	17.58	20.00	0.07
2011	300.00	47.68	10.00	-	1 574.80	1 686.44	1 010.40	1 084.22	80.50	17.11	20.00	0.24
2012	300.00	45.27	10.00	-	1 574.80	1 602.59	1 010.40	1 037.32	80.50	14.16	20.00	0.01
2013	300.00	21.56	10.00	-	1 574.80	1 605.09	1 010.40	1 013.08	80.50	39.37	20.00	0.09
2014	300.00	29.15	10.00	-	1 574.80	1 550.83	1 010.40	929.73	80.50	58.01	20.00	0.10
2015	300.00	52.59	10.00	-	1 574.80	1 617.45	1 010.40	996.74	80.50	26.48	20.00	0.04
2016	300.00	24.08	10.00	-	1 574.80	1 573.41	1 010.40	1 103.94	80.50	27.48	20.00	0.03
2017	300.00	21.57	10.00	-	1 574.80	1 610.62	1 010.40	990.78	80.50	28.79	20.00	0.03
2018	300.00	73.36	10.00	-	1 574.80	1 691.75	1 010.40	754.06	80.50	11.78	20.00	0.04
2019	300.00	10.79	10.00	-	1 574.80	1 513.60	1 010.40	806.68	80.50	11.11	20.00	0.03
2020	300.00	3.49	10.00	-	1 574.80	1 672.77	1 010.40	712.83	80.50	3.33	20.00	0.04
2021	300.00	10.30	10.00	-	1 574.80	1 594.40	1 010.40	427.48	80.50	6.14	20.00	0.08
2022	300.00	9.89	10.00	-	1 574.80	1 631.05	1 010.40	564.82	80.50	5.27	20.00	0.04
2023	300.00	22.82	10.00	-	1 574.80	1 561.18	1 010.40	264.07	80.50	3.87	20.00	0.02

Table B.2: Annual BYX 2 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 alfonsino was targeted. – : no observations.

Fishing year	QMR/MHR (t)	Catches (t)	Allocated catches				Target catches	
			Total (t)	MW-PRM (%)	BT-PRB (%)	BLL (%)	tonnes	%
1990	1 495.82	1 517.30	1 456.97	91.11	8.83	0.02	1 183.12	81.20
1991	1 458.74	1 312.99	1 240.31	81.95	17.77	0.25	837.17	67.50
1992	1 368.02	1 574.64	1 576.21	89.64	9.95	0.37	1 331.31	84.46
1993	1 650.20	1 867.54	1 838.29	88.96	10.84	0.14	1 461.61	79.51
1994	1 688.22	1 677.96	1 667.41	77.91	21.74	0.27	1 303.75	78.19
1995	1 669.96	1 629.78	1 706.75	63.73	35.99	0.27	1 211.20	70.97
1996	1 868.81	1 699.31	1 706.05	53.31	46.45	0.22	956.21	56.05
1997	1 854.12	1 824.05	1 780.72	48.27	51.43	0.15	864.58	48.55
1998	1 651.74	1 584.93	1 471.81	69.88	29.85	0.26	819.36	55.67
1999	1 658.43	1 679.04	1 691.77	75.62	23.97	0.40	1 001.91	59.22
2000	1 856.88	1 852.46	1 879.94	68.77	30.54	0.68	1 040.58	55.35
2001	1 665.42	1 664.59	1 650.14	74.66	24.34	0.98	1 010.33	61.23
2002	1 573.91	1 454.02	1 505.27	78.76	20.76	0.44	1 033.02	68.63
2003	1 665.15	1 723.79	1 720.84	68.43	30.93	0.63	1 002.70	58.27
2004	1 467.91	1 468.37	1 465.04	82.88	16.26	0.85	951.44	64.94
2005	1 668.85	1 673.58	1 666.14	71.29	27.70	1.00	1 243.28	74.62
2006	1 633.35	1 616.64	1 621.33	60.94	36.97	2.08	1 143.14	70.51
2007	1 643.86	1 644.97	1 650.04	50.35	46.18	3.47	1 183.68	71.74
2008	1 531.52	1 512.84	1 512.31	54.76	37.41	7.36	984.66	65.11
2009	1 589.49	1 588.97	1 585.82	58.32	33.11	8.07	1 040.30	65.60
2010	1 691.11	1 644.42	1 660.15	50.71	44.48	4.79	1 293.32	77.90
2011	1 686.44	1 590.42	1 645.70	44.40	50.85	4.75	1 156.40	70.27
2012	1 602.59	1 608.21	1 601.90	46.38	49.88	3.72	1 248.40	77.93
2013	1 605.09	1 605.19	1 632.29	73.49	24.46	2.03	1 212.41	74.28
2014	1 550.83	1 531.38	1 530.60	41.63	55.33	2.92	1 148.49	75.04
2015	1 617.45	1 633.12	1 627.29	55.03	40.78	4.16	1 068.74	65.68
2016	1 573.41	1 611.07	1 567.92	55.43	39.48	5.06	1 143.17	72.91
2017	1 610.62	1 617.56	1 636.71	59.63	36.29	3.99	1 033.67	63.16
2018	1 691.75	1 673.16	1 651.42	64.64	33.00	2.26	1 281.06	77.57
2019	1 513.60	1 524.84	1 520.96	64.73	33.39	1.77	1 392.00	91.52
2020	1 672.77	1 671.86	1 705.00	68.66	29.57	1.74	1 403.44	82.31
2021	1 594.40	1 602.50	1 605.70	70.17	28.16	1.42	1 462.19	91.06
2022	1 631.05	1 600.97	1 600.95	49.98	49.05	0.77	1 335.58	83.42
2023	1 561.18	1 591.55	1 594.36	63.11	35.46	1.22	1 343.77	84.28

Table B.3: Annual BYX 3 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 alfonsino was targeted. – : no observations.

Fishing year	QMR/MHR (t)	Catches (t)	Allocated catches				Target catches	
			Total (t)	MW-PRM (%)	BT-PRB (%)	BLL (%)	tonnes	%
1990	147.31	140.25	66.60	67.28	31.33	-	57.86	86.87
1991	202.35	207.33	140.19	48.78	50.64	-	56.20	40.09
1992	263.76	267.78	253.36	24.99	74.39	0.00	42.08	16.61
1993	113.20	120.81	91.10	7.75	89.89	0.09	3.69	4.06
1994	274.62	401.81	386.59	4.78	94.59	0.01	23.11	5.98
1995	500.76	381.99	349.54	27.22	72.07	0.07	120.24	34.40
1996	976.93	926.88	868.78	13.35	86.46	0.02	540.90	62.26
1997	983.12	949.82	918.28	6.99	92.59	0.02	653.92	71.21
1998	1 164.21	1 140.64	1 158.23	7.68	92.17	0.02	687.14	59.33
1999	911.90	868.30	1 034.63	9.18	90.56	0.04	857.12	82.84
2000	742.54	740.69	723.98	9.13	90.66	0.03	569.42	78.65
2001	889.68	870.21	874.13	6.70	93.00	0.02	647.63	74.09
2002	1 197.00	1 261.01	1 228.48	1.55	98.28	0.03	608.00	49.49
2003	1 117.86	1 110.07	1 104.88	2.66	97.28	0.01	699.74	63.33
2004	884.02	870.23	869.90	0.82	99.09	0.04	645.63	74.22
2005	1 067.45	1 061.48	1 064.41	8.52	91.44	0.03	877.06	82.40
2006	1 067.66	1 179.52	1 180.44	26.12	73.85	0.02	987.21	83.63
2007	945.21	940.93	942.73	36.08	63.76	0.15	882.09	93.57
2008	1 030.02	1 033.11	1 032.94	55.47	44.20	0.31	941.71	91.17
2009	894.58	896.02	896.33	37.26	62.63	0.09	829.56	92.55
2010	997.20	997.92	978.65	48.59	51.07	0.32	899.25	91.89
2011	1 084.22	1 152.26	1 094.78	41.84	57.85	0.29	1 046.96	95.63
2012	1 037.32	1 037.00	1 037.63	62.15	37.72	0.10	1 014.22	97.74
2013	1 013.08	1 020.10	1 002.29	78.32	21.60	0.05	976.15	97.39
2014	929.73	930.81	930.31	47.56	52.29	0.09	865.53	93.04
2015	996.74	891.62	889.24	62.12	37.82	0.03	812.22	91.34
2016	1 103.94	1 040.65	1 081.19	60.34	39.60	0.02	1 018.73	94.22
2017	990.78	957.72	965.24	80.19	19.66	0.01	900.41	93.28
2018	754.06	767.32	766.68	95.07	4.84	0.02	723.78	94.40
2019	806.68	901.41	905.11	83.20	16.76	0.01	855.50	94.52
2020	712.83	655.51	656.07	92.23	7.68	0.01	617.58	94.13
2021	427.48	484.77	483.79	88.67	11.19	0.02	457.56	94.58
2022	564.82	564.35	564.74	86.75	13.21	0.01	546.78	96.82
2023	264.07	264.22	262.68	72.46	27.43	0.01	226.84	86.36

Table B.4: Annual alfonsino catches (t) by destination code for the BYX 2 Quota Management Area. L = Landings to an LFR, O = Catch transported outside the EEZ. A complete list of destination codes is provided in Table 2. – : no observations.

Fishing year	L	Other	Total
1990	1 509.07	8.23	1 517.30
1991	1 307.70	5.29	1 312.99
1992	1 574.63	0.01	1 574.64
1993	1 866.82	0.71	1 867.54
1994	1 677.94	0.02	1 677.96
1995	1 629.78	-	1 629.78
1996	1 699.13	0.18	1 699.31
1997	1 823.90	0.15	1 824.05
1998	1 584.88	0.05	1 584.93
1999	1 678.98	0.06	1 679.04
2000	1 852.41	0.05	1 852.46
2001	1 663.92	0.67	1 664.59
2002	1 454.02	0.00	1 454.02
2003	1 723.78	0.01	1 723.79
2004	1 468.33	0.04	1 468.37
2005	1 668.40	5.18	1 673.58
2006	1 615.23	1.42	1 616.64
2007	1 642.94	2.02	1 644.97
2008	1 512.83	0.01	1 512.84
2009	1 585.89	3.08	1 588.97
2010	1 636.94	7.48	1 644.42
2011	1 590.30	0.12	1 590.42
2012	1 608.07	0.14	1 608.21
2013	1 604.91	0.28	1 605.19
2014	1 531.24	0.14	1 531.38
2015	1 632.85	0.27	1 633.12
2016	1 610.96	0.11	1 611.07
2017	1 617.34	0.22	1 617.56
2018	1 672.82	0.34	1 673.16
2019	1 505.87	18.97	1 524.84
2020	1 663.59	8.27	1 671.86
2021	1 593.55	8.95	1 602.50
2022	1 600.17	0.80	1 600.97
2023	1 561.01	30.54	1 591.55

Table B.5: Annual alfonsino catches (t) by destination code for the BYX 3 Quota Management Area. L = Landings to an LFR, O = Catch transported outside the EEZ. A complete list of destination codes is provided in Table 2. – : no observations.

Fishing year	L	O	Other	Total
1990	134.07	-	6.19	140.25
1991	181.47	11.33	14.53	207.33
1992	167.21	79.03	21.54	267.78
1993	63.27	33.34	24.19	120.81
1994	381.01	0.74	20.07	401.81
1995	337.26	2.84	41.89	381.99
1996	913.59	1.44	11.84	926.88
1997	915.87	0.38	33.57	949.82
1998	1 082.02	15.26	43.36	1 140.64
1999	867.53	-	0.78	868.30
2000	723.25	2.26	15.18	740.69
2001	867.07	-	3.14	870.21
2002	1 258.33	-	2.68	1 261.01
2003	1 108.84	0.01	1.21	1 110.07
2004	869.27	0.04	0.91	870.23
2005	1 060.73	-	0.75	1 061.48
2006	1 179.13	-	0.39	1 179.52
2007	939.46	-	1.47	940.93
2008	1 032.37	-	0.74	1 033.11
2009	894.51	-	1.51	896.02
2010	997.12	-	0.80	997.92
2011	1 151.00	-	1.26	1 152.26
2012	1 035.79	-	1.22	1 037.00
2013	1 014.68	-	5.42	1 020.10
2014	928.61	-	2.20	930.81
2015	889.57	-	2.05	891.62
2016	1 038.80	-	1.85	1 040.65
2017	956.93	-	0.79	957.72
2018	765.04	-	2.28	767.32
2019	805.16	-	96.26	901.41
2020	655.18	-	0.32	655.51
2021	426.98	-	57.78	484.77
2022	563.86	-	0.49	564.35
2023	263.16	-	1.06	264.22

Table B.6: Annual catches by landed state of alfonsino from the BYX 2 Quota Management Area. DRE = Dressed, FIL = Fillets: skin-on, GRE = Green (or whole), GUT = Gutted, HGU = Headed and gutted, MEA = Fish meal. A complete list of product state codes is provided in Table F.1. – : no observations. Records where the landed state was missing were excluded.

Fishing year	GRE	DRE	HGU	GUT	MEA	FIL	Other	Total
1990	1 407.17	-	110.14	-	-	-	-	1 517.30
1991	797.02	0.14	515.83	-	-	-	-	1 312.99
1992	837.82	483.23	253.58	0.01	-	-	-	1 574.64
1993	1 048.85	818.10	0.58	-	-	-	-	1 867.54
1994	1 464.51	100.84	112.61	-	-	-	-	1 677.96
1995	1 620.86	8.80	0.12	-	-	-	-	1 629.78
1996	1 498.54	196.95	3.82	-	-	-	-	1 699.31
1997	1 613.18	111.02	1.75	-	-	-	-	1 725.96
1998	1 474.46	110.47	-	-	-	-	-	1 584.93
1999	1 567.16	110.09	1.78	-	-	0.01	-	1 679.04
2000	1 745.73	105.01	1.65	-	-	0.08	-	1 852.46
2001	1 521.39	142.82	0.22	-	0.03	0.09	0.04	1 664.59
2002	1 343.56	110.13	0.17	-	0.03	0.12	0.03	1 454.02
2003	1 520.59	203.07	0.04	-	0.10	-	-	1 723.79
2004	1 359.77	107.92	0.21	-	0.41	-	0.06	1 468.37
2005	1 581.02	92.37	-	-	0.17	0.02	-	1 673.58
2006	1 487.07	129.55	0.00	-	0.01	-	-	1 616.64
2007	1 514.03	130.92	-	-	-	0.02	-	1 644.97
2008	1 404.93	107.91	-	-	-	-	-	1 512.84
2009	1 572.37	16.54	0.03	-	0.03	-	-	1 588.97
2010	1 225.56	418.54	-	0.01	0.31	-	-	1 644.42
2011	1 057.13	533.12	-	0.00	0.17	-	0.00	1 590.42
2012	1 166.35	441.13	-	-	0.72	0.01	-	1 608.21
2013	1 107.68	478.67	0.01	18.02	0.82	-	-	1 605.19
2014	1 191.53	337.37	0.01	0.00	2.47	-	-	1 531.38
2015	1 200.97	420.45	0.03	-	11.67	-	-	1 633.12
2016	1 436.25	151.69	-	22.76	0.38	-	-	1 611.07
2017	1 338.97	209.96	-	68.35	0.18	-	-	1 617.46
2018	1 512.81	48.14	-	112.00	0.03	0.18	-	1 673.16
2019	1 320.98	203.66	-	-	0.14	0.06	-	1 524.84
2020	1 322.75	348.74	0.01	-	0.37	0.00	-	1 671.86
2021	1 250.56	351.57	-	-	0.23	0.14	-	1 602.50
2022	971.33	627.88	-	-	1.17	0.58	0.00	1 600.97
2023	1 026.86	561.24	-	-	0.61	2.84	-	1 591.55

Table B.7: Annual catches by landed state of alfonsino from the BYX 3 Quota Management Area. DRE = Dressed, FIL = Fillets: skin-on, GRE = Green (or whole), GUT = Gutted, HGU = Headed and gutted, MEA = Fish meal. A complete list of product state codes is provided in Table F.1. – : no observations. Records where the landed state was missing were excluded.

Fishing year	GRE	DRE	MEA	HGU	FIL	GUT	Other	Total
1990	139.67	-	-	0.59	-	-	-	140.25
1991	168.81	22.73	0.12	15.67	-	-	-	207.33
1992	88.62	169.59	-	9.57	-	-	-	267.78
1993	19.20	101.52	0.02	0.08	-	-	-	120.81
1994	81.43	244.81	3.32	72.25	-	-	-	401.81
1995	178.67	202.31	0.82	0.19	-	-	-	381.99
1996	723.69	202.42	0.64	0.01	0.11	0.00	-	926.88
1997	349.04	590.59	3.13	6.80	0.26	-	-	949.82
1998	475.34	591.98	18.69	54.51	0.06	-	-	1 140.57
1999	576.87	288.92	2.48	0.02	0.02	-	-	868.30
2000	525.85	204.04	10.27	0.52	-	-	-	740.69
2001	679.81	187.52	2.87	0.01	-	-	-	870.21
2002	1 041.56	214.20	5.24	0.00	-	-	-	1 261.01
2003	827.86	262.65	19.47	0.00	-	-	0.09	1 110.07
2004	761.23	106.36	2.64	-	-	-	-	870.23
2005	1 001.63	46.81	13.04	-	-	0.01	-	1 061.48
2006	1 084.22	94.49	0.80	0.00	-	-	-	1 179.52
2007	682.24	257.07	1.62	-	-	-	-	940.93
2008	736.51	294.66	1.59	0.20	-	0.14	0.02	1 033.11
2009	843.62	49.95	2.27	-	-	0.19	-	896.02
2010	487.83	508.47	0.62	-	-	1.00	-	997.92
2011	612.19	539.08	0.57	0.16	-	0.26	-	1 152.26
2012	715.23	320.71	0.66	-	-	0.39	0.01	1 037.00
2013	592.81	426.17	1.10	0.01	-	0.02	-	1 020.10
2014	799.04	128.92	2.35	0.01	-	0.49	-	930.81
2015	701.97	179.64	9.07	0.76	-	0.18	-	891.62
2016	634.97	401.42	4.19	0.00	-	0.07	-	1 040.65
2017	209.09	736.95	8.41	0.00	3.19	0.09	-	957.72
2018	305.31	450.73	11.15	-	0.12	0.01	-	767.32
2019	578.76	313.12	9.28	0.02	0.21	0.02	-	901.41
2020	593.75	56.58	5.09	-	0.09	-	-	655.51
2021	365.99	111.72	6.94	-	0.12	-	-	484.77
2022	545.44	11.12	7.79	0.00	-	-	-	564.35
2023	171.13	81.76	10.98	-	0.35	-	-	264.22

Table B.8: Annual modal conversion factor reported for product state codes of alfonsino from the BYX 2 and BYX 3 Quota Management Areas. DRE = Dressed, FIL = Fillets: skin-on, GGU = Gilled and gutted, GRE = Green (or whole), GUT = Gutted, HGT = Headed, gutted, and tailed, HGU = Headed and gutted, MEA = Fish meal, ROE = Roe, SKF = Fillets: skin-off. – : no observations.

Fishing year	GGU	GRE	HGT	HGU	MEA	DRE	GUT	ROE	FIL	SKF
1990	1.10	1.00	1.40	1.40	5.56	-	-	-	-	-
1991	-	1.00	-	1.40	5.60	1.80	-	-	-	-
1992	-	1.00	-	1.40	5.60	1.80	1.10	-	-	-
1993	-	1.00	-	1.40	5.60	1.80	-	0.00	-	-
1994	-	1.00	-	1.40	5.60	1.80	-	-	-	-
1995	-	1.00	-	1.40	5.60	1.80	-	-	-	-
1996	-	1.00	-	1.40	5.60	1.95	1.10	-	2.30	-
1997	-	1.00	-	1.40	5.60	1.95	-	-	2.30	-
1998	-	1.00	-	1.40	5.60	1.95	-	-	2.30	-
1999	-	1.00	-	1.40	5.60	1.95	-	-	2.30	-
2000	-	1.00	-	1.40	5.60	1.95	-	-	2.30	-
2001	-	1.00	-	1.40	5.60	1.95	-	-	2.30	2.85
2002	-	1.00	-	1.40	5.60	1.95	-	-	2.30	2.85
2003	-	1.00	-	1.40	5.60	1.95	-	-	2.30	2.85
2004	-	1.00	-	1.40	5.60	1.95	-	-	-	2.85
2005	-	1.00	-	-	5.60	1.95	1.10	-	2.30	-
2006	-	1.00	-	1.40	5.60	1.95	-	-	2.30	-
2007	-	1.00	-	1.40	5.60	1.95	-	-	2.30	-
2008	-	1.00	-	1.40	5.60	1.95	1.10	-	-	2.85
2009	-	1.00	-	1.40	5.60	1.95	1.10	-	-	-
2010	-	1.00	-	1.40	5.60	1.95	1.10	-	-	2.85
2011	-	1.00	-	1.40	5.60	1.95	1.10	-	-	2.85
2012	-	1.00	-	-	5.60	1.95	1.10	-	2.30	2.85
2013	-	1.00	-	1.40	5.60	1.95	1.10	-	-	-
2014	-	1.00	-	1.40	5.60	1.95	1.10	-	-	-
2015	-	1.00	-	1.40	5.60	1.95	1.10	-	-	-
2016	-	1.00	-	1.40	5.60	1.95	1.10	-	-	-
2017	-	1.00	-	1.40	5.60	1.95	1.10	-	2.30	-
2018	-	1.00	-	-	5.60	1.95	1.10	-	2.30	-
2019	-	1.00	-	1.40	5.60	1.95	1.10	-	2.30	-
2020	-	1.00	-	1.40	-	1.95	-	-	2.30	-
2021	-	1.00	-	-	-	1.95	-	-	2.30	-
2022	-	1.00	-	1.40	-	1.95	-	-	2.30	2.85
2023	-	1.00	-	-	-	1.95	-	-	2.30	-

Table B.9: Reporting forms used for effort on trips landing alfonsino from the BYX 2 Quota Management Area in terms of data records and their allocated catches. A complete list of form type codes is provided in Table F.2. – : no observations.

	Records (N)											Allocated catches (t)										
Fishing year	TCP	CEL	TUN	LCE	Other	LTC	TCE	ERS - Trawl	ERS - Lining	ERS - Netting	Total	TCP	CEL	TUN	LCE	Other	LTC	TCE	ERS - Trawl	ERS - Lining	ERS - Netting	Total
1990	1161	612	-	-	-	-	-	-	-	-	1773	668.72	788.25	-	-	-	-	-	-	-	-	1456.97
1991	2251	635	-	-	-	-	-	-	-	-	2886	816.85	423.46	-	-	-	-	-	-	-	-	1240.31
1992	3318	607	-	-	-	-	-	-	-	-	3925	1421.40	154.81	-	-	-	-	-	-	-	-	1576.21
1993	3265	524	4	-	-	-	-	-	-	-	3793	1755.92	82.37	0	-	-	-	-	-	-	-	1838.29
1994	4487	511	-	-	-	-	-	-	-	-	4998	1617.17	50.25	-	-	-	-	-	-	-	-	1667.41
1995	5023	384	-	-	-	-	-	-	-	-	5407	1663.00	43.74	-	-	-	-	-	-	-	-	1706.75
1996	5737	447	3	-	-	-	-	-	-	-	6187	1655.39	50.65	0	-	-	-	-	-	-	-	1706.05
1997	6406	362	-	-	-	-	-	-	-	-	6768	1753.72	27.00	-	-	-	-	-	-	-	-	1780.72
1998	6934	432	-	-	-	-	-	-	-	-	7366	1439.48	32.33	-	-	-	-	-	-	-	-	1471.81
1999	7688	402	-	-	-	-	-	-	-	-	8090	1312.91	378.86	-	-	-	-	-	-	-	-	1691.77
2000	7016	505	10	-	-	-	-	-	-	-	7531	1519.16	360.78	0	-	-	-	-	-	-	-	1879.94
2001	5604	471	1	-	-	-	-	-	-	-	6076	1319.45	330.69	0	-	-	-	-	-	-	-	1650.14
2002	5676	404	-	-	-	-	-	-	-	-	6080	1168.32	336.95	-	-	-	-	-	-	-	-	1505.27
2003	5274	583	12	-	-	-	-	-	-	-	5869	1644.69	76.14	0	-	-	-	-	-	-	-	1720.84
2004	3907	581	3	122	-	-	-	-	-	-	4613	1291.01	173.75	0	0.28	-	-	-	-	-	-	1465.04
2005	3821	761	6	144	13	-	-	-	-	-	4745	1474.37	188.27	0	3.50	0.00	-	-	-	-	-	1666.14
2006	3137	825	-	254	-	-	-	-	-	-	4216	1507.54	112.90	-	0.89	-	-	-	-	-	-	1621.33
2007	3604	986	7	192	5	-	-	-	-	-	4794	1565.70	83.91	0	0.42	0.01	-	-	-	-	-	1650.04
2008	3021	54	7	611	62	1509	421	-	-	-	5685	1362.88	0.34	0	10.74	7.21	100.26	30.88	-	-	-	1512.31
2009	3166	17	15	826	102	1305	155	-	-	-	5586	1449.76	0.04	0	27.94	7.88	100.05	0.16	-	-	-	1585.82
2010	3528	22	8	730	75	1659	253	-	-	-	6275	1557.85	0.01	0	20.93	0.22	58.60	22.54	-	-	-	1660.15
2011	3310	12	6	687	14	1650	304	-	-	-	5983	1543.10	0.00	0	18.33	0.00	59.80	24.47	-	-	-	1645.70
2012	2068	59	3	209	49	1302	291	-	-	-	3981	1541.40	0.04	0	18.30	0.40	41.29	0.45	-	-	-	1601.90
2013	2171	41	-	3	18	1049	641	-	-	-	3923	1485.94	0.01	-	0.00	0.34	33.17	112.82	-	-	-	1632.29
2014	2416	46	3	-	27	1114	726	-	-	-	4332	1414.63	0.62	0	-	1.00	44.93	69.41	-	-	-	1530.60
2015	2136	31	2	17	39	1425	503	-	-	-	4153	1460.49	0.18	0	0.01	0.35	67.65	98.62	-	-	-	1627.29
2016	1822	45	4	-	17	1347	463	-	-	-	3698	1381.90	0.24	0	-	0.11	79.37	106.31	-	-	-	1567.92
2017	1924	29	-	-	93	1468	664	-	-	-	4178	1499.12	0.17	-	-	23.78	65.37	48.28	-	-	-	1636.71
2018	301	34	-	77	47	1448	745	1532	-	-	4184	18.32	0.08	-	2.41	1.31	35.03	77.85	1516.42	-	-	1651.42
2019	98	24	-	-	26	1241	486	1846	572	115	4408	0.04	0.05	-	-	0.50	24.56	30.47	1461.84	2.41	1.08	1520.96
2020	-	-	-	-	41	32	69	2114	1981	65	4302	-	-	-	-	0.00	0.00	0.10	1674.69	29.80	0.40	1705.00
2021	-	-	-	-	87	-	-	1807	2272	193	4359	-	-	-	-	0.00	-	-	1579.03	22.82	3.85	1605.70
2022	-	-	-	-	14	-	-	1675	1419	210	3318	-	-	-	-	0.04	-	-	1585.35	12.31	3.25	1600.95
2023	-	-	-	-	11	-	-	1888	1205	475	3579	-	-	-	-	0.00	-	-	1571.47	19.40	3.48	1594.36

Table B.10: Reporting forms used for effort on trips landing alfonsino from the BYX 3 Quota Management Area in terms of data records and their allocated catches. A complete list of form type codes is provided in Table F.2. – : no observations.

	Records (N)										Allocated catches (t)									
Fishing year	TCP	CEL	Other	LCE	LTC	TCE	ERS - Trawl	ERS - Lining	ERS - Netting	Total	TCP	CEL	Other	LCE	LTC	TCE	ERS - Trawl	ERS - Lining	ERS - Netting	Total
1990	1865	176	-	-	-	-	-	-	-	2041	7.80	58.80	-	-	-	-	-	-	-	66.60
1991	3074	179	-	-	-	-	-	-	-	3253	111.53	28.65	-	-	-	-	-	-	-	140.19
1992	3067	298	-	-	-	-	-	-	-	3365	250.99	2.37	-	-	-	-	-	-	-	253.36
1993	3675	487	-	-	-	-	-	-	-	4162	87.76	3.34	-	-	-	-	-	-	-	91.10
1994	7028	547	-	-	-	-	-	-	-	7575	382.09	4.51	-	-	-	-	-	-	-	386.59
1995	8682	325	-	-	-	-	-	-	-	9007	331.71	17.83	-	-	-	-	-	-	-	349.54
1996	7101	197	-	-	-	-	-	-	-	7298	864.23	4.55	-	-	-	-	-	-	-	868.78
1997	9106	226	-	-	-	-	-	-	-	9332	916.81	1.47	-	-	-	-	-	-	-	918.28
1998	12678	188	-	-	-	-	-	-	-	12866	1156.74	1.48	-	-	-	-	-	-	-	1158.23
1999	14678	228	-	-	-	-	-	-	-	14906	1031.82	2.81	-	-	-	-	-	-	-	1034.63
2000	13366	151	-	-	-	-	-	-	-	13517	722.14	1.83	-	-	-	-	-	-	-	723.98
2001	15324	314	39	-	-	-	-	-	-	15677	870.17	3.94	0.02	-	-	-	-	-	-	874.13
2002	12925	167	-	-	-	-	-	-	-	13092	1225.43	3.05	-	-	-	-	-	-	-	1228.48
2003	14340	230	-	-	-	-	-	-	-	14570	1103.84	1.05	-	-	-	-	-	-	-	1104.88
2004	11971	124	20	619	-	-	-	-	-	12734	864.51	5.10	0.00	0.29	-	-	-	-	-	869.90
2005	10480	149	-	381	-	-	-	-	-	11010	1034.21	30.05	-	0.15	-	-	-	-	-	1064.41
2006	8160	109	-	780	-	-	-	-	-	9049	1179.36	0.88	-	0.21	-	-	-	-	-	1180.44
2007	9186	32	139	779	-	-	-	-	-	10136	938.38	0.14	2.91	1.30	-	-	-	-	-	942.73
2008	8563	47	44	1746	153	34	-	-	-	10587	1029.47	0.14	0.06	1.40	1.81	0.06	-	-	-	1032.94
2009	8974	38	71	676	108	27	-	-	-	9894	895.33	0.05	0.12	0.37	0.45	0.02	-	-	-	896.33
2010	7525	33	122	1455	42	139	-	-	-	9316	931.85	0.10	0.16	3.12	0.03	43.38	-	-	-	978.65
2011	7111	24	130	1471	116	63	-	-	-	8915	1090.63	0.07	0.16	3.12	0.03	0.75	-	-	-	1094.78
2012	6937	30	108	928	446	79	-	-	-	8528	1036.18	0.10	0.18	0.63	0.44	0.10	-	-	-	1037.63
2013	6717	36	102	382	454	68	-	-	-	7759	1001.28	0.11	0.19	0.05	0.44	0.21	-	-	-	1002.29
2014	8058	39	193	656	269	70	-	-	-	9285	919.72	0.23	0.23	0.51	0.36	9.26	-	-	-	930.31
2015	8216	36	76	353	314	133	-	-	-	9128	887.90	0.11	0.12	0.18	0.09	0.84	-	-	-	889.24
2016	8346	37	176	259	277	87	-	-	-	9182	1080.47	0.15	0.27	0.04	0.15	0.11	-	-	-	1081.19
2017	8675	38	319	488	78	40	-	-	-	9638	963.61	0.61	0.85	0.12	0.02	0.03	-	-	-	965.24
2018	1374	39	86	353	139	78	7037	-	-	9106	114.12	0.33	0.21	0.02	0.14	0.12	651.72	-	-	766.68
2019	569	-	4	163	79	89	8511	64	85	9564	0.83	-	0.00	0.03	0.02	0.07	903.83	0.00	0.33	905.11
2020	-	-	3	-	24	-	7771	457	99	8354	-	-	0.00	-	0.01	-	655.47	0.06	0.53	656.07
2021	-	-	-	-	-	-	8171	567	67	8805	-	-	-	-	-	-	483.13	0.07	0.59	483.79
2022	-	-	34	-	-	-	8626	167	46	8873	-	-	0.01	-	-	-	564.51	0.06	0.16	564.74
2023	-	-	6	-	-	-	9055	249	51	9361	-	-	0.00	-	-	-	262.38	0.02	0.28	262.68

Table B.11: Allocated catches (t) of alfonsino in BYX 2 by method of capture and fishing year. A complete list of fishing method codes is provided in Table F.3. – : no observations.

Fishing year	BLL	BT	MW	SN	PRM	PRB	Other	Total
1990	0.23	128.66	1 327.46	0.59	-	-	0.04	1 456.97
1991	3.13	220.42	1 016.47	0.29	-	-	0.00	1 240.31
1992	5.79	156.88	1 412.91	0.61	-	-	0.03	1 576.21
1993	2.65	199.29	1 635.32	0.78	-	-	0.24	1 838.29
1994	4.46	362.53	1 299.13	1.28	-	-	0.00	1 667.41
1995	4.64	614.19	1 087.71	0.07	-	-	0.13	1 706.75
1996	3.72	792.47	909.53	0.01	-	-	0.32	1 706.05
1997	2.67	915.83	859.49	0.03	-	-	2.71	1 780.72
1998	3.86	439.32	1 028.57	0.05	-	-	0.01	1 471.81
1999	6.84	405.55	1 279.25	0.02	-	-	0.11	1 691.77
2000	12.73	574.12	1 292.88	-	-	-	0.21	1 879.94
2001	16.25	401.72	1 232.06	-	-	-	0.12	1 650.14
2002	6.62	312.53	1 185.54	0.27	-	-	0.31	1 505.27
2003	10.81	532.20	1 177.50	0.07	-	-	0.26	1 720.84
2004	12.46	238.27	1 214.19	0.01	-	-	0.12	1 465.04
2005	16.71	461.52	1 187.85	0.00	-	-	0.06	1 666.14
2006	33.73	599.39	988.11	0.08	-	-	0.03	1 621.33
2007	57.29	761.97	830.77	0.01	-	-	0.00	1 650.04
2008	111.34	565.68	828.08	7.21	-	-	0.00	1 512.31
2009	127.98	525.00	924.92	7.88	-	-	0.04	1 585.82
2010	79.53	738.47	841.91	0.22	-	-	0.01	1 660.15
2011	78.13	836.90	730.66	0.00	-	-	0.00	1 645.70
2012	59.60	799.02	742.92	0.31	-	-	0.04	1 601.90
2013	33.17	399.19	1 199.57	0.34	-	-	0.01	1 632.29
2014	44.74	846.88	637.16	1.00	-	-	0.82	1 530.60
2015	67.66	663.67	895.43	0.35	-	-	0.18	1 627.29
2016	79.37	619.04	532.37	0.11	336.79	-	0.24	1 567.92
2017	65.37	593.99	470.58	1.23	505.36	0.02	0.17	1 636.71
2018	37.32	544.98	671.19	1.31	396.35	0.07	0.20	1 651.42
2019	26.96	507.90	984.45	1.58	0.00	0.00	0.05	1 520.96
2020	29.63	504.19	1 170.61	0.40	-	-	0.17	1 705.00
2021	22.81	452.24	1 126.79	3.85	-	0.00	0.01	1 605.70
2022	12.28	785.22	800.13	3.25	-	-	0.07	1 600.95
2023	19.40	565.33	1 006.15	3.48	-	0.00	0.00	1 594.36

Table B.12: Allocated catches (t) of alfonsino in BYX 3 by method of capture and fishing year. A complete list of fishing method codes is provided in Table F.3. – : no observations.

Fishing year	BT	MW	SN	BLL	PRB	PRM	Other	Total
1990	20.87	44.81	0.92	-	-	-	0.00	66.60
1991	70.99	68.38	0.81	-	-	-	0.00	140.19
1992	188.47	63.31	1.58	0.00	-	-	-	253.36
1993	81.89	7.06	2.07	0.08	-	-	-	91.10
1994	365.69	18.49	2.35	0.06	-	-	-	386.59
1995	251.93	95.14	2.21	0.26	-	-	-	349.54
1996	751.15	116.02	1.39	0.18	-	-	0.03	868.78
1997	850.27	64.21	0.42	0.15	-	-	3.22	918.28
1998	1 067.57	88.90	1.04	0.26	-	-	0.46	1 158.23
1999	936.99	94.97	2.25	0.37	-	-	0.05	1 034.63
2000	656.34	66.11	1.31	0.22	-	-	0.00	723.98
2001	812.90	58.53	2.53	0.16	-	-	0.00	874.13
2002	1 207.30	19.09	1.69	0.40	-	-	-	1 228.48
2003	1 074.81	29.36	0.56	0.15	-	-	-	1 104.88
2004	862.01	7.14	0.38	0.38	-	-	0.00	869.90
2005	973.35	90.64	0.09	0.32	-	-	0.01	1 064.41
2006	871.72	308.31	0.19	0.22	-	-	0.00	1 180.44
2007	601.10	340.14	0.10	1.38	-	-	0.02	942.73
2008	456.56	572.97	0.18	3.22	-	-	0.01	1 032.94
2009	561.40	333.94	0.15	0.82	-	-	0.01	896.33
2010	499.75	475.49	0.19	3.15	-	-	0.07	978.65
2011	633.32	458.06	0.17	3.16	-	-	0.06	1 094.78
2012	391.36	644.92	0.23	1.07	-	-	0.04	1 037.63
2013	216.47	785.02	0.27	0.50	-	-	0.03	1 002.29
2014	486.49	442.49	0.29	0.88	-	-	0.16	930.31
2015	336.33	552.41	0.16	0.27	-	-	0.06	889.24
2016	427.91	597.56	0.30	0.19	0.29	54.87	0.06	1 081.19
2017	189.68	773.30	0.92	0.14	0.06	0.72	0.43	965.24
2018	36.46	728.88	0.54	0.16	0.63	0.00	0.01	766.68
2019	140.95	753.05	0.33	0.05	10.73	0.00	0.00	905.11
2020	37.27	605.06	0.53	0.07	13.09	0.05	0.00	656.07
2021	53.46	429.00	0.59	0.07	0.68	-	-	483.79
2022	73.90	489.91	0.16	0.06	0.70	0.00	0.01	564.74
2023	71.76	190.33	0.28	0.02	0.30	-	0.00	262.68

APPENDIX C: CLUSTER CHARACTERISATION BY SUB-REGION

As part of the initial evaluation of the effort clusters identified by the dbscan algorithm, summaries were produced for three sub-regions of the alfonsino fishery:

- East Cape south to the Mahia Peninsula;
- Hawke Bay and the northern Wairarapa coast;
- Cook Strait and the southern Wairarapa coast; and
- the Chatham Rise.

For each region, the summaries below provide:

- a map of the clusters in relation to the bathymetry;
- a summary of the aggregate 1990–2023 alfonsio catch from each cluster, the total effort, raw catch rate, and number of vessels that have fisher in the area;
- annual trends in catch, effort, catch rate, and vessels per cluster; and
- the species targeted in each cluster area.

The clusters are mapped using the concave hull that encloses the tow locations assigned to a cluster, using a concavity parameter of 0.8. The locations of individual tows, including tows not assigned to a cluster, are not shown. For plots of annual catch and effort, it should be noted that the introduction of fishing event scale reporting for inshore fisheries in 2008 will impact the patterns for some clusters.

C.1 East Cape - Mahia

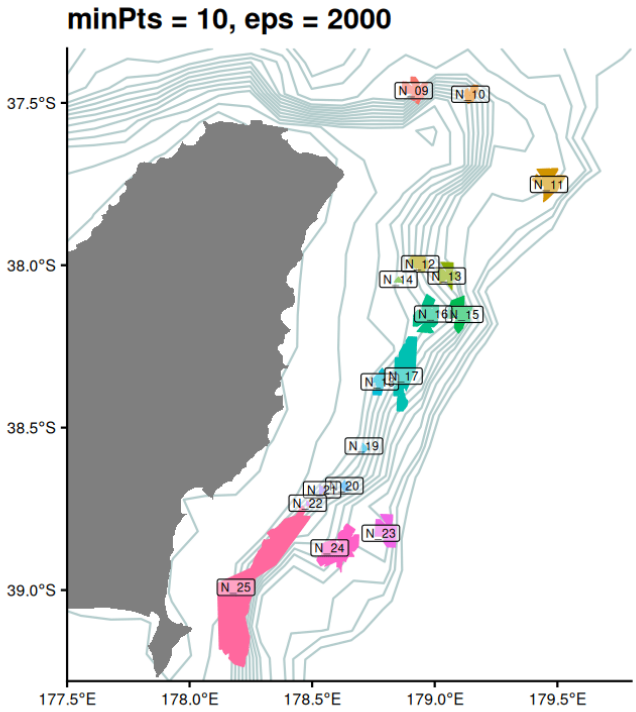

Figure C.1: Fishing effort clusters and bathymetry for the East Cape - Mahia region.

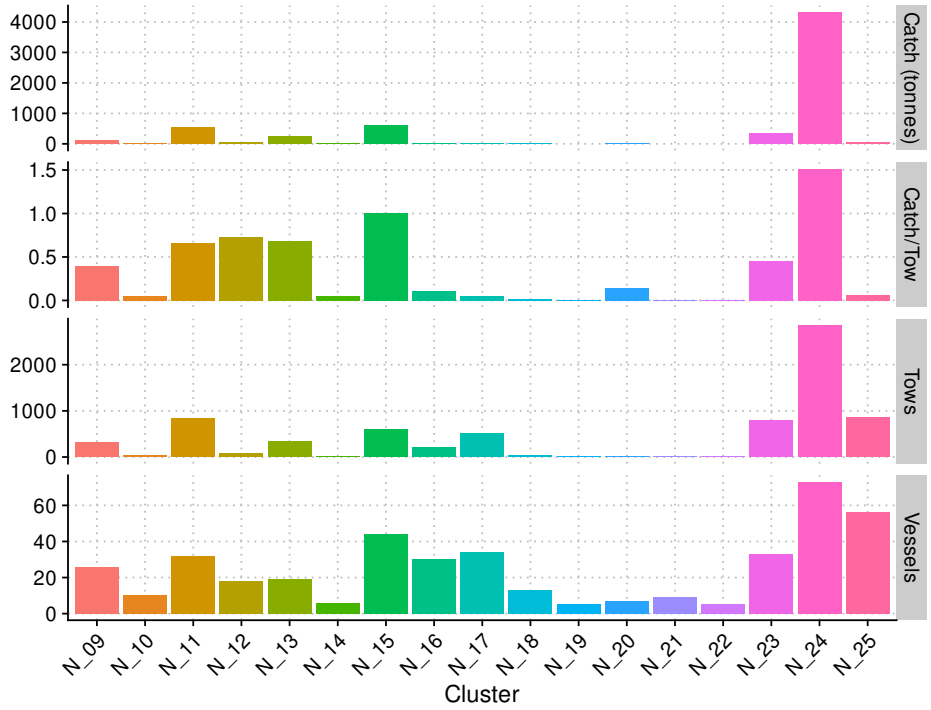

Figure C.2: Overall cluster catch and effort for the East Cape - Mahia region.

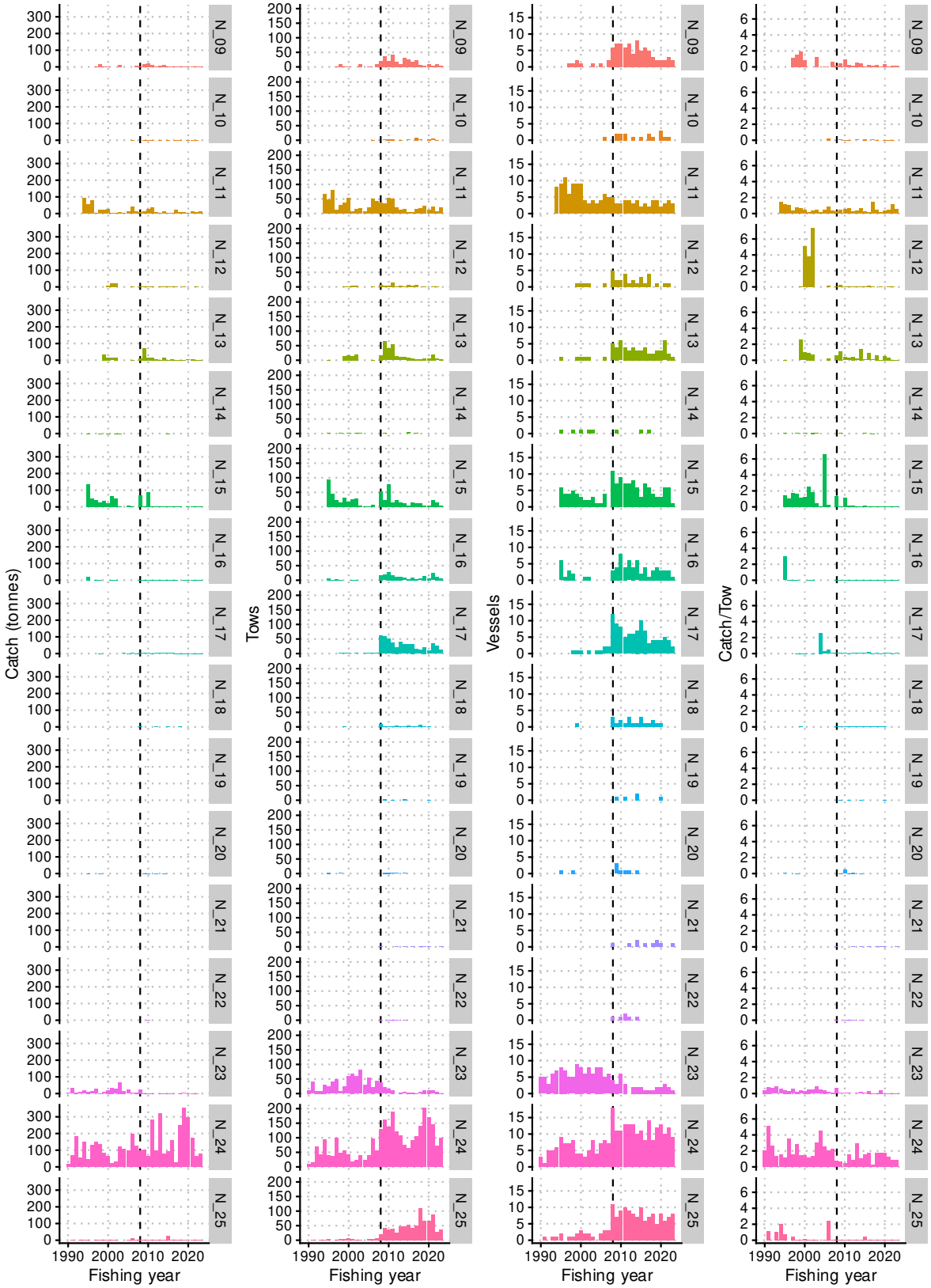

Figure C.3: Annual cluster catch and effort for the East Cape - Mahia region. The dashed vertical line indicates 2008 when event level reporting was introduced for inshore trawl and line fisheries.

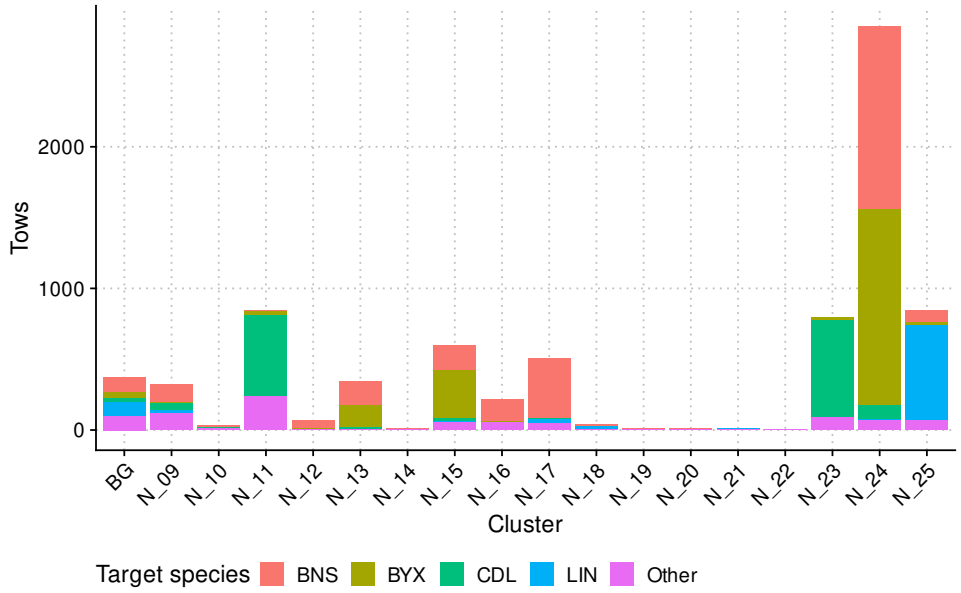

Figure C.4: Cluster target species for the East Cape - Mahia region.

C.2 Hawke Bay - Wairarapa

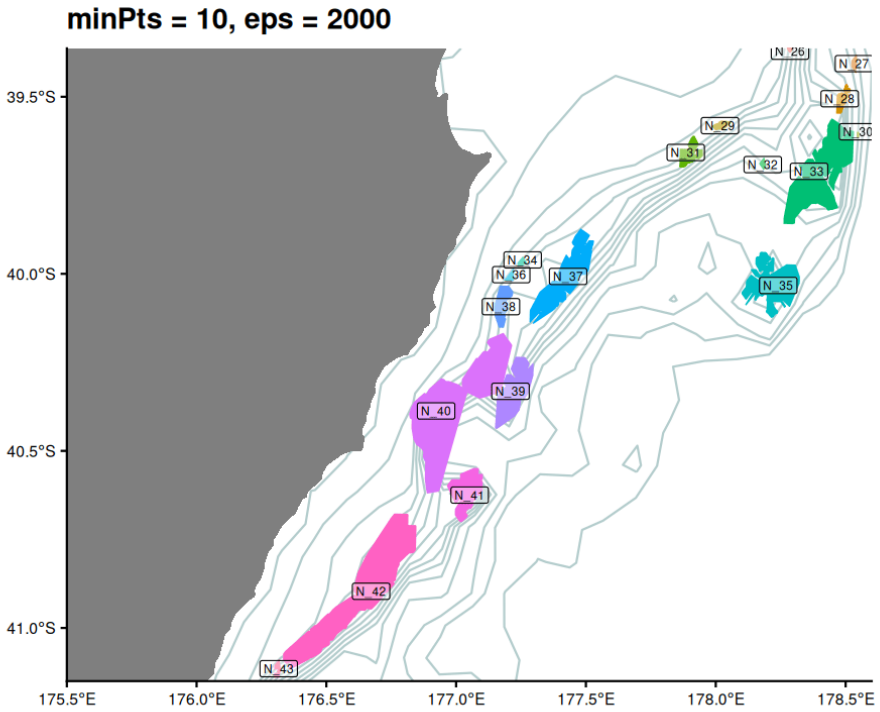

Figure C.5: Fishing effort clusters and bathymetry for the Hawke Bay - Wairarapa region.

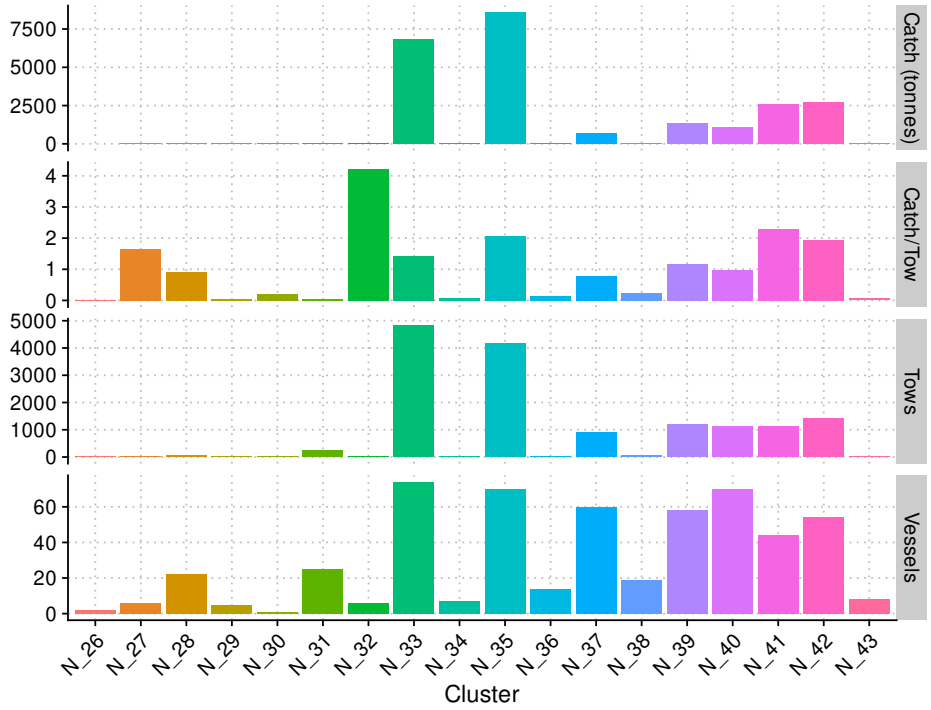

Figure C.6: Overall cluster catch and effort for the Hawke Bay - Wairarapa region.

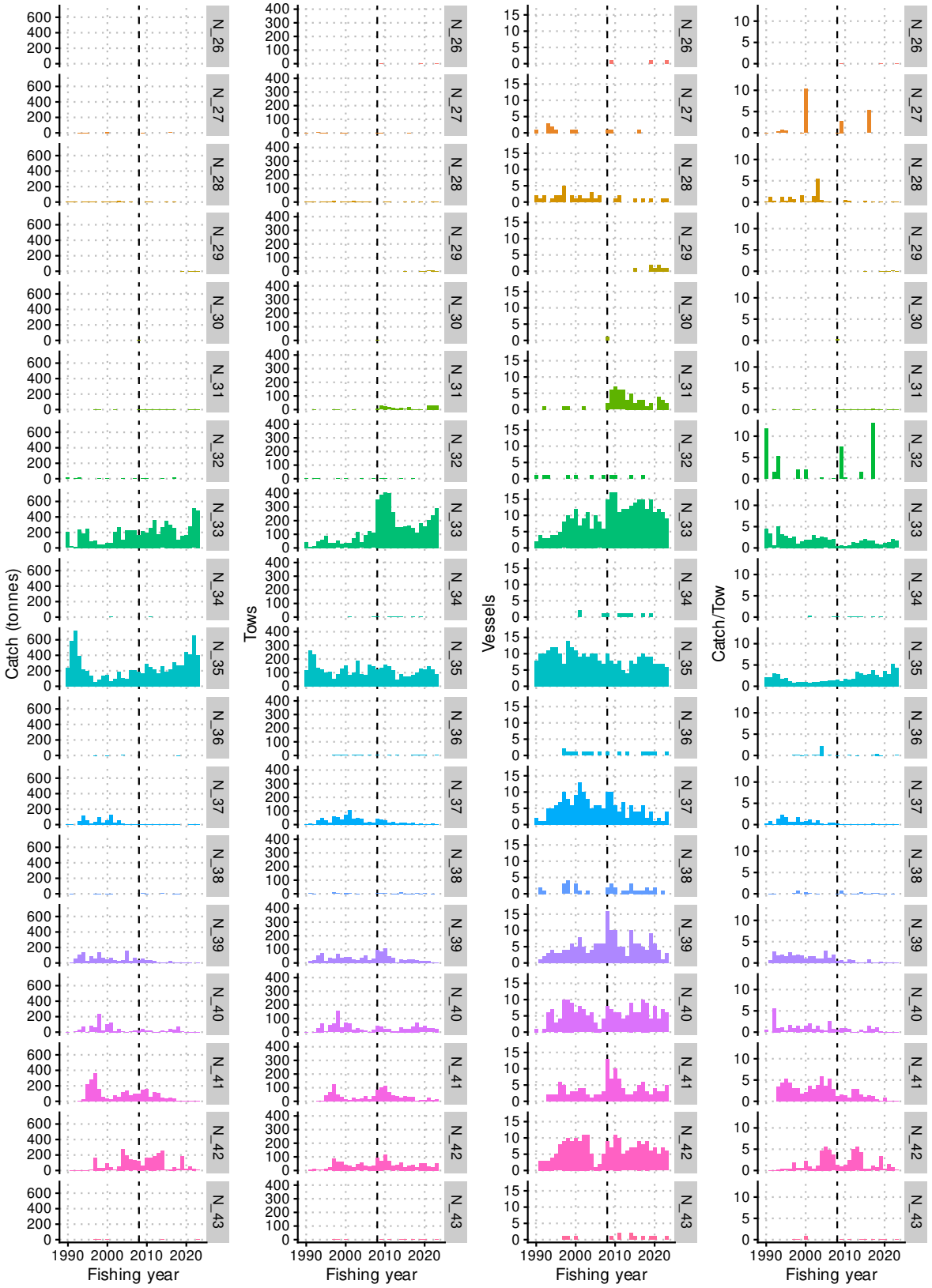

Figure C.7: Annual cluster catch and effort for the Hawke Bay - Wairarapa region. The dashed vertical line indicates 2008 when event level reporting was introduced for inshore trawl and line fisheries.

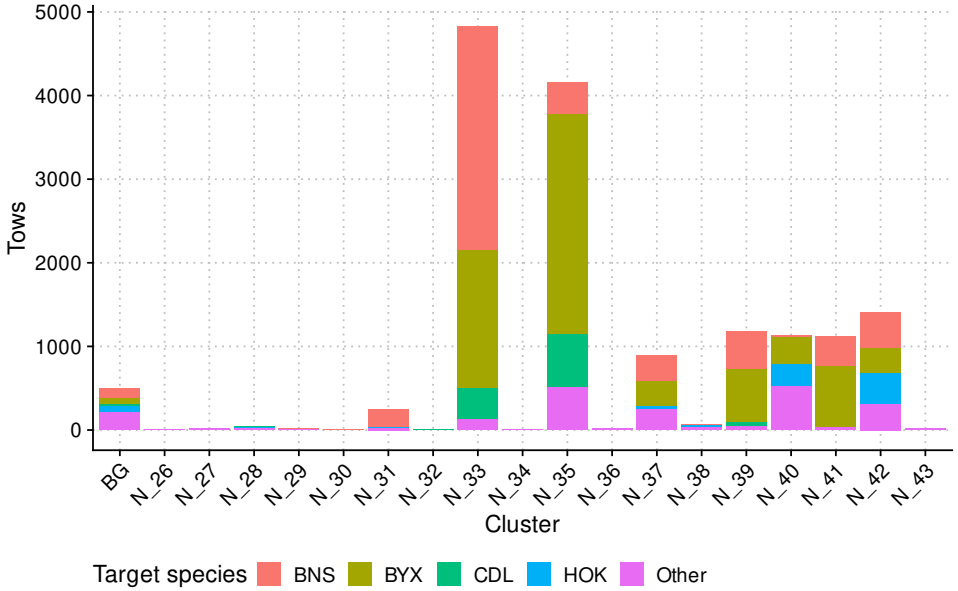

Figure C.8: Cluster target species for the Hawke Bay - Wairarapa region.

C.3 Cook Strait - Wairarapa

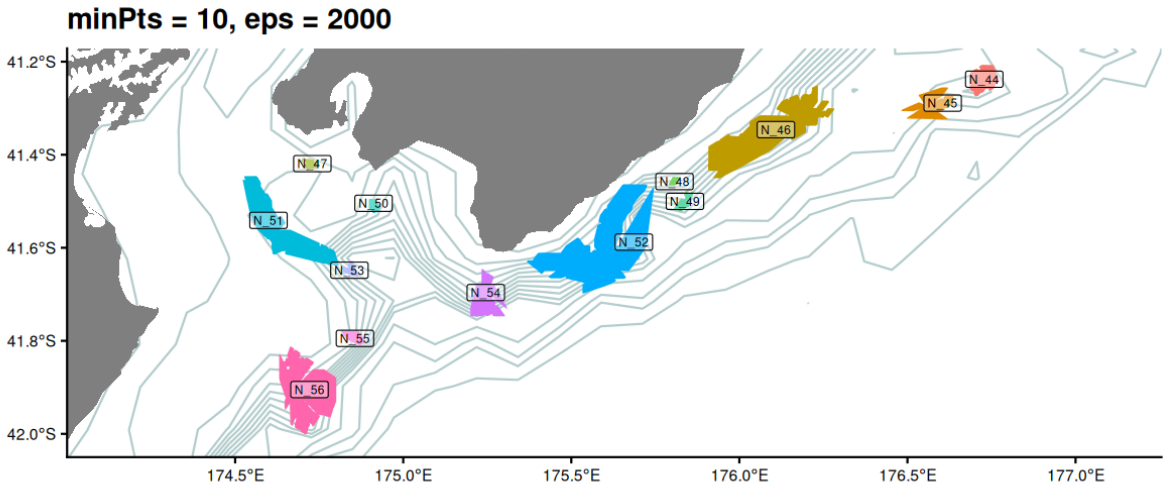

Figure C.9: Fishing effort clusters and bathymetry for the Cook Strait - Wairarapa region.

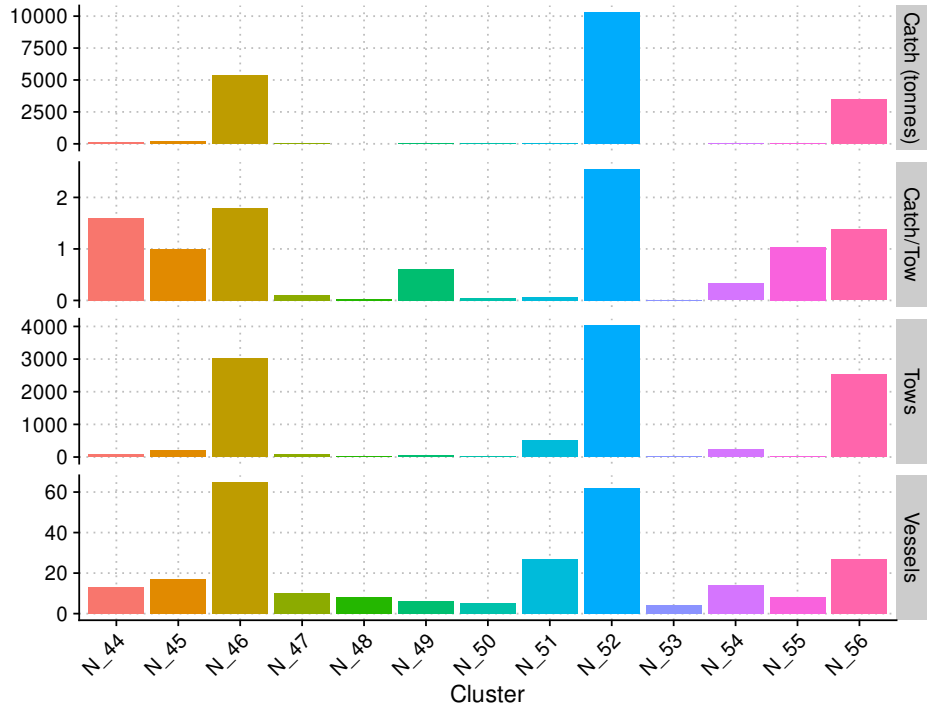

Figure C.10: Overall cluster catch and effort for the Cook Strait - Wairarapa region.

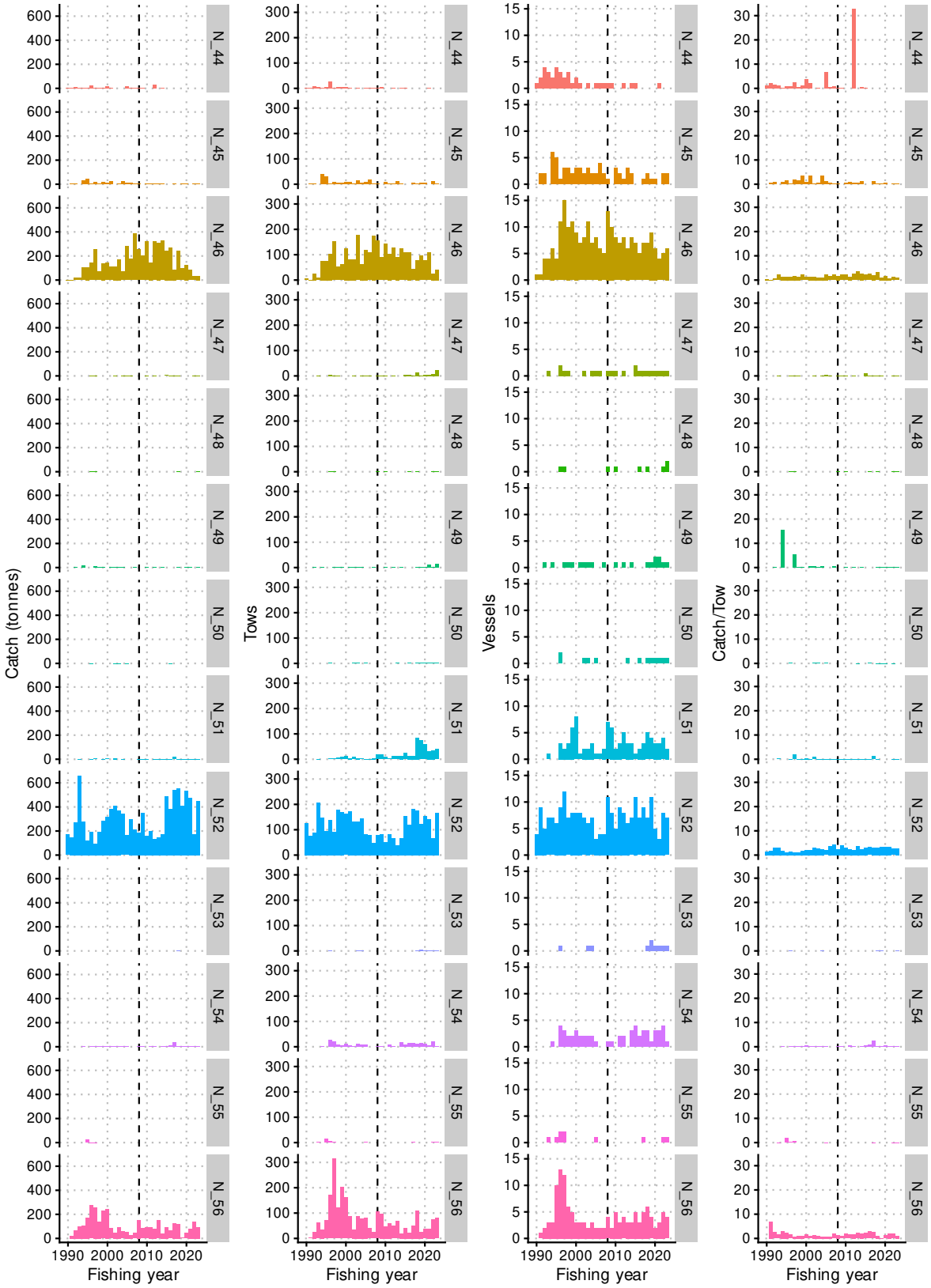

Figure C.11: Annual cluster catch and effort for the Cook Strait - Wairarapa region. The dashed vertical line indicates 2008 when event level reporting was introduced for inshore trawl and line fisheries.

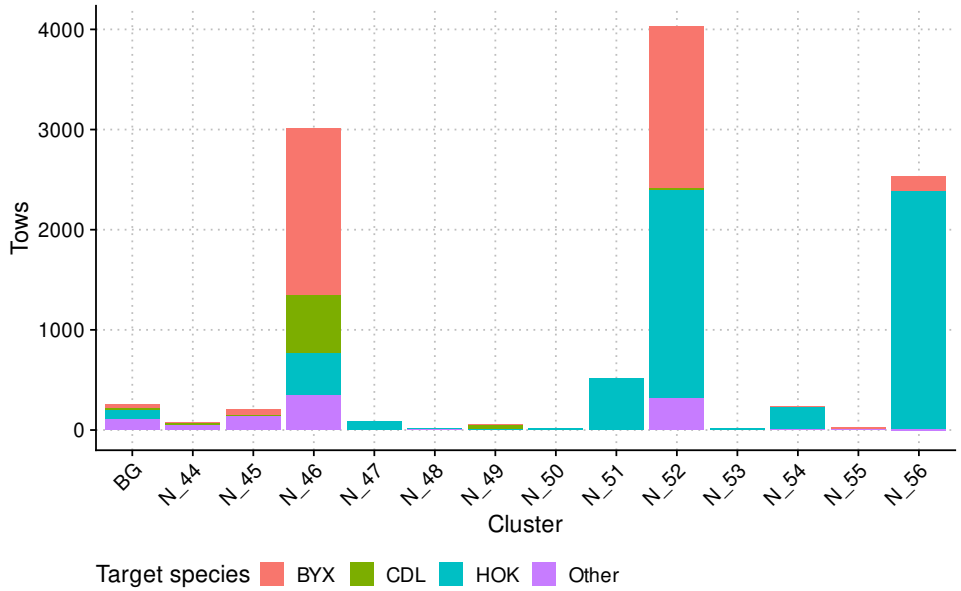

Figure C.12: Cluster target species for the Cook Strait - Wairarapa region.

C.4 Chatham Rise

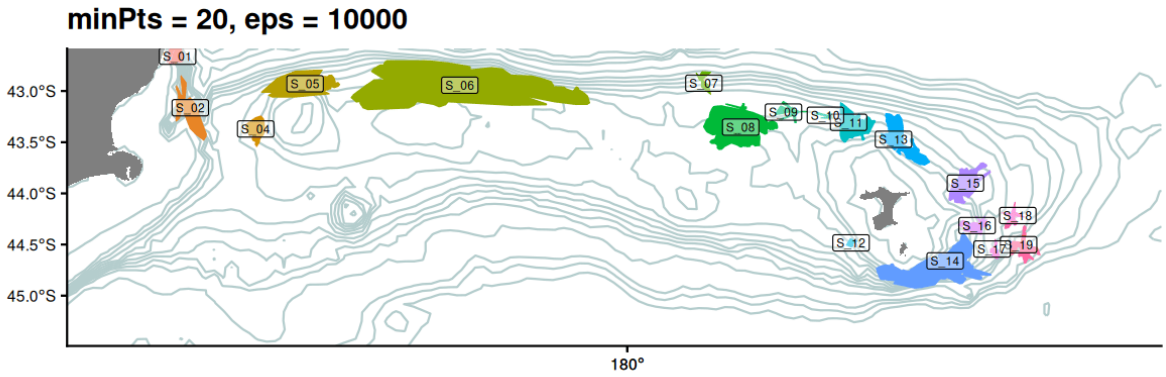

Figure C.13: Fishing effort clusters and bathymetry on the Chatham Rise.

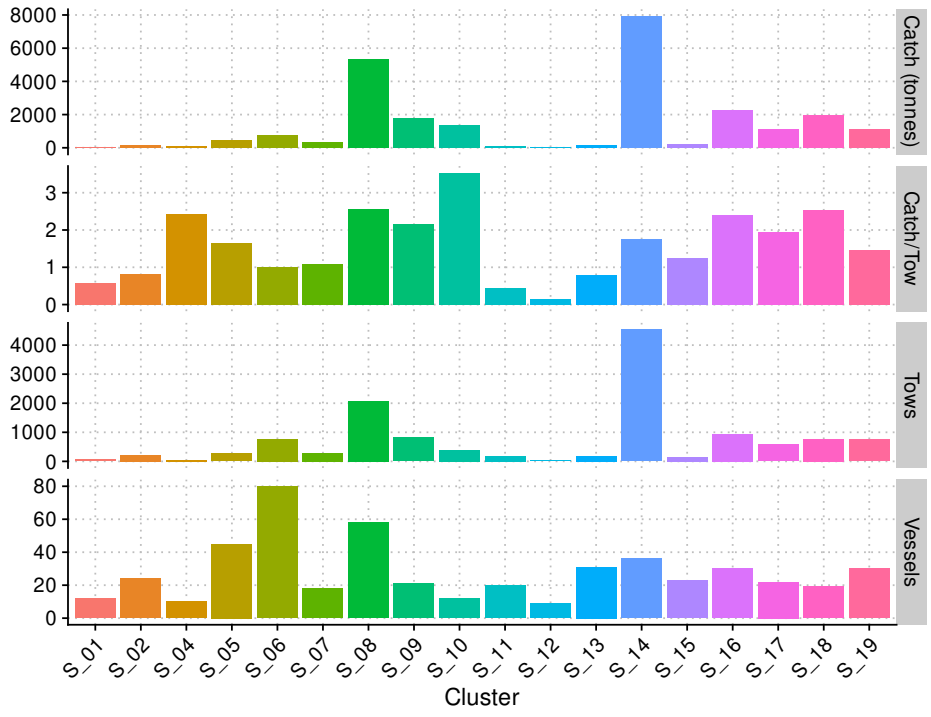

Figure C.14: Overall cluster catch and effort on the Chatham Rise.

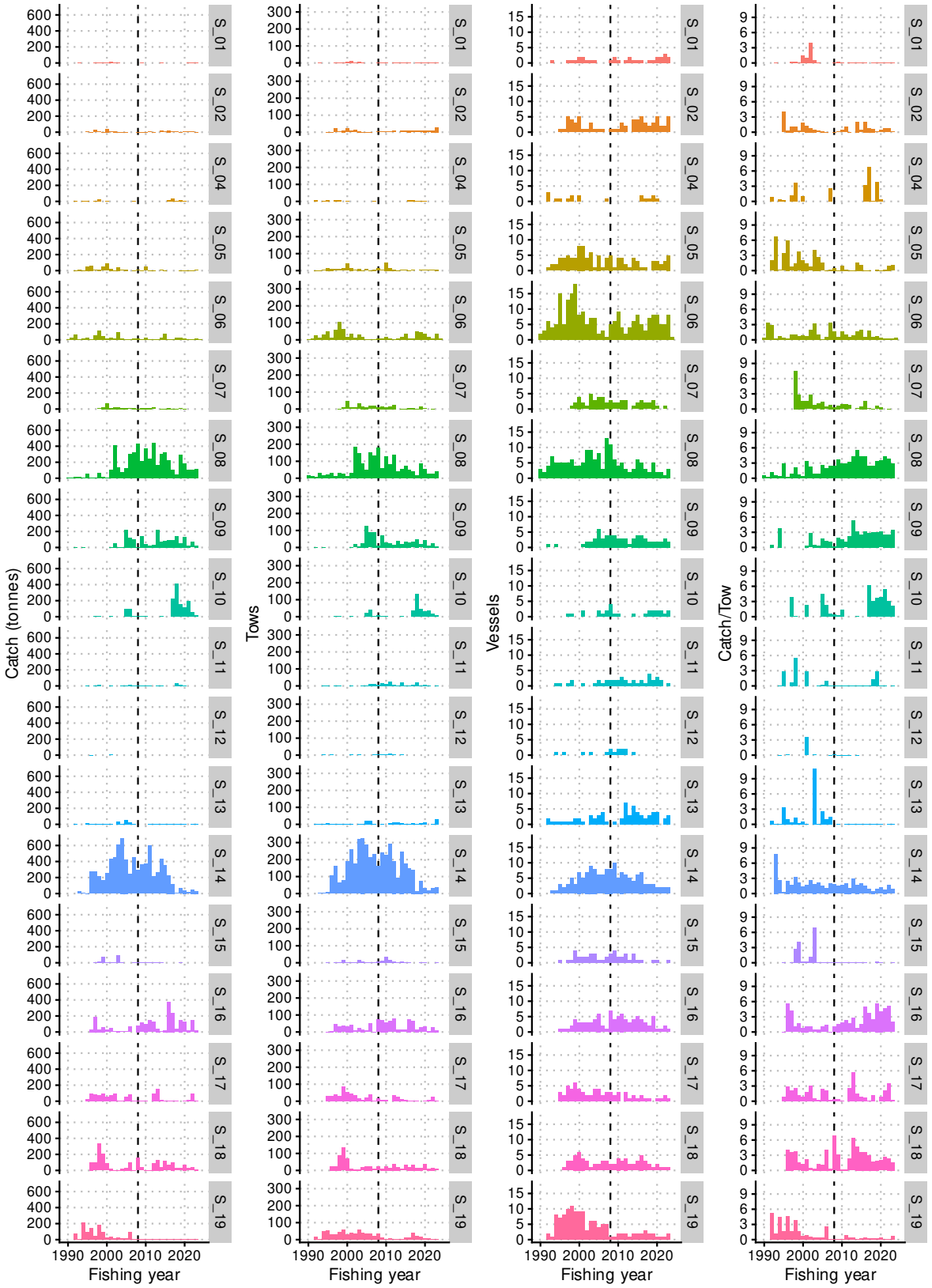

Figure C.15: Annual cluster catch and effort on the Chatham Rise. The dashed vertical line indicates 2008 when event level reporting was introduced for inshore trawl and line fisheries.

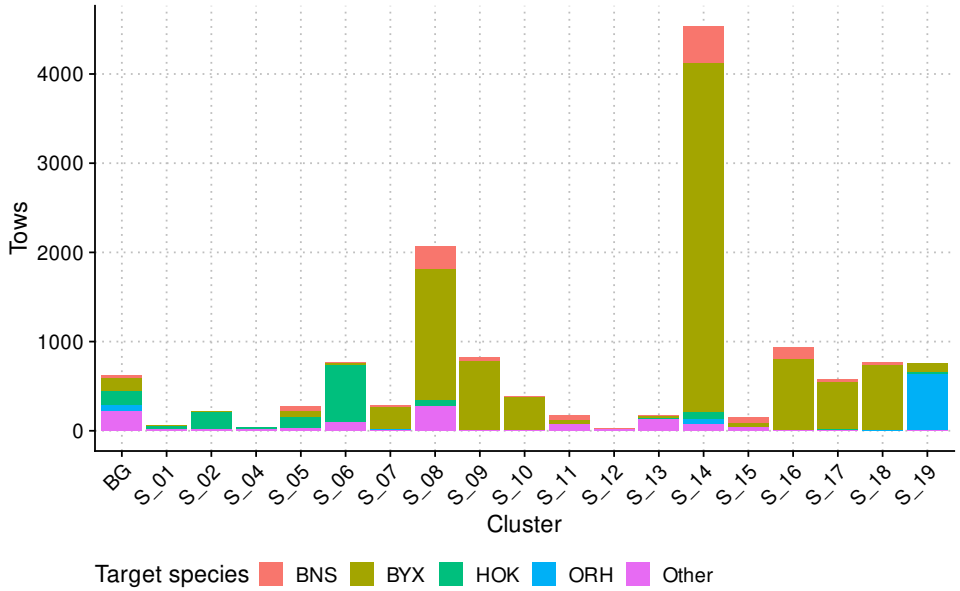

Figure C.16: Cluster target species on the Chatham Rise.

APPENDIX D: CPUE SERIES

D.1 BYX 2 BYX 3 event (regions)

Table D.1: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the BYX 2 BYX 3 event (regions) CPUE series.

Series	BYX 2 BYX 3 event (regions)
QMS stock	BYX 2, BYX 3
Reporting forms	TCP, TCE, ERS - Trawl
Fishing methods	BT, PRB, MW, PRM
Target species	BYX
Statistical Areas	011, 012, 013, 014, 015, 016, 017, 018, 019, 020, 021, 202, 203, 204, 205, 401, 402, 403, 404, 405, 410, 049, 050, 051, 052, 406, 412
Period	1989-10-01, 2023-09-30
Resolution	Fishing event
Core fleet years	5
Core fleet trips	3
Default model	allockg_top5 ~ fyear + region + vessel_key + primary_method + month + ns(log(fishing_duration), 3) + ns(log(effort_height), 3) + ns(log(effort_depth), 3)
Stepwise selection	Yes
Positive catch distribution	Weibull

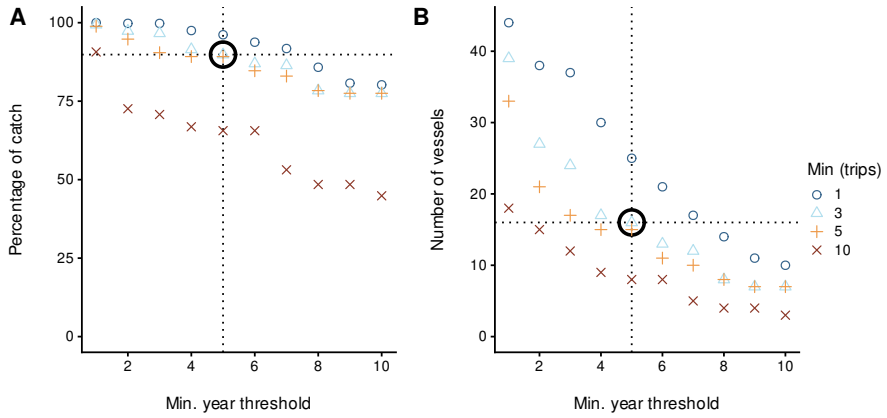

Figure D.1: Percentage of catch and number of vessels for different core vessel selection criteria for the BYX 2 BYX 3 event (regions) CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

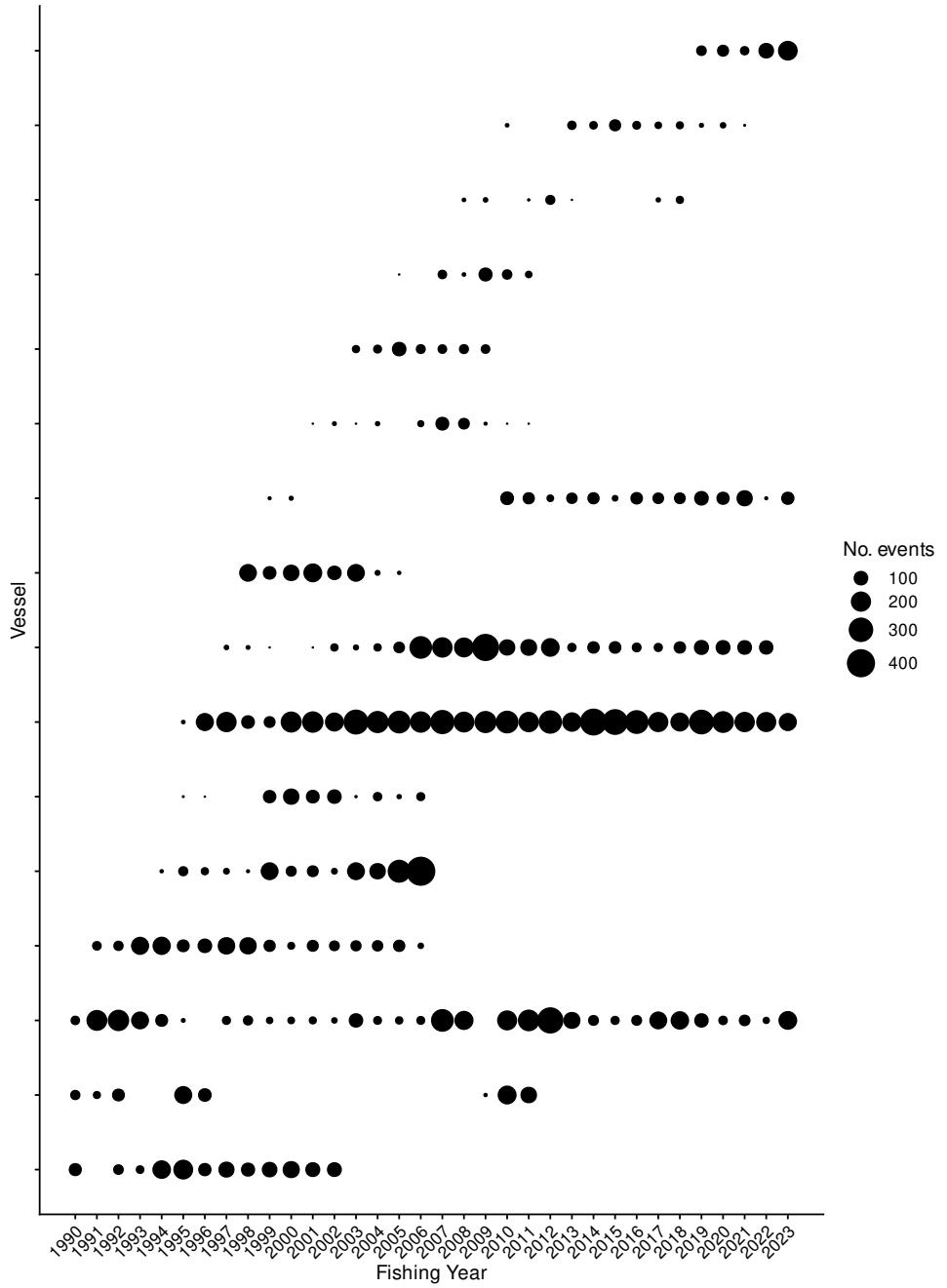

Figure D.2: Number of events by fishing year for core vessels in the BYX 2 BYX 3 event (regions) series. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table D.2: Summary of the BYX 2 BYX 3 event (regions) 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 2 pages)

Filter	1990	1991	1992	1993	1994	1995	1996	1997	1998
Ungroomed data	669 (100%) n: 335	749 (100%) n: 294	1260 (100%) n: 458	1444 (100%) n: 530	1332 (100%) n: 708	1307 (100%) n: 794	1503 (100%) n: 769	1500 (100%) n: 736	1540 (100%) n: 730
Fishing duration is not NA	669 (100%) n: 335	749 (100%) n: 294	1260 (100%) n: 458	1444 (100%) n: 530	1332 (100%) n: 708	1307 (100%) n: 794	1503 (100%) n: 769	1500 (100%) n: 736	1540 (100%) n: 730
Positive fishing duration	669 (100%) n: 335	749 (100%) n: 294	1260 (100%) n: 458	1444 (100%) n: 530	1332 (100%) n: 708	1307 (100%) n: 793	1502 (100%) n: 762	1500 (100%) n: 729	1540 (100%) n: 728
Duration under 12h	669 (100%) n: 335	739 (99%) n: 292	1260 (100%) n: 458	1416 (98%) n: 528	1332 (100%) n: 707	1304 (100%) n: 785	1498 (100%) n: 756	1472 (98%) n: 720	1534 (100%) n: 720
Headline under 60m	669 (100%) n: 335	739 (99%) n: 292	1260 (100%) n: 458	1416 (98%) n: 528	1332 (100%) n: 707	1294 (99%) n: 769	1467 (98%) n: 751	1450 (97%) n: 711	1457 (95%) n: 694
In a cluster	654 (98%) n: 330	739 (99%) n: 288	1241 (98%) n: 446	1380 (96%) n: 510	1271 (95%) n: 681	1256 (96%) n: 718	1436 (96%) n: 725	1419 (95%) n: 695	1396 (91%) n: 679
150+ events per cluster	592 (89%) n: 316	708 (94%) n: 281	1197 (95%) n: 437	1364 (95%) n: 499	1269 (95%) n: 664	1124 (86%) n: 651	1389 (92%) n: 704	1395 (93%) n: 683	1388 (90%) n: 665
Core fleet selection	293 (44%) n: 164	708 (94%) n: 281	1151 (91%) n: 399	1111 (77%) n: 346	913 (69%) n: 412	906 (69%) n: 487	1109 (74%) n: 456	1058 (71%) n: 537	1141 (74%) n: 535

Filter	1999	2000	2001	2002	2003	2004	2005	2006	2007
Ungroomed data	1541 (100%) n: 1040	1269 (100%) n: 968	1352 (100%) n: 849	1329 (100%) n: 639	1602 (100%) n: 881	1430 (100%) n: 644	1942 (100%) n: 849	2045 (100%) n: 1139	2035 (100%) n: 1008
Fishing duration is not NA	1541 (100%) n: 1040	1269 (100%) n: 968	1352 (100%) n: 849	1329 (100%) n: 639	1602 (100%) n: 881	1430 (100%) n: 644	1942 (100%) n: 849	2045 (100%) n: 1139	2035 (100%) n: 1008
Positive fishing duration	1538 (100%) n: 1038	1269 (100%) n: 966	1341 (99%) n: 846	1326 (100%) n: 634	1602 (100%) n: 875	1430 (100%) n: 644	1942 (100%) n: 848	2045 (100%) n: 1139	2031 (100%) n: 1000
Duration under 12h	1535 (100%) n: 1030	1266 (100%) n: 959	1341 (99%) n: 846	1322 (99%) n: 631	1602 (100%) n: 875	1430 (100%) n: 644	1942 (100%) n: 848	2044 (100%) n: 1138	2031 (100%) n: 999
Headline under 60m	1492 (97%) n: 1011	1265 (100%) n: 953	1338 (99%) n: 845	1322 (99%) n: 631	1602 (100%) n: 875	1420 (99%) n: 637	1942 (100%) n: 848	2044 (100%) n: 1138	2031 (100%) n: 999
In a cluster	1437 (93%) n: 969	1232 (97%) n: 929	1310 (97%) n: 830	1313 (99%) n: 624	1588 (99%) n: 867	1415 (99%) n: 631	1939 (100%) n: 844	2035 (99%) n: 1127	2025 (100%) n: 991
150+ events per cluster	1182 (77%) n: 799	1179 (93%) n: 902	1256 (93%) n: 802	1269 (95%) n: 614	1498 (94%) n: 833	1394 (97%) n: 616	1872 (96%) n: 814	1976 (97%) n: 1067	2013 (99%) n: 969
Core fleet selection	991 (64%) n: 599	1064 (84%) n: 730	1199 (89%) n: 750	1251 (94%) n: 600	1450 (91%) n: 820	1355 (95%) n: 588	1843 (95%) n: 794	1968 (96%) n: 1057	1967 (97%) n: 920

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	1926 (100%) n: 796	1867 (100%) n: 838	2252 (100%) n: 1072	2185 (100%) n: 883	2253 (100%) n: 873	2187 (100%) n: 480	2008 (100%) n: 653	1976 (100%) n: 617	2136 (100%) n: 590
Fishing duration is not NA	1926 (100%) n: 796	1867 (100%) n: 838	2252 (100%) n: 1072	2185 (100%) n: 883	2253 (100%) n: 873	2187 (100%) n: 480	2008 (100%) n: 653	1976 (100%) n: 617	2136 (100%) n: 590
Positive fishing duration	1905 (99%) n: 792	1855 (99%) n: 829	2252 (100%) n: 1070	2182 (100%) n: 880	2250 (100%) n: 870	2187 (100%) n: 479	2008 (100%) n: 652	1976 (100%) n: 617	2136 (100%) n: 590
Duration under 12h	1903 (99%) n: 791	1855 (99%) n: 829	2252 (100%) n: 1070	2182 (100%) n: 879	2250 (100%) n: 870	2187 (100%) n: 479	2008 (100%) n: 652	1961 (99%) n: 616	2136 (100%) n: 590
Headline under 60m	1903 (99%) n: 791	1854 (99%) n: 828	2245 (100%) n: 1067	2182 (100%) n: 878	2250 (100%) n: 870	2187 (100%) n: 479	2008 (100%) n: 652	1961 (99%) n: 616	2126 (100%) n: 588
In a cluster	1877 (97%) n: 779	1853 (99%) n: 827	2240 (99%) n: 1059	2133 (98%) n: 869	2247 (100%) n: 862	2184 (100%) n: 476	1980 (99%) n: 643	1953 (99%) n: 613	2126 (100%) n: 587
150+ events per cluster	1853 (96%) n: 763	1845 (99%) n: 822	2170 (96%) n: 1017	2127 (97%) n: 855	2246 (100%) n: 858	2181 (100%) n: 469	1975 (98%) n: 636	1910 (97%) n: 602	2126 (100%) n: 586
Core fleet selection	1776 (92%) n: 705	1742 (93%) n: 768	1890 (84%) n: 897	1999 (91%) n: 796	2221 (99%) n: 854	2147 (98%) n: 459	1842 (92%) n: 588	1610 (81%) n: 526	1714 (80%) n: 481

Filter	2017	2018	2019	2020	2021	2022	2023
Ungroomed data	1894 (100%) n: 645	2005 (100%) n: 595	2141 (100%) n: 757	2075 (100%) n: 704	1853 (100%) n: 611	1882 (100%) n: 512	1569 (100%) n: 624
Fishing duration is not NA	1894 (100%) n: 645	2005 (100%) n: 595	2141 (100%) n: 757	2075 (100%) n: 704	1853 (100%) n: 610	1882 (100%) n: 512	1569 (100%) n: 624
Positive fishing duration	1894 (100%) n: 645	2005 (100%) n: 595	2141 (100%) n: 754	2075 (100%) n: 702	1853 (100%) n: 608	1882 (100%) n: 512	1569 (100%) n: 623
Duration under 12h	1894 (100%) n: 644	2005 (100%) n: 595	2137 (100%) n: 752	2074 (100%) n: 701	1853 (100%) n: 608	1882 (100%) n: 512	1569 (100%) n: 623
Headline under 60m	1894 (100%) n: 644	2005 (100%) n: 595	2125 (99%) n: 749	2048 (99%) n: 698	1853 (100%) n: 608	1882 (100%) n: 512	1569 (100%) n: 623
In a cluster	1874 (99%) n: 634	1991 (99%) n: 587	2122 (99%) n: 746	2048 (99%) n: 695	1841 (99%) n: 604	1882 (100%) n: 512	1569 (100%) n: 621
150+ events per cluster	1836 (97%) n: 624	1953 (97%) n: 568	2093 (98%) n: 729	2013 (97%) n: 637	1835 (99%) n: 600	1882 (100%) n: 507	1569 (100%) n: 615
Core fleet selection	1454 (77%) n: 484	1806 (90%) n: 528	1965 (92%) n: 669	1776 (86%) n: 540	1655 (89%) n: 531	1433 (76%) n: 437	1499 (96%) n: 601

Table D.3: Summary of the BYX 2 BYX 3 event (regions) 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 alfonsino.

Fishing year	Vessels	Trips	Records	Hours	Catch (t)	Records caught
1990	3	11	164	146.18	292.95	82.93
1991	3	24	281	144.95	707.58	95.37
1992	4	42	399	361.83	1 151.07	80.70
1993	3	51	346	380.18	1 111.00	90.46
1994	4	59	412	412.72	912.99	91.26
1995	7	83	487	365.10	906.20	83.37
1996	6	64	456	255.85	1 109.50	89.25
1997	6	59	537	328.88	1 058.47	86.41
1998	7	64	535	417.98	1 140.97	85.23
1999	9	70	599	361.05	991.26	84.14
2000	8	76	730	374.77	1 064.47	86.03
2001	9	72	750	324.47	1 199.28	80.93
2002	9	92	600	281.07	1 250.61	80.33
2003	9	87	820	296.53	1 450.24	86.46
2004	9	86	588	244.48	1 355.06	89.63
2005	9	95	794	375.05	1 843.04	89.67
2006	8	85	1 057	430.62	1 968.35	86.00
2007	6	92	920	437.87	1 966.80	85.76
2008	7	81	705	379.85	1 776.32	90.21
2009	7	87	768	364.68	1 741.67	92.45
2010	8	74	897	484.92	1 889.54	87.63
2011	8	60	796	436.93	1 998.57	92.59
2012	5	53	854	633.28	2 221.44	91.92
2013	6	56	459	346.33	2 147.21	93.90
2014	5	65	588	407.18	1 842.44	95.07
2015	5	61	526	373.85	1 609.99	93.35
2016	5	72	481	383.28	1 714.04	95.63
2017	6	82	484	373.28	1 454.40	92.36
2018	6	73	528	622.42	1 806.43	96.97
2019	6	62	669	730.05	1 964.63	97.61
2020	6	59	540	798.00	1 775.73	96.30
2021	6	49	531	645.78	1 655.23	96.80
2022	5	40	437	560.72	1 433.30	98.17
2023	4	45	601	759.22	1 498.66	95.67

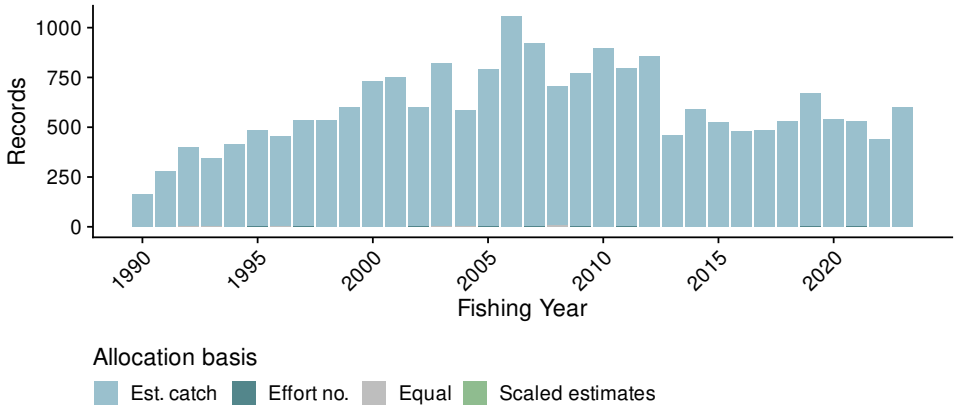

Figure D.3: Allocation basis for attributing landings to records in the BYX 2 BYX 3 event (regions) catch-per-unit-effort dataset. Allocation basis is in terms of estimated catch, effort number, and/or equal.

Table D.4: Summary of stepwise selection for occurrence of positive catch in the BYX 2 BYX 3 event (regions) series. 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	32	12 898	4.4	4.4	*
+ vessel_key	15	12 444	8.0	3.6	*
+ ns(log(fishing_duration), 3)	3	12 027	11.2	3.1	*
+ ns(log(effort_depth), 3)	3	11 888	12.2	1.1	*
+ region	4	11 828	12.7	0.5	
+ ns(log(effort_height), 3)	3	11 818	12.9	0.1	

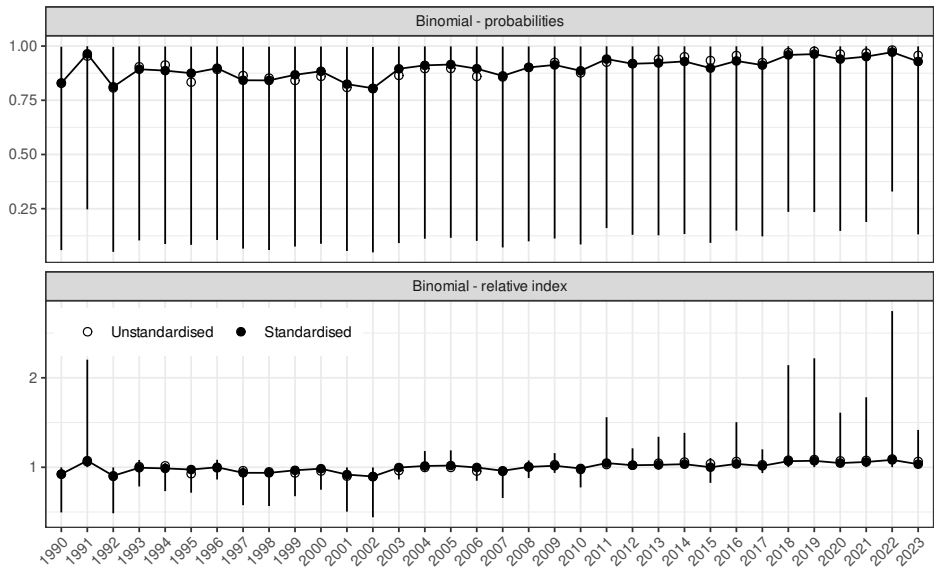

Figure D.4: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the BYX 2 BYX 3 event (regions) dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

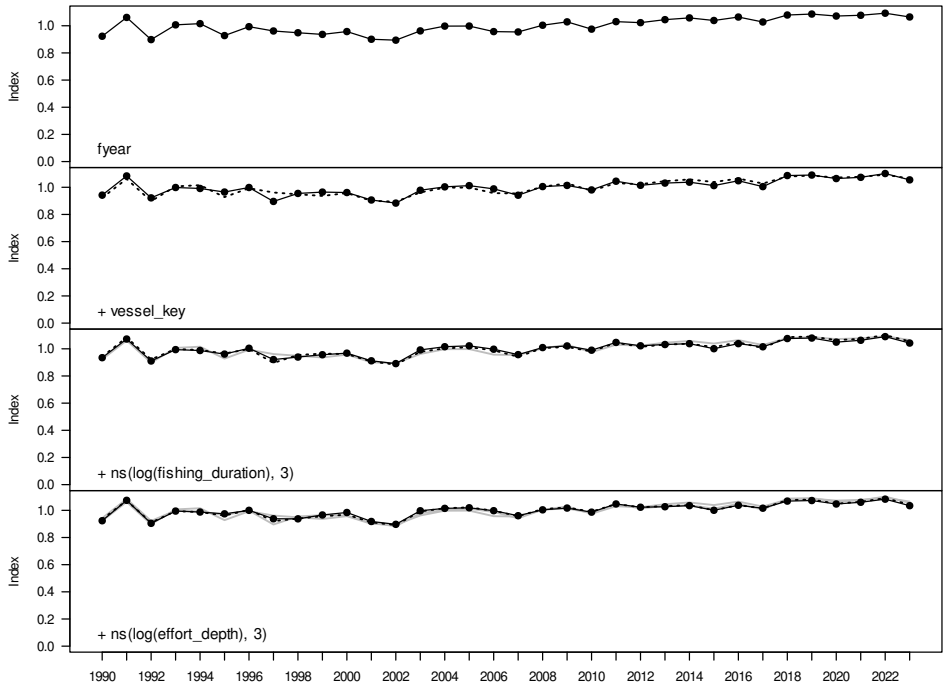

Figure D.5: Step plot for occurrence of catch in the BYX 2 BYX 3 event (regions) dataset.

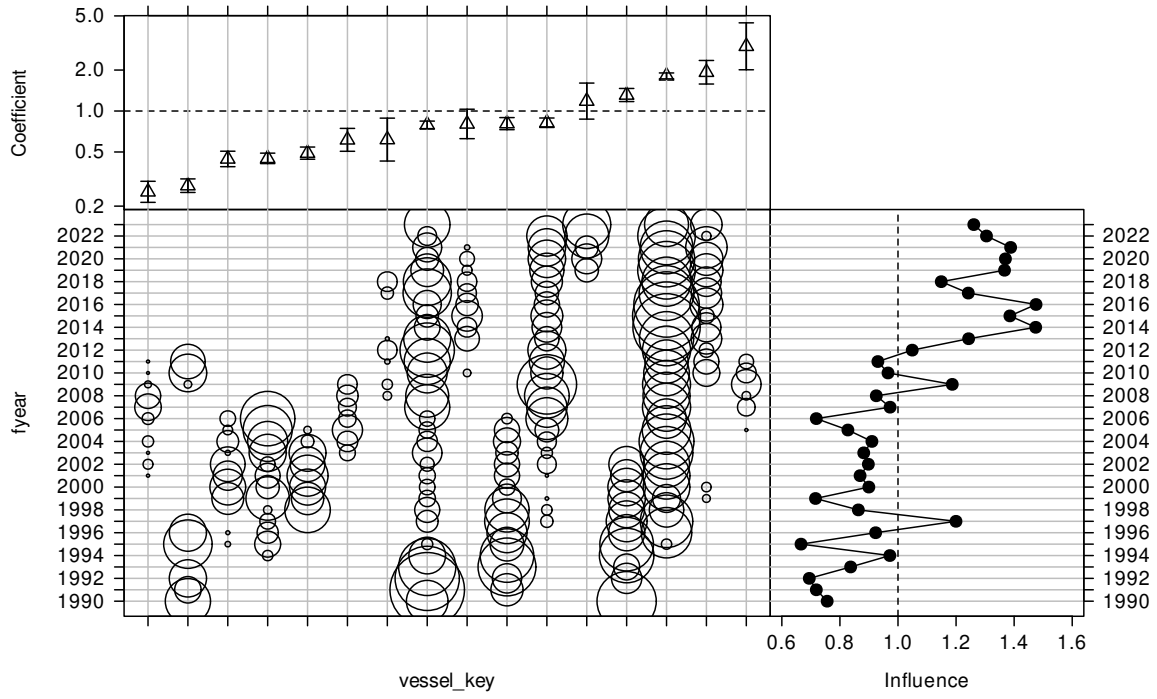

Figure D.6: CDI plot for vessel key for the occurrence of positive catch in the BYX 2 BYX 3 event (regions) catch-per-unit-effort dataset.

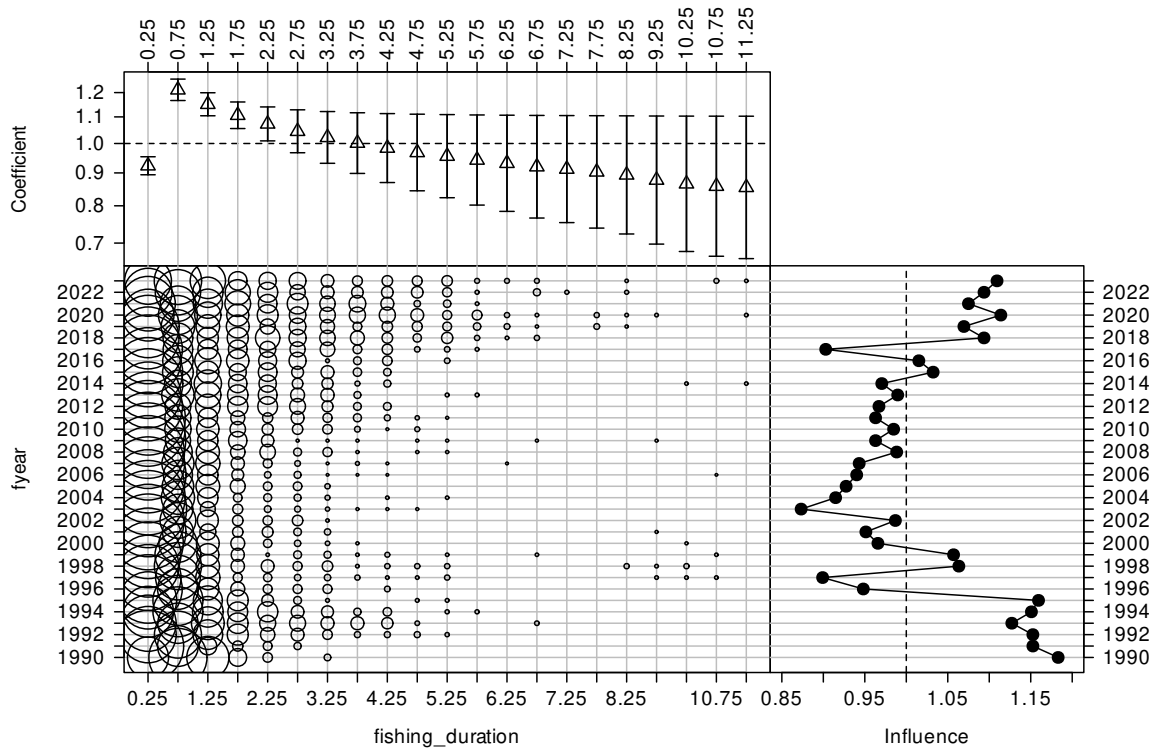

Figure D.7: CDI plot for fishing duration (h) for the occurrence of positive catch in the BYX 2 BYX 3 event (regions) catch-per-unit-effort dataset.

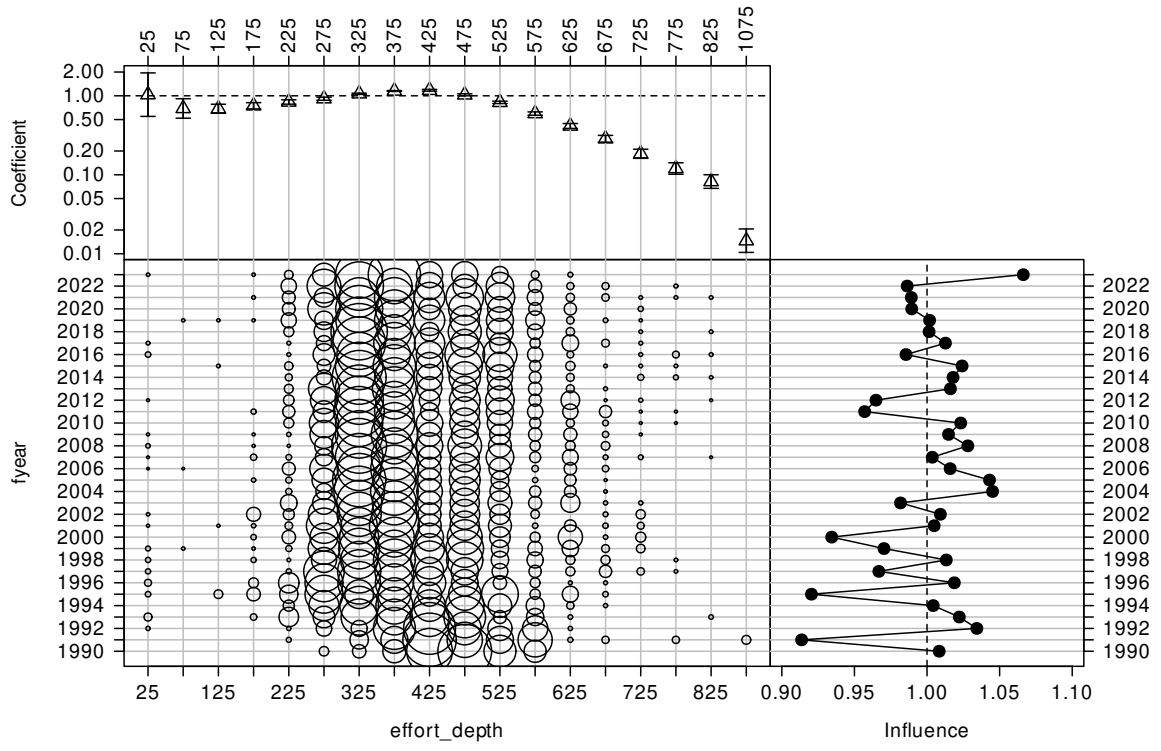

Figure D.8: CDI plot for effort depth (m) for the occurrence of positive catch in the BYX 2 BYX 3 event (regions) catch-per-unit-effort dataset.

Table D.5: Summary of stepwise selection for the Weibull model for positive catches in the BYX 2 BYX 3 event (regions) series. 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	35	322 717	2.5	2.5	*
+ ns(log(effort_height), 3)	3	321 813	6.8	4.2	*
+ vessel_key	15	321 379	9.0	2.2	*
+ region	4	320 982	10.8	1.9	*
+ month	11	320 814	11.7	0.9	
+ ns(log(effort_depth), 3)	3	320 645	12.5	0.8	
+ ns(log(fishing_duration), 3)	3	320 603	12.8	0.2	
+ primary_method	2	320 573	12.9	0.2	

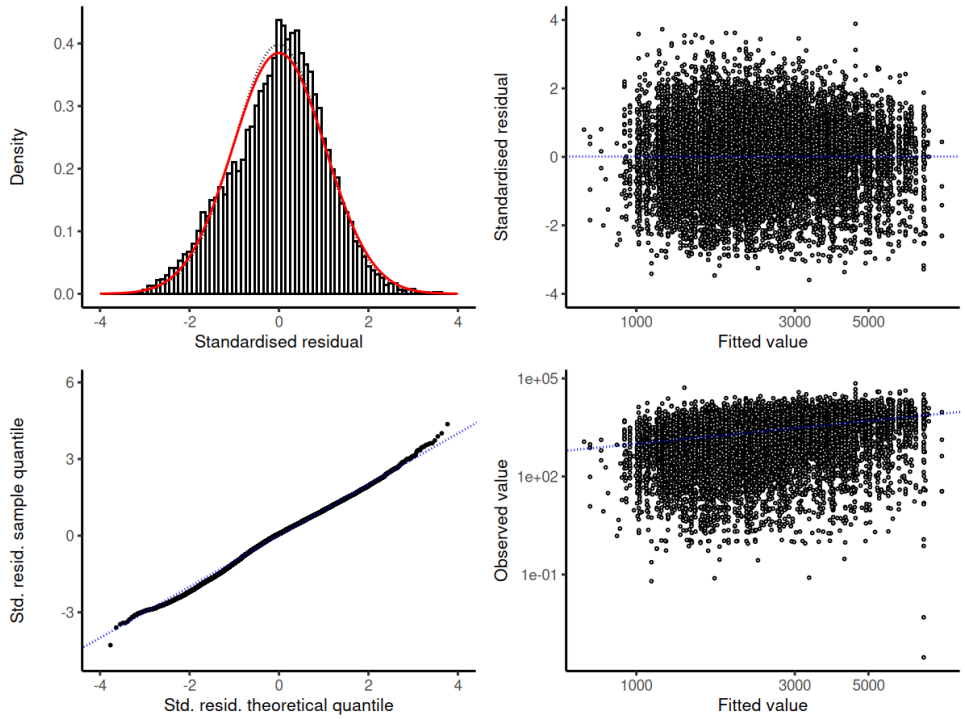

Figure D.9: Diagnostic plots for the selected Weibull model for positive catches in the BYX 2 BYX 3 event (regions) dataset.

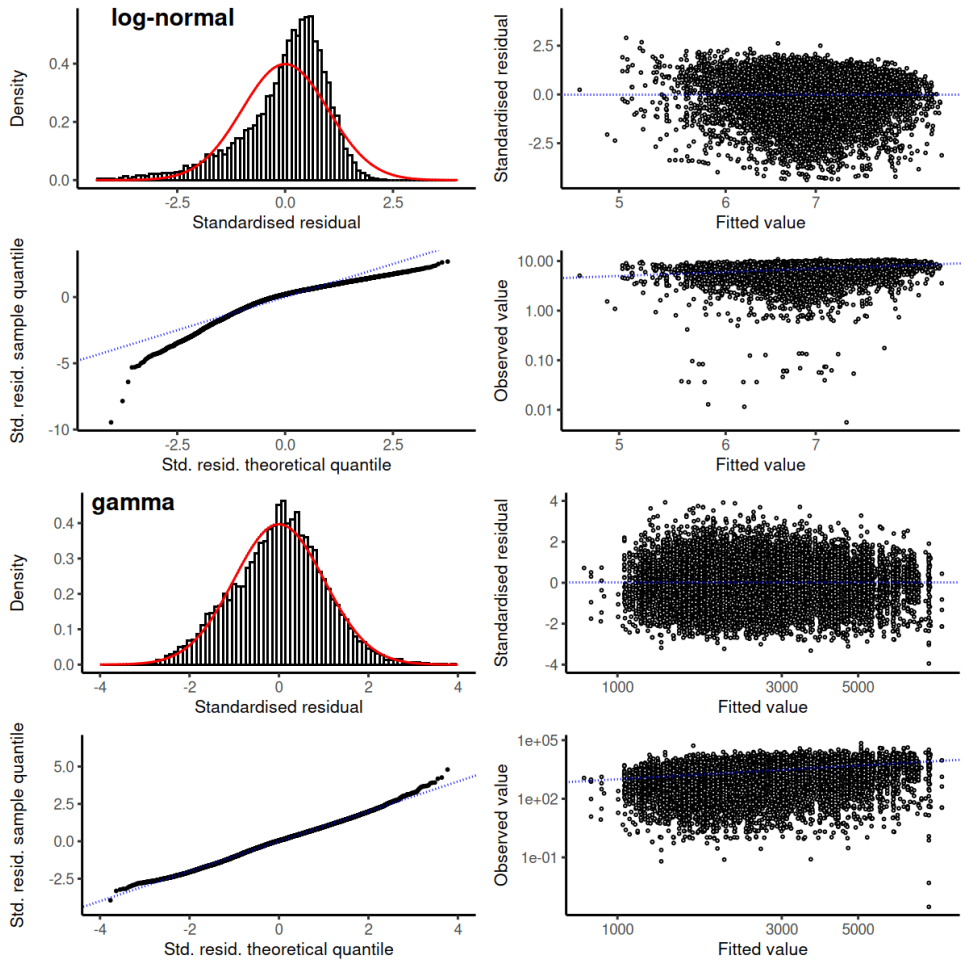

Figure D.10: Diagnostic plots for the alternative log-normal and gamma models considered for positive catches in the BYX 2 BYX 3 event (regions) dataset.

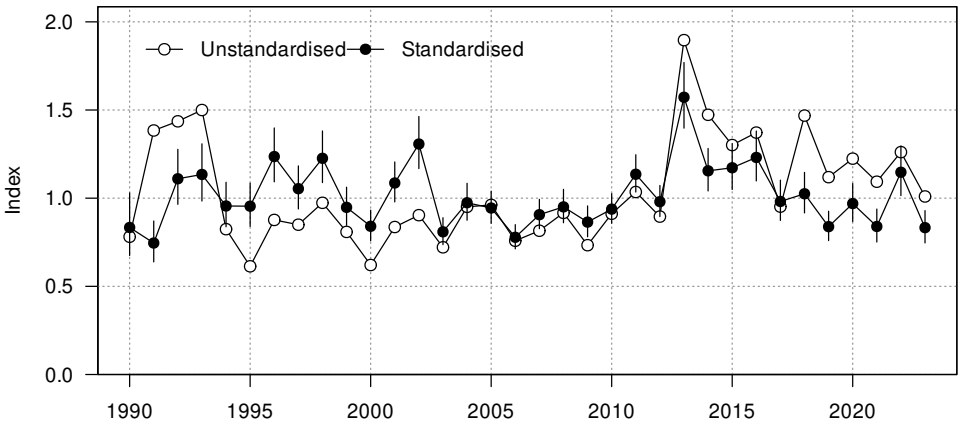

Figure D.11: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch using the Weibull model for the BYX 2 BYX 3 event (regions) dataset.

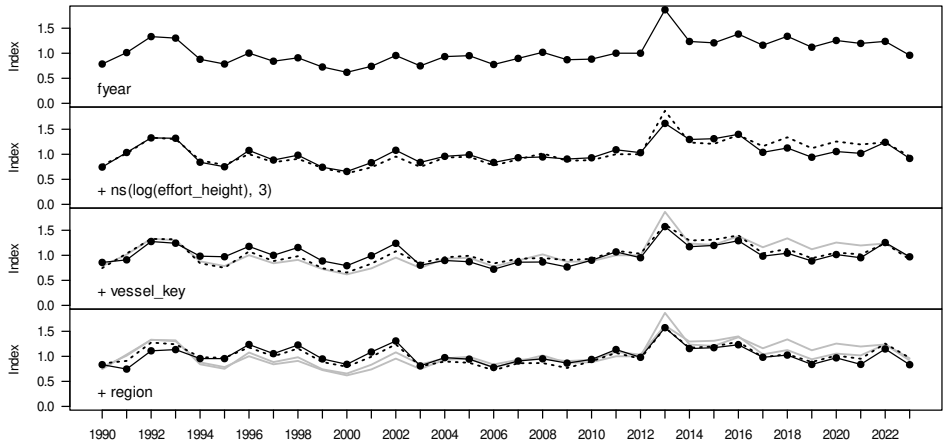

Figure D.12: Changes to the BYX 2 BYX 3 event (regions) positive catch index as terms are successively entered into the Weibull model.

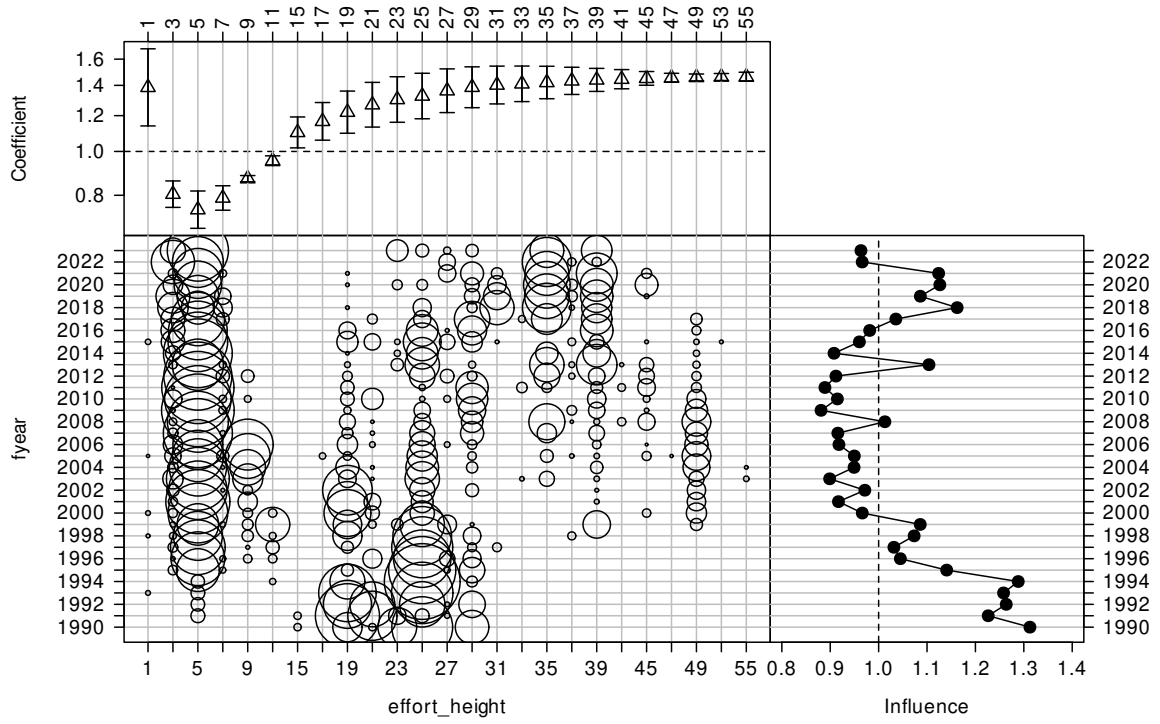

Figure D.13: CDI plot for effort height (m) for the Weibull model of positive catches in the BYX 2 BYX 3 event (regions) catch-per-unit-effort dataset.

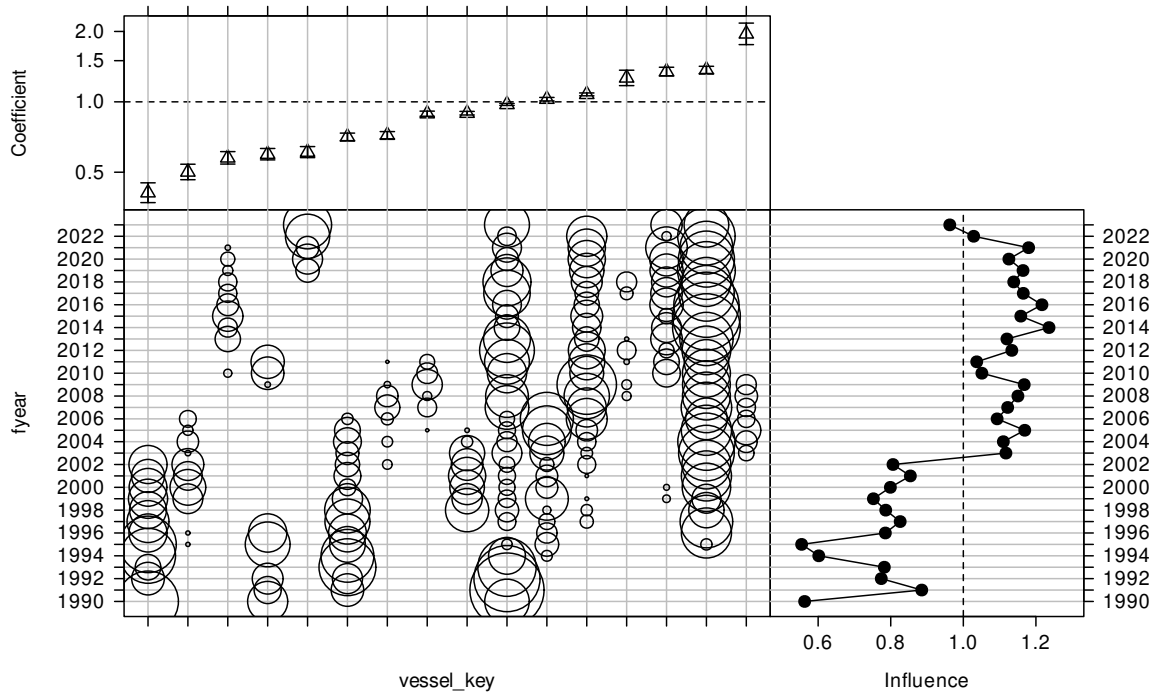

Figure D.14: CDI plot for vessel key for the Weibull model of positive catches in the BYX 2 BYX 3 event (regions) catch-per-unit-effort dataset.

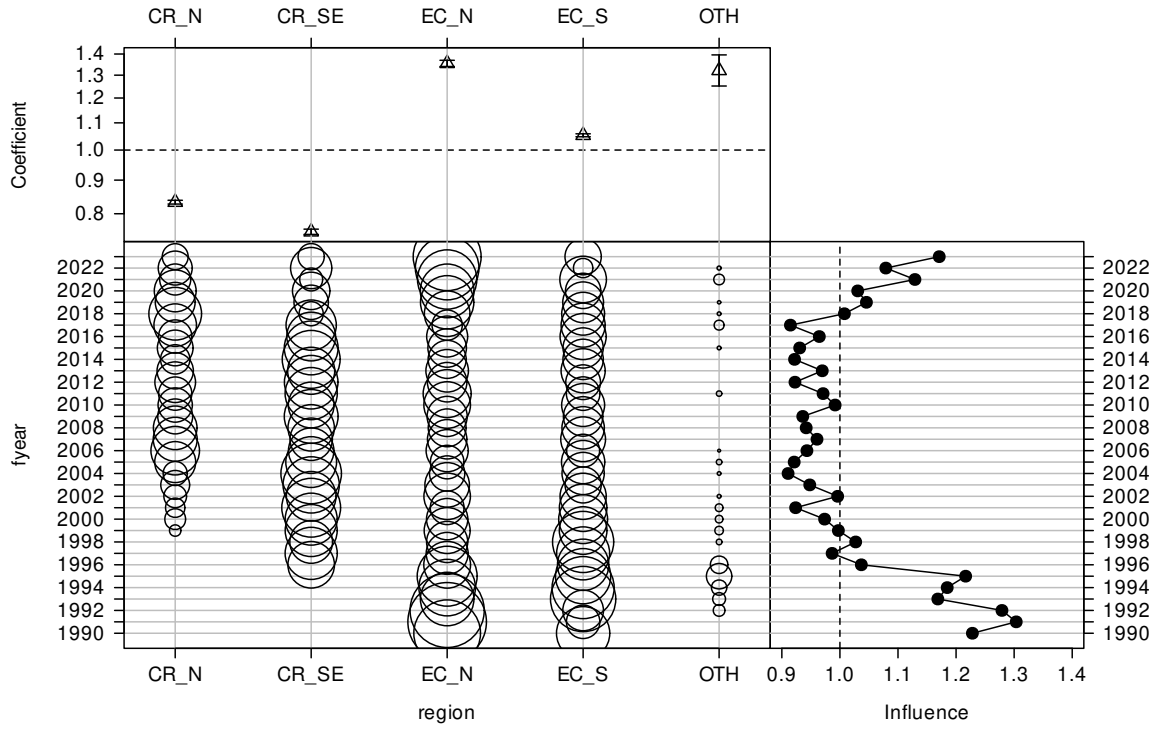

Figure D.15: CDI plot for region for the Weibull model of positive catches in the BYX 2 BYX 3 event (regions) catch-per-unit-effort dataset.

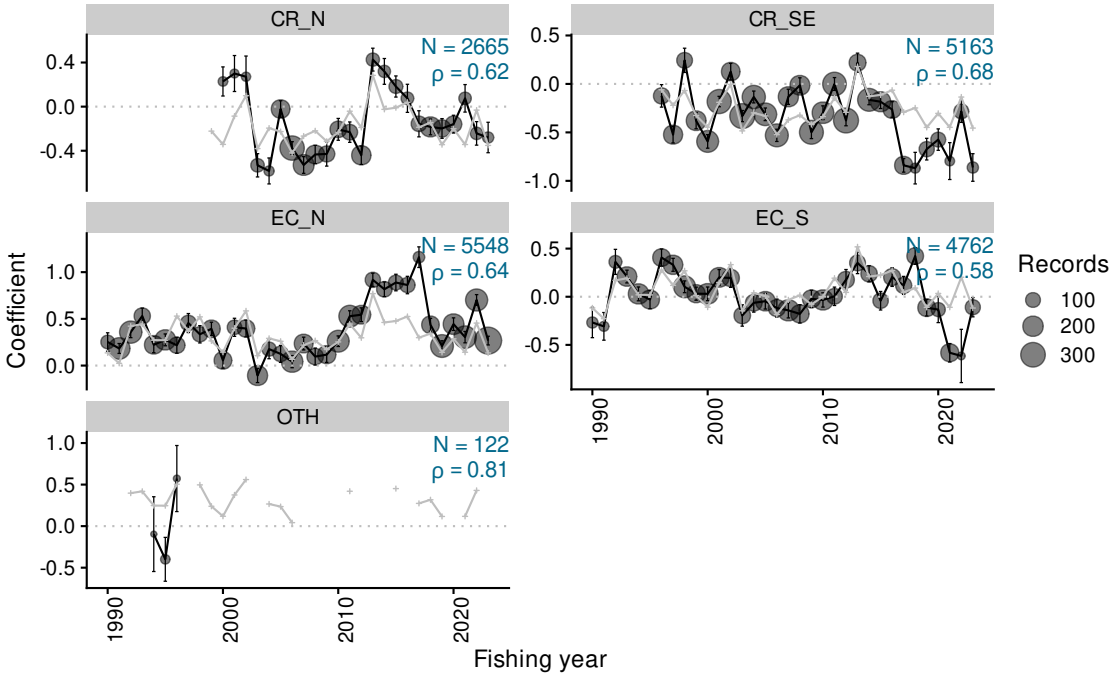

Figure D.16: Residual implied coefficients for area-year in the Weibull positive catch model for the BYX 2 BYX 3 event (regions) dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 10 data points in an area-year stratum. The light grey line and points indicate the overall year indices; these are only plotted where there are data in a stratum.

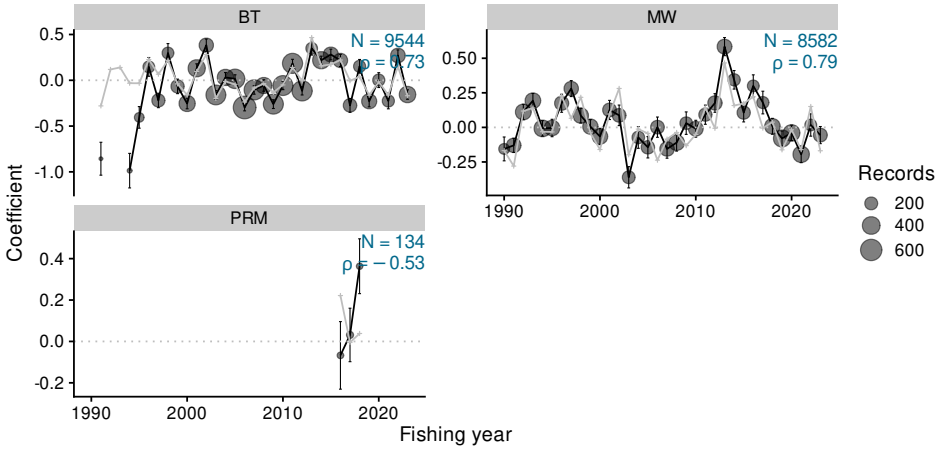

Figure D.17: Residual implied coefficients for primary method-year in the Weibull positive catch model for the BYX 2 BYX 3 event (regions) dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 10 data points in a method-year stratum. The light grey line and points indicate the overall year indices; these are only plotted where there are data in a stratum.

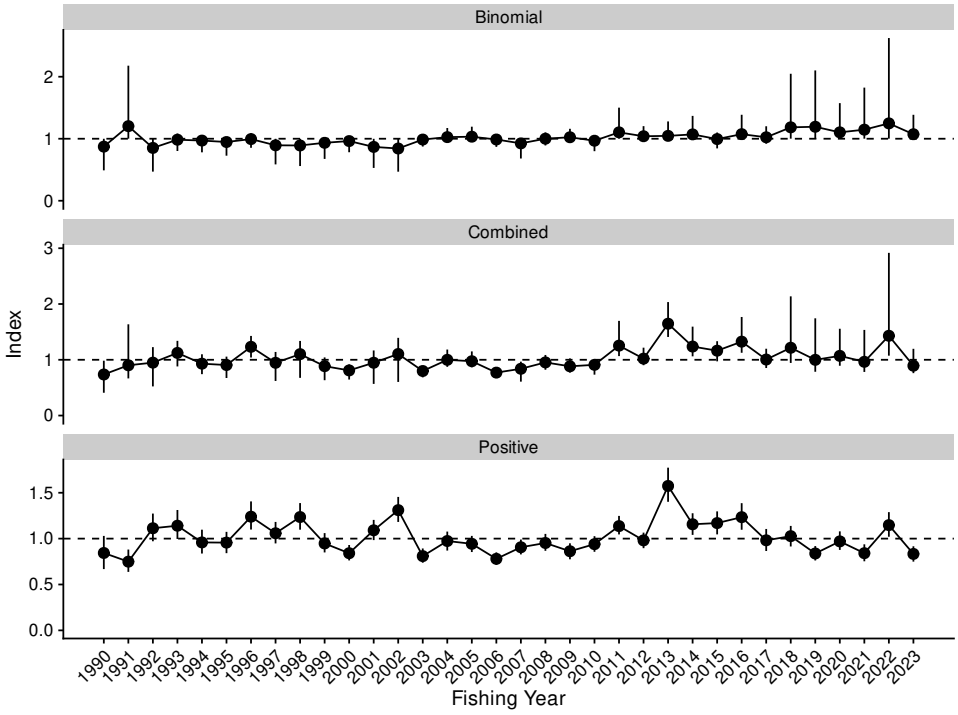

Figure D.18: Standardised indices and 95% confidence intervals for the BYX 2 BYX 3 event (regions) dataset.

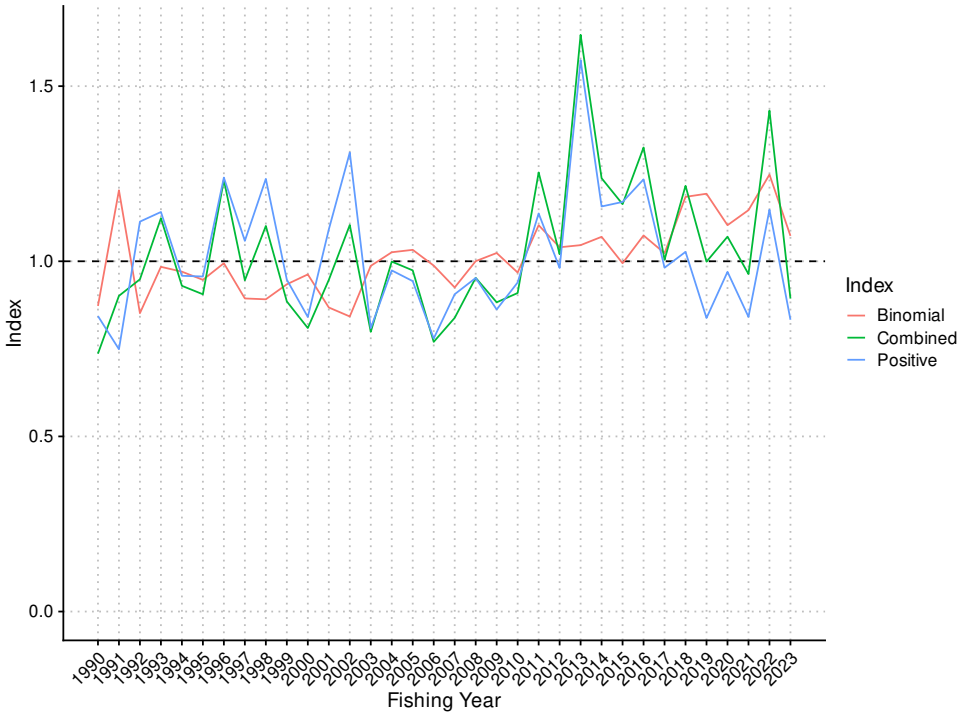

Figure D.19: Standardised indices for the BYX 2 BYX 3 event (regions) dataset.

Table D.6: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in BYX 2 BYX 3 event (regions).

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
1990	0.873	0.130	0.490	0.999	0.736	0.147	0.409	0.983	0.844	0.092	0.668	1.030
1991	1.203	0.300	1.001	2.178	0.901	0.248	0.666	1.636	0.749	0.062	0.637	0.881
1992	0.852	0.135	0.470	0.998	0.949	0.180	0.522	1.227	1.113	0.077	0.971	1.273
1993	0.984	0.072	0.802	1.084	1.123	0.117	0.881	1.339	1.141	0.081	0.996	1.312
1994	0.970	0.068	0.781	1.048	0.930	0.091	0.742	1.099	0.959	0.066	0.838	1.097
1995	0.947	0.071	0.727	1.004	0.906	0.098	0.673	1.057	0.956	0.059	0.841	1.074
1996	0.994	0.060	0.854	1.089	1.232	0.099	1.041	1.428	1.239	0.078	1.099	1.406
1997	0.894	0.105	0.586	0.999	0.946	0.133	0.620	1.140	1.058	0.060	0.948	1.182
1998	0.891	0.112	0.560	0.999	1.101	0.169	0.676	1.338	1.235	0.074	1.098	1.387
1999	0.934	0.083	0.675	1.000	0.885	0.104	0.634	1.042	0.947	0.054	0.849	1.060
2000	0.962	0.057	0.782	1.007	0.809	0.069	0.646	0.918	0.841	0.043	0.762	0.930
2001	0.868	0.120	0.529	0.999	0.947	0.153	0.568	1.167	1.091	0.056	0.984	1.204
2002	0.842	0.135	0.468	0.998	1.104	0.202	0.603	1.393	1.310	0.070	1.182	1.455
2003	0.987	0.043	0.874	1.042	0.799	0.052	0.685	0.890	0.809	0.040	0.737	0.893
2004	1.026	0.056	0.951	1.173	0.999	0.079	0.873	1.183	0.974	0.053	0.870	1.077
2005	1.033	0.055	0.977	1.194	0.974	0.073	0.865	1.150	0.943	0.045	0.854	1.030
2006	0.988	0.044	0.869	1.040	0.770	0.045	0.672	0.848	0.780	0.035	0.714	0.850
2007	0.925	0.081	0.681	0.999	0.839	0.091	0.608	0.966	0.906	0.041	0.828	0.990
2008	1.000	0.054	0.891	1.102	0.953	0.068	0.821	1.086	0.952	0.047	0.867	1.051
2009	1.024	0.051	0.962	1.160	0.883	0.065	0.770	1.025	0.862	0.044	0.775	0.949
2010	0.968	0.055	0.799	1.013	0.909	0.072	0.733	1.014	0.940	0.043	0.856	1.027
2011	1.103	0.128	1.001	1.501	1.254	0.161	1.066	1.697	1.136	0.052	1.046	1.248
2012	1.040	0.052	0.997	1.203	1.020	0.080	0.903	1.217	0.981	0.043	0.896	1.065
2013	1.046	0.076	0.979	1.279	1.647	0.160	1.409	2.034	1.574	0.095	1.401	1.773
2014	1.070	0.094	1.000	1.368	1.237	0.136	1.062	1.594	1.156	0.060	1.041	1.276
2015	0.994	0.065	0.844	1.100	1.163	0.092	0.972	1.333	1.169	0.064	1.046	1.297
2016	1.074	0.101	0.992	1.386	1.325	0.164	1.126	1.767	1.234	0.074	1.097	1.386
2017	1.023	0.072	0.919	1.201	1.004	0.088	0.852	1.198	0.982	0.061	0.865	1.105
2018	1.184	0.267	1.001	2.048	1.215	0.305	0.943	2.137	1.027	0.057	0.914	1.138
2019	1.193	0.281	1.001	2.101	0.999	0.244	0.785	1.743	0.838	0.040	0.762	0.919
2020	1.103	0.146	1.001	1.574	1.070	0.169	0.893	1.556	0.970	0.052	0.877	1.079
2021	1.146	0.210	1.001	1.824	0.964	0.192	0.782	1.535	0.841	0.047	0.753	0.938
2022	1.248	0.414	1.001	2.624	1.430	0.470	1.074	2.917	1.147	0.068	1.020	1.289
2023	1.072	0.100	0.994	1.386	0.893	0.111	0.760	1.197	0.833	0.043	0.749	0.916

D.2 BYX WCR (HOK target) trip

Table D.7: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the BYX WCR (HOK target) trip CPUE series.

Series	BYX WCR (HOK target) trip
QMS stock	BYX 2, BYX 3
Reporting forms	TCP, TCE, ERS - Trawl
Fishing methods	BT, PRB, MW, PRM
Target species	HOK
Statistical Areas	015, 016, 017, 018, 019, 020, 021, 401, 402
Period	1993-10-01, 2023-09-30
Resolution	Trip
Core fleet years	10
Core fleet trips	3
Default model	landkg ~ fyear + vessel_key + primary_method + modal_stat_area + modal_month + ns(log(total_fishing_duration), 3) + ns(log(total_effort_num), 3)
Stepwise selection	Yes
Positive catch distribution	Lognormal

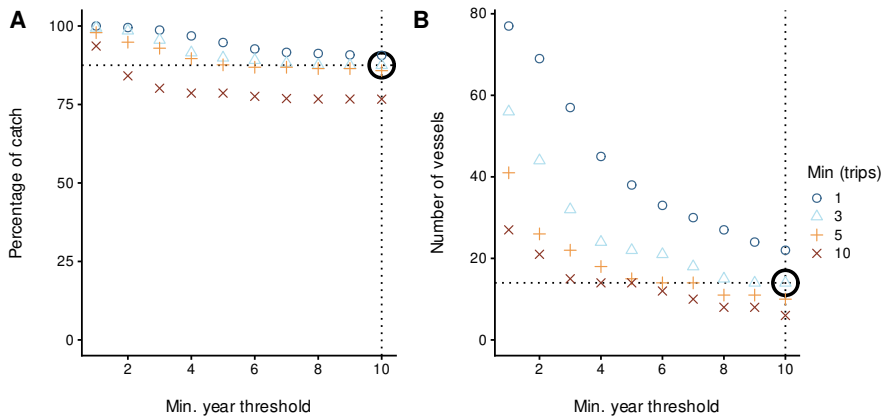

Figure D.20: Percentage of catch and number of vessels for different core vessel selection criteria for the BYX WCR (HOK target) trip CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

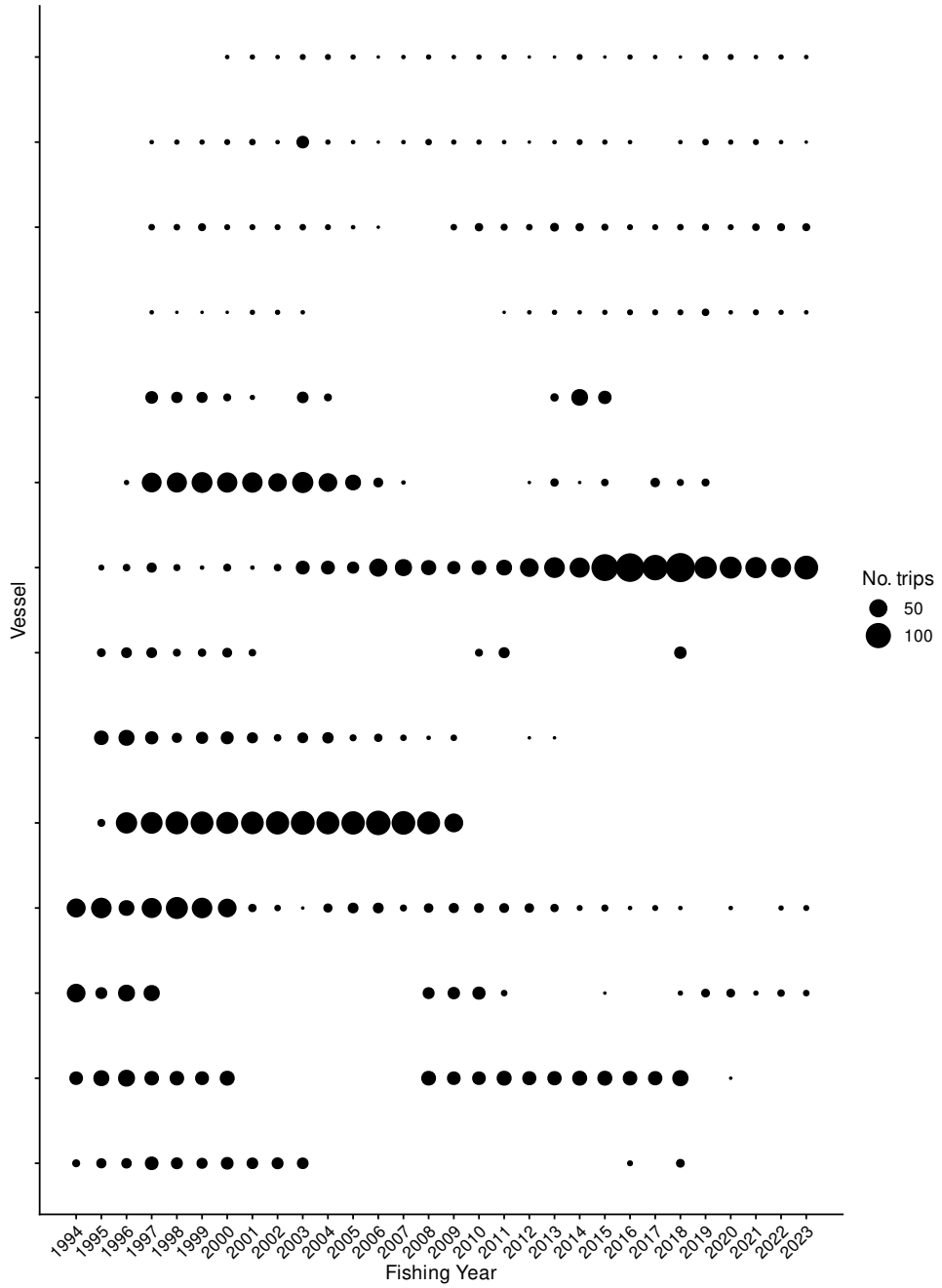

Figure D.21: Number of trips by fishing year for core vessels in the BYX WCR (HOK target) trip series. The area of the circles is proportional to the number of trips undertaken by a vessel in a fishing year.

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

Filter	1993	1994	1995	1996	1997	1998	1999	2000	2001
Ungroomed data	0 (100%) n: 1	126 (100%) n: 544	143 (100%) n: 565	414 (100%) n: 1050	536 (100%) n: 871	442 (100%) n: 662	523 (100%) n: 486	565 (100%) n: 506	439 (100%) n: 410
Positive fishing duration	0 n: 1	126 (100%) n: 544	143 (100%) n: 565	414 (100%) n: 1050	536 (100%) n: 871	442 (100%) n: 662	523 (100%) n: 486	565 (100%) n: 506	439 (100%) n: 410
Start 1994	0 (0%) n: 0	126 (100%) n: 544	143 (100%) n: 565	414 (100%) n: 1050	536 (100%) n: 871	442 (100%) n: 662	523 (100%) n: 486	565 (100%) n: 506	439 (100%) n: 410
Core fleet selection	0 (0%) n: 0	77 (61%) n: 143	109 (76%) n: 190	87 (21%) n: 272	149 (28%) n: 379	284 (64%) n: 324	479 (92%) n: 319	537 (95%) n: 311	402 (92%) n: 216

Filter	2002	2003	2004	2005	2006	2007	2008	2009	2010
Ungroomed data	473 (100%) n: 259	699 (100%) n: 424	685 (100%) n: 380	526 (100%) n: 290	564 (100%) n: 280	456 (100%) n: 173	558 (100%) n: 353	617 (100%) n: 317	283 (100%) n: 286
Positive fishing duration	473 (100%) n: 259	699 (100%) n: 424	685 (100%) n: 380	526 (100%) n: 290	564 (100%) n: 280	456 (100%) n: 173	558 (100%) n: 353	617 (100%) n: 317	283 (100%) n: 286
Start 1994	473 (100%) n: 259	699 (100%) n: 424	685 (100%) n: 380	526 (100%) n: 290	564 (100%) n: 280	456 (100%) n: 173	558 (100%) n: 353	617 (100%) n: 317	283 (100%) n: 286
Core fleet selection	408 (86%) n: 186	609 (87%) n: 274	666 (97%) n: 211	507 (97%) n: 172	562 (100%) n: 185	454 (100%) n: 148	544 (97%) n: 190	616 (100%) n: 157	269 (95%) n: 120

Filter	2011	2012	2013	2014	2015	2016	2017	2018	2019
Ungroomed data	452 (100%) n: 287	606 (100%) n: 273	427 (100%) n: 268	448 (100%) n: 285	657 (100%) n: 364	637 (100%) n: 374	804 (100%) n: 326	608 (100%) n: 402	189 (100%) n: 394
Positive fishing duration	452 (100%) n: 287	606 (100%) n: 273	427 (100%) n: 268	448 (100%) n: 285	657 (100%) n: 364	637 (100%) n: 374	804 (100%) n: 326	608 (100%) n: 402	189 (100%) n: 394
Start 1994	452 (100%) n: 287	606 (100%) n: 273	427 (100%) n: 268	448 (100%) n: 285	657 (100%) n: 364	637 (100%) n: 374	804 (100%) n: 326	608 (100%) n: 402	189 (100%) n: 394
Core fleet selection	447 (99%) n: 117	604 (100%) n: 105	420 (98%) n: 140	445 (99%) n: 161	652 (99%) n: 200	634 (100%) n: 180	692 (86%) n: 158	581 (96%) n: 229	129 (68%) n: 118

Filter	2020	2021	2022	2023
Ungroomed data	320 (100%) n: 250	72 (100%) n: 206	261 (100%) n: 185	153 (100%) n: 203
Positive fishing duration	320 (100%) n: 250	72 (100%) n: 206	261 (100%) n: 185	153 (100%) n: 203
Start 1994	320 (100%) n: 250	72 (100%) n: 206	261 (100%) n: 185	153 (100%) n: 203
Core fleet selection	189 (59%) n: 101	69 (96%) n: 89	197 (76%) n: 87	151 (99%) n: 111

Table D.9: Summary of the BYX WCR (HOK target) trip dataset after core fleet selection. Trips caught represents the percentage of trips with alfonsino catch.

Fishing year	Vessels	Trips	Events	Hours	Catch (t)	Trips caught
1994	4	143	1 443	2 217.88	77.37	16.08
1995	8	190	1 951	2 823.45	108.70	14.74
1996	9	272	3 420	4 993.95	87.12	24.63
1997	13	379	4 740	9 591.37	149.43	28.76
1998	12	324	4 964	10 460.25	283.67	42.90
1999	12	319	5 666	12 413.31	478.92	48.59
2000	13	311	5 541	12 702.80	537.38	40.51
2001	12	216	4 869	12 951.64	401.61	51.39
2002	10	186	3 441	8 170.42	407.86	50.54
2003	11	274	4 866	12 073.33	609.38	39.42
2004	9	211	4 166	10 233.37	665.99	48.82
2005	8	172	3 484	7 808.50	507.27	44.77
2006	8	185	2 008	3 579.13	562.26	29.73
2007	7	148	2 332	4 963.65	454.25	35.14
2008	8	190	3 067	7 585.75	543.69	40.00
2009	9	157	2 991	7 101.40	616.49	42.04
2010	8	120	2 700	7 433.61	269.31	31.67
2011	9	117	2 481	6 844.14	447.42	30.77
2012	9	105	2 264	4 994.42	603.95	43.81
2013	10	140	2 930	7 162.02	420.33	46.43
2014	9	161	3 478	9 305.70	444.84	50.93
2015	10	200	2 485	5 409.93	651.87	62.00
2016	8	180	2 751	7 463.98	634.48	58.33
2017	7	158	2 462	7 186.77	691.75	66.46
2018	11	229	2 724	7 592.38	580.88	51.09
2019	7	118	2 735	10 216.43	128.55	57.63
2020	8	101	1 804	5 947.20	189.24	61.39
2021	6	89	1 817	5 868.48	69.21	50.56
2022	7	87	2 055	6 762.15	197.34	57.47
2023	7	111	1 939	4 909.12	151.39	54.95

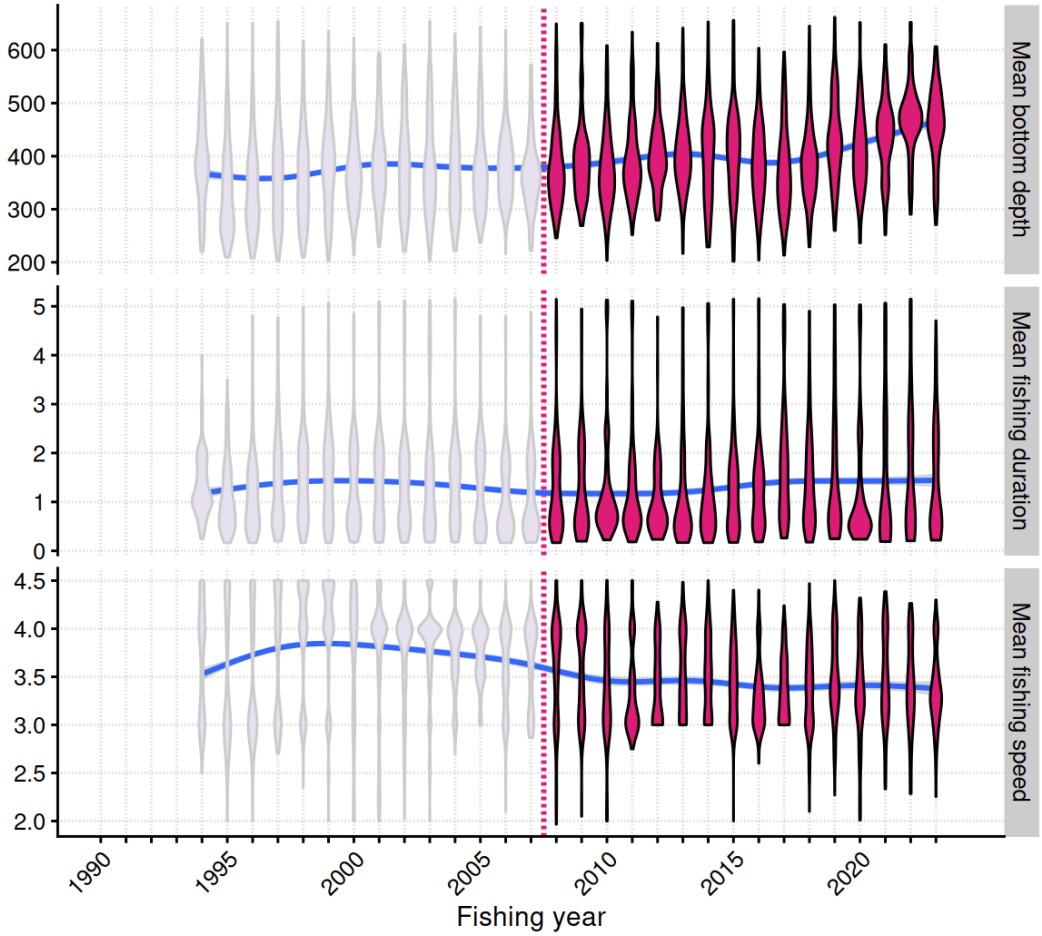

Figure D.22: Characteristics of trips in the BYX WCR (HOK target) trip catch-per-unit-effort dataset using variables that are only defined in event-level reporting. The violin plot fill colour distinguishes data before and after the replacement of the CELR form by fishing event level reporting, which is also indicated by the dashed vertical line. Values plotted for a given variable were restricted to values between the 1st and 99th percentile of reported values.

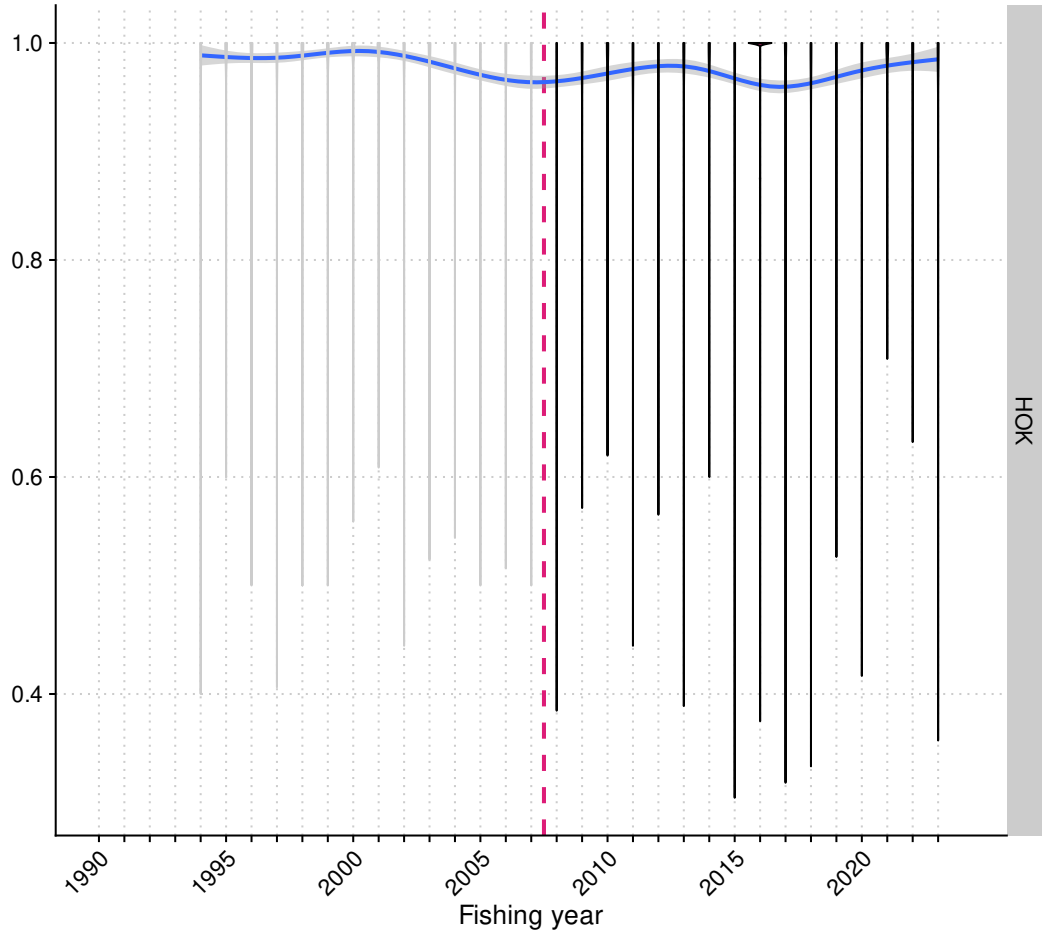

Figure D.23: The proportion of events on trips in the BYX WCR (HOK target) trip catch-per-unit-effort dataset that reported the modal target species for the trip. The violin plot fill colour distinguishes data before and after the replacement of the CELR form by fishing event level reporting, which is also indicated by the dashed vertical line.

Table D.10: Summary of stepwise selection for occurrence of positive catch in the BYX WCR (HOK target) trip series. 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	28	7282	4.8	4.8	*
+ ns(log(total_effort_num), 3)	3	4723	38.6	33.8	*
+ modal_month	11	4372	43.5	4.9	*
+ vessel_key	13	4188	46.3	2.8	*
+ modal_stat_area	6	4063	48.1	1.8	*
+ ns(log(total_fishing_duration), 3)	3	4039	48.5	0.4	

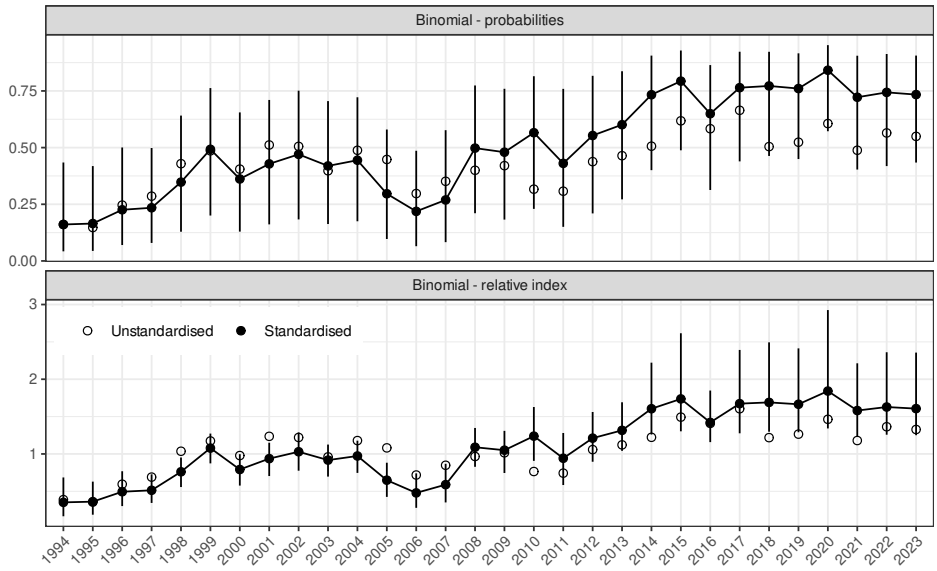

Figure D.24: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the BYX WCR (HOK target) trip dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

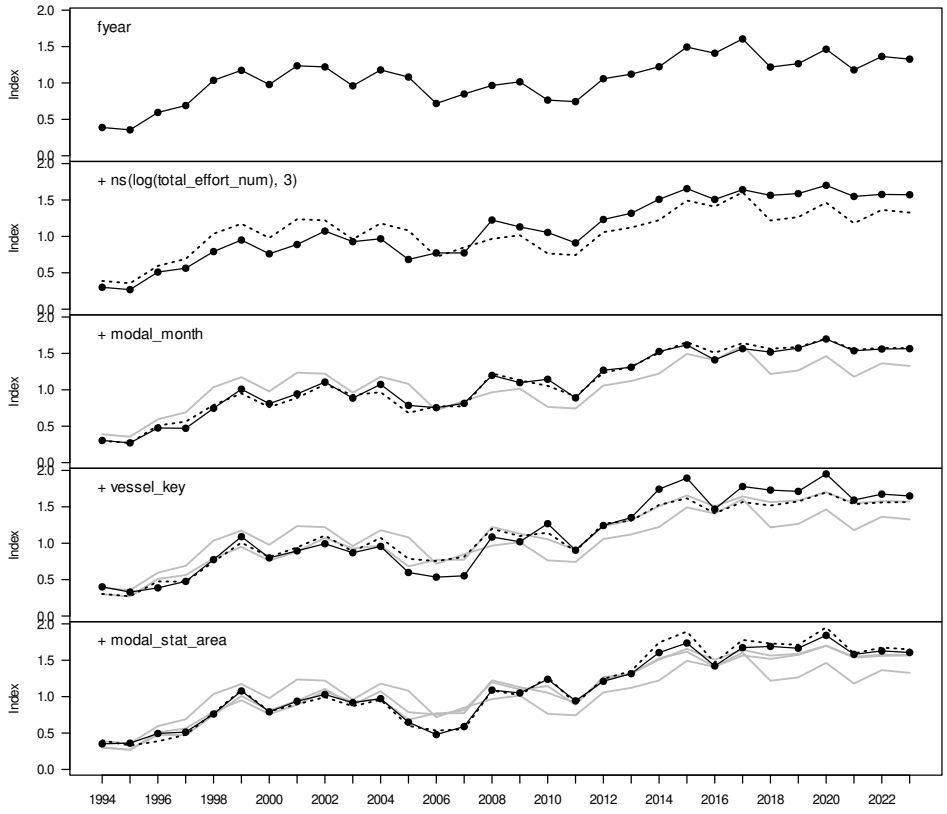

Figure D.25: Step plot for occurrence of catch in the BYX WCR (HOK target) trip dataset.

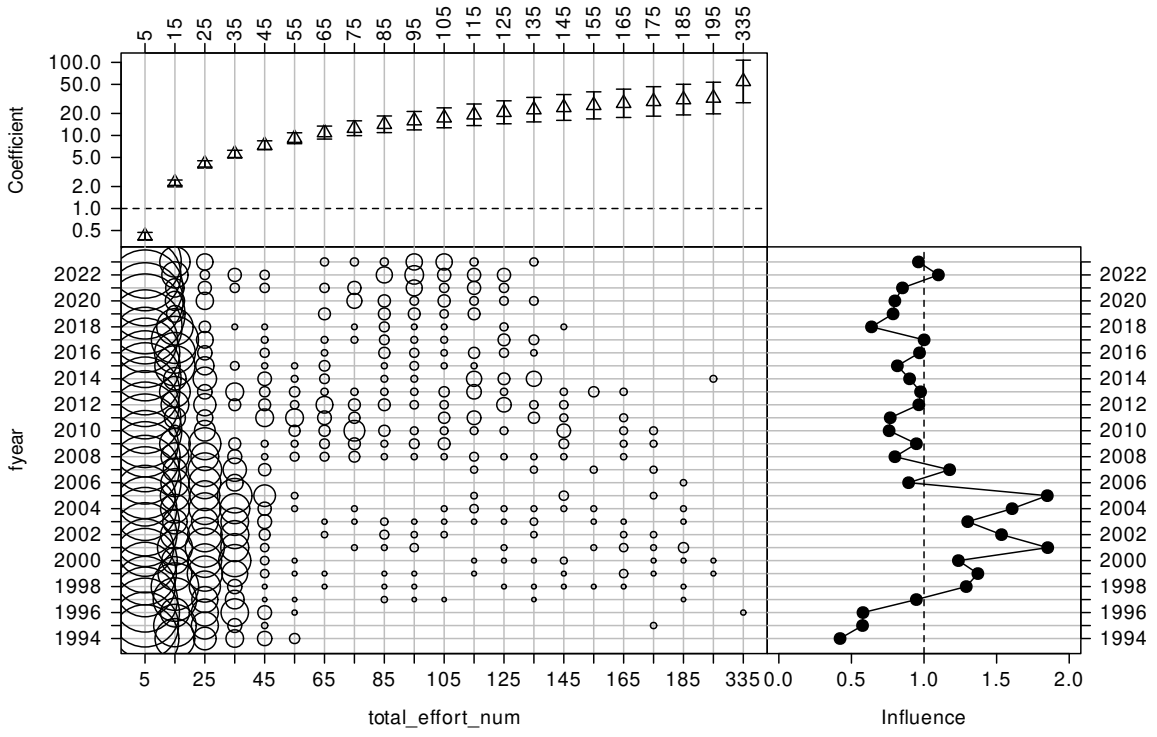

Figure D.26: CDI plot for total effort num for the occurrence of positive catch in the BYX WCR (HOK target) trip catch-per-unit-effort dataset.

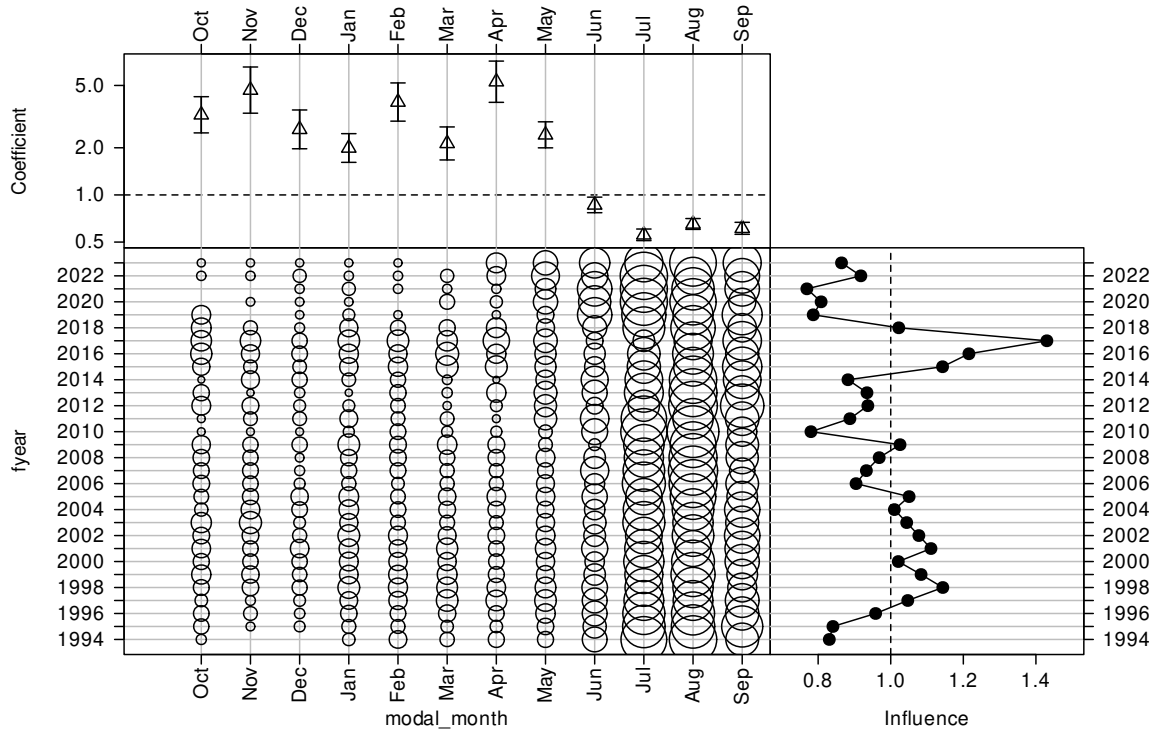

Figure D.27: CDI plot for modal month for the occurrence of positive catch in the BYX WCR (HOK target) trip catch-per-unit-effort dataset.

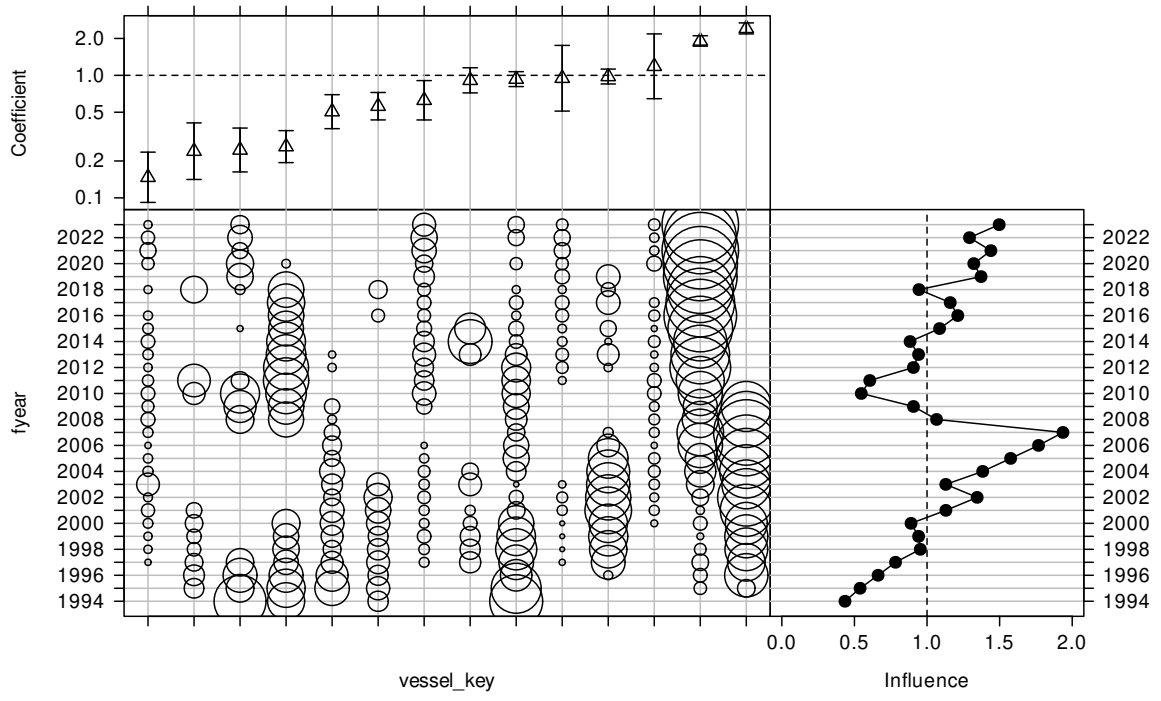

Figure D.28: CDI plot for vessel key for the occurrence of positive catch in the BYX WCR (HOK target) trip catch-per-unit-effort dataset.

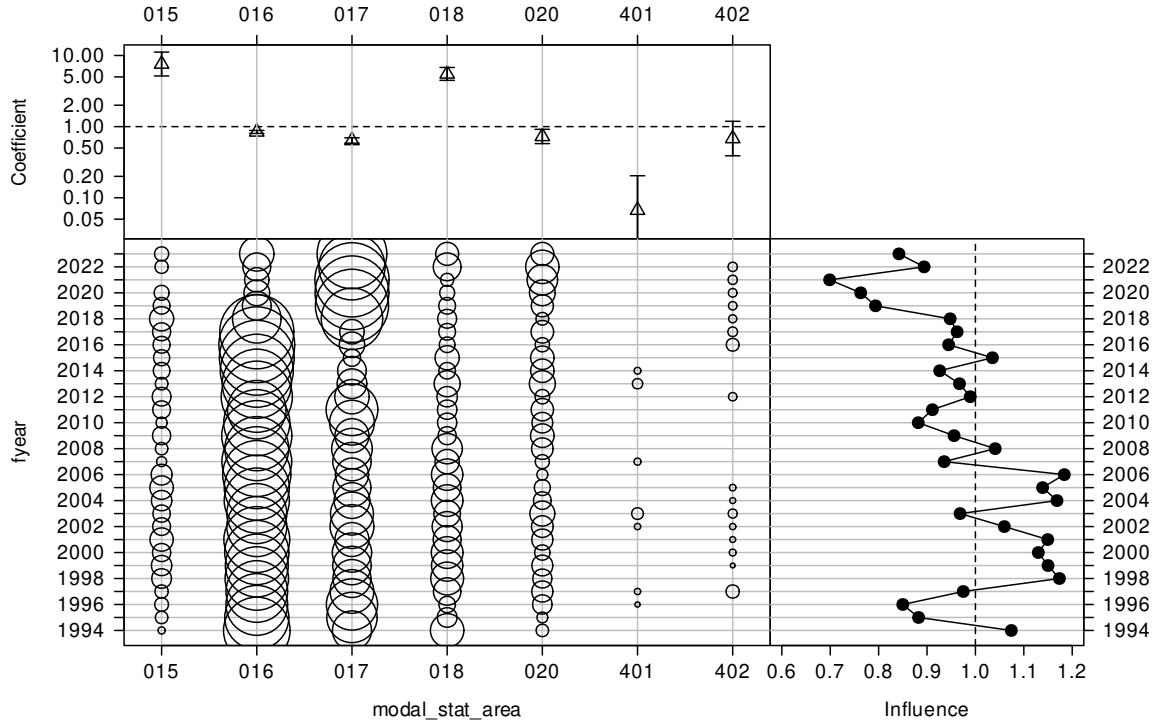

Figure D.29: CDI plot for modal statistical area for the occurrence of positive catch in the BYX WCR (HOK target) trip catch-per-unit-effort dataset.

Table D.11: Summary of stepwise selection for the lognormal model for positive catches in the BYX WCR (HOK target) trip series. 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	28	12 841	7.0	7.0	*
+ modal_month	11	11 130	55.3	48.3	*
+ modal_stat_area	6	10 818	61.0	5.7	*
+ ns(log(total_fishing_duration), 3)	3	10 568	65.0	4.0	*
+ primary_method	2	10 532	65.6	0.6	
+ vessel_key	13	10 492	66.6	1.0	*
+ ns(log(total_effort_num), 3)	3	10 469	67.0	0.4	

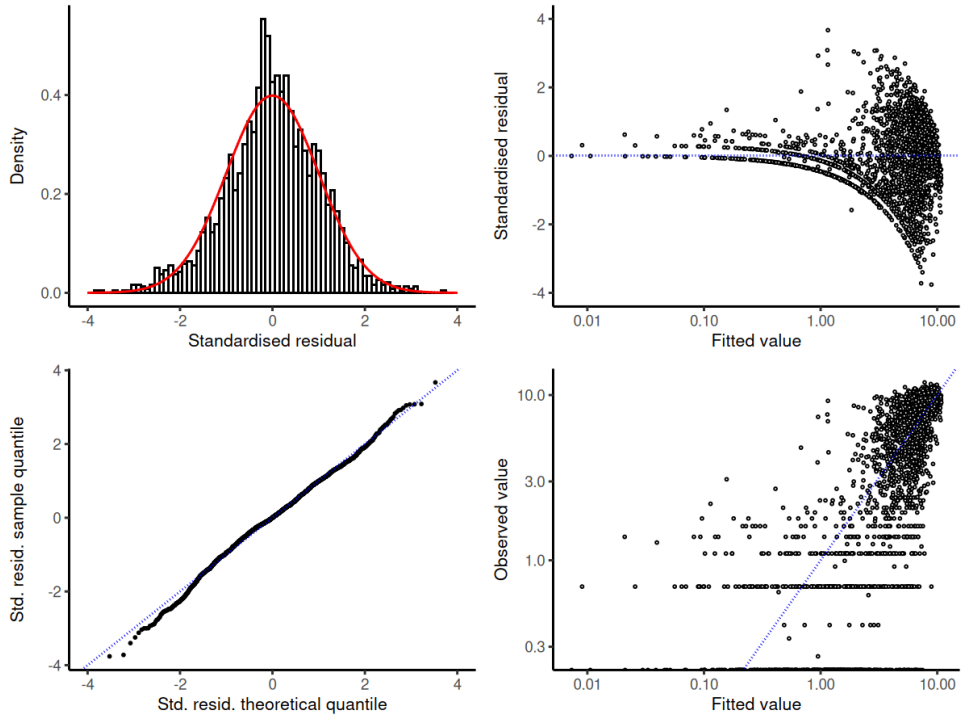

Figure D.30: Diagnostic plots for the selected lognormal model for positive catches in the BYX WCR (HOK target) trip dataset.

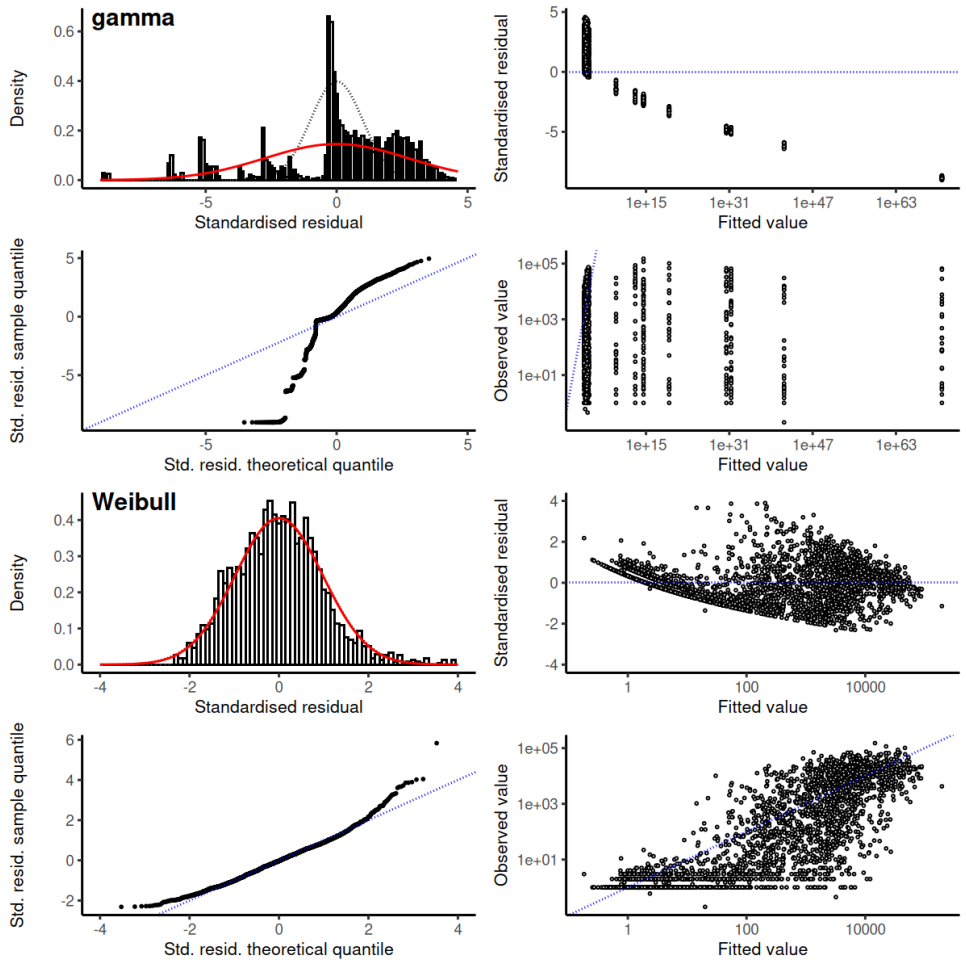

Figure D.31: Diagnostic plots for the alternative gamma and Weibull models considered for positive catches in the BYX WCR (HOK target) trip dataset.

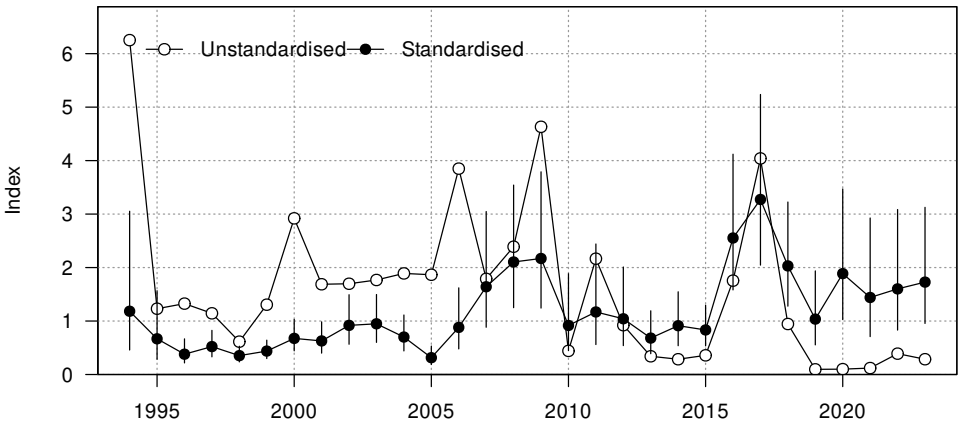

Figure D.32: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch using the lognormal model for the BYX WCR (HOK target) trip dataset.

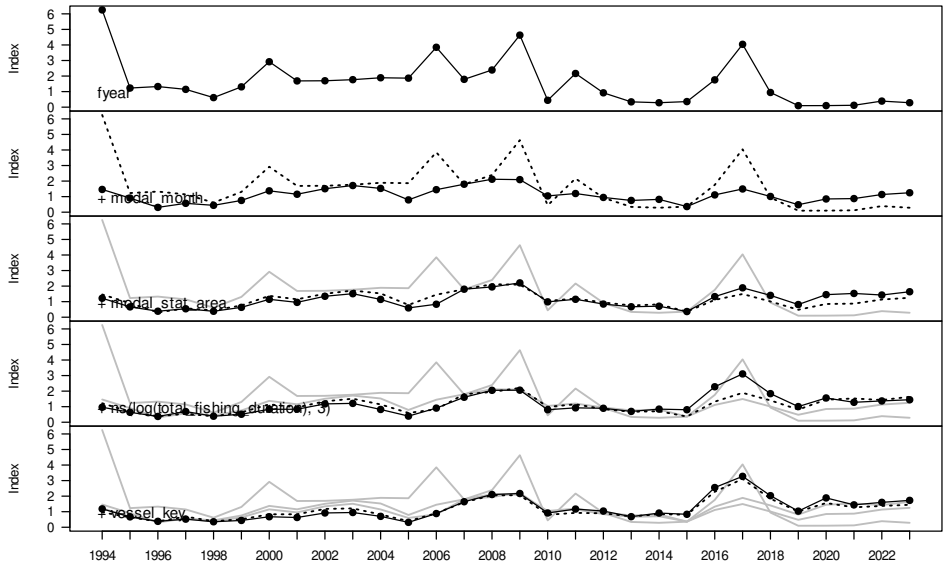

Figure D.33: Changes to the BYX WCR (HOK target) trip positive catch index as terms are successively entered into the lognormal model.

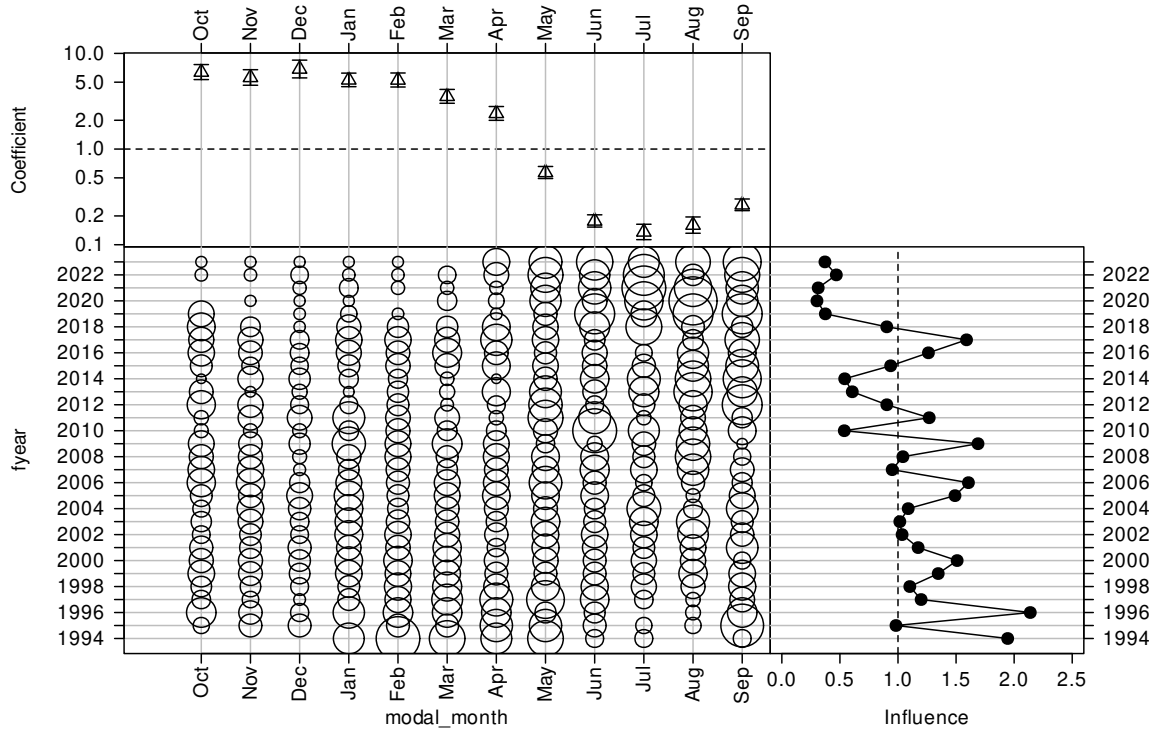

Figure D.34: CDI plot for modal month for the lognormal model of positive catches in the BYX WCR (HOK target) trip catch-per-unit-effort dataset.

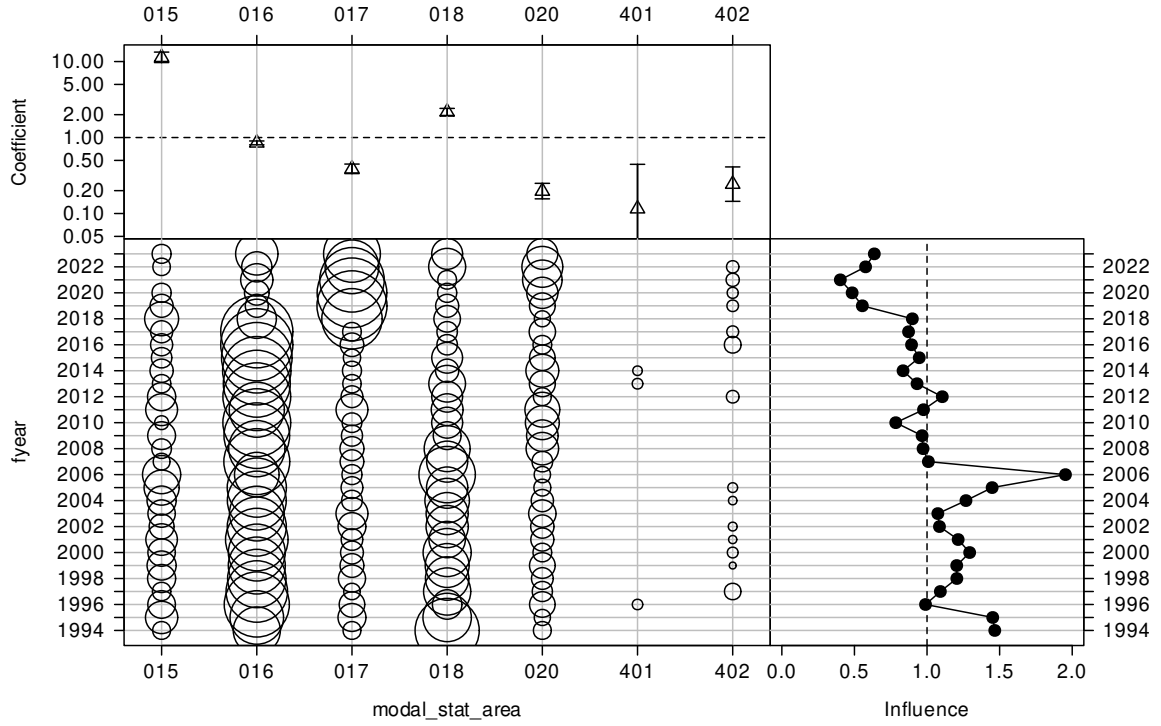

Figure D.35: CDI plot for modal statistical area for the lognormal model of positive catches in the BYX WCR (HOK target) trip catch-per-unit-effort dataset.

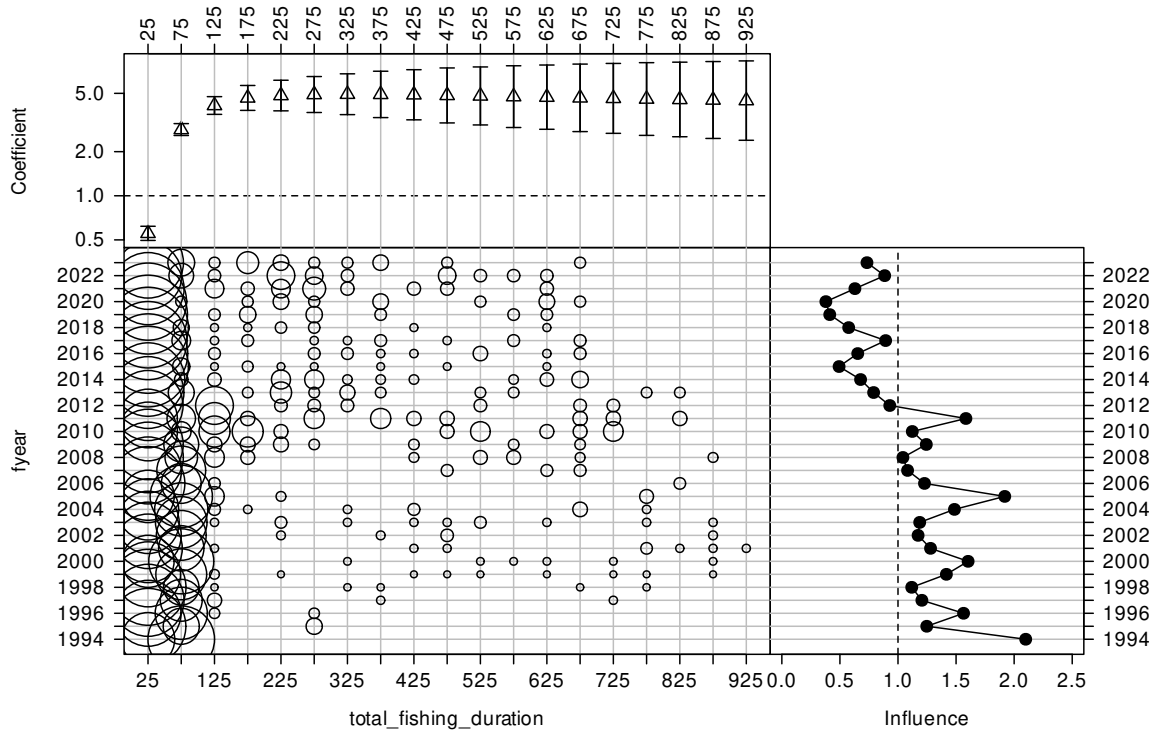

Figure D.36: CDI plot for total fishing duration (h) for the lognormal model of positive catches in the BYX WCR (HOK target) trip catch-per-unit-effort dataset.

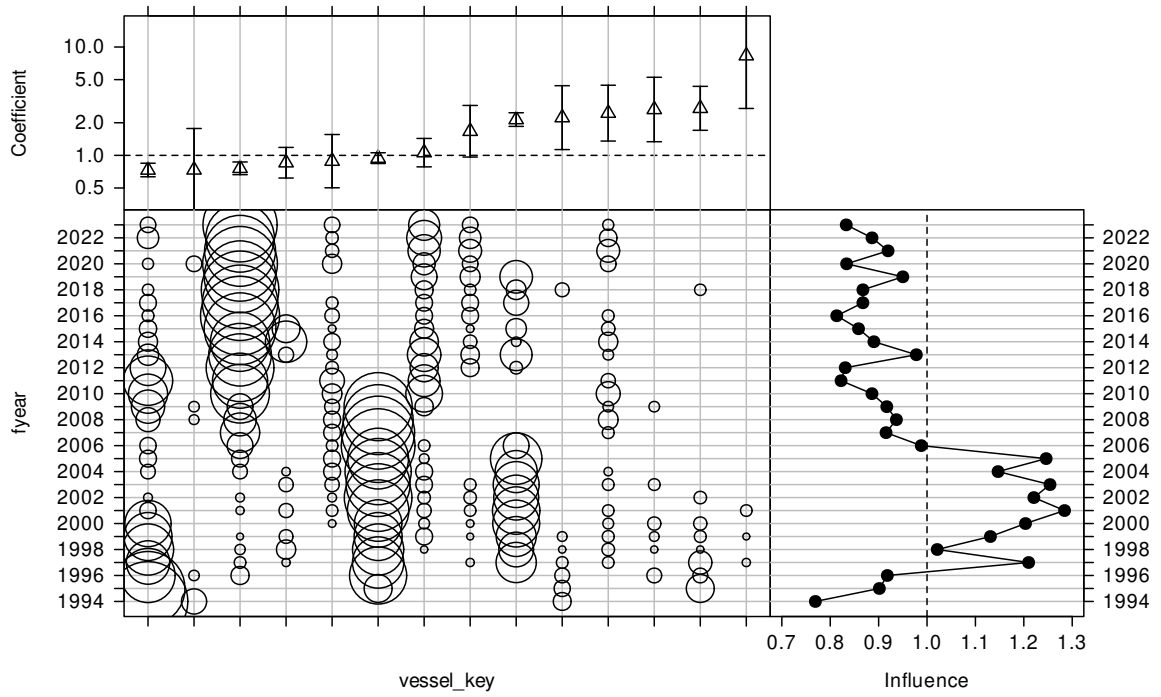

Figure D.37: CDI plot for vessel key for the lognormal model of positive catches in the BYX WCR (HOK target) trip catch-per-unit-effort dataset.

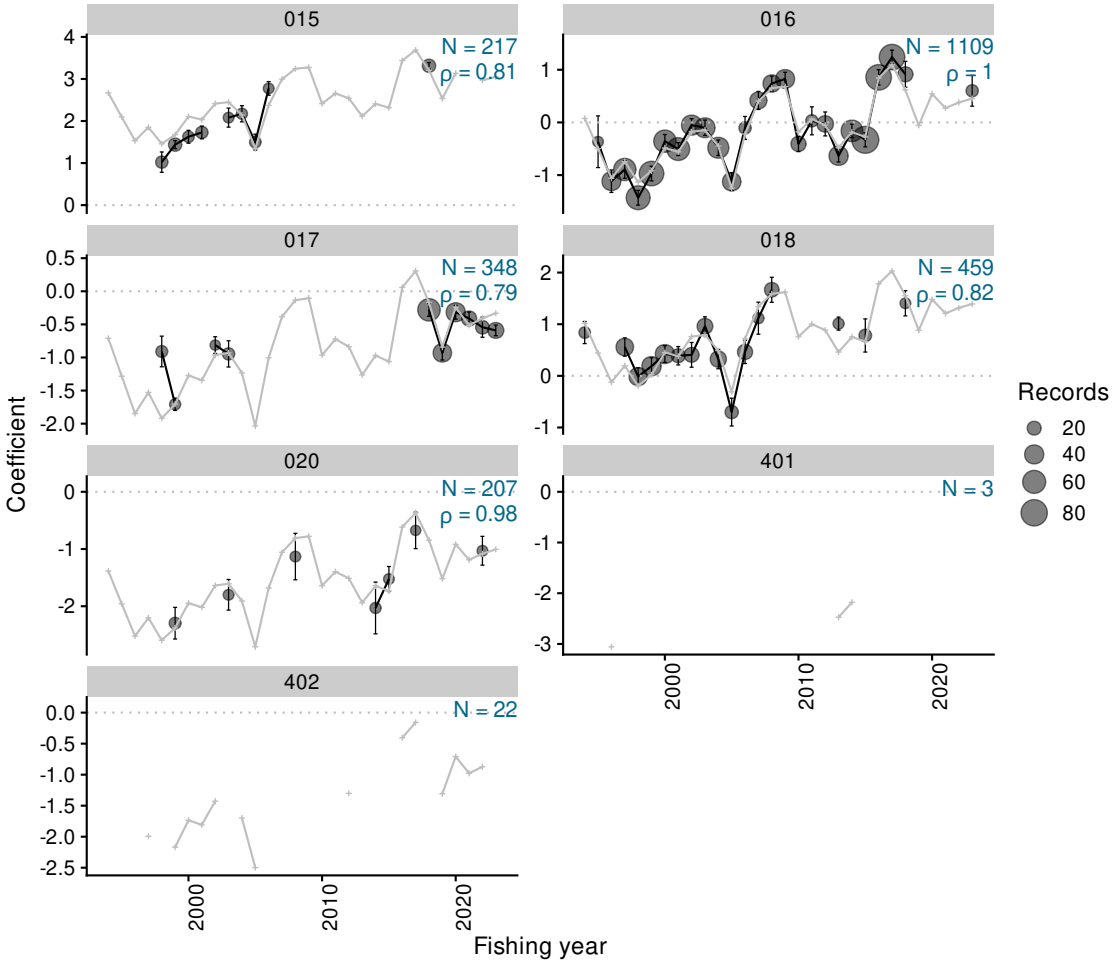

Figure D.38: Residual implied coefficients for area-year in the lognormal positive catch model for the BYX WCR (HOK target) trip dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 10 data points in an area-year stratum. The light grey line and points indicate the overall year indices; these are only plotted where there are data in a stratum.

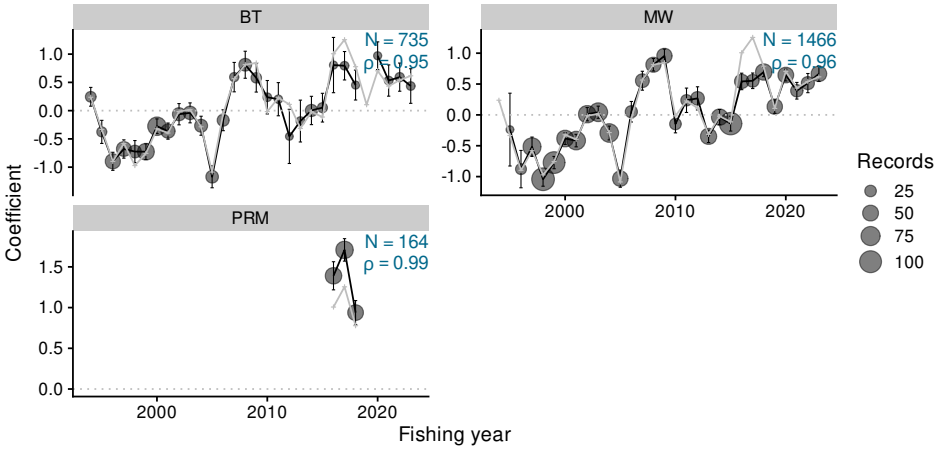

Figure D.39: Residual implied coefficients for primary method-year in the lognormal positive catch model for the BYX WCR (HOK target) trip dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 10 data points in a method-year stratum. The light grey line and points indicate the overall year indices; these are only plotted where there are data in a stratum.

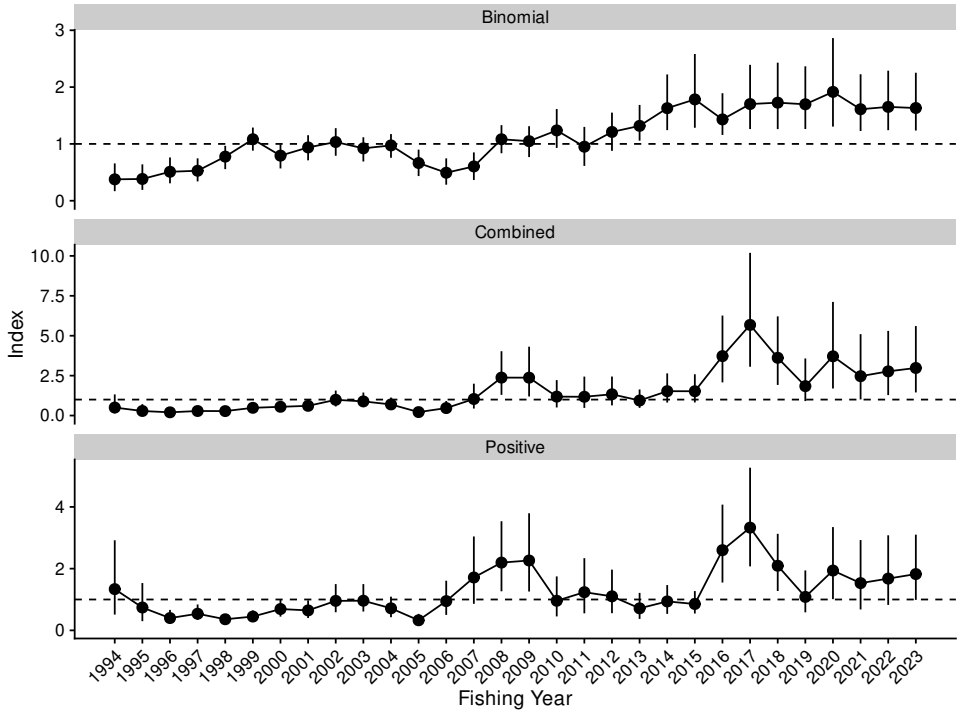

Figure D.40: Standardised indices and 95% confidence intervals for the BYX WCR (HOK target) trip dataset.

Figure D.41: Standardised indices for the BYX WCR (HOK target) trip dataset.

Table D.12: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in BYX WCR (HOK target) trip.

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
1994	0.377	0.125	0.168	0.657	0.500	0.303	0.135	1.325	1.336	0.614	0.511	2.919
1995	0.383	0.115	0.191	0.640	0.285	0.160	0.087	0.716	0.740	0.315	0.298	1.533
1996	0.510	0.116	0.307	0.762	0.203	0.074	0.088	0.378	0.398	0.112	0.222	0.663
1997	0.528	0.104	0.340	0.746	0.284	0.088	0.148	0.491	0.539	0.128	0.337	0.838
1998	0.776	0.105	0.556	0.966	0.279	0.069	0.167	0.437	0.359	0.070	0.245	0.521
1999	1.082	0.104	0.882	1.288	0.484	0.108	0.306	0.730	0.447	0.090	0.296	0.647
2000	0.794	0.108	0.568	0.993	0.548	0.138	0.322	0.864	0.691	0.142	0.445	1.002
2001	0.938	0.113	0.711	1.153	0.608	0.158	0.347	0.968	0.647	0.146	0.400	0.971
2002	1.033	0.124	0.792	1.277	0.986	0.254	0.571	1.565	0.956	0.233	0.587	1.499
2003	0.922	0.109	0.691	1.116	0.886	0.233	0.528	1.441	0.961	0.227	0.610	1.499
2004	0.973	0.106	0.756	1.173	0.696	0.186	0.398	1.126	0.715	0.170	0.426	1.092
2005	0.664	0.119	0.435	0.899	0.217	0.073	0.107	0.392	0.326	0.088	0.187	0.534
2006	0.493	0.118	0.283	0.746	0.468	0.182	0.198	0.909	0.947	0.283	0.501	1.609
2007	0.604	0.124	0.365	0.851	1.037	0.397	0.438	1.995	1.713	0.557	0.861	3.042
2008	1.082	0.126	0.836	1.330	2.377	0.698	1.294	4.030	2.195	0.579	1.266	3.536
2009	1.048	0.139	0.769	1.312	2.373	0.796	1.195	4.314	2.264	0.647	1.258	3.794
2010	1.238	0.174	0.930	1.614	1.185	0.437	0.506	2.220	0.959	0.331	0.452	1.748
2011	0.951	0.175	0.613	1.299	1.175	0.501	0.478	2.440	1.237	0.456	0.552	2.339
2012	1.211	0.172	0.878	1.551	1.333	0.461	0.638	2.443	1.103	0.360	0.556	1.968
2013	1.318	0.160	1.057	1.686	0.941	0.294	0.480	1.634	0.714	0.215	0.371	1.214
2014	1.629	0.250	1.243	2.223	1.526	0.466	0.813	2.641	0.938	0.238	0.534	1.468
2015	1.783	0.331	1.284	2.582	1.523	0.450	0.821	2.586	0.854	0.185	0.546	1.273
2016	1.431	0.187	1.158	1.892	3.723	1.067	2.078	6.262	2.599	0.644	1.550	4.074
2017	1.702	0.288	1.262	2.392	5.678	1.820	3.057	10.191	3.328	0.816	2.073	5.272
2018	1.726	0.298	1.261	2.430	3.617	1.095	1.918	6.211	2.093	0.473	1.275	3.128
2019	1.697	0.281	1.262	2.366	1.841	0.681	0.907	3.575	1.084	0.347	0.584	1.942
2020	1.915	0.398	1.305	2.863	3.710	1.383	1.695	7.118	1.938	0.595	1.012	3.346
2021	1.610	0.255	1.227	2.226	2.465	1.043	1.012	5.098	1.531	0.573	0.677	2.926
2022	1.651	0.267	1.242	2.289	2.768	1.026	1.281	5.303	1.677	0.576	0.824	3.080
2023	1.632	0.259	1.236	2.253	2.980	1.061	1.447	5.606	1.824	0.539	0.988	3.101

D.3 BYX event (Chatham Rise - South East)

Table D.13: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the BYX event (Chatham Rise - South East) CPUE series.

Series	BYX event (Chatham Rise - South East)
QMS stock	BYX 2, BYX 3
Reporting forms	TCP, TCE, ERS - Trawl
Fishing methods	BT, PRB, MW, PRM
Target species	BYX
Statistical Areas	011, 012, 013, 014, 015, 016, 017, 018, 019, 020, 021, 202, 203, 204, 205, 401, 402, 403, 404, 405, 410, 049, 050, 051, 052, 406, 412
Period	1989-10-01, 2023-09-30
Resolution	Fishing event
Core fleet years	5
Core fleet trips	3
Default model	allockg_top5 ~ fyear + cluster + vessel_key + primary_method + ns(log(fishing_duration), 3) + ns(log(effort_height), 3) + ns(log(effort_depth), 3)
Stepwise selection	Yes
Positive catch distribution	Weibull

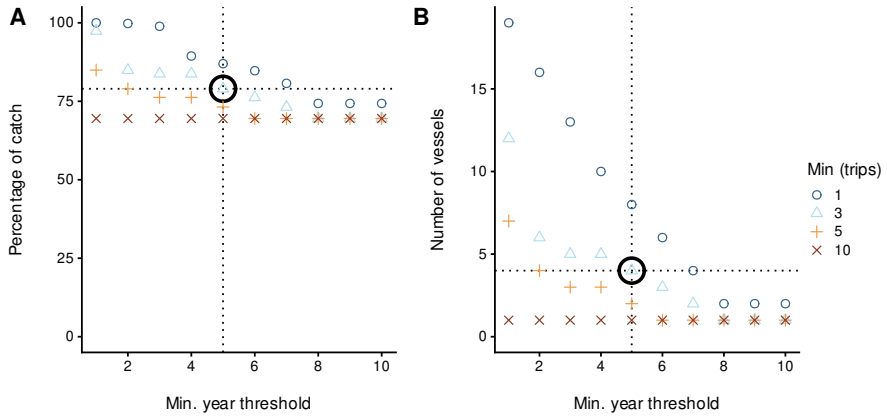

Figure D.42: Percentage of catch and number of vessels for different core vessel selection criteria for the BYX event (Chatham Rise - South East) CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

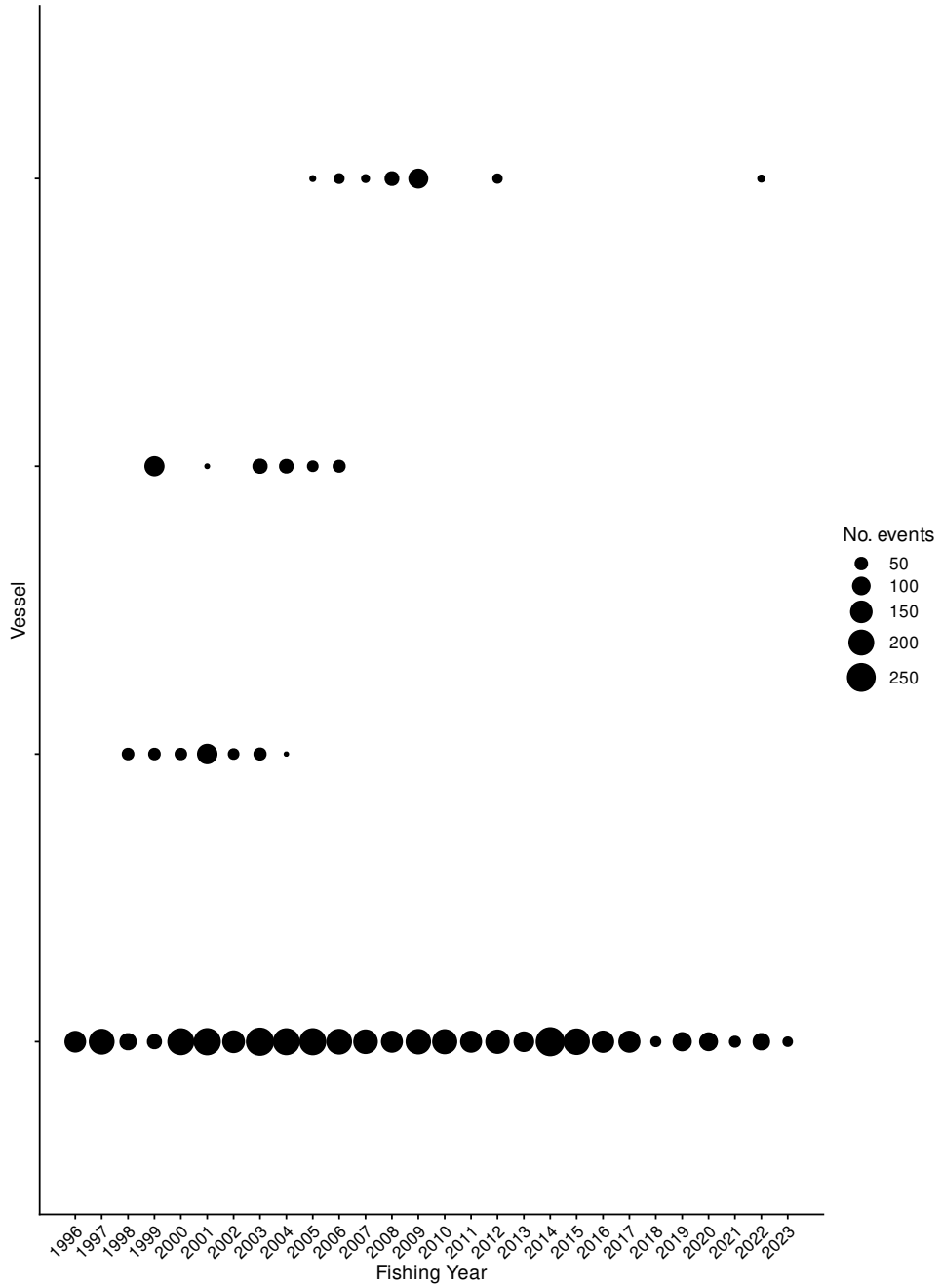

Figure D.43: Number of events by fishing year for core vessels in the BYX event (Chatham Rise - South East) series. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table D.14: Summary of the BYX event (Chatham Rise - South East) 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 2 pages)

Filter	1990	1991	1992	1993	1994	1995	1996	1997	1998
Ungroomed data	669 (100%) n: 335	749 (100%) n: 294	1260 (100%) n: 458	1444 (100%) n: 530	1332 (100%) n: 708	1307 (100%) n: 794	1503 (100%) n: 769	1500 (100%) n: 736	1540 (100%) n: 730
Fishing duration is not NA	669 (100%) n: 335	749 (100%) n: 294	1260 (100%) n: 458	1444 (100%) n: 530	1332 (100%) n: 708	1307 (100%) n: 794	1503 (100%) n: 769	1500 (100%) n: 736	1540 (100%) n: 730
Positive fishing duration	669 (100%) n: 335	749 (100%) n: 294	1260 (100%) n: 458	1444 (100%) n: 530	1332 (100%) n: 708	1307 (100%) n: 793	1502 (100%) n: 762	1500 (100%) n: 729	1540 (100%) n: 728
Duration under 12h	669 (100%) n: 335	739 (99%) n: 292	1260 (100%) n: 458	1416 (98%) n: 528	1332 (100%) n: 707	1304 (100%) n: 785	1498 (100%) n: 756	1472 (98%) n: 720	1534 (100%) n: 720
Headline under 60m	669 (100%) n: 335	739 (99%) n: 292	1260 (100%) n: 458	1416 (98%) n: 528	1332 (100%) n: 707	1294 (99%) n: 769	1467 (98%) n: 751	1450 (97%) n: 711	1457 (95%) n: 694
In a cluster	654 (98%) n: 330	739 (99%) n: 288	1241 (98%) n: 446	1380 (96%) n: 510	1271 (95%) n: 681	1256 (96%) n: 718	1436 (96%) n: 725	1419 (95%) n: 695	1396 (91%) n: 679
150+ events per cluster	592 (89%) n: 316	708 (94%) n: 281	1197 (95%) n: 437	1364 (95%) n: 499	1269 (95%) n: 664	1124 (86%) n: 651	1389 (92%) n: 704	1395 (93%) n: 683	1388 (90%) n: 665
In area	0 (0%) n: 0	0 (0%) n: 0	0 (0%) n: 0	0 (0%) n: 0	0 (0%) n: 2	18 (1%) n: 46	491 (33%) n: 252	564 (38%) n: 282	650 (42%) n: 244
Core fleet selection	0 (0%) n: 0	0 (0%) n: 0	0 (0%) n: 0	0 (0%) n: 0	0 (0%) n: 0	0 (0%) n: 0	326 (22%) n: 138	294 (20%) n: 198	418 (27%) n: 128

Filter	1999	2000	2001	2002	2003	2004	2005	2006	2007
Ungroomed data	1541 (100%) n: 1040	1269 (100%) n: 968	1352 (100%) n: 849	1329 (100%) n: 639	1602 (100%) n: 881	1430 (100%) n: 644	1942 (100%) n: 849	2045 (100%) n: 1139	2035 (100%) n: 1008
Fishing duration is not NA	1541 (100%) n: 1040	1269 (100%) n: 968	1352 (100%) n: 849	1329 (100%) n: 639	1602 (100%) n: 881	1430 (100%) n: 644	1942 (100%) n: 849	2045 (100%) n: 1139	2035 (100%) n: 1008
Positive fishing duration	1538 (100%) n: 1038	1269 (100%) n: 966	1341 (99%) n: 846	1326 (100%) n: 634	1602 (100%) n: 875	1430 (100%) n: 644	1942 (100%) n: 848	2045 (100%) n: 1139	2031 (100%) n: 1000
Duration under 12h	1535 (100%) n: 1030	1266 (100%) n: 959	1341 (99%) n: 846	1322 (99%) n: 631	1602 (100%) n: 875	1430 (100%) n: 644	1942 (100%) n: 848	2044 (100%) n: 1138	2031 (100%) n: 999
Headline under 60m	1492 (97%) n: 1011	1265 (100%) n: 953	1338 (99%) n: 845	1322 (99%) n: 631	1602 (100%) n: 875	1420 (99%) n: 637	1942 (100%) n: 848	2044 (100%) n: 1138	2031 (100%) n: 999
In a cluster	1437 (93%) n: 969	1232 (97%) n: 929	1310 (97%) n: 830	1313 (99%) n: 624	1588 (99%) n: 867	1415 (99%) n: 631	1939 (100%) n: 844	2035 (99%) n: 1127	2025 (100%) n: 991
150+ events per cluster	1182 (77%) n: 799	1179 (93%) n: 902	1256 (93%) n: 802	1269 (95%) n: 614	1498 (94%) n: 833	1394 (97%) n: 616	1872 (96%) n: 814	1976 (97%) n: 1067	2013 (99%) n: 969
In area	516 (33%) n: 401	414 (33%) n: 399	495 (37%) n: 373	455 (34%) n: 200	557 (35%) n: 354	596 (42%) n: 302	455 (23%) n: 269	431 (21%) n: 274	452 (22%) n: 213
Core fleet selection	344 (22%) n: 225	307 (24%) n: 259	474 (35%) n: 351	439 (33%) n: 189	519 (32%) n: 351	565 (39%) n: 284	454 (23%) n: 267	431 (21%) n: 274	449 (22%) n: 200

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	1926 (100%) n: 796	1867 (100%) n: 838	2252 (100%) n: 1072	2185 (100%) n: 883	2253 (100%) n: 873	2187 (100%) n: 480	2008 (100%) n: 653	1976 (100%) n: 617	2136 (100%) n: 590
Fishing duration is not NA	1926 (100%) n: 796	1867 (100%) n: 838	2252 (100%) n: 1072	2185 (100%) n: 883	2253 (100%) n: 873	2187 (100%) n: 480	2008 (100%) n: 653	1976 (100%) n: 617	2136 (100%) n: 590
Positive fishing duration	1905 (99%) n: 792	1855 (99%) n: 829	2252 (100%) n: 1070	2182 (100%) n: 880	2250 (100%) n: 870	2187 (100%) n: 479	2008 (100%) n: 652	1976 (100%) n: 617	2136 (100%) n: 590
Duration under 12h	1903 (99%) n: 791	1855 (99%) n: 829	2252 (100%) n: 1070	2182 (100%) n: 879	2250 (100%) n: 870	2187 (100%) n: 479	2008 (100%) n: 652	1961 (99%) n: 616	2136 (100%) n: 590
Headline under 60m	1903 (99%) n: 791	1854 (99%) n: 828	2245 (100%) n: 1067	2182 (100%) n: 878	2250 (100%) n: 870	2187 (100%) n: 479	2008 (100%) n: 652	1961 (99%) n: 616	2126 (100%) n: 588
In a cluster	1877 (97%) n: 779	1853 (99%) n: 827	2240 (99%) n: 1059	2133 (98%) n: 869	2247 (100%) n: 862	2184 (100%) n: 476	1980 (99%) n: 643	1953 (99%) n: 613	2126 (100%) n: 587
150+ events per cluster	1853 (96%) n: 763	1845 (99%) n: 822	2170 (96%) n: 1017	2127 (97%) n: 855	2246 (100%) n: 858	2181 (100%) n: 469	1975 (98%) n: 636	1910 (97%) n: 602	2126 (100%) n: 586
In area	520 (27%) n: 205	472 (25%) n: 309	471 (21%) n: 270	742 (34%) n: 308	519 (23%) n: 328	586 (27%) n: 147	486 (24%) n: 276	492 (25%) n: 231	674 (32%) n: 248
Core fleet selection	520 (27%) n: 203	472 (25%) n: 309	376 (17%) n: 187	422 (19%) n: 142	331 (15%) n: 204	498 (23%) n: 124	466 (23%) n: 255	436 (22%) n: 210	263 (12%) n: 146

Filter	2017	2018	2019	2020	2021	2022	2023
Ungroomed data	1894 (100%) n: 645	2005 (100%) n: 595	2141 (100%) n: 757	2075 (100%) n: 704	1853 (100%) n: 611	1882 (100%) n: 512	1569 (100%) n: 624
Fishing duration is not NA	1894 (100%) n: 645	2005 (100%) n: 595	2141 (100%) n: 757	2075 (100%) n: 704	1853 (100%) n: 610	1882 (100%) n: 512	1569 (100%) n: 624
Positive fishing duration	1894 (100%) n: 645	2005 (100%) n: 595	2141 (100%) n: 754	2075 (100%) n: 702	1853 (100%) n: 608	1882 (100%) n: 512	1569 (100%) n: 623
Duration under 12h	1894 (100%) n: 644	2005 (100%) n: 595	2137 (100%) n: 752	2074 (100%) n: 701	1853 (100%) n: 608	1882 (100%) n: 512	1569 (100%) n: 623
Headline under 60m	1894 (100%) n: 644	2005 (100%) n: 595	2125 (99%) n: 749	2048 (99%) n: 698	1853 (100%) n: 608	1882 (100%) n: 512	1569 (100%) n: 623
In a cluster	1874 (99%) n: 634	1991 (99%) n: 587	2122 (99%) n: 746	2048 (99%) n: 695	1841 (99%) n: 604	1882 (100%) n: 512	1569 (100%) n: 621
150+ events per cluster	1836 (97%) n: 624	1953 (97%) n: 568	2093 (98%) n: 729	2013 (97%) n: 637	1835 (99%) n: 600	1882 (100%) n: 507	1569 (100%) n: 615
In area	456 (24%) n: 257	70 (3%) n: 44	242 (11%) n: 116	242 (12%) n: 105	78 (4%) n: 39	329 (17%) n: 103	65 (4%) n: 61
Core fleet selection	126 (7%) n: 143	61 (3%) n: 32	219 (10%) n: 107	241 (12%) n: 103	78 (4%) n: 39	329 (17%) n: 103	44 (3%) n: 29

Table D.15: Summary of the BYX event (Chatham Rise - South East) 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 alfonsino.

Fishing year	Vessels	Trips	Records	Hours	Catch (t)	Records caught
1996	1	6	138	22.88	325.77	87.68
1997	1	6	198	54.87	293.52	87.37
1998	2	10	128	48.73	418.02	89.06
1999	3	12	225	104.38	343.56	82.67
2000	2	11	259	72.87	307.29	89.96
2001	3	18	351	68.45	473.62	82.05
2002	2	16	189	39.00	439.24	86.24
2003	3	24	351	56.92	519.05	87.75
2004	3	24	284	58.05	564.69	92.96
2005	3	18	267	102.00	454.41	94.38
2006	3	21	274	112.17	430.81	94.16
2007	2	15	200	65.23	449.48	93.50
2008	2	12	203	84.70	519.80	92.61
2009	2	17	309	97.63	471.50	91.26
2010	1	8	187	56.28	376.30	97.33
2011	1	6	142	25.63	421.67	97.18
2012	2	14	204	130.42	330.76	94.12
2013	1	7	124	104.33	497.94	87.90
2014	1	12	255	143.37	465.77	96.08
2015	1	11	210	103.83	435.55	92.86
2016	1	8	146	76.28	263.20	94.52
2017	1	4	143	67.25	126.00	95.80
2018	1	3	32	54.52	61.36	96.88
2019	1	6	107	101.87	218.76	96.26
2020	1	10	103	192.12	241.32	95.15
2021	1	4	39	50.73	78.17	94.87
2022	2	11	103	148.22	329.26	97.09
2023	1	6	29	49.57	44.42	100.00

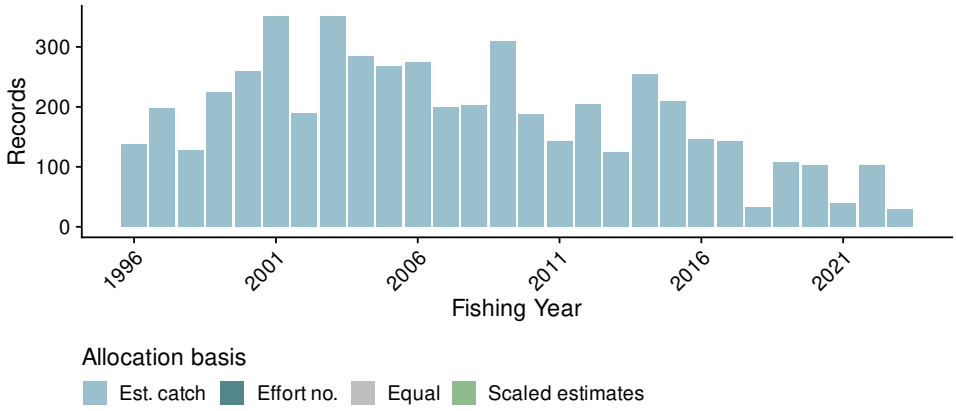

Figure D.44: Allocation basis for attributing landings to records in the BYX event (Chatham Rise - South East) catch-per-unit-effort dataset. Allocation basis is in terms of estimated catch, effort number, and/or equal.

Table D.16: Summary of stepwise selection for occurrence of positive catch in the BYX event (Chatham Rise - South East) series. 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	26	2 981	4.3	4.3	*
+ vessel_key	3	2 853	8.7	4.4	*
+ ns(log(fishing_duration), 3)	3	2 790	11.0	2.3	*
+ ns(log(effort_depth), 3)	3	2 747	12.6	1.6	*

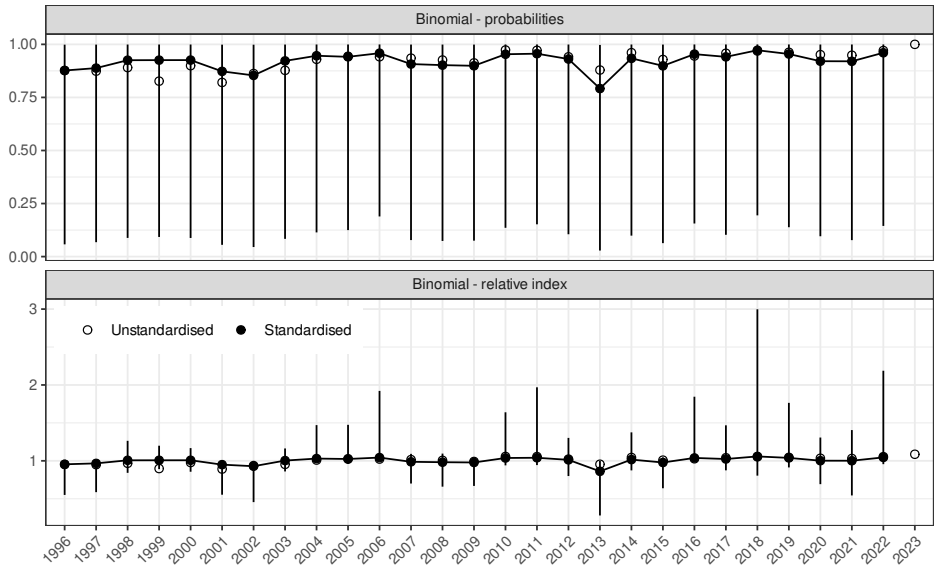

Figure D.45: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the BYX event (Chatham Rise - South East) dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

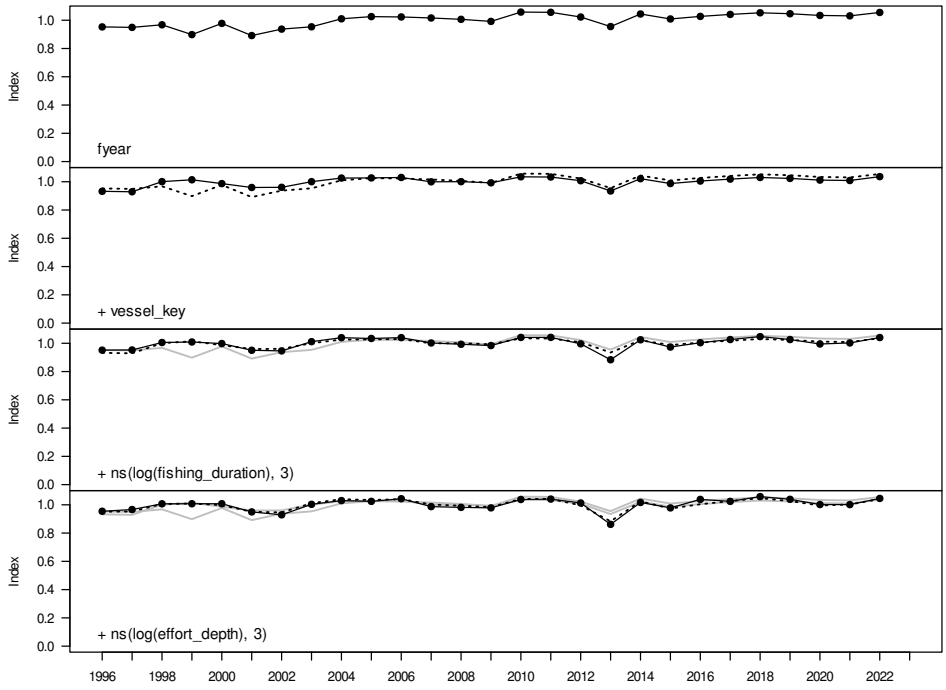

Figure D.46: Step plot for occurrence of catch in the BYX event (Chatham Rise - South East) dataset.

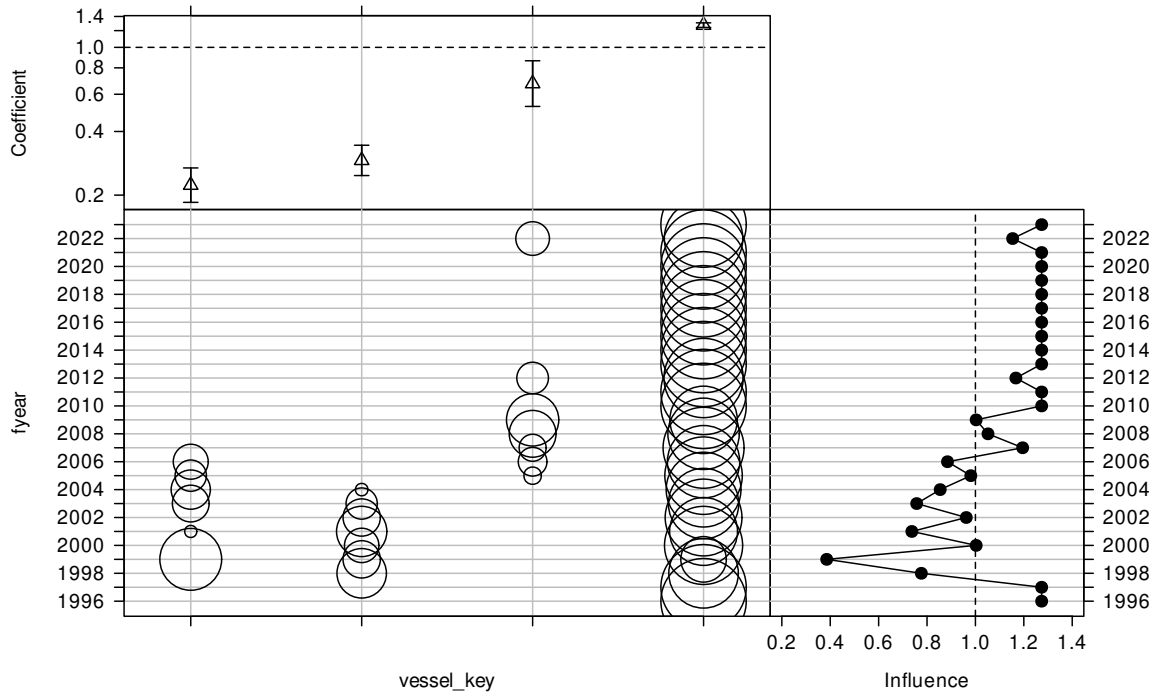

Figure D.47: CDI plot for vessel key for the occurrence of positive catch in the BYX event (Chatham Rise - South East) catch-per-unit-effort dataset.

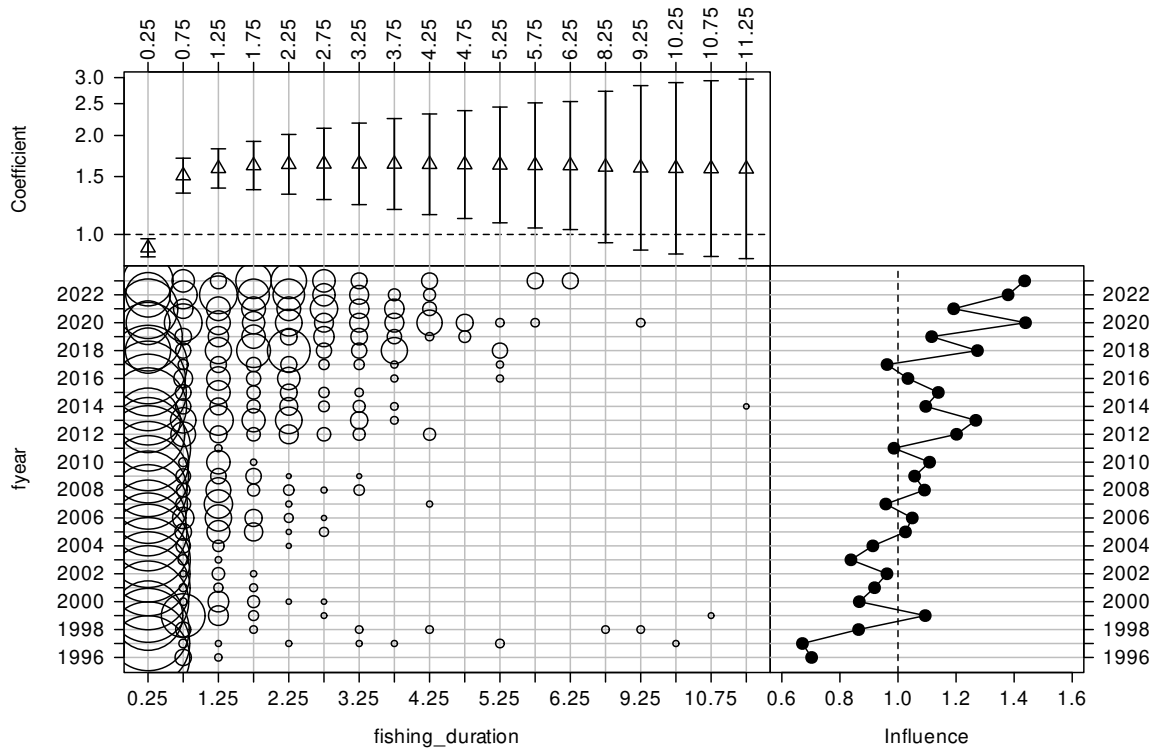

Figure D.48: CDI plot for fishing duration (h) for the occurrence of positive catch in the BYX event (Chatham Rise - South East) catch-per-unit-effort dataset.

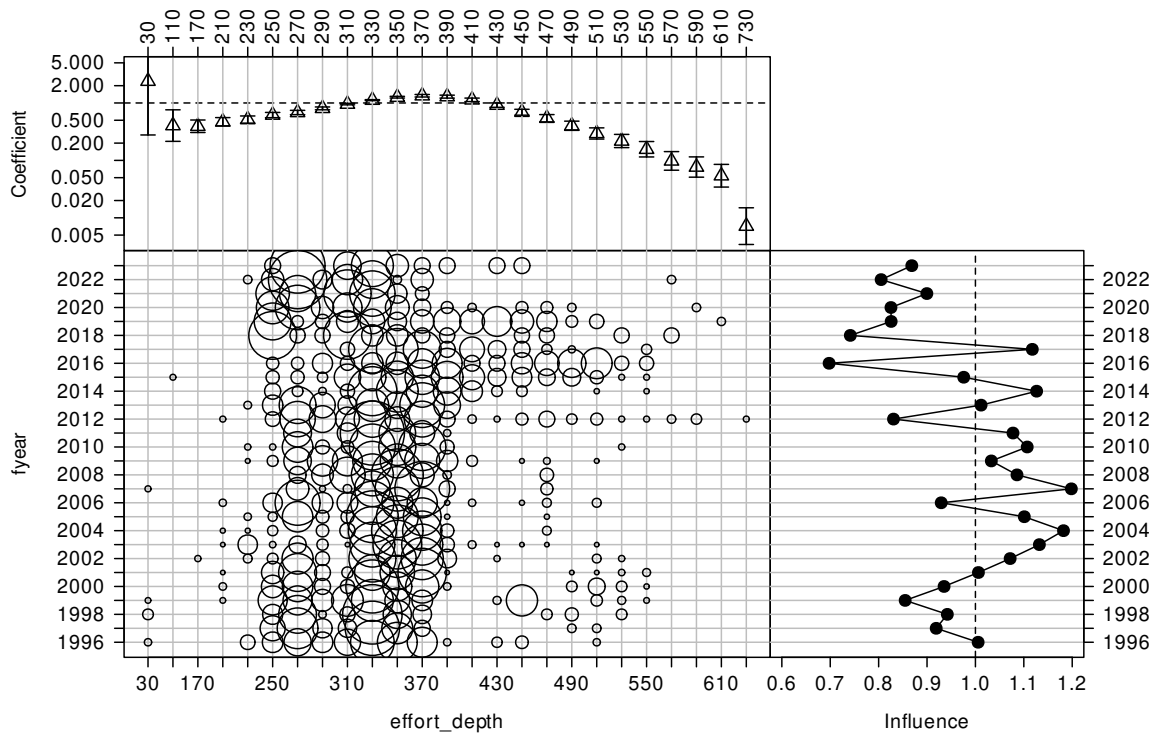

Figure D.49: CDI plot for effort depth (m) for the occurrence of positive catch in the BYX event (Chatham Rise - South East) catch-per-unit-effort dataset.

Table D.17: Summary of stepwise selection for the Weibull model for positive catches in the BYX event (Chatham Rise - South East) series. 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	29	81 283	4.4	4.4	*
+ primary_method	1	81 124	7.4	2.9	*
+ vessel_key	3	81 079	8.3	0.9	
+ ns(log(fishing_duration), 3)	3	81 046	9.0	0.7	
+ ns(log(effort_depth), 3)	3	81 045	9.1	0.1	

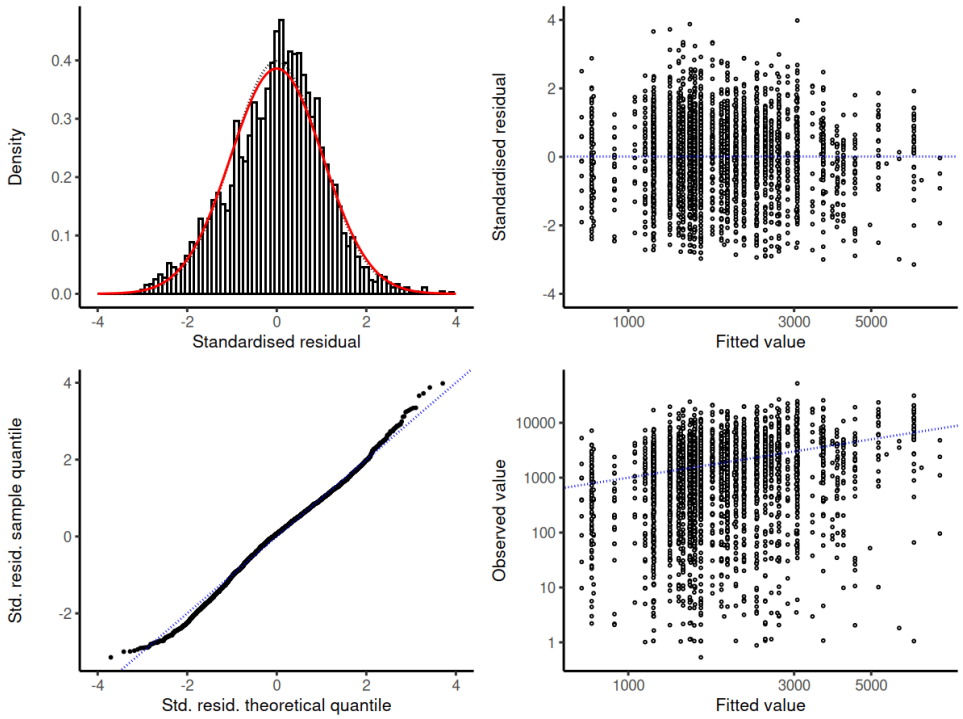

Figure D.50: Diagnostic plots for the selected Weibull model for positive catches in the BYX event (Chatham Rise - South East) dataset.

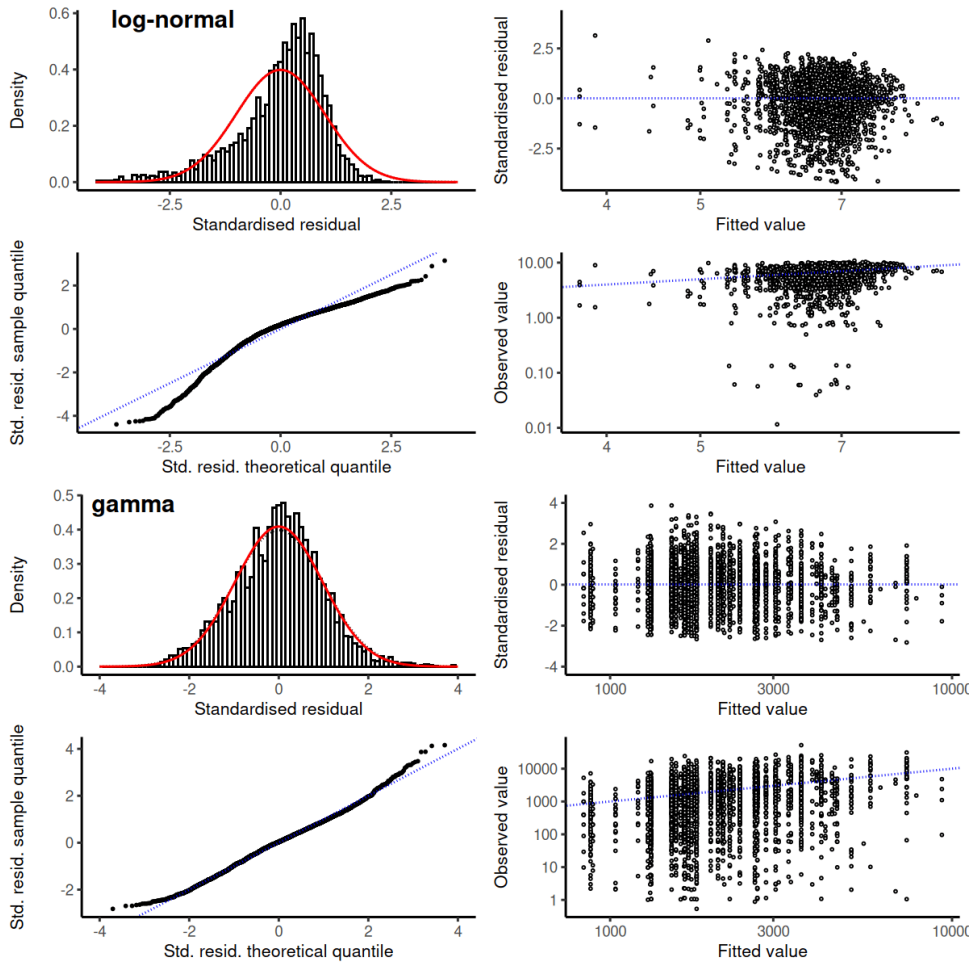

Figure D.51: Diagnostic plots for the alternative log-normal and gamma models considered for positive catches in the BYX event (Chatham Rise - South East) dataset.

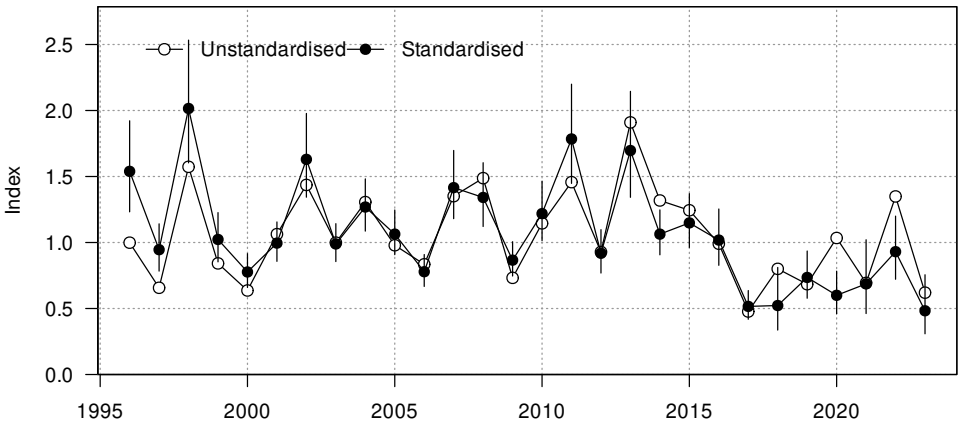

Figure D.52: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch using the Weibull model for the BYX event (Chatham Rise - South East) dataset.

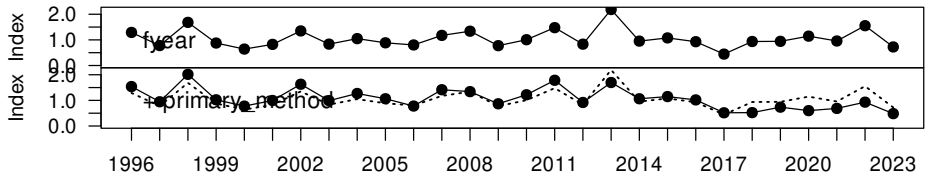

Figure D.53: Changes to the BYX event (Chatham Rise - South East) positive catch index as terms are successively entered into the Weibull model.

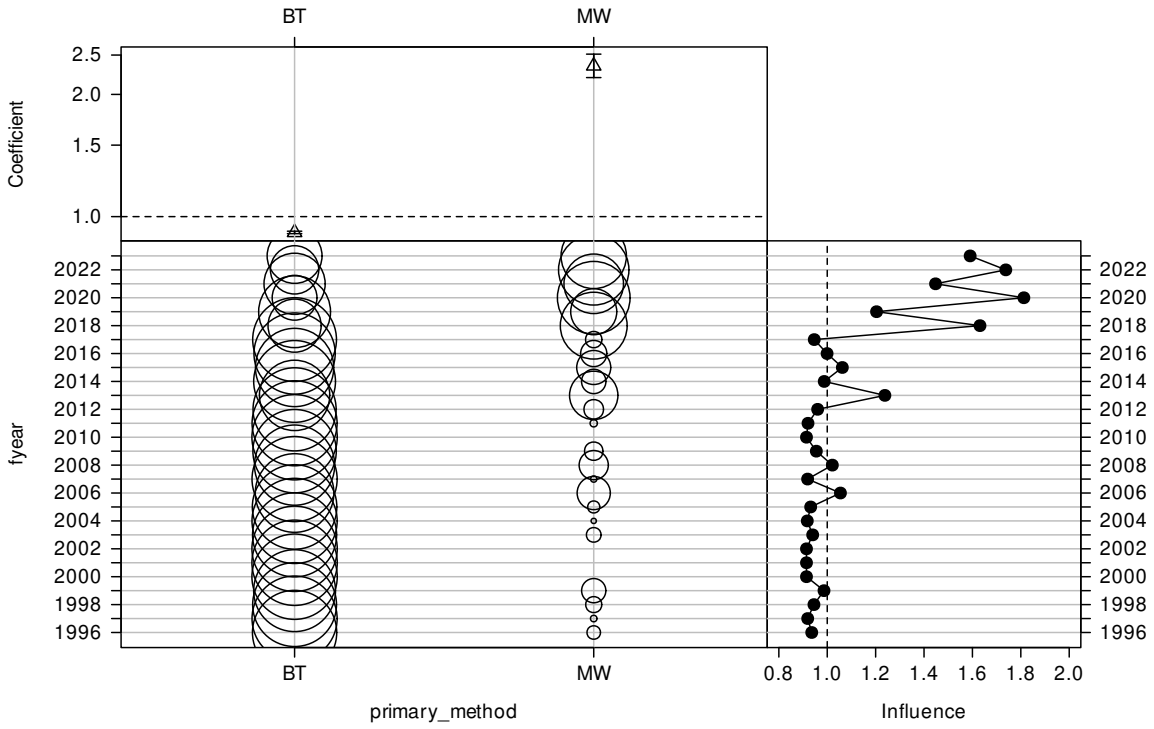

Figure D.54: CDI plot for primary method for the Weibull model of positive catches in the BYX event (Chatham Rise - South East) catch-per-unit-effort dataset.

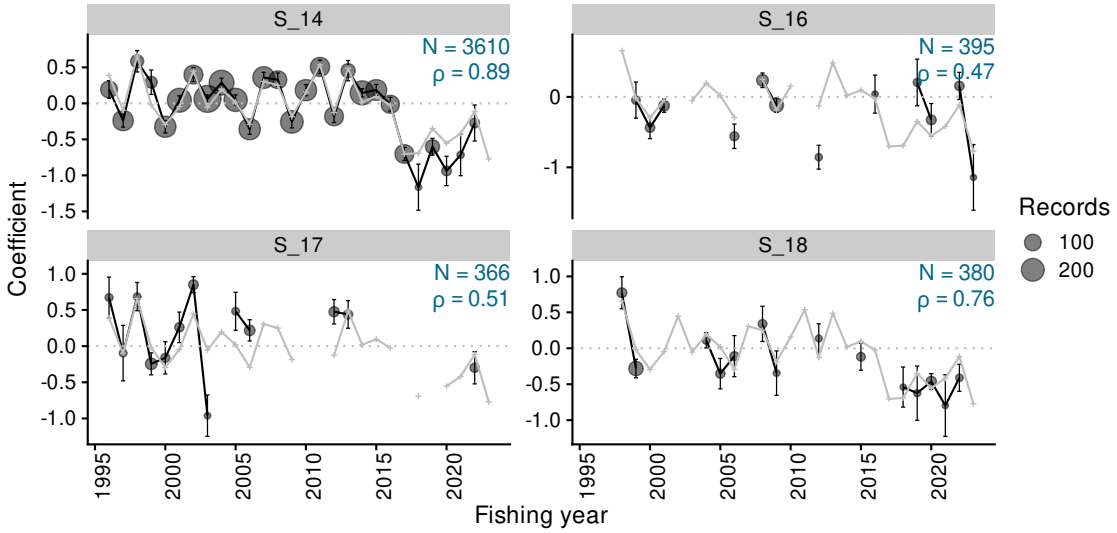

Figure D.55: Residual implied coefficients for area-year in the Weibull positive catch model for the BYX event (Chatham Rise - South East) dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 10 data points in an area-year stratum. The light grey line and points indicate the overall year indices; these are only plotted where there are data in a stratum.

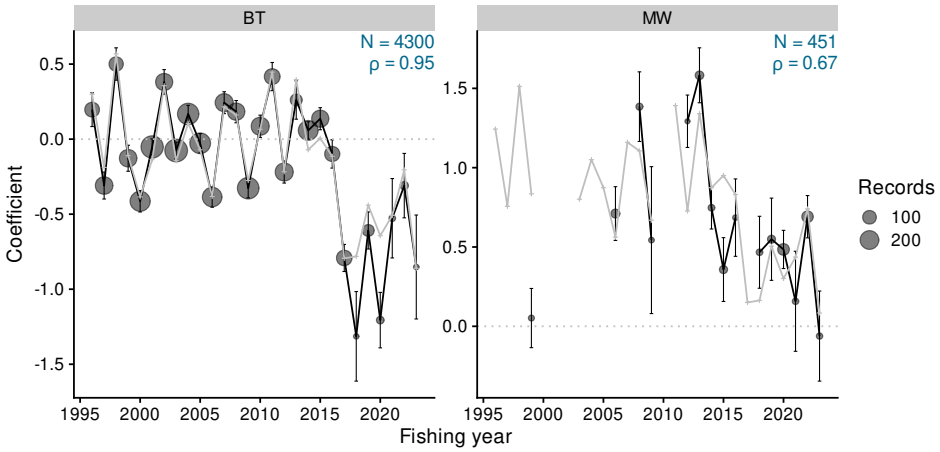

Figure D.56: Residual implied coefficients for primary method-year in the Weibull positive catch model for the BYX event (Chatham Rise - South East) dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 10 data points in a method-year stratum. The light grey line and points indicate the overall year indices; these are only plotted where there are data in a stratum.

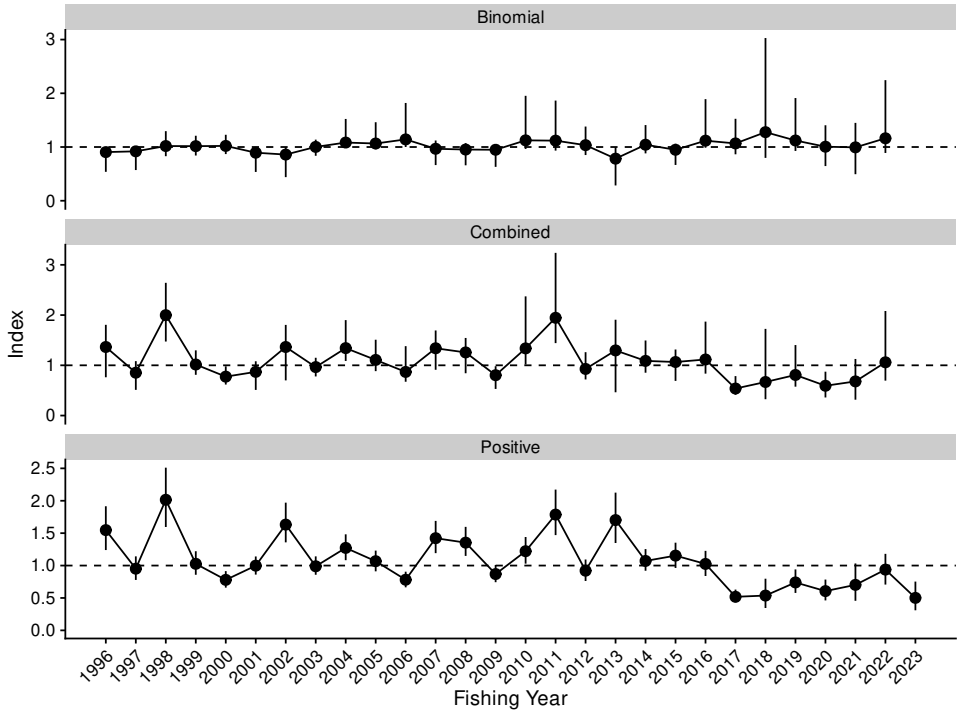

Figure D.57: Standardised indices and 95% confidence intervals for the BYX event (Chatham Rise - South East) dataset.

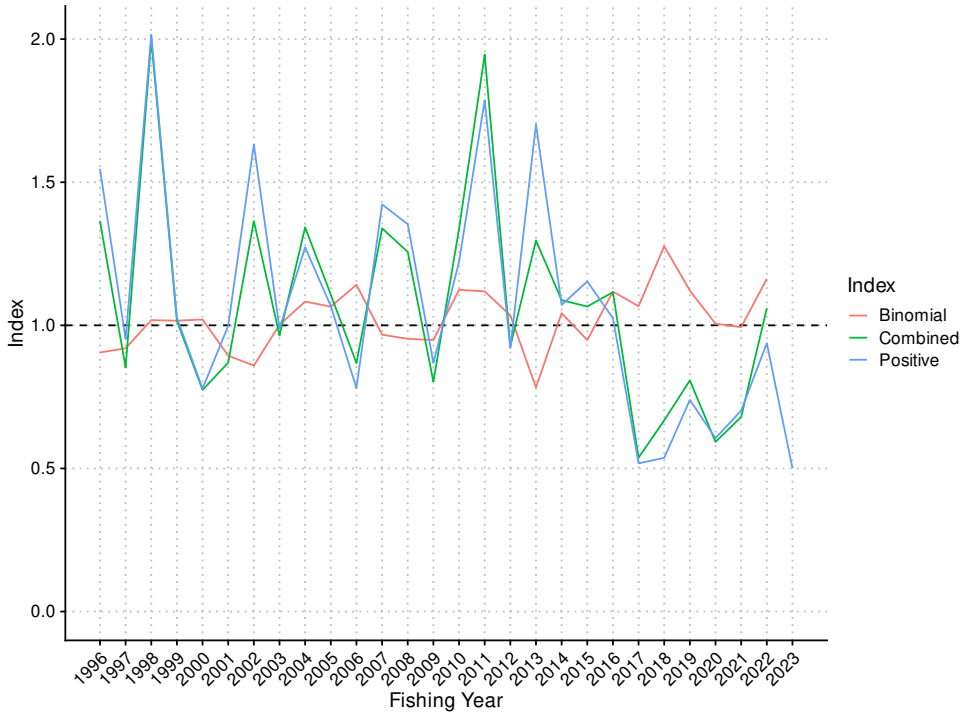

Figure D.58: Standardised indices for the BYX event (Chatham Rise - South East) dataset.

Table D.18: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in BYX event (Chatham Rise - South East).

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
1996	0.905	0.119	0.538	1.005	1.364	0.266	0.762	1.806	1.547	0.172	1.239	1.915
1997	0.920	0.112	0.571	1.011	0.853	0.146	0.511	1.083	0.952	0.093	0.778	1.142
1998	1.018	0.119	0.829	1.295	1.998	0.298	1.473	2.642	2.015	0.234	1.595	2.511
1999	1.016	0.094	0.842	1.210	1.016	0.124	0.811	1.298	1.027	0.093	0.858	1.221
2000	1.020	0.092	0.869	1.228	0.774	0.093	0.617	0.980	0.779	0.065	0.659	0.914
2001	0.894	0.118	0.536	1.000	0.869	0.145	0.510	1.080	0.998	0.071	0.860	1.140
2002	0.859	0.143	0.439	1.000	1.365	0.282	0.700	1.804	1.632	0.156	1.358	1.971
2003	1.002	0.077	0.837	1.137	0.965	0.095	0.778	1.150	0.989	0.072	0.858	1.142
2004	1.083	0.134	0.996	1.522	1.342	0.207	1.087	1.900	1.272	0.102	1.083	1.482
2005	1.065	0.129	0.956	1.461	1.107	0.159	0.884	1.509	1.067	0.082	0.911	1.231
2006	1.142	0.209	1.000	1.820	0.868	0.181	0.673	1.381	0.781	0.062	0.664	0.905
2007	0.967	0.117	0.664	1.121	1.339	0.200	0.911	1.693	1.422	0.127	1.192	1.689
2008	0.953	0.105	0.660	1.073	1.256	0.179	0.842	1.544	1.354	0.114	1.149	1.597
2009	0.949	0.104	0.631	1.039	0.803	0.115	0.530	0.982	0.869	0.068	0.743	1.009
2010	1.124	0.252	0.964	1.953	1.337	0.346	1.016	2.372	1.221	0.105	1.029	1.440
2011	1.119	0.238	0.933	1.864	1.946	0.458	1.442	3.238	1.786	0.179	1.470	2.172
2012	1.035	0.135	0.851	1.381	0.928	0.138	0.718	1.261	0.921	0.085	0.762	1.094
2013	0.783	0.182	0.284	0.999	1.296	0.368	0.463	1.907	1.702	0.198	1.348	2.125
2014	1.043	0.134	0.882	1.409	1.088	0.164	0.852	1.494	1.071	0.085	0.920	1.254
2015	0.948	0.101	0.666	1.061	1.066	0.159	0.690	1.315	1.153	0.099	0.963	1.353
2016	1.118	0.231	0.987	1.891	1.116	0.264	0.834	1.870	1.025	0.099	0.839	1.227
2017	1.067	0.169	0.864	1.525	0.538	0.095	0.413	0.785	0.518	0.051	0.430	0.629
2018	1.277	0.569	0.798	3.028	0.668	0.357	0.325	1.725	0.537	0.115	0.345	0.797
2019	1.121	0.251	0.927	1.911	0.808	0.211	0.575	1.403	0.739	0.093	0.578	0.940
2020	1.006	0.194	0.645	1.405	0.593	0.131	0.360	0.873	0.606	0.082	0.462	0.784
2021	0.994	0.244	0.494	1.449	0.680	0.207	0.316	1.126	0.702	0.147	0.456	1.032
2022	1.162	0.346	0.889	2.245	1.060	0.354	0.695	2.081	0.938	0.121	0.707	1.181
2023	-	-	-	-	-	-	-	-	0.501	0.113	0.310	0.753

D.4 BYX event (Chatham Rise - North)

Table D.19: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the BYX event (Chatham Rise - North) CPUE series.

Series	BYX event (Chatham Rise - North)
QMS stock	BYX 2, BYX 3
Reporting forms	TCP, TCE, ERS - Trawl
Fishing methods	BT, PRB, MW, PRM
Target species	BYX
Statistical Areas	011, 012, 013, 014, 015, 016, 017, 018, 019, 020, 021, 202, 203, 204, 205, 401, 402, 403, 404, 405, 410, 049, 050, 051, 052, 406, 412
Period	1989-10-01, 2023-09-30
Resolution	Fishing event
Core fleet years	5
Core fleet trips	3
Default model	allockg_top5 ~ fyear + cluster + vessel_key + primary_method + month + ns(log(fishing_duration), 3) + ns(log(effort_height), 3) + ns(log(effort_depth), 3)
Stepwise selection	Yes
Positive catch distribution	Weibull

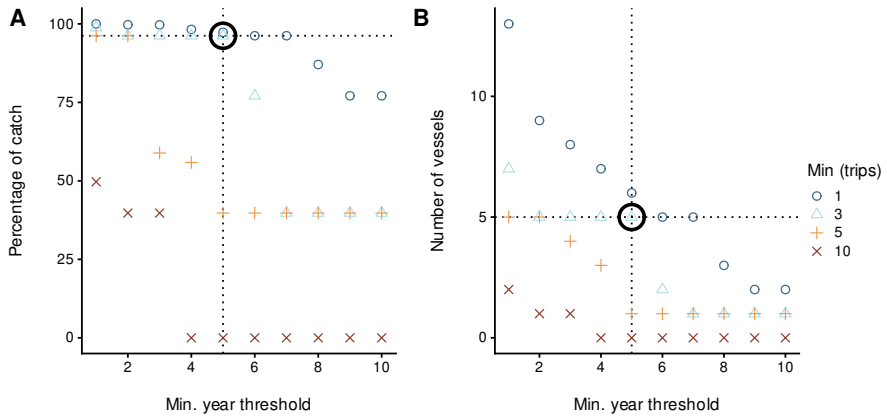

Figure D.59: Percentage of catch and number of vessels for different core vessel selection criteria for the BYX event (Chatham Rise - North) CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

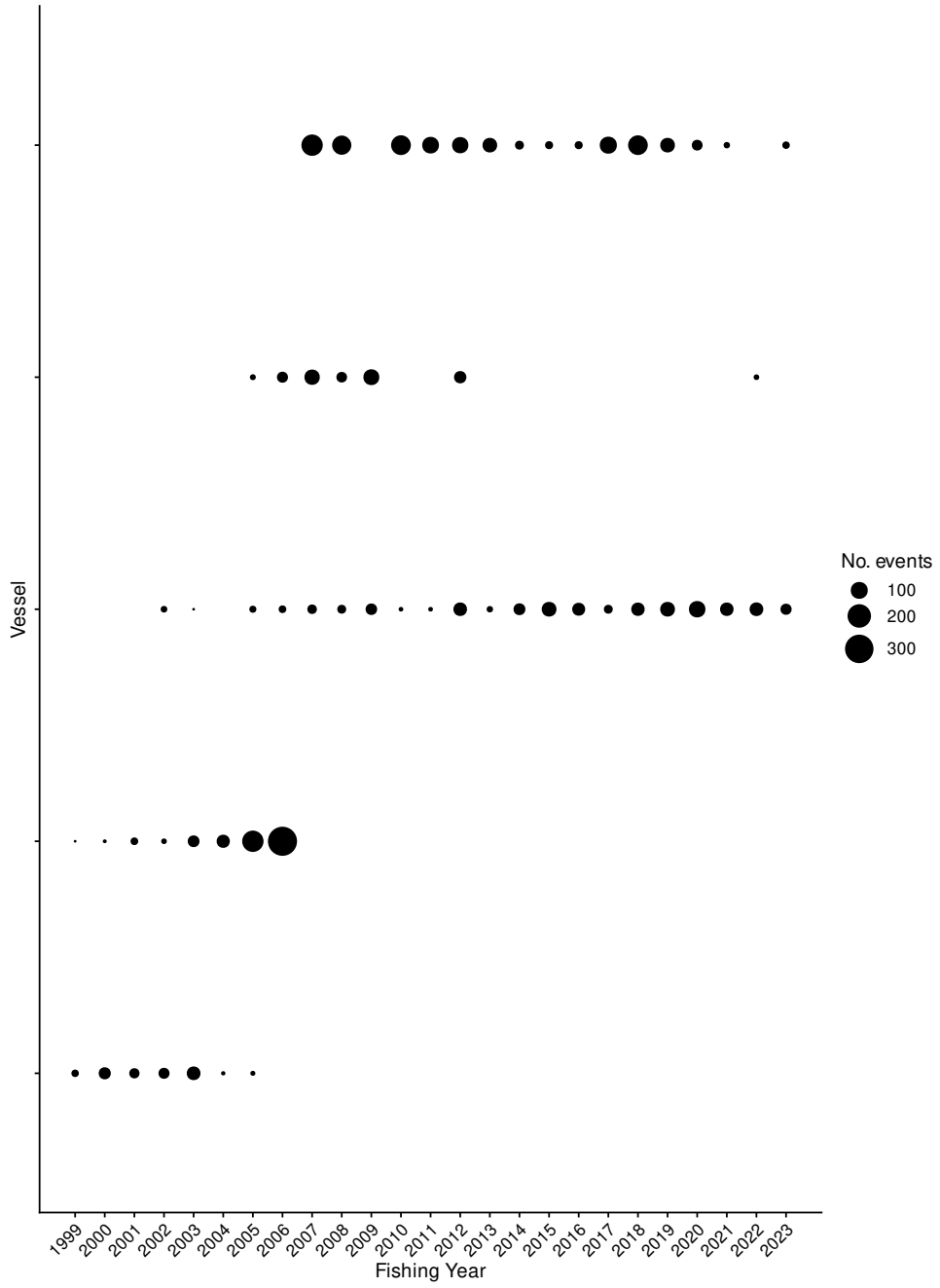

Figure D.60: Number of events by fishing year for core vessels in the BYX event (Chatham Rise - North) series. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table D.20: Summary of the BYX event (Chatham Rise - North) 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 2 pages)

Filter	1990	1991	1992	1993	1994	1995	1996	1997	1998
Ungroomed data	669 (100%) n: 335	749 (100%) n: 294	1260 (100%) n: 458	1444 (100%) n: 530	1332 (100%) n: 708	1307 (100%) n: 794	1503 (100%) n: 769	1500 (100%) n: 736	1540 (100%) n: 730
Fishing duration is not NA	669 (100%) n: 335	749 (100%) n: 294	1260 (100%) n: 458	1444 (100%) n: 530	1332 (100%) n: 708	1307 (100%) n: 794	1503 (100%) n: 769	1500 (100%) n: 736	1540 (100%) n: 730
Positive fishing duration	669 (100%) n: 335	749 (100%) n: 294	1260 (100%) n: 458	1444 (100%) n: 530	1332 (100%) n: 708	1307 (100%) n: 793	1502 (100%) n: 762	1500 (100%) n: 729	1540 (100%) n: 728
Duration under 12h	669 (100%) n: 335	739 (99%) n: 292	1260 (100%) n: 458	1416 (98%) n: 528	1332 (100%) n: 707	1304 (100%) n: 785	1498 (100%) n: 756	1472 (98%) n: 720	1534 (100%) n: 720
Headline under 60m	669 (100%) n: 335	739 (99%) n: 292	1260 (100%) n: 458	1416 (98%) n: 528	1332 (100%) n: 707	1294 (99%) n: 769	1467 (98%) n: 751	1450 (97%) n: 711	1457 (95%) n: 694
In a cluster	654 (98%) n: 330	739 (99%) n: 288	1241 (98%) n: 446	1380 (96%) n: 510	1271 (95%) n: 681	1256 (96%) n: 718	1436 (96%) n: 725	1419 (95%) n: 695	1396 (91%) n: 679
150+ events per cluster	592 (89%) n: 316	708 (94%) n: 281	1197 (95%) n: 437	1364 (95%) n: 499	1269 (95%) n: 664	1124 (86%) n: 651	1389 (92%) n: 704	1395 (93%) n: 683	1388 (90%) n: 665
In area	0 (0%) n: 0	0 (0%) n: 0	0 (0%) n: 0	0 (0%) n: 0	0 (0%) n: 1	0 (0%) n: 0	0 (0%) n: 0	0 (0%) n: 0	0 (0%) n: 0
Core fleet selection	0 (0%) n: 0	0 (0%) n: 0	0 (0%) n: 0	0 (0%) n: 0	0 (0%) n: 0	0 (0%) n: 0	0 (0%) n: 0	0 (0%) n: 0	0 (0%) n: 0

Filter	1999	2000	2001	2002	2003	2004	2005	2006	2007
Ungroomed data	1541 (100%) n: 1040	1269 (100%) n: 968	1352 (100%) n: 849	1329 (100%) n: 639	1602 (100%) n: 881	1430 (100%) n: 644	1942 (100%) n: 849	2045 (100%) n: 1139	2035 (100%) n: 1008
Fishing duration is not NA	1541 (100%) n: 1040	1269 (100%) n: 968	1352 (100%) n: 849	1329 (100%) n: 639	1602 (100%) n: 881	1430 (100%) n: 644	1942 (100%) n: 849	2045 (100%) n: 1139	2035 (100%) n: 1008
Positive fishing duration	1538 (100%) n: 1038	1269 (100%) n: 966	1341 (99%) n: 846	1326 (100%) n: 634	1602 (100%) n: 875	1430 (100%) n: 644	1942 (100%) n: 848	2045 (100%) n: 1139	2031 (100%) n: 1000
Duration under 12h	1535 (100%) n: 1030	1266 (100%) n: 959	1341 (99%) n: 846	1322 (99%) n: 631	1602 (100%) n: 875	1430 (100%) n: 644	1942 (100%) n: 848	2044 (100%) n: 1138	2031 (100%) n: 999
Headline under 60m	1492 (97%) n: 1011	1265 (100%) n: 953	1338 (99%) n: 845	1322 (99%) n: 631	1602 (100%) n: 875	1420 (99%) n: 637	1942 (100%) n: 848	2044 (100%) n: 1138	2031 (100%) n: 999
In a cluster	1437 (93%) n: 969	1232 (97%) n: 929	1310 (97%) n: 830	1313 (99%) n: 624	1588 (99%) n: 867	1415 (99%) n: 631	1939 (100%) n: 844	2035 (99%) n: 1127	2025 (100%) n: 991
150+ events per cluster	1182 (77%) n: 799	1179 (93%) n: 902	1256 (93%) n: 802	1269 (95%) n: 614	1498 (94%) n: 833	1394 (97%) n: 616	1872 (96%) n: 814	1976 (97%) n: 1067	2013 (99%) n: 969
In area	25 (2%) n: 17	73 (6%) n: 63	72 (5%) n: 50	85 (6%) n: 59	81 (5%) n: 113	39 (3%) n: 62	362 (19%) n: 193	520 (25%) n: 370	414 (20%) n: 302
Core fleet selection	25 (2%) n: 17	68 (5%) n: 51	72 (5%) n: 50	85 (6%) n: 59	80 (5%) n: 109	39 (3%) n: 62	362 (19%) n: 193	520 (25%) n: 370	395 (19%) n: 273

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	1926 (100%) n: 796	1867 (100%) n: 838	2252 (100%) n: 1072	2185 (100%) n: 883	2253 (100%) n: 873	2187 (100%) n: 480	2008 (100%) n: 653	1976 (100%) n: 617	2136 (100%) n: 590
Fishing duration is not NA	1926 (100%) n: 796	1867 (100%) n: 838	2252 (100%) n: 1072	2185 (100%) n: 883	2253 (100%) n: 873	2187 (100%) n: 480	2008 (100%) n: 653	1976 (100%) n: 617	2136 (100%) n: 590
Positive fishing duration	1905 (99%) n: 792	1855 (99%) n: 829	2252 (100%) n: 1070	2182 (100%) n: 880	2250 (100%) n: 870	2187 (100%) n: 479	2008 (100%) n: 652	1976 (100%) n: 617	2136 (100%) n: 590
Duration under 12h	1903 (99%) n: 791	1855 (99%) n: 829	2252 (100%) n: 1070	2182 (100%) n: 879	2250 (100%) n: 870	2187 (100%) n: 479	2008 (100%) n: 652	1961 (99%) n: 616	2136 (100%) n: 590
Headline under 60m	1903 (99%) n: 791	1854 (99%) n: 828	2245 (100%) n: 1067	2182 (100%) n: 878	2250 (100%) n: 870	2187 (100%) n: 479	2008 (100%) n: 652	1961 (99%) n: 616	2126 (100%) n: 588
In a cluster	1877 (97%) n: 779	1853 (99%) n: 827	2240 (99%) n: 1059	2133 (98%) n: 869	2247 (100%) n: 862	2184 (100%) n: 476	1980 (99%) n: 643	1953 (99%) n: 613	2126 (100%) n: 587
150+ events per cluster	1853 (96%) n: 763	1845 (99%) n: 822	2170 (96%) n: 1017	2127 (97%) n: 855	2246 (100%) n: 858	2181 (100%) n: 469	1975 (98%) n: 636	1910 (97%) n: 602	2126 (100%) n: 586
In area	414 (21%) n: 214	344 (18%) n: 148	416 (18%) n: 188	276 (13%) n: 130	489 (22%) n: 204	388 (18%) n: 84	369 (18%) n: 84	402 (20%) n: 113	321 (15%) n: 83
Core fleet selection	379 (20%) n: 191	285 (15%) n: 130	355 (16%) n: 144	257 (12%) n: 102	489 (22%) n: 204	388 (18%) n: 84	345 (17%) n: 70	380 (19%) n: 93	312 (15%) n: 75

Filter	2017	2018	2019	2020	2021	2022	2023
Ungroomed data	1894 (100%) n: 645	2005 (100%) n: 595	2141 (100%) n: 757	2075 (100%) n: 704	1853 (100%) n: 611	1882 (100%) n: 512	1569 (100%) n: 624
Fishing duration is not NA	1894 (100%) n: 645	2005 (100%) n: 595	2141 (100%) n: 757	2075 (100%) n: 704	1853 (100%) n: 610	1882 (100%) n: 512	1569 (100%) n: 624
Positive fishing duration	1894 (100%) n: 645	2005 (100%) n: 595	2141 (100%) n: 754	2075 (100%) n: 702	1853 (100%) n: 608	1882 (100%) n: 512	1569 (100%) n: 623
Duration under 12h	1894 (100%) n: 644	2005 (100%) n: 595	2137 (100%) n: 752	2074 (100%) n: 701	1853 (100%) n: 608	1882 (100%) n: 512	1569 (100%) n: 623
Headline under 60m	1894 (100%) n: 644	2005 (100%) n: 595	2125 (99%) n: 749	2048 (99%) n: 698	1853 (100%) n: 608	1882 (100%) n: 512	1569 (100%) n: 623
In a cluster	1874 (99%) n: 634	1991 (99%) n: 587	2122 (99%) n: 746	2048 (99%) n: 695	1841 (99%) n: 604	1882 (100%) n: 512	1569 (100%) n: 621
150+ events per cluster	1836 (97%) n: 624	1953 (97%) n: 568	2093 (98%) n: 729	2013 (97%) n: 637	1835 (99%) n: 600	1882 (100%) n: 507	1569 (100%) n: 615
In area	414 (22%) n: 132	596 (30%) n: 204	500 (23%) n: 161	430 (21%) n: 132	318 (17%) n: 72	217 (12%) n: 71	161 (10%) n: 56
Core fleet selection	413 (22%) n: 126	580 (29%) n: 198	481 (22%) n: 147	430 (21%) n: 131	318 (17%) n: 72	217 (12%) n: 71	161 (10%) n: 56

Table D.21: Summary of the BYX event (Chatham Rise - North) 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 alfonsino.

Fishing year	Vessels	Trips	Records	Hours	Catch (t)	Records caught
1999	2	4	17	3.50	25.49	52.94
2000	2	9	51	11.07	67.58	72.55
2001	2	9	50	12.70	72.46	62.00
2002	3	8	59	9.67	84.72	57.63
2003	3	12	109	18.03	80.06	74.31
2004	2	7	62	9.77	38.91	67.74
2005	4	15	193	35.02	361.81	84.97
2006	3	22	370	86.63	519.72	79.46
2007	3	13	273	81.13	395.45	76.56
2008	3	12	191	67.13	378.72	86.91
2009	2	13	130	62.95	284.54	91.54
2010	2	8	144	113.37	354.70	87.50
2011	2	6	102	111.93	256.95	95.10
2012	3	14	204	166.43	489.23	87.25
2013	2	4	84	107.88	387.60	92.86
2014	2	8	70	90.50	345.12	94.29
2015	2	11	93	153.37	379.50	92.47
2016	2	9	75	125.73	311.94	93.33
2017	2	8	126	160.18	412.72	88.10
2018	2	11	198	364.88	580.45	98.48
2019	2	10	147	361.15	481.12	96.60
2020	2	14	131	332.57	429.97	95.42
2021	2	8	72	133.85	318.47	94.44
2022	2	12	71	216.85	216.84	95.77
2023	2	8	56	155.75	161.35	94.64

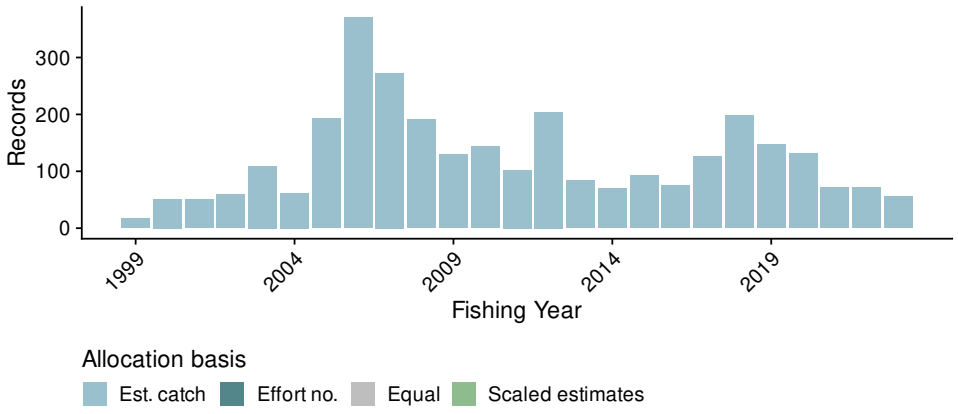

Figure D.61: Allocation basis for attributing landings to records in the BYX event (Chatham Rise - North) catch-per-unit-effort dataset. Allocation basis is in terms of estimated catch, effort number, and/or equal.

Table D.22: Summary of stepwise selection for occurrence of positive catch in the BYX event (Chatham Rise - North) series. 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	23	2295	9.4	9.4	*
+ ns(log(fishing_duration), 3)	3	2073	18.6	9.2	*
+ ns(log(effort_depth), 3)	3	2035	20.4	1.8	*
+ month	9	2019	21.8	1.4	*
+ ns(log(effort_height), 3)	3	2003	22.6	0.9	
+ cluster	3	2001	22.9	0.3	

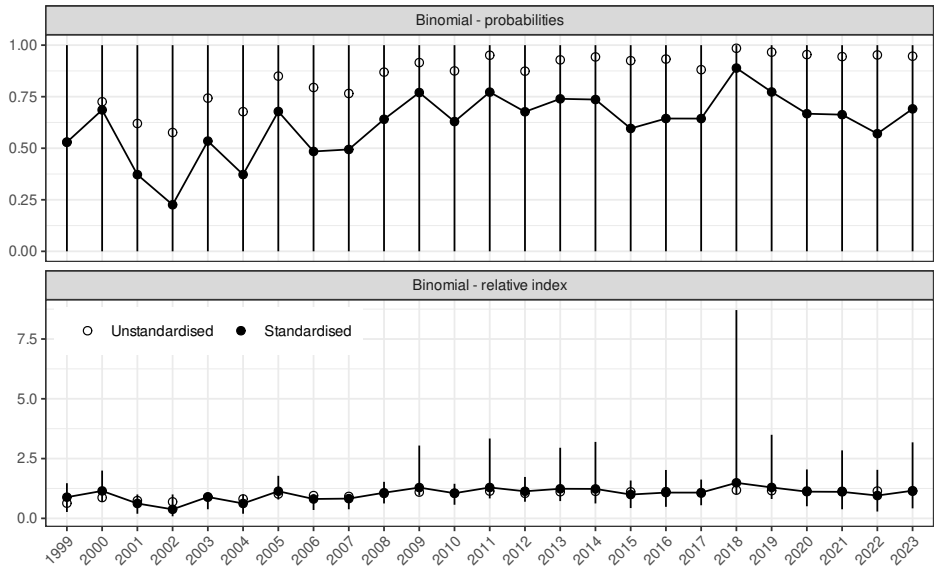

Figure D.62: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the BYX event (Chatham Rise - North) dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

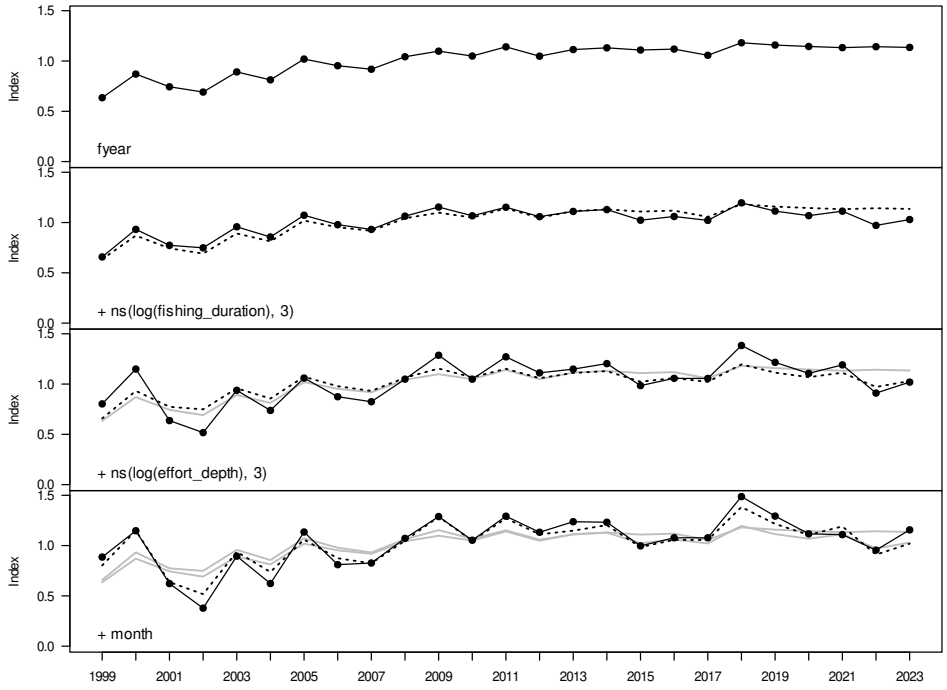

Figure D.63: Step plot for occurrence of catch in the BYX event (Chatham Rise - North) dataset.

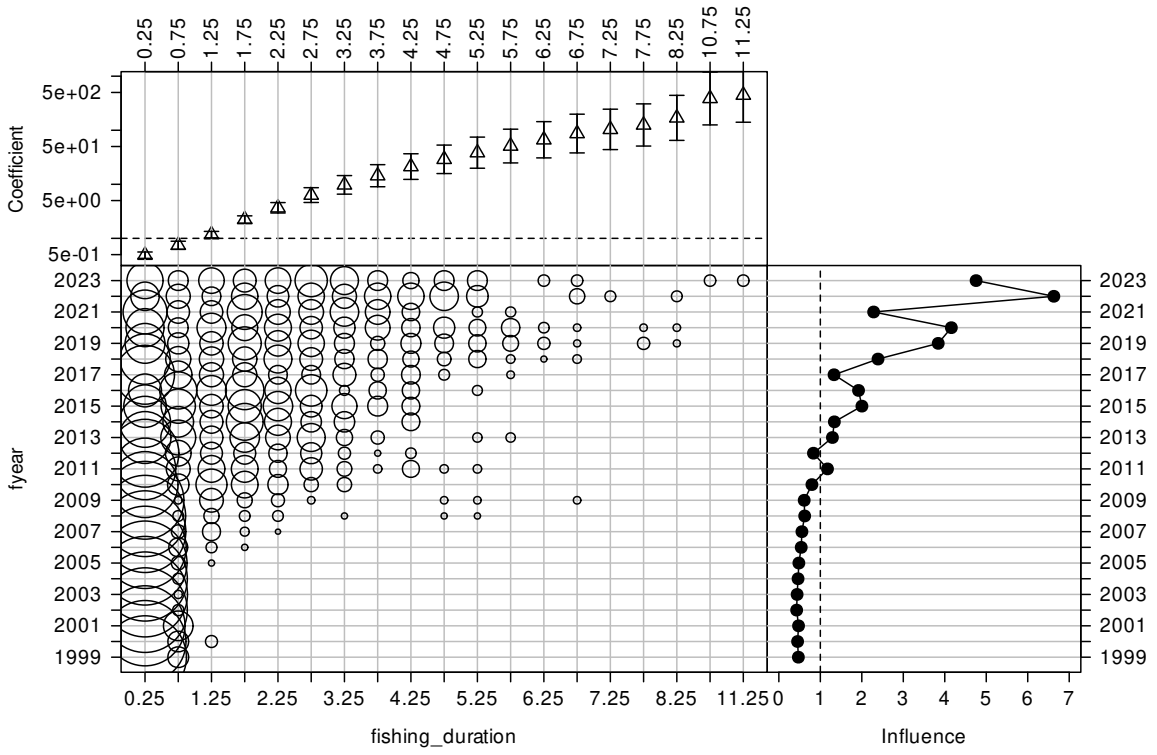

Figure D.64: CDI plot for fishing duration (h) for the occurrence of positive catch in the BYX event (Chatham Rise - North) catch-per-unit-effort dataset.

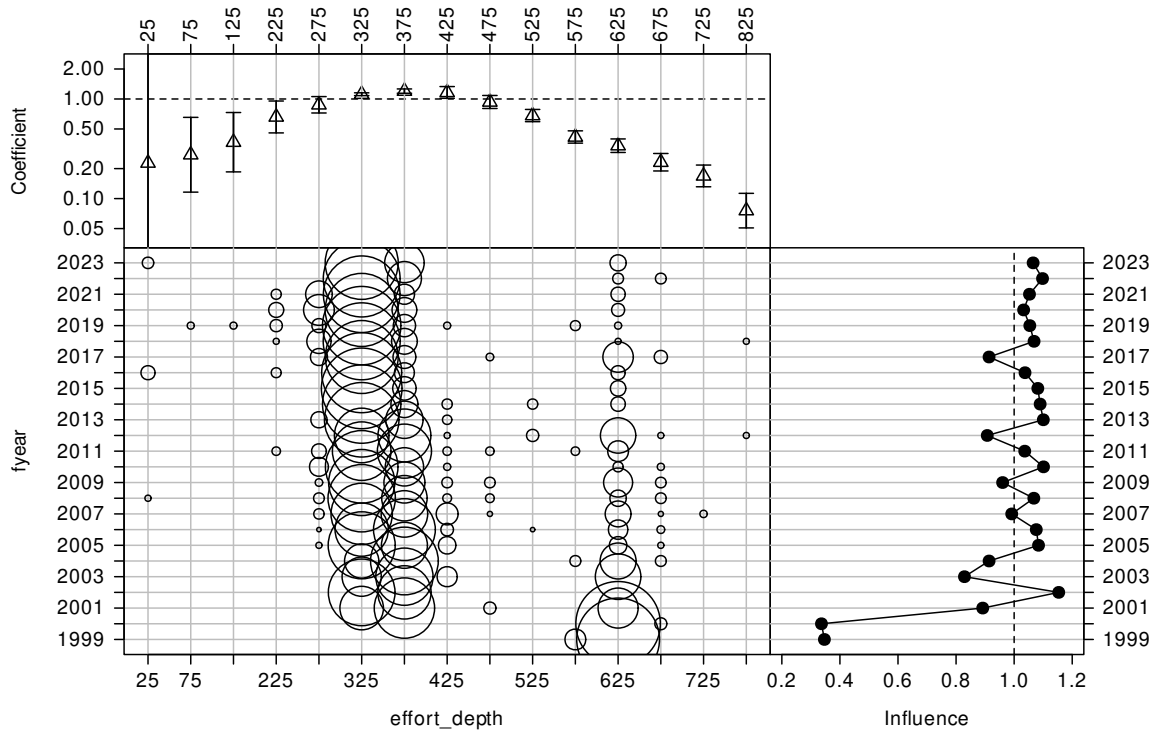

Figure D.65: CDI plot for effort depth (m) for the occurrence of positive catch in the BYX event (Chatham Rise - North) catch-per-unit-effort dataset.

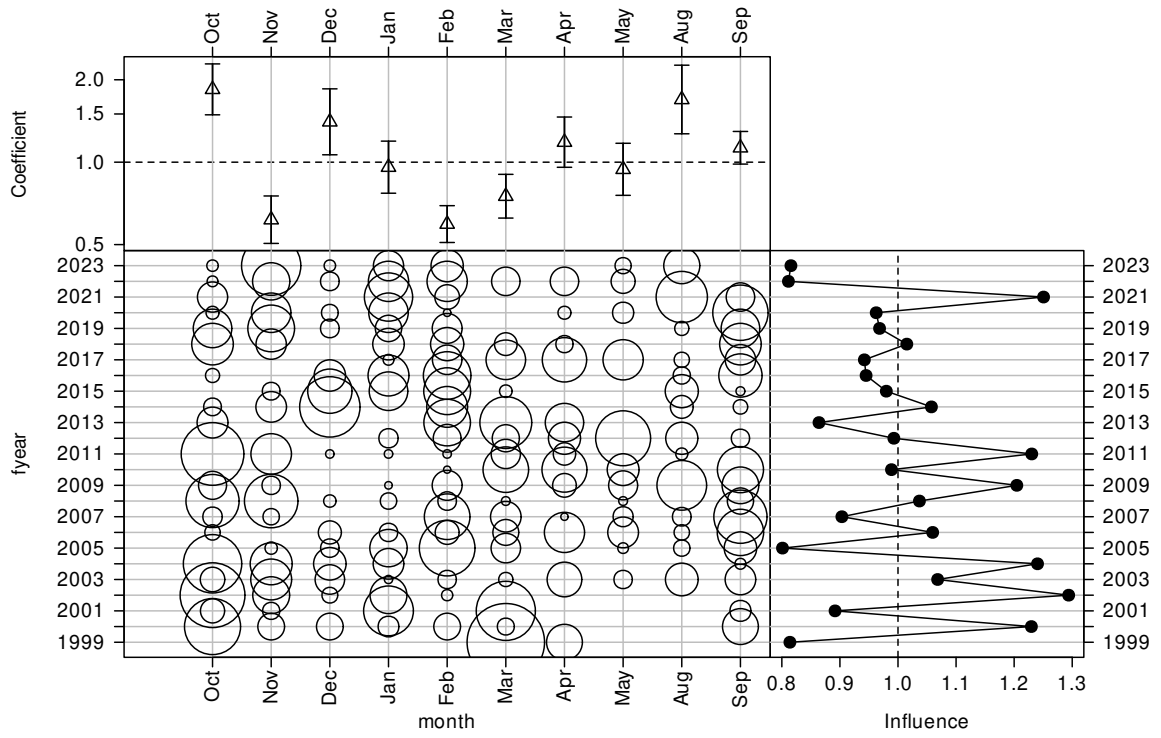

Figure D.66: CDI plot for month for the occurrence of positive catch in the BYX event (Chatham Rise - North) catch-per-unit-effort dataset.

Table D.23: Summary of stepwise selection for the Weibull model for positive catches in the BYX event (Chatham Rise - North) series. 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	26	46 565	7.6	7.6	*
+ ns(log(effort_height), 3)	3	46 300	16.3	8.7	*
+ month	11	46 237	19.0	2.7	*
+ ns(log(fishing_duration), 3)	3	46 181	21.0	2.0	*
+ cluster	3	46 138	22.6	1.5	*
+ vessel_key	4	46 129	23.1	0.6	

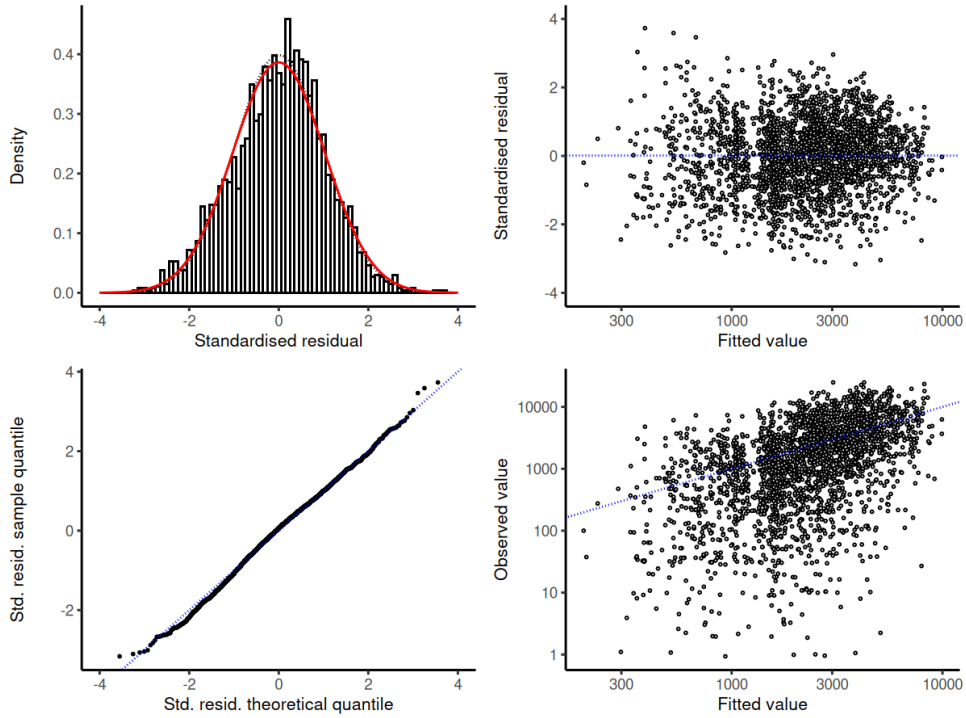

Figure D.67: Diagnostic plots for the selected Weibull model for positive catches in the BYX event (Chatham Rise - North) dataset.

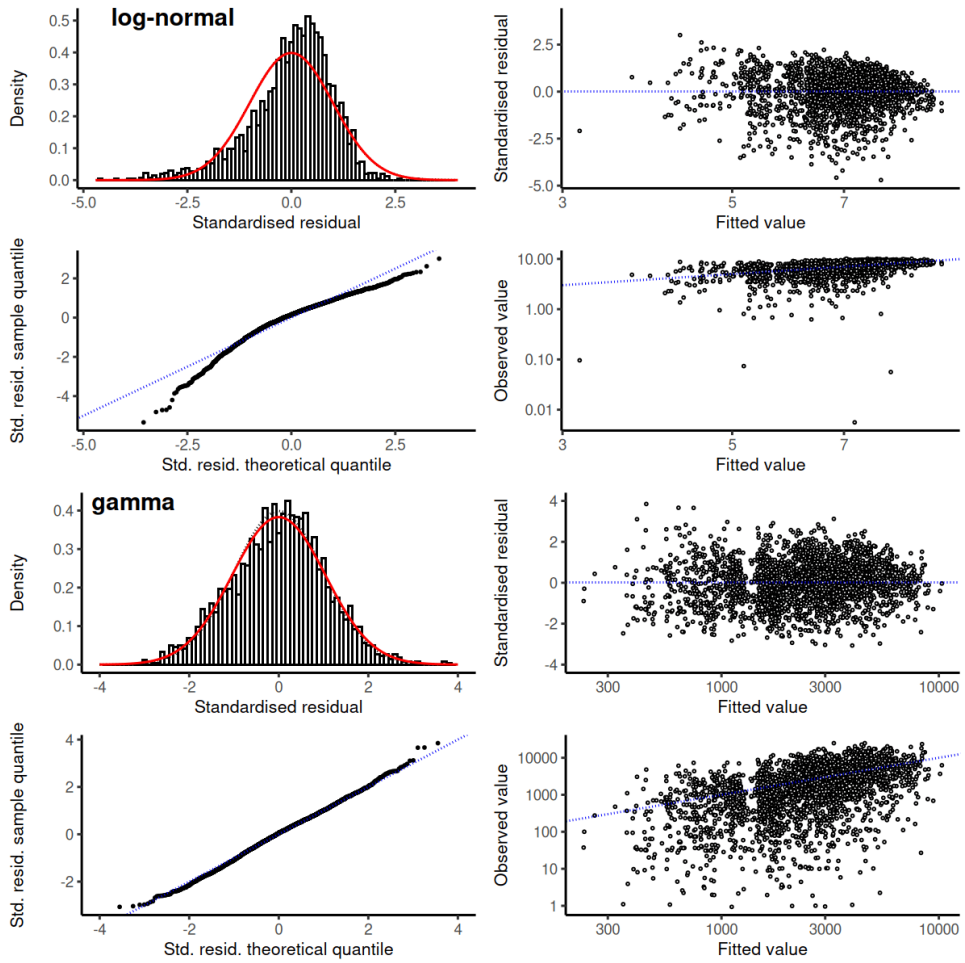

Figure D.68: Diagnostic plots for the alternative log-normal and gamma models considered for positive catches in the BYX event (Chatham Rise - North) dataset.

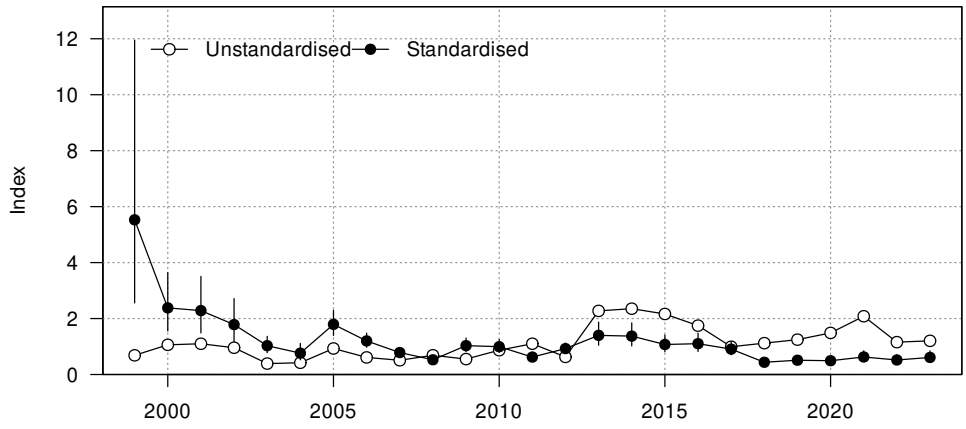

Figure D.69: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch using the Weibull model for the BYX event (Chatham Rise - North) dataset.

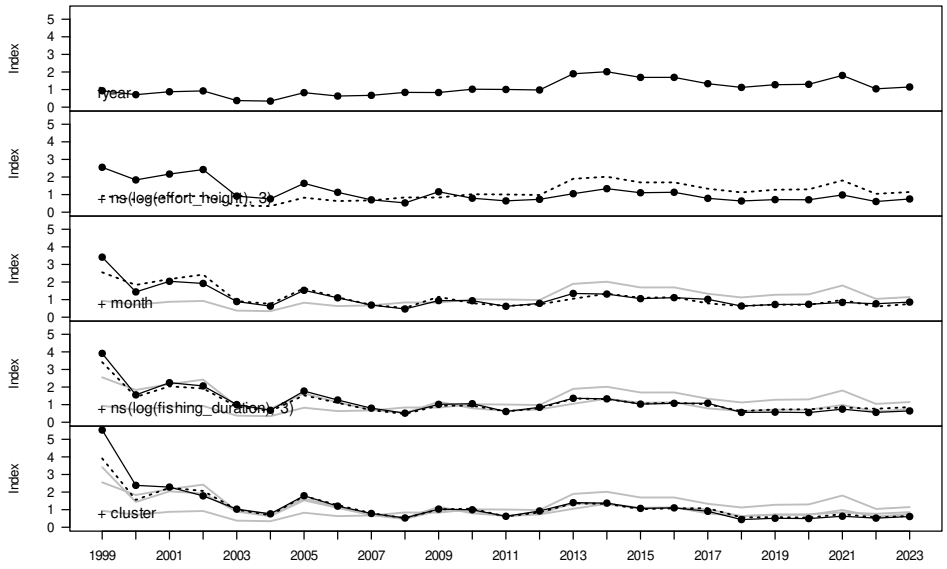

Figure D.70: Changes to the BYX event (Chatham Rise - North) positive catch index as terms are successively entered into the Weibull model.

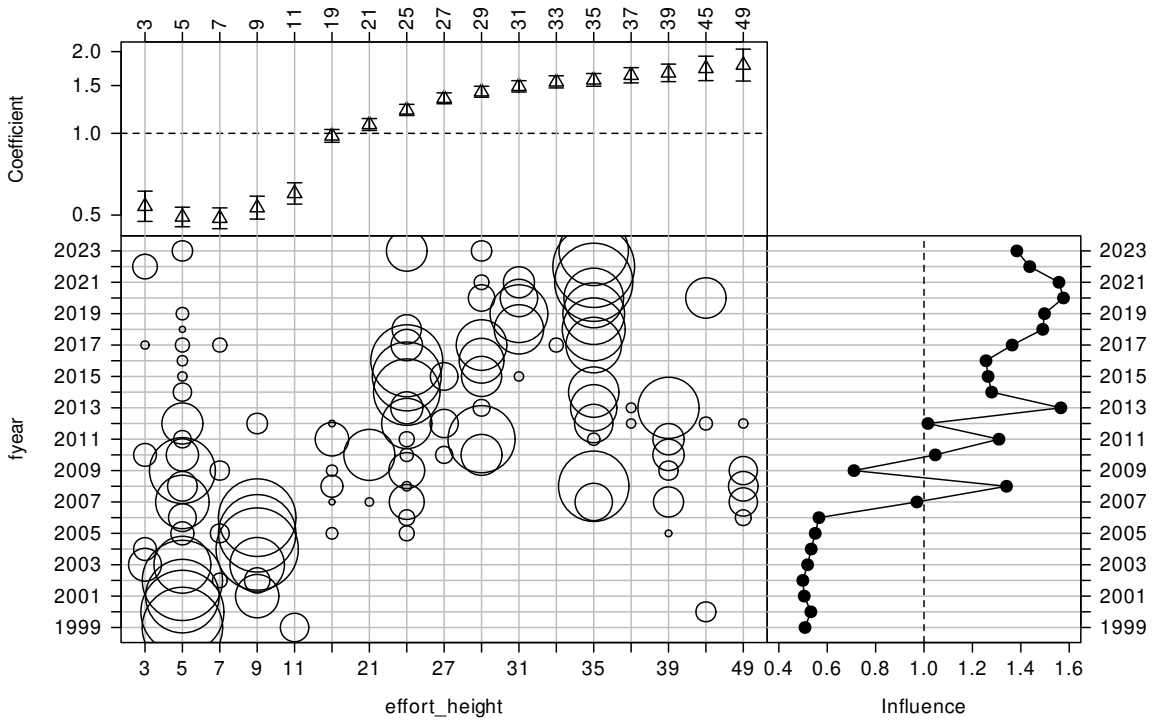

Figure D.71: CDI plot for effort height (m) for the Weibull model of positive catches in the BYX event (Chatham Rise - North) catch-per-unit-effort dataset.

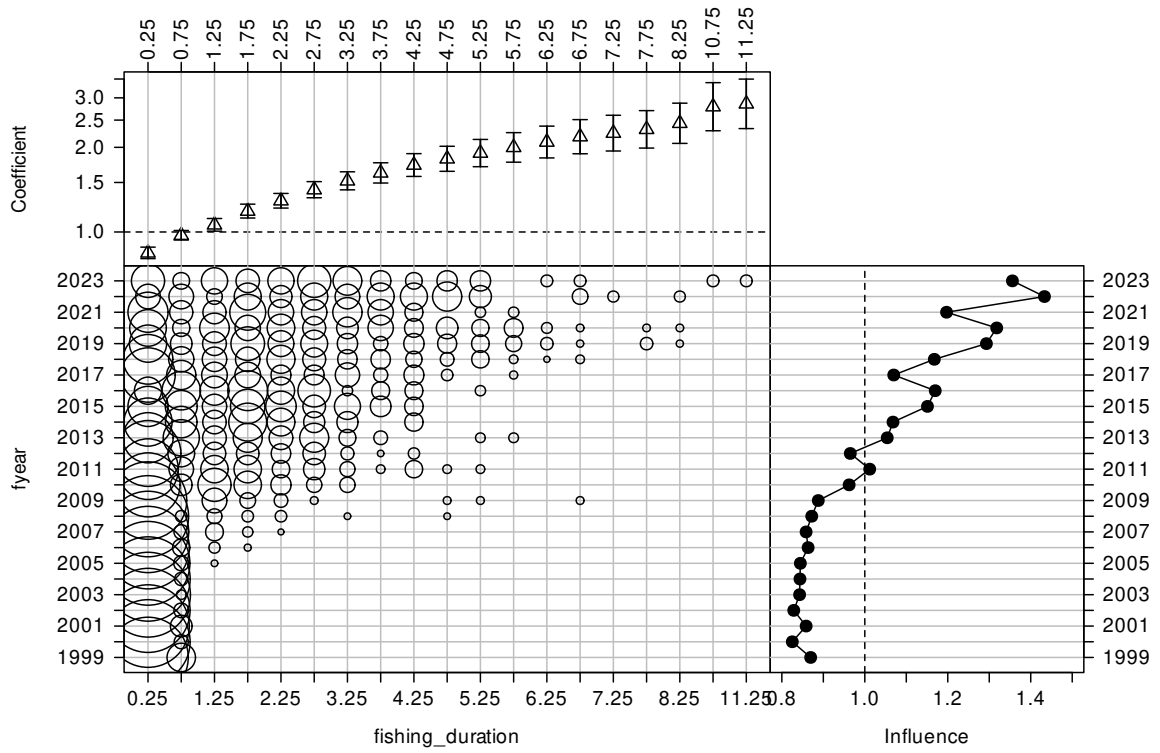

Figure D.72: CDI plot for fishing duration (h) for the Weibull model of positive catches in the BYX event (Chatham Rise - North) catch-per-unit-effort dataset.

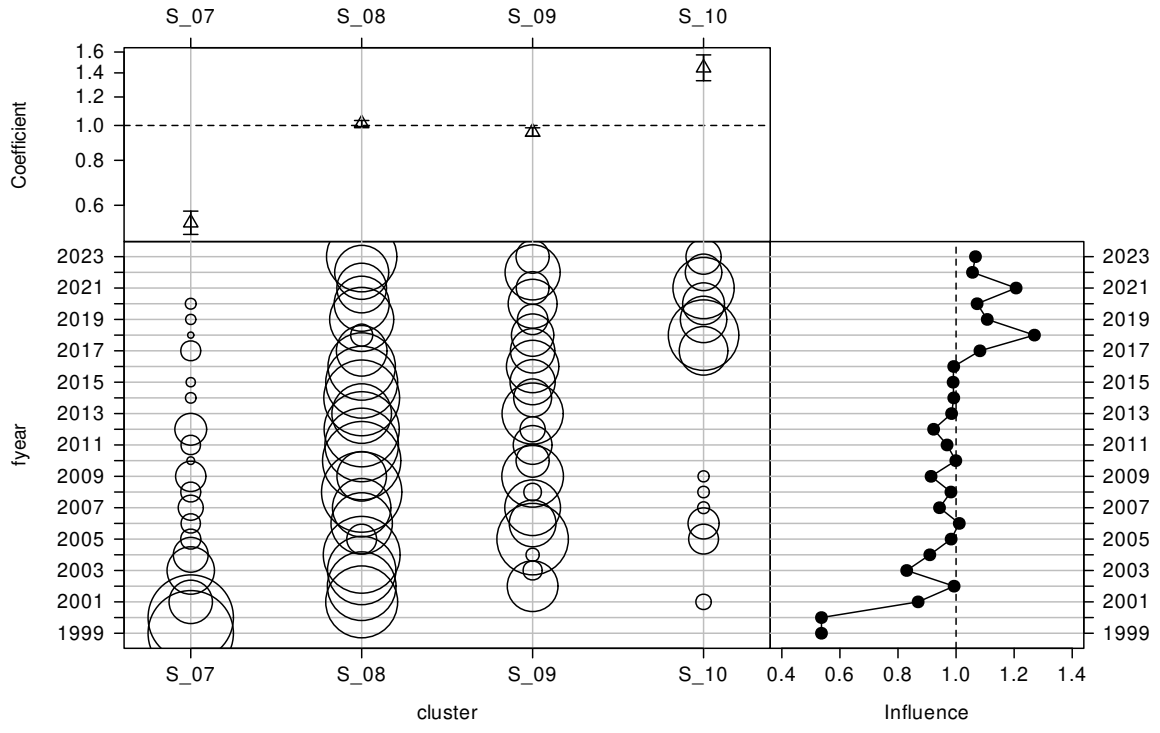

Figure D.73: CDI plot for cluster for the Weibull model of positive catches in the BYX event (Chatham Rise - North) catch-per-unit-effort dataset.

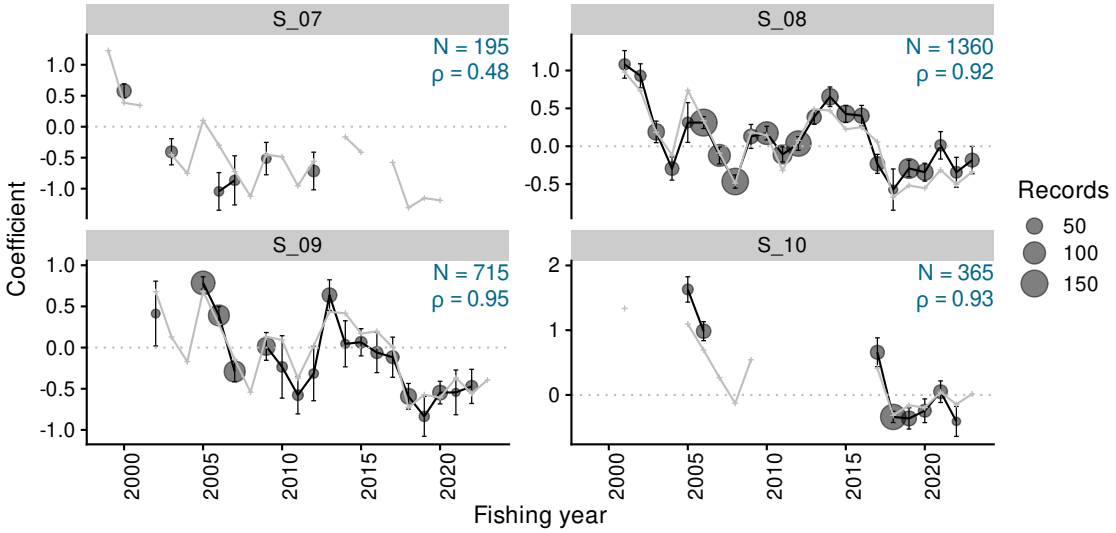

Figure D.74: Residual implied coefficients for area-year in the Weibull positive catch model for the BYX event (Chatham Rise - North) dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 10 data points in an area-year stratum. The light grey line and points indicate the overall year indices; these are only plotted where there are data in a stratum.

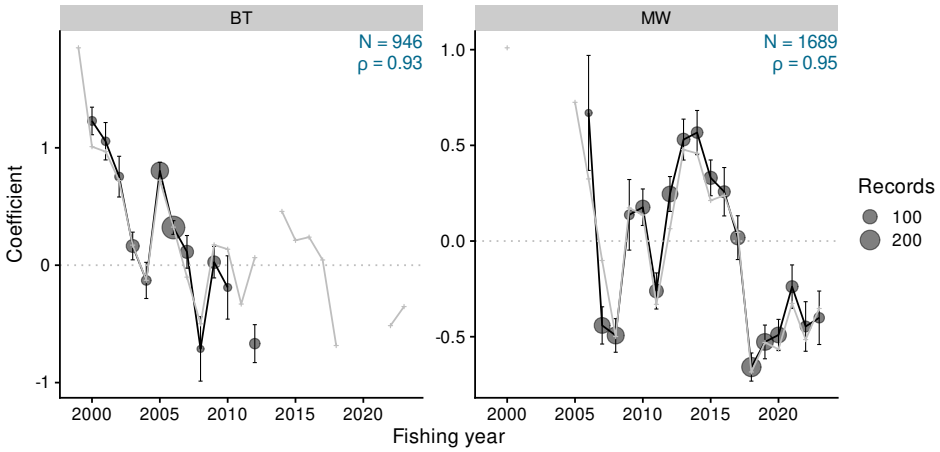

Figure D.75: Residual implied coefficients for primary method-year in the Weibull positive catch model for the BYX event (Chatham Rise - North) dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 10 data points in a method-year stratum. The light grey line and points indicate the overall year indices; these are only plotted where there are data in a stratum.

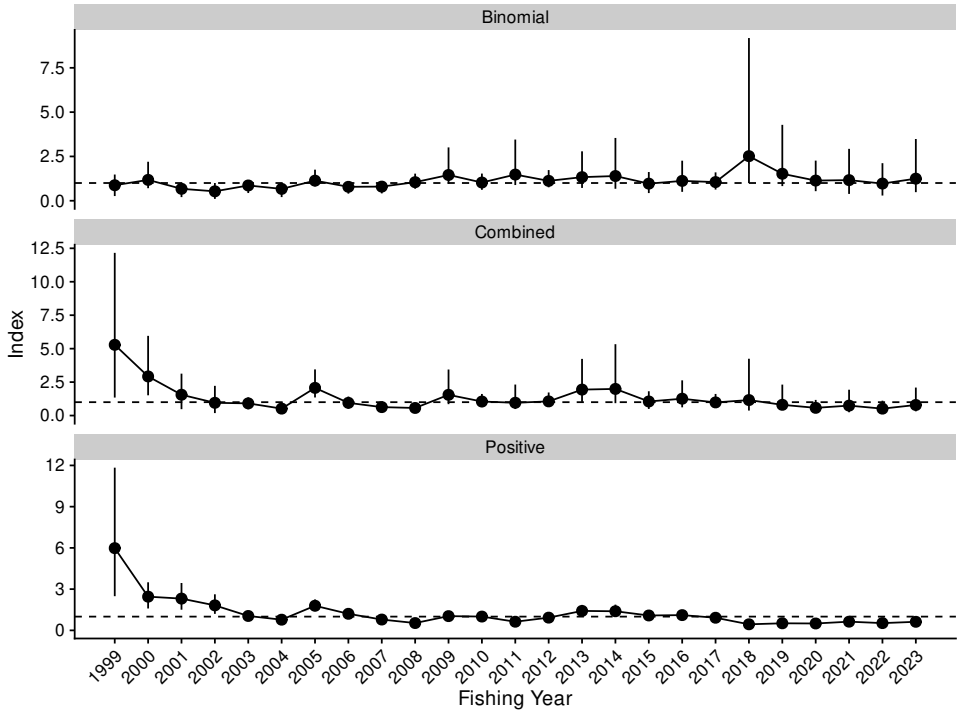

Figure D.76: Standardised indices and 95% confidence intervals for the BYX event (Chatham Rise - North) dataset.

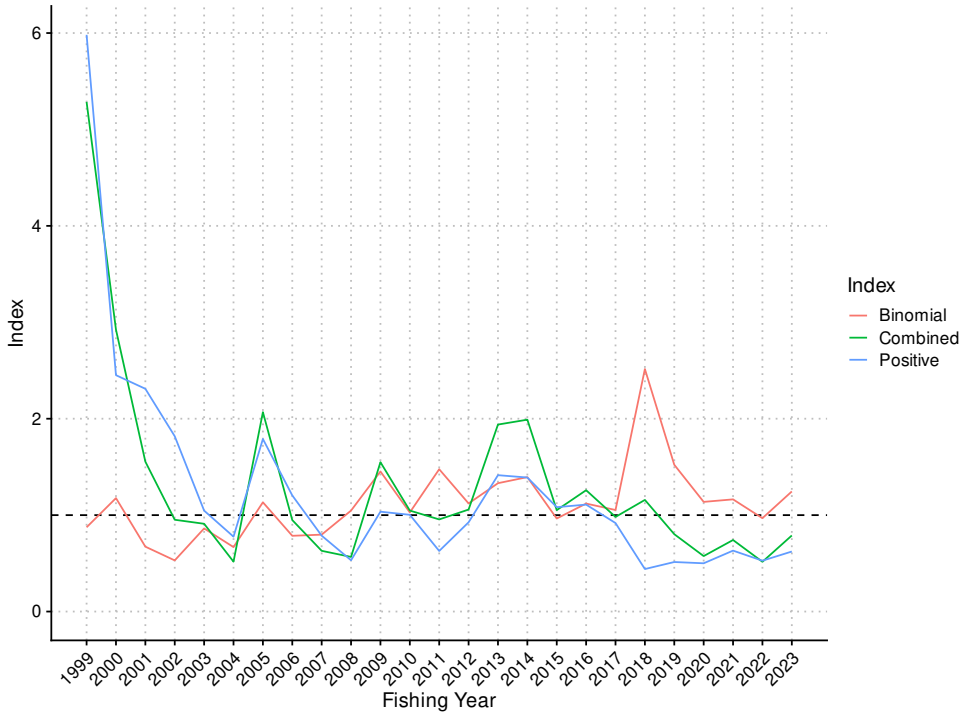

Figure D.77: Standardised indices for the BYX event (Chatham Rise - North) dataset.

Table D.24: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in BYX event (Chatham Rise - North).

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
1999	0.874	0.310	0.264	1.479	5.286	2.759	1.344	12.160	5.982	2.385	2.486	11.837
2000	1.176	0.381	0.708	2.200	2.923	1.133	1.514	5.957	2.452	0.486	1.591	3.497
2001	0.673	0.203	0.205	1.000	1.555	0.677	0.476	3.131	2.310	0.495	1.503	3.445
2002	0.530	0.229	0.104	1.000	0.952	0.519	0.184	2.220	1.818	0.363	1.200	2.623
2003	0.862	0.161	0.435	1.068	0.910	0.228	0.466	1.362	1.047	0.150	0.778	1.367
2004	0.668	0.203	0.206	1.000	0.517	0.210	0.163	0.987	0.777	0.148	0.534	1.113
2005	1.133	0.241	0.809	1.754	2.068	0.535	1.351	3.448	1.790	0.218	1.394	2.249
2006	0.786	0.153	0.400	1.000	0.949	0.233	0.507	1.420	1.204	0.137	0.952	1.488
2007	0.798	0.149	0.414	1.000	0.630	0.142	0.345	0.901	0.787	0.074	0.651	0.942
2008	1.047	0.217	0.679	1.529	0.566	0.132	0.357	0.873	0.532	0.058	0.425	0.653
2009	1.453	0.523	0.959	3.010	1.549	0.661	0.851	3.441	1.036	0.121	0.819	1.295
2010	1.028	0.234	0.617	1.533	1.047	0.251	0.631	1.613	1.003	0.110	0.808	1.238
2011	1.476	0.655	0.886	3.452	0.955	0.467	0.487	2.317	0.628	0.082	0.488	0.808
2012	1.121	0.248	0.758	1.730	1.058	0.258	0.713	1.724	0.926	0.093	0.754	1.117
2013	1.331	0.527	0.723	2.788	1.939	0.819	1.023	4.234	1.414	0.207	1.040	1.852
2014	1.394	0.732	0.675	3.543	1.990	1.124	0.925	5.333	1.390	0.217	1.023	1.872
2015	0.965	0.303	0.433	1.620	1.052	0.337	0.495	1.815	1.082	0.141	0.830	1.382
2016	1.120	0.448	0.502	2.260	1.258	0.514	0.614	2.631	1.109	0.155	0.851	1.457
2017	1.053	0.247	0.631	1.600	0.981	0.263	0.582	1.614	0.918	0.120	0.702	1.173
2018	2.515	2.087	1.000	9.181	1.158	0.988	0.373	4.246	0.441	0.049	0.348	0.539
2019	1.522	0.882	0.826	4.283	0.802	0.484	0.416	2.313	0.514	0.055	0.414	0.628
2020	1.137	0.440	0.540	2.264	0.575	0.227	0.280	1.168	0.500	0.058	0.396	0.622
2021	1.163	0.649	0.385	2.928	0.742	0.429	0.247	1.930	0.632	0.089	0.468	0.818
2022	0.968	0.466	0.293	2.119	0.516	0.243	0.161	1.112	0.527	0.088	0.386	0.729
2023	1.246	0.765	0.484	3.484	0.789	0.453	0.316	2.091	0.623	0.101	0.446	0.843

D.5 BYX event (East Coast - South)

Table D.25: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the BYX event (East Coast - South) CPUE series.

Series	BYX event (East Coast - South)
QMS stock	BYX 2, BYX 3
Reporting forms	TCP, TCE, ERS - Trawl
Fishing methods	BT, PRB, MW, PRM
Target species	BYX
Statistical Areas	011, 012, 013, 014, 015, 016, 017, 018, 019, 020, 021, 202, 203, 204, 205, 401, 402, 403, 404, 405, 410, 049, 050, 051, 052, 406, 412
Period	1989-10-01, 2023-09-30
Resolution	Fishing event
Core fleet years	5
Core fleet trips	3
Default model	allockg_top5 ~ fyear + cluster + vessel_key + primary_method + month + ns(log(fishing_duration), 3) + ns(log(effort_height), 3) + ns(log(effort_depth), 3)
Stepwise selection	Yes
Positive catch distribution	Weibull

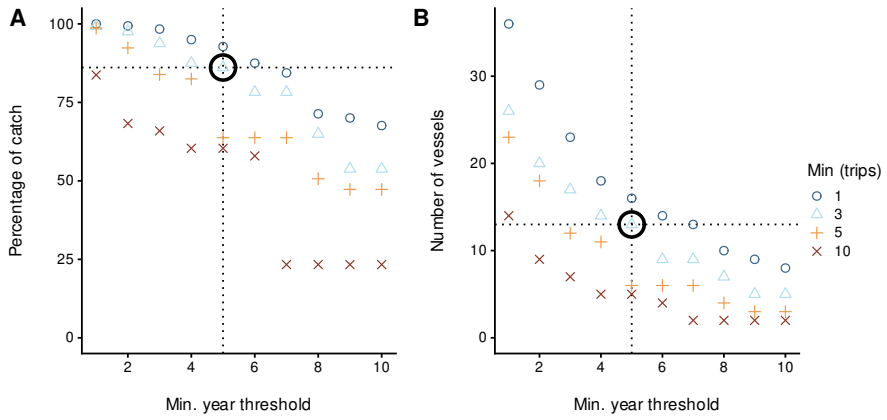

Figure D.78: Percentage of catch and number of vessels for different core vessel selection criteria for the BYX event (East Coast - South) CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

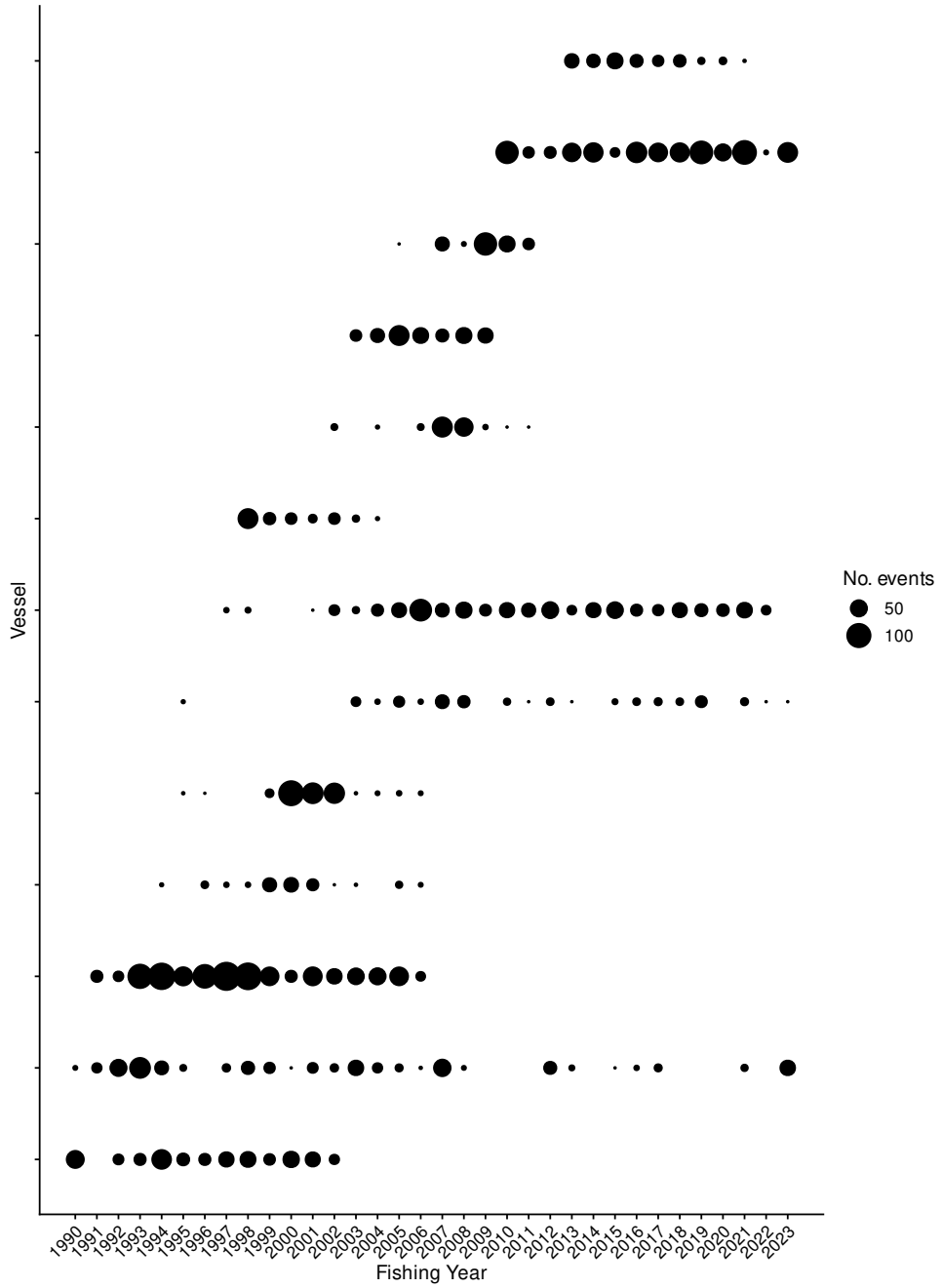

Figure D.79: Number of events by fishing year for core vessels in the BYX event (East Coast - South) series. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table D.26: Summary of the BYX event (East Coast - South) 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 2 pages)

Filter	1990	1991	1992	1993	1994	1995	1996	1997	1998
Ungroomed data	669 (100%) n: 335	749 (100%) n: 294	1260 (100%) n: 458	1444 (100%) n: 530	1332 (100%) n: 708	1307 (100%) n: 794	1503 (100%) n: 769	1500 (100%) n: 736	1540 (100%) n: 730
Fishing duration is not NA	669 (100%) n: 335	749 (100%) n: 294	1260 (100%) n: 458	1444 (100%) n: 530	1332 (100%) n: 708	1307 (100%) n: 794	1503 (100%) n: 769	1500 (100%) n: 736	1540 (100%) n: 730
Positive fishing duration	669 (100%) n: 335	749 (100%) n: 294	1260 (100%) n: 458	1444 (100%) n: 530	1332 (100%) n: 708	1307 (100%) n: 793	1502 (100%) n: 762	1500 (100%) n: 729	1540 (100%) n: 728
Duration under 12h	669 (100%) n: 335	739 (99%) n: 292	1260 (100%) n: 458	1416 (98%) n: 528	1332 (100%) n: 707	1304 (100%) n: 785	1498 (100%) n: 756	1472 (98%) n: 720	1534 (100%) n: 720
Headline under 60m	669 (100%) n: 335	739 (99%) n: 292	1260 (100%) n: 458	1416 (98%) n: 528	1332 (100%) n: 707	1294 (99%) n: 769	1467 (98%) n: 751	1450 (97%) n: 711	1457 (95%) n: 694
In a cluster	654 (98%) n: 330	739 (99%) n: 288	1241 (98%) n: 446	1380 (96%) n: 510	1271 (95%) n: 681	1256 (96%) n: 718	1436 (96%) n: 725	1419 (95%) n: 695	1396 (91%) n: 679
150+ events per cluster	592 (89%) n: 316	708 (94%) n: 281	1197 (95%) n: 437	1364 (95%) n: 499	1269 (95%) n: 664	1124 (86%) n: 651	1389 (92%) n: 704	1395 (93%) n: 683	1388 (90%) n: 665
In area	156 (23%) n: 154	73 (10%) n: 43	273 (22%) n: 99	698 (48%) n: 294	639 (48%) n: 376	451 (34%) n: 256	469 (31%) n: 208	545 (36%) n: 237	481 (31%) n: 275
Core fleet selection	59 (9%) n: 59	73 (10%) n: 43	270 (21%) n: 89	549 (38%) n: 200	440 (33%) n: 222	298 (23%) n: 103	377 (25%) n: 132	491 (33%) n: 198	481 (31%) n: 275

Filter	1999	2000	2001	2002	2003	2004	2005	2006	2007
Ungroomed data	1541 (100%) n: 1040	1269 (100%) n: 968	1352 (100%) n: 849	1329 (100%) n: 639	1602 (100%) n: 881	1430 (100%) n: 644	1942 (100%) n: 849	2045 (100%) n: 1139	2035 (100%) n: 1008
Fishing duration is not NA	1541 (100%) n: 1040	1269 (100%) n: 968	1352 (100%) n: 849	1329 (100%) n: 639	1602 (100%) n: 881	1430 (100%) n: 644	1942 (100%) n: 849	2045 (100%) n: 1139	2035 (100%) n: 1008
Positive fishing duration	1538 (100%) n: 1038	1269 (100%) n: 966	1341 (99%) n: 846	1326 (100%) n: 634	1602 (100%) n: 875	1430 (100%) n: 644	1942 (100%) n: 848	2045 (100%) n: 1139	2031 (100%) n: 1000
Duration under 12h	1535 (100%) n: 1030	1266 (100%) n: 959	1341 (99%) n: 846	1322 (99%) n: 631	1602 (100%) n: 875	1430 (100%) n: 644	1942 (100%) n: 848	2044 (100%) n: 1138	2031 (100%) n: 999
Headline under 60m	1492 (97%) n: 1011	1265 (100%) n: 953	1338 (99%) n: 845	1322 (99%) n: 631	1602 (100%) n: 875	1420 (99%) n: 637	1942 (100%) n: 848	2044 (100%) n: 1138	2031 (100%) n: 999
In a cluster	1437 (93%) n: 969	1232 (97%) n: 929	1310 (97%) n: 830	1313 (99%) n: 624	1588 (99%) n: 867	1415 (99%) n: 631	1939 (100%) n: 844	2035 (99%) n: 1127	2025 (100%) n: 991
150+ events per cluster	1182 (77%) n: 799	1179 (93%) n: 902	1256 (93%) n: 802	1269 (95%) n: 614	1498 (94%) n: 833	1394 (97%) n: 616	1872 (96%) n: 814	1976 (97%) n: 1067	2013 (99%) n: 969
In area	343 (22%) n: 178	445 (35%) n: 248	488 (36%) n: 257	357 (27%) n: 197	341 (21%) n: 153	504 (35%) n: 147	699 (36%) n: 213	491 (24%) n: 163	646 (32%) n: 254
Core fleet selection	343 (22%) n: 178	444 (35%) n: 239	462 (34%) n: 233	354 (27%) n: 194	340 (21%) n: 150	498 (35%) n: 142	699 (36%) n: 213	491 (24%) n: 163	645 (32%) n: 250

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	1926 (100%) n: 796	1867 (100%) n: 838	2252 (100%) n: 1072	2185 (100%) n: 883	2253 (100%) n: 873	2187 (100%) n: 480	2008 (100%) n: 653	1976 (100%) n: 617	2136 (100%) n: 590
Fishing duration is not NA	1926 (100%) n: 796	1867 (100%) n: 838	2252 (100%) n: 1072	2185 (100%) n: 883	2253 (100%) n: 873	2187 (100%) n: 480	2008 (100%) n: 653	1976 (100%) n: 617	2136 (100%) n: 590
Positive fishing duration	1905 (99%) n: 792	1855 (99%) n: 829	2252 (100%) n: 1070	2182 (100%) n: 880	2250 (100%) n: 870	2187 (100%) n: 479	2008 (100%) n: 652	1976 (100%) n: 617	2136 (100%) n: 590
Duration under 12h	1903 (99%) n: 791	1855 (99%) n: 829	2252 (100%) n: 1070	2182 (100%) n: 879	2250 (100%) n: 870	2187 (100%) n: 479	2008 (100%) n: 652	1961 (99%) n: 616	2136 (100%) n: 590
Headline under 60m	1903 (99%) n: 791	1854 (99%) n: 828	2245 (100%) n: 1067	2182 (100%) n: 878	2250 (100%) n: 870	2187 (100%) n: 479	2008 (100%) n: 652	1961 (99%) n: 616	2126 (100%) n: 588
In a cluster	1877 (97%) n: 779	1853 (99%) n: 827	2240 (99%) n: 1059	2133 (98%) n: 869	2247 (100%) n: 862	2184 (100%) n: 476	1980 (99%) n: 643	1953 (99%) n: 613	2126 (100%) n: 587
150+ events per cluster	1853 (96%) n: 763	1845 (99%) n: 822	2170 (96%) n: 1017	2127 (97%) n: 855	2246 (100%) n: 858	2181 (100%) n: 469	1975 (98%) n: 636	1910 (97%) n: 602	2126 (100%) n: 586
In area	556 (29%) n: 193	619 (33%) n: 183	760 (34%) n: 284	396 (18%) n: 139	626 (28%) n: 146	584 (27%) n: 128	580 (29%) n: 161	473 (24%) n: 150	525 (25%) n: 141
Core fleet selection	538 (28%) n: 181	577 (31%) n: 155	548 (24%) n: 180	271 (12%) n: 81	513 (23%) n: 112	550 (25%) n: 118	477 (24%) n: 134	251 (13%) n: 115	525 (25%) n: 141

Filter	2017	2018	2019	2020	2021	2022	2023
Ungroomed data	1894 (100%) n: 645	2005 (100%) n: 595	2141 (100%) n: 757	2075 (100%) n: 704	1853 (100%) n: 611	1882 (100%) n: 512	1569 (100%) n: 624
Fishing duration is not NA	1894 (100%) n: 645	2005 (100%) n: 595	2141 (100%) n: 757	2075 (100%) n: 704	1853 (100%) n: 610	1882 (100%) n: 512	1569 (100%) n: 624
Positive fishing duration	1894 (100%) n: 645	2005 (100%) n: 595	2141 (100%) n: 754	2075 (100%) n: 702	1853 (100%) n: 608	1882 (100%) n: 512	1569 (100%) n: 623
Duration under 12h	1894 (100%) n: 644	2005 (100%) n: 595	2137 (100%) n: 752	2074 (100%) n: 701	1853 (100%) n: 608	1882 (100%) n: 512	1569 (100%) n: 623
Headline under 60m	1894 (100%) n: 644	2005 (100%) n: 595	2125 (99%) n: 749	2048 (99%) n: 698	1853 (100%) n: 608	1882 (100%) n: 512	1569 (100%) n: 623
In a cluster	1874 (99%) n: 634	1991 (99%) n: 587	2122 (99%) n: 746	2048 (99%) n: 695	1841 (99%) n: 604	1882 (100%) n: 512	1569 (100%) n: 621
150+ events per cluster	1836 (97%) n: 624	1953 (97%) n: 568	2093 (98%) n: 729	2013 (97%) n: 637	1835 (99%) n: 600	1882 (100%) n: 507	1569 (100%) n: 615
In area	482 (25%) n: 140	700 (35%) n: 162	603 (28%) n: 179	497 (24%) n: 155	564 (30%) n: 223	106 (6%) n: 34	396 (25%) n: 124
Core fleet selection	460 (24%) n: 126	590 (29%) n: 139	537 (25%) n: 151	303 (15%) n: 87	398 (21%) n: 161	39 (2%) n: 21	368 (23%) n: 109

Table D.27: Summary of the BYX event (East Coast - South) 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 alfonsino.

Fishing year	Vessels	Trips	Records	Hours	Catch (t)	Records caught
1990	2	4	59	66.60	59.14	81.36
1991	2	13	43	32.02	73.09	95.35
1992	3	20	89	95.98	270.20	80.90
1993	3	34	200	245.00	548.61	91.50
1994	4	45	222	274.67	439.65	89.64
1995	5	29	103	92.52	298.46	88.35
1996	4	35	132	115.85	377.24	83.33
1997	5	34	198	177.73	491.32	90.40
1998	6	45	275	272.15	481.06	85.09
1999	6	35	178	149.97	343.14	88.20
2000	6	45	239	200.22	444.25	86.19
2001	7	46	233	193.28	462.30	80.69
2002	8	57	194	161.38	354.42	72.68
2003	8	50	150	119.83	340.12	84.67
2004	8	45	142	119.77	497.68	90.85
2005	8	56	213	168.78	698.87	85.92
2006	8	41	163	97.80	491.03	82.82
2007	6	56	250	167.93	644.61	86.80
2008	6	50	181	159.33	538.40	86.74
2009	4	56	155	103.47	576.64	96.13
2010	5	39	180	139.30	548.44	93.89
2011	5	25	81	59.80	271.46	96.30
2012	4	22	112	52.37	513.16	91.07
2013	5	31	118	68.92	550.31	97.46
2014	3	33	134	100.97	476.89	93.28
2015	5	35	115	67.62	251.48	94.78
2016	5	50	141	114.32	524.70	95.04
2017	5	61	126	99.15	459.89	94.44
2018	4	56	139	122.32	590.37	92.81
2019	4	33	151	140.68	536.97	97.35
2020	3	22	87	123.53	303.06	96.55
2021	5	30	161	261.17	397.84	95.03
2022	3	7	21	21.75	38.65	100.00
2023	3	12	109	165.60	368.15	93.58

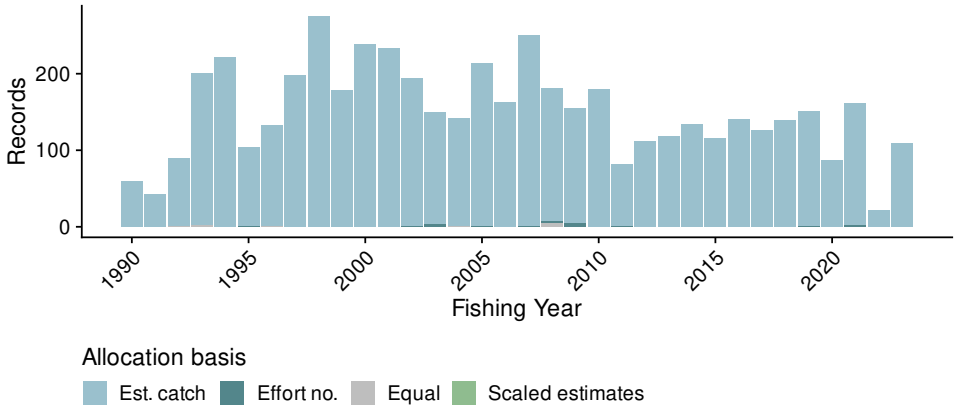

Figure D.80: Allocation basis for attributing landings to records in the BYX event (East Coast - South) catch-per-unit-effort dataset. Allocation basis is in terms of estimated catch, effort number, and/or equal.

Table D.28: Summary of stepwise selection for occurrence of positive catch in the BYX event (East Coast - South) series. 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	32	3 422	5.1	5.1	*
+ vessel_key	12	3 334	8.2	3.2	*
+ cluster	6	3 297	9.6	1.4	*
+ ns(log(fishing_duration), 3)	3	3 271	10.5	0.9	
+ ns(log(effort_height), 3)	3	3 264	10.9	0.4	
+ month	11	3 258	11.7	0.8	

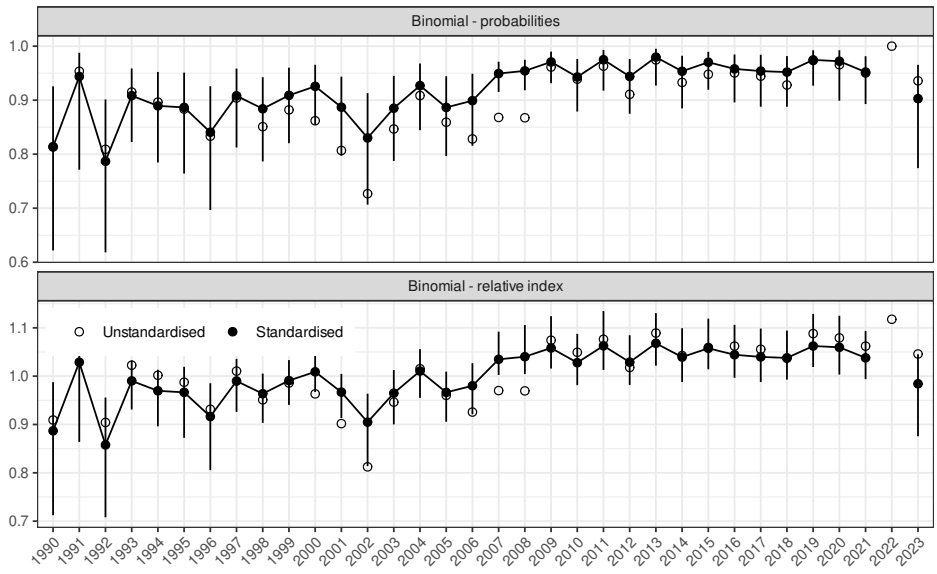

Figure D.81: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the BYX event (East Coast - South) dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

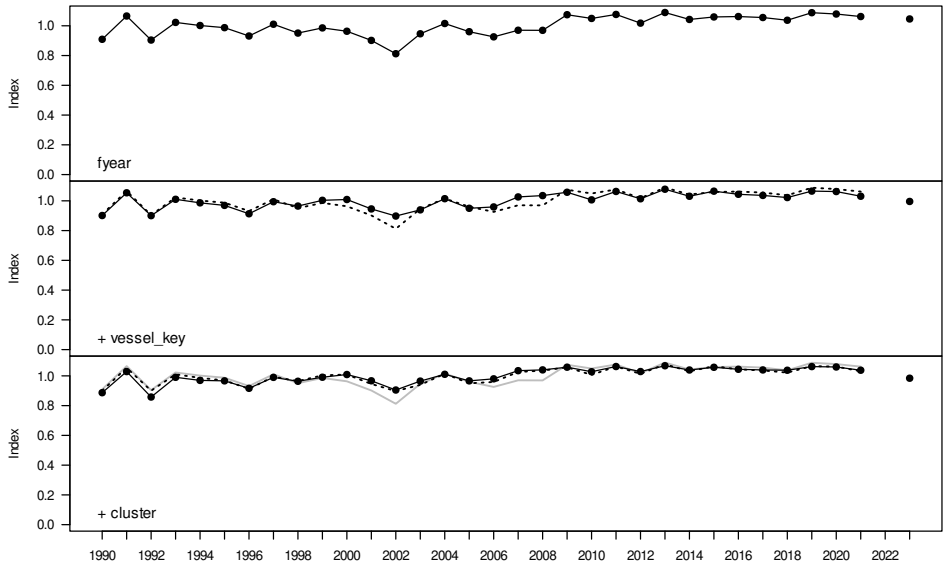

Figure D.82: Step plot for occurrence of catch in the BYX event (East Coast - South) dataset.

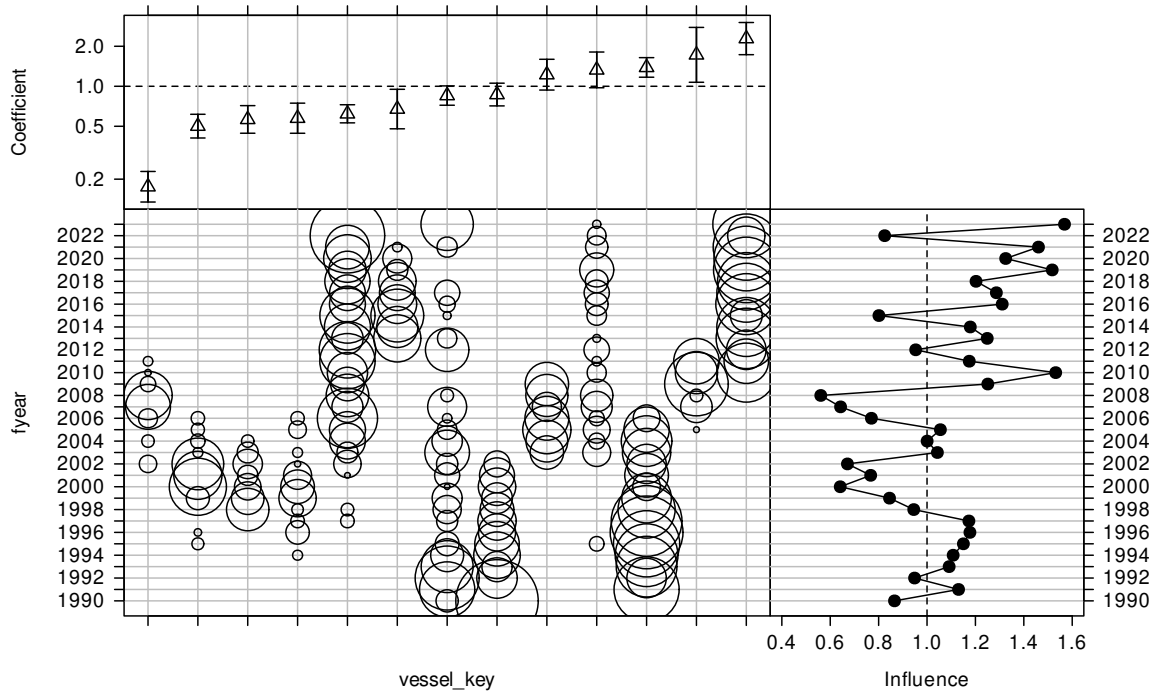

Figure D.83: CDI plot for vessel key for the occurrence of positive catch in the BYX event (East Coast - South) catch-per-unit-effort dataset.

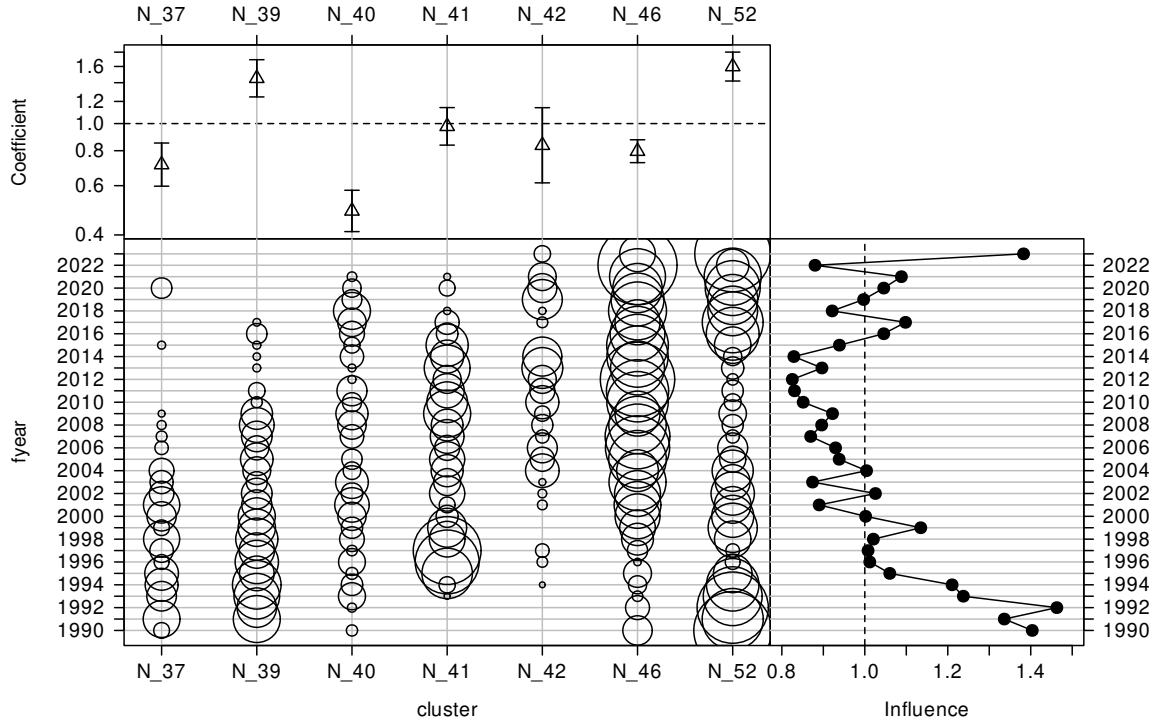

Figure D.84: CDI plot for cluster for the occurrence of positive catch in the BYX event (East Coast - South) catch-per-unit-effort dataset.

Table D.29: Summary of stepwise selection for the Weibull model for positive catches in the BYX event (East Coast - South) series. 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	35	81 099	3.2	3.2	*
+ vessel_key	12	80 651	12.0	8.8	*
+ cluster	6	80 426	16.4	4.4	*
+ month	11	80 374	17.8	1.4	*
+ primary_method	2	80 333	18.6	0.8	

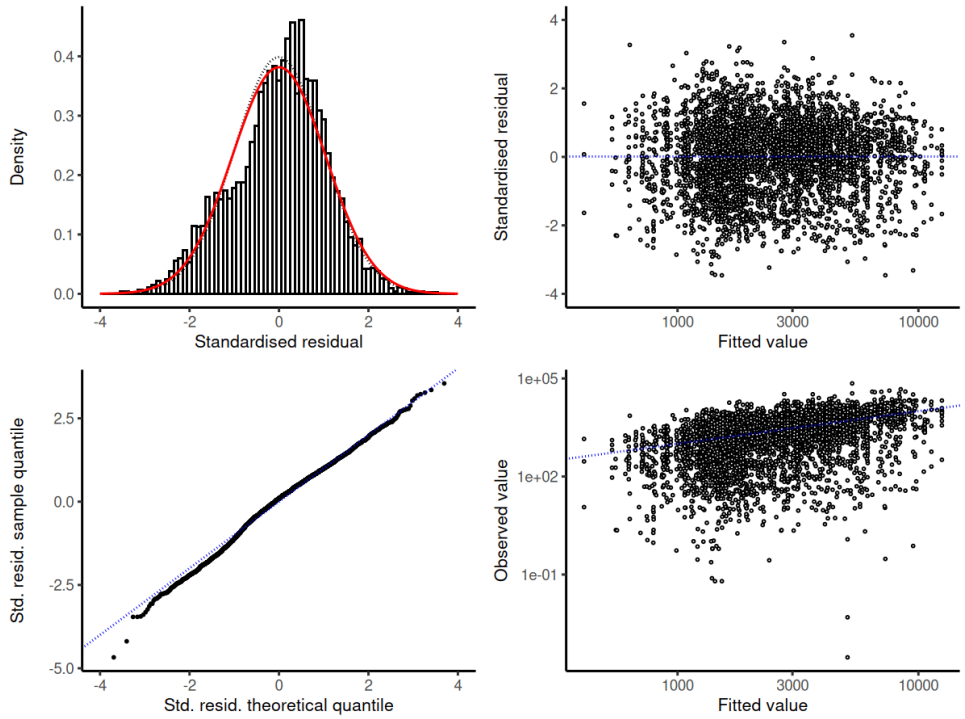

Figure D.85: Diagnostic plots for the selected Weibull model for positive catches in the BYX event (East Coast - South) dataset.

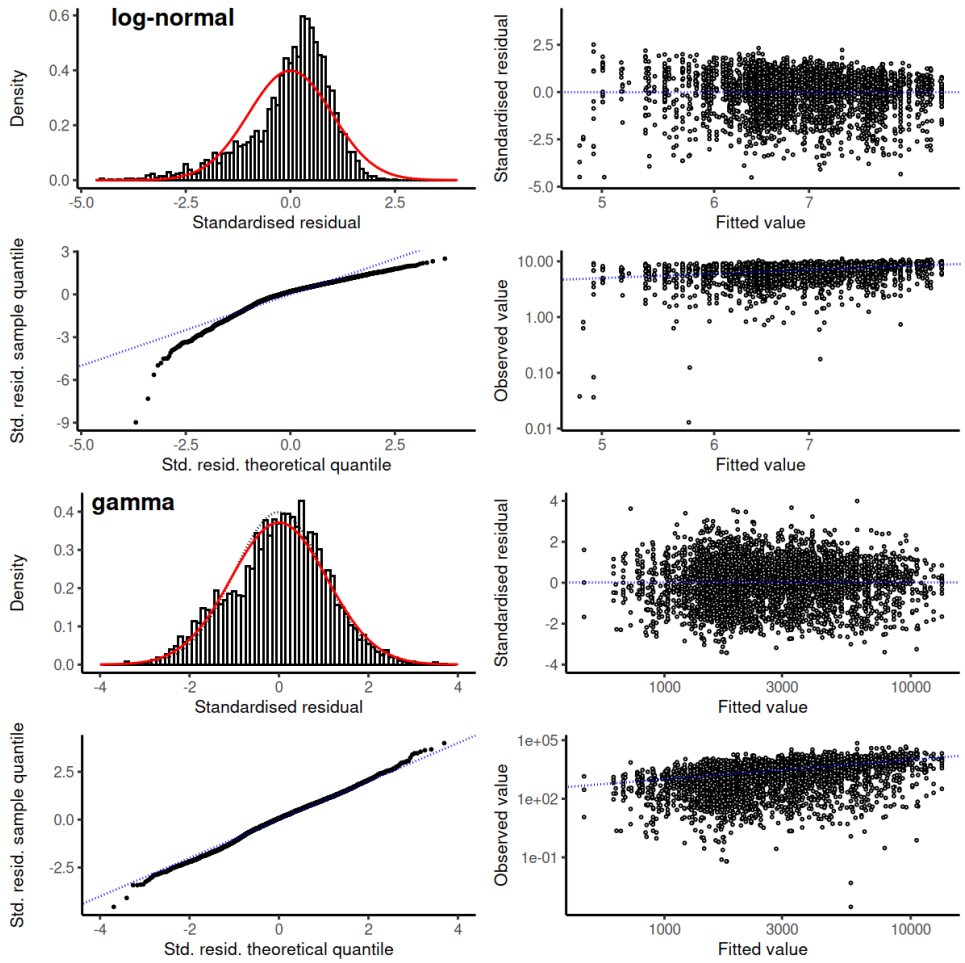

Figure D.86: Diagnostic plots for the alternative log-normal and gamma models considered for positive catches in the BYX event (East Coast - South) dataset.

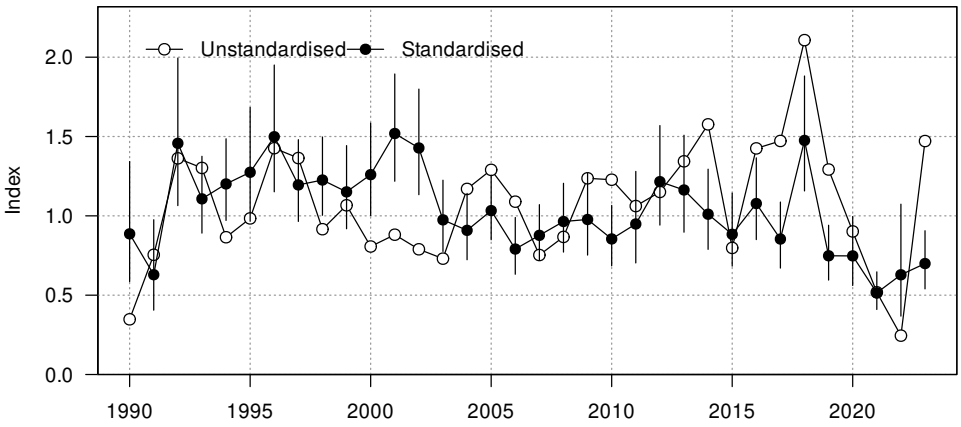

Figure D.87: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch using the Weibull model for the BYX event (East Coast - South) dataset.

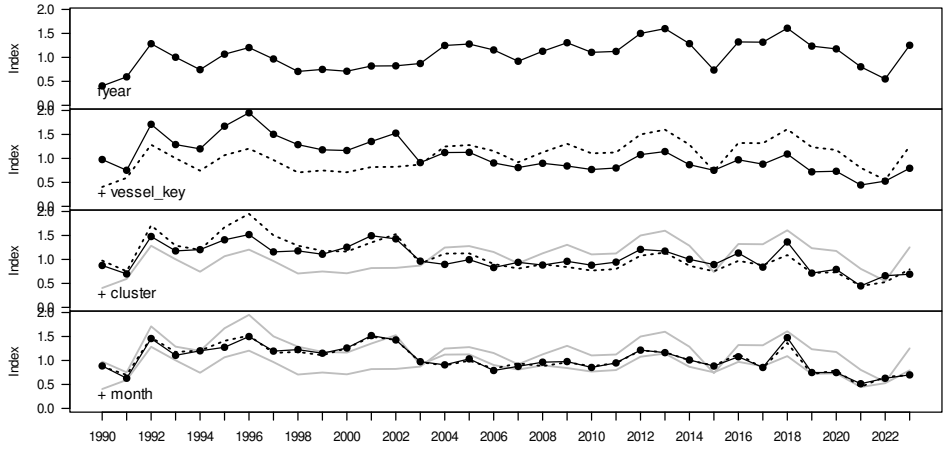

Figure D.88: Changes to the BYX event (East Coast - South) positive catch index as terms are successively entered into the Weibull model.

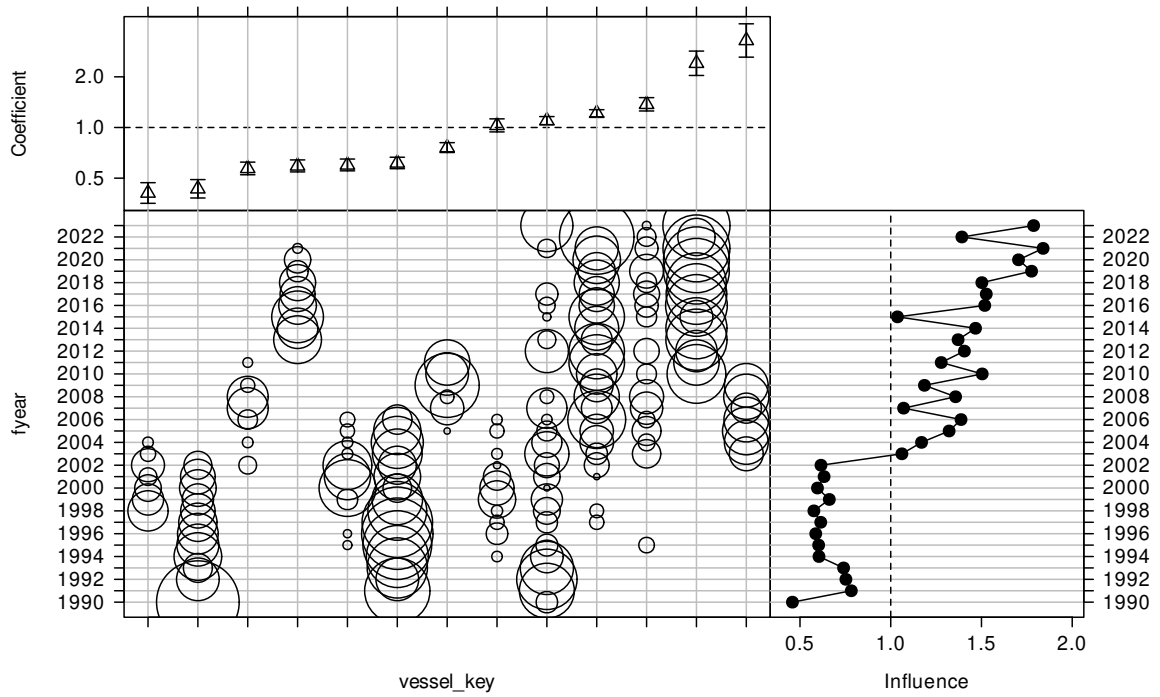

Figure D.89: CDI plot for vessel key for the Weibull model of positive catches in the BYX event (East Coast - South) catch-per-unit-effort dataset.

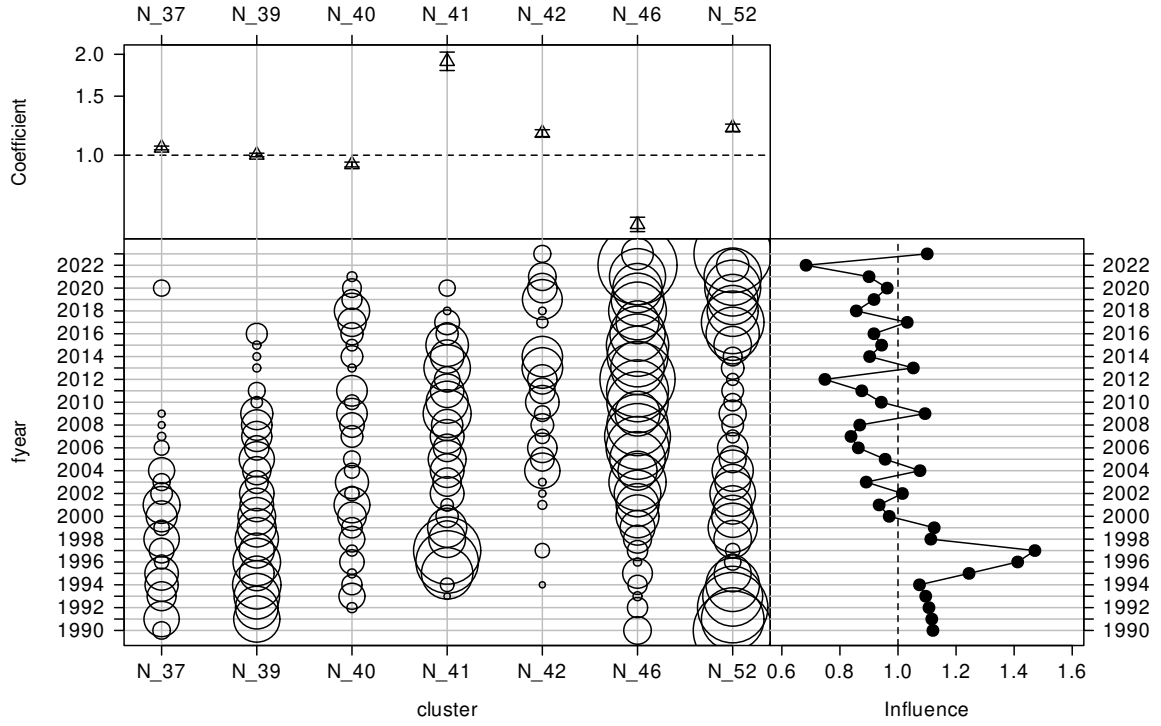

Figure D.90: CDI plot for cluster for the Weibull model of positive catches in the BYX event (East Coast - South) catch-per-unit-effort dataset.

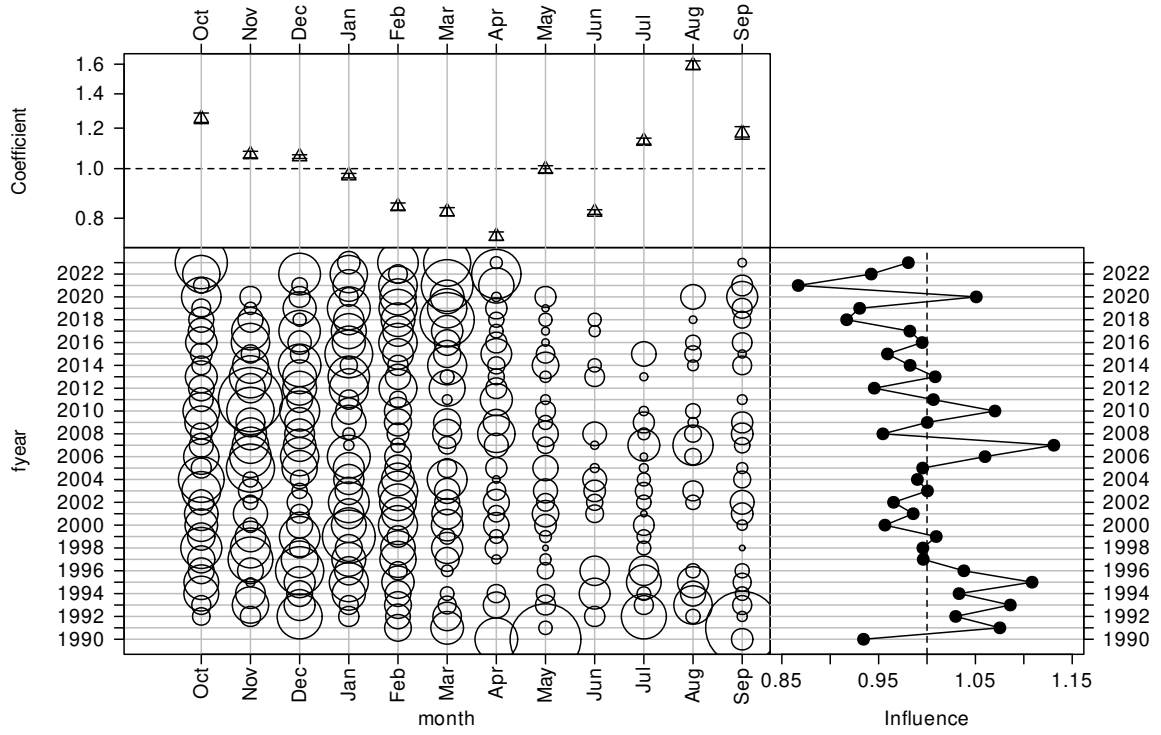

Figure D.91: CDI plot for month for the Weibull model of positive catches in the BYX event (East Coast - South) catch-per-unit-effort dataset.

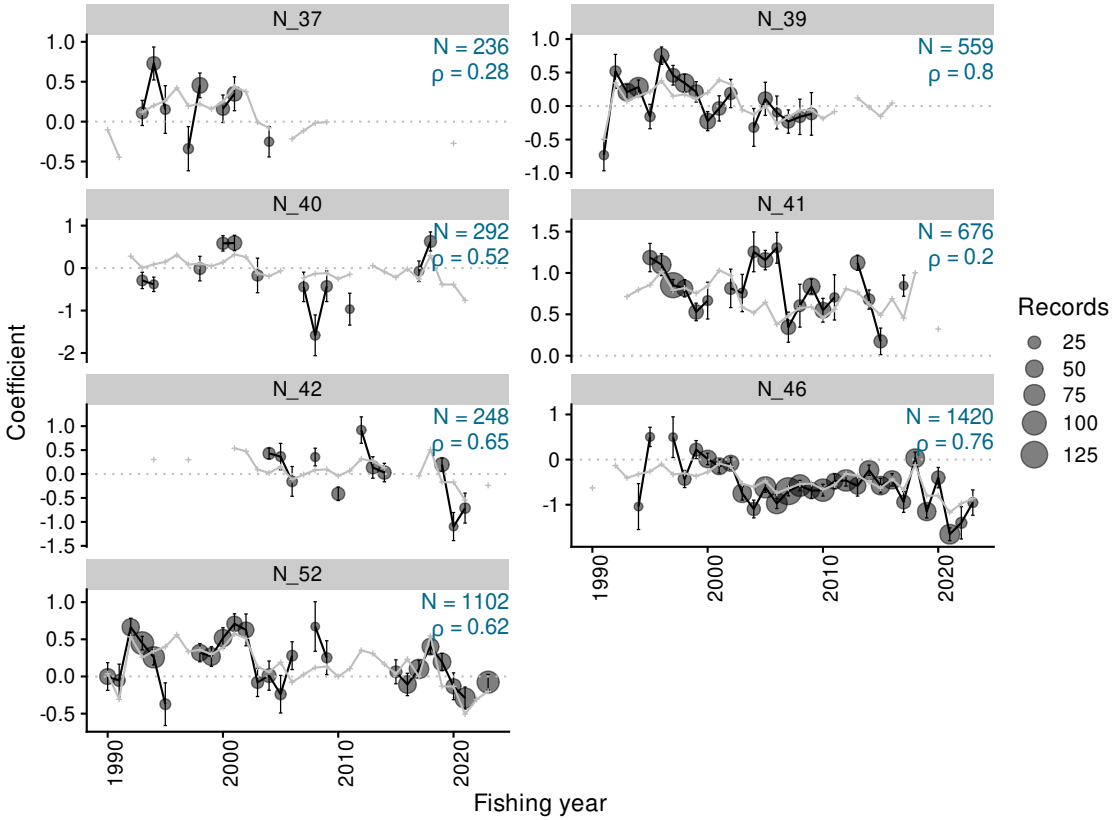

Figure D.92: Residual implied coefficients for area-year in the Weibull positive catch model for the BYX event (East Coast - South) dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 10 data points in an area-year stratum. The light grey line and points indicate the overall year indices; these are only plotted where there are data in a stratum.

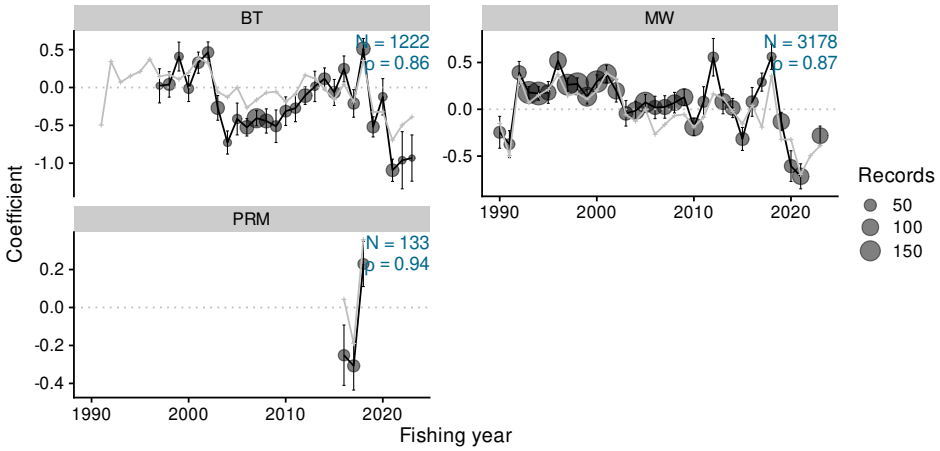

Figure D.93: Residual implied coefficients for primary method-year in the Weibull positive catch model for the BYX event (East Coast - South) dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 10 data points in a method-year stratum. The light grey line and points indicate the overall year indices; these are only plotted where there are data in a stratum.

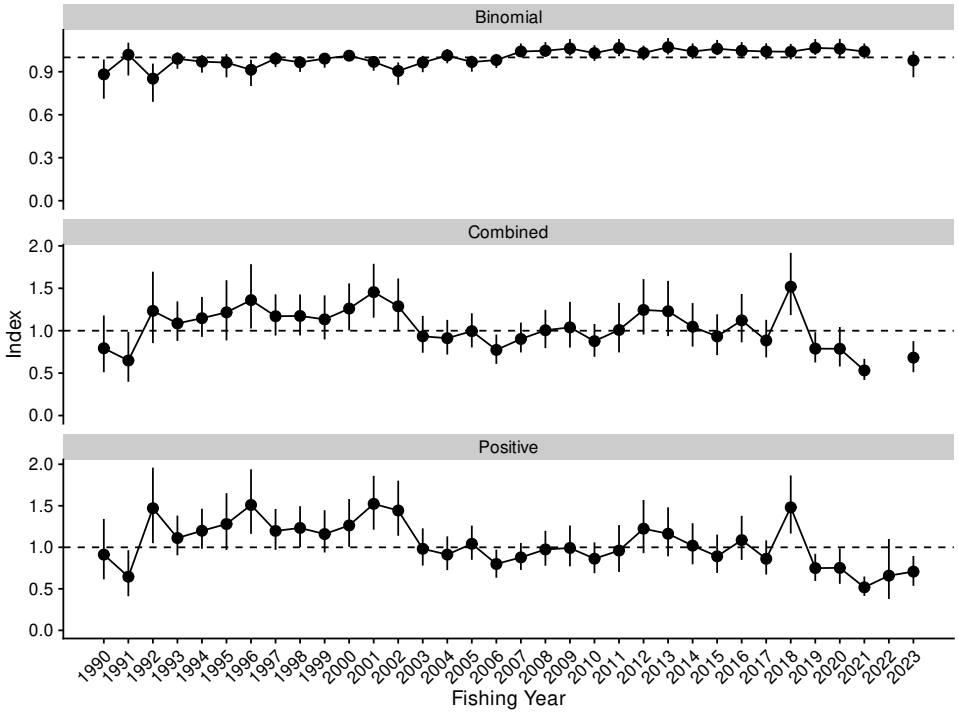

Figure D.94: Standardised indices and 95% confidence intervals for the BYX event (East Coast - South) dataset.

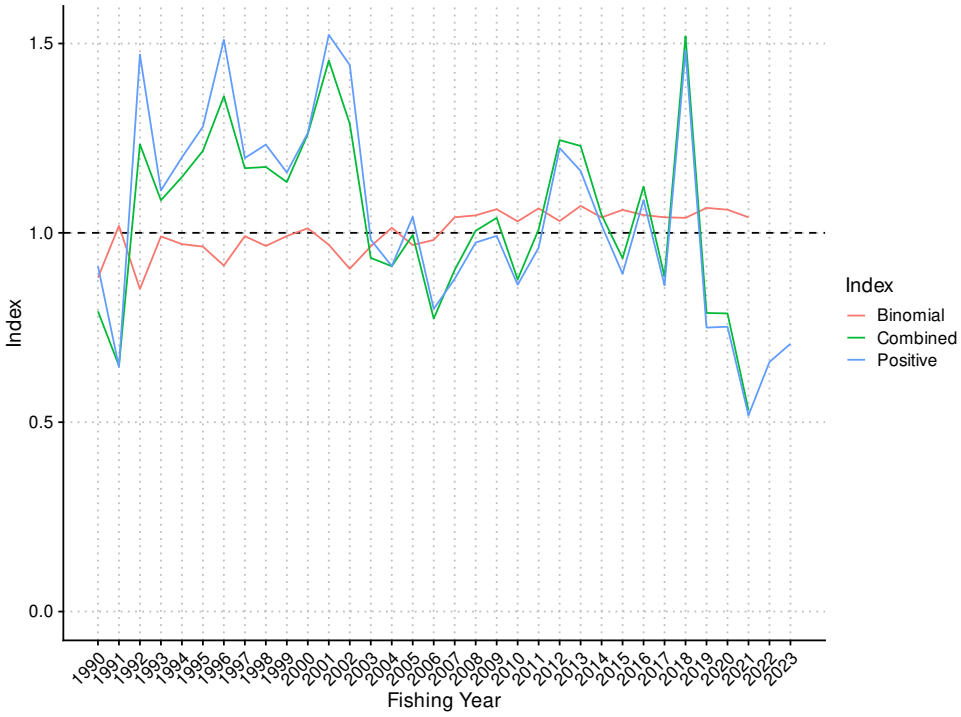

Figure D.95: Standardised indices for the BYX event (East Coast - South) dataset.

Table D.30: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in BYX event (East Coast - South).

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
1990	0.882	0.070	0.712	0.985	0.793	0.171	0.511	1.179	0.912	0.185	0.614	1.341
1991	1.019	0.058	0.874	1.102	0.649	0.149	0.398	0.984	0.646	0.141	0.411	0.965
1992	0.852	0.068	0.690	0.957	1.234	0.215	0.854	1.695	1.470	0.232	1.050	1.959
1993	0.991	0.029	0.921	1.036	1.086	0.119	0.880	1.346	1.112	0.122	0.904	1.382
1994	0.970	0.031	0.893	1.016	1.147	0.120	0.928	1.398	1.199	0.123	0.982	1.465
1995	0.964	0.042	0.861	1.024	1.216	0.181	0.886	1.595	1.280	0.175	0.967	1.652
1996	0.914	0.047	0.800	0.983	1.360	0.193	1.026	1.784	1.510	0.198	1.162	1.939
1997	0.991	0.027	0.932	1.036	1.171	0.124	0.943	1.428	1.198	0.126	0.969	1.461
1998	0.965	0.028	0.899	1.007	1.174	0.123	0.944	1.427	1.233	0.126	1.003	1.495
1999	0.991	0.026	0.928	1.029	1.134	0.133	0.897	1.416	1.160	0.130	0.937	1.447
2000	1.012	0.019	0.974	1.049	1.261	0.141	1.004	1.558	1.264	0.147	1.005	1.581
2001	0.969	0.026	0.907	1.009	1.455	0.162	1.154	1.789	1.523	0.165	1.212	1.861
2002	0.905	0.040	0.809	0.965	1.288	0.156	1.003	1.616	1.443	0.169	1.139	1.802
2003	0.964	0.029	0.897	1.011	0.934	0.111	0.740	1.175	0.982	0.114	0.780	1.228
2004	1.013	0.025	0.959	1.058	0.912	0.104	0.719	1.128	0.912	0.104	0.725	1.131
2005	0.968	0.028	0.900	1.012	0.995	0.103	0.803	1.206	1.042	0.105	0.849	1.261
2006	0.981	0.025	0.925	1.024	0.773	0.088	0.609	0.955	0.799	0.086	0.634	0.972
2007	1.041	0.024	1.003	1.097	0.902	0.090	0.744	1.096	0.879	0.083	0.727	1.053
2008	1.046	0.026	1.003	1.106	1.006	0.115	0.794	1.246	0.974	0.107	0.778	1.199
2009	1.062	0.029	1.013	1.128	1.040	0.138	0.801	1.341	0.992	0.125	0.771	1.262
2010	1.030	0.028	0.975	1.085	0.877	0.099	0.693	1.079	0.863	0.095	0.688	1.059
2011	1.065	0.031	1.008	1.129	1.009	0.149	0.744	1.328	0.961	0.144	0.704	1.267
2012	1.031	0.026	0.980	1.082	1.245	0.167	0.955	1.608	1.224	0.164	0.929	1.570
2013	1.071	0.029	1.021	1.135	1.229	0.166	0.936	1.587	1.164	0.151	0.891	1.481
2014	1.041	0.028	0.989	1.098	1.047	0.131	0.813	1.326	1.020	0.126	0.795	1.290
2015	1.061	0.027	1.016	1.122	0.933	0.123	0.712	1.193	0.892	0.118	0.692	1.153
2016	1.047	0.029	0.994	1.106	1.122	0.145	0.864	1.433	1.086	0.135	0.848	1.379
2017	1.041	0.029	0.986	1.098	0.885	0.113	0.686	1.128	0.862	0.105	0.672	1.084
2018	1.040	0.028	0.986	1.094	1.519	0.187	1.184	1.918	1.481	0.178	1.166	1.866
2019	1.066	0.028	1.018	1.128	0.788	0.091	0.626	0.982	0.750	0.083	0.595	0.922
2020	1.061	0.034	0.997	1.129	0.787	0.119	0.579	1.044	0.752	0.109	0.560	0.987
2021	1.041	0.027	0.991	1.097	0.532	0.063	0.420	0.669	0.518	0.059	0.415	0.648
2022	-	-	-	-	-	-	-	-	0.659	0.184	0.378	1.101
2023	0.979	0.046	0.861	1.043	0.683	0.094	0.510	0.877	0.707	0.092	0.536	0.896

D.6 BYX event (East Coast - North)

Table D.31: Definition for the dataset, core fleet criteria, and Generalised Linear Modelling approach used in the catch-per-unit-effort (CPUE) standardisation for the BYX event (East Coast - North) CPUE series.

Series	BYX event (East Coast - North)
QMS stock	BYX 2, BYX 3
Reporting forms	TCP, TCE, ERS - Trawl
Fishing methods	BT, PRB, MW, PRM
Target species	BYX
Statistical Areas	011, 012, 013, 014, 015, 016, 017, 018, 019, 020, 021, 202, 203, 204, 205, 401, 402, 403, 404, 405, 410, 049, 050, 051, 052, 406, 412
Period	1989-10-01, 2023-09-30
Resolution	Fishing event
Core fleet years	5
Core fleet trips	3
Default model	allockg_top5 ~ fyear + cluster + vessel_key + primary_method + month + ns(log(fishing_duration), 3) + ns(log(effort_height), 3) + ns(log(effort_depth), 3)
Stepwise selection	Yes
Positive catch distribution	Weibull

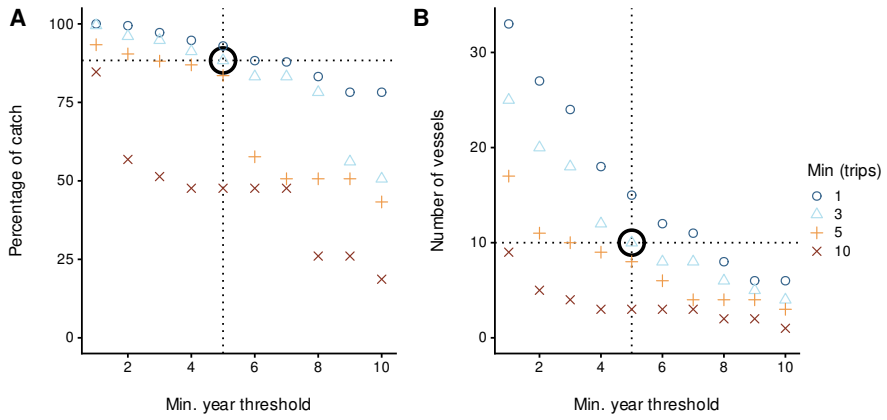

Figure D.96: Percentage of catch and number of vessels for different core vessel selection criteria for the BYX event (East Coast - North) CPUE series. The bold open circle represents the core vessel selection criteria applied in the modelling dataset, specified by the number of years a vessel participated in the fishery and the number of trips per year.

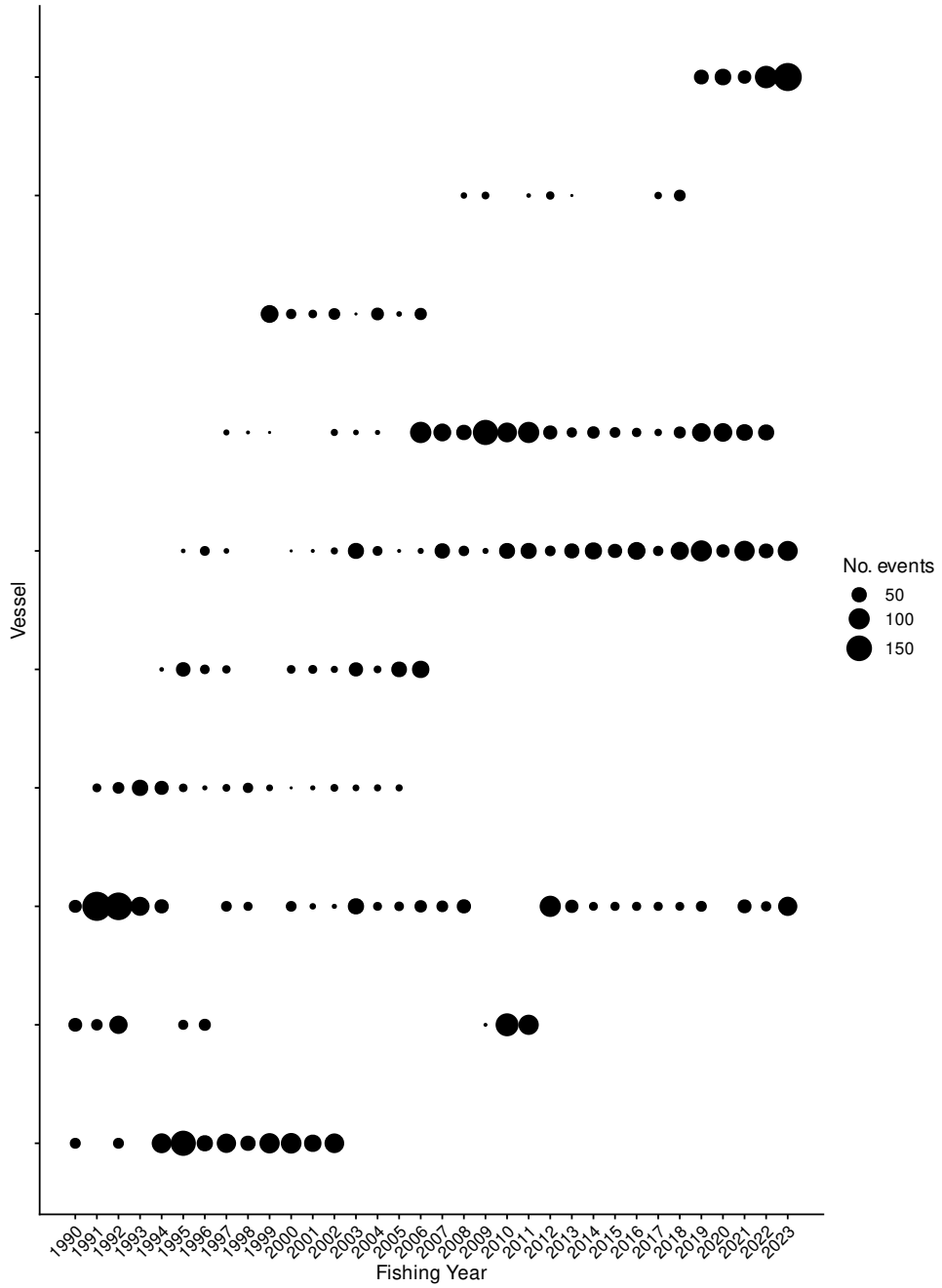

Figure D.97: Number of events by fishing year for core vessels in the BYX event (East Coast - North) series. The area of the circles is proportional to the number of events undertaken by a vessel in a fishing year.

Table D.32: Summary of the BYX event (East Coast - North) 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 2 pages)

Filter	1990	1991	1992	1993	1994	1995	1996	1997	1998
Ungroomed data	669 (100%) n: 335	749 (100%) n: 294	1260 (100%) n: 458	1444 (100%) n: 530	1332 (100%) n: 708	1307 (100%) n: 794	1503 (100%) n: 769	1500 (100%) n: 736	1540 (100%) n: 730
Fishing duration is not NA	669 (100%) n: 335	749 (100%) n: 294	1260 (100%) n: 458	1444 (100%) n: 530	1332 (100%) n: 708	1307 (100%) n: 794	1503 (100%) n: 769	1500 (100%) n: 736	1540 (100%) n: 730
Positive fishing duration	669 (100%) n: 335	749 (100%) n: 294	1260 (100%) n: 458	1444 (100%) n: 530	1332 (100%) n: 708	1307 (100%) n: 793	1502 (100%) n: 762	1500 (100%) n: 729	1540 (100%) n: 728
Duration under 12h	669 (100%) n: 335	739 (99%) n: 292	1260 (100%) n: 458	1416 (98%) n: 528	1332 (100%) n: 707	1304 (100%) n: 785	1498 (100%) n: 756	1472 (98%) n: 720	1534 (100%) n: 720
Headline under 60m	669 (100%) n: 335	739 (99%) n: 292	1260 (100%) n: 458	1416 (98%) n: 528	1332 (100%) n: 707	1294 (99%) n: 769	1467 (98%) n: 751	1450 (97%) n: 711	1457 (95%) n: 694
In a cluster	654 (98%) n: 330	739 (99%) n: 288	1241 (98%) n: 446	1380 (96%) n: 510	1271 (95%) n: 681	1256 (96%) n: 718	1436 (96%) n: 725	1419 (95%) n: 695	1396 (91%) n: 679
150+ events per cluster	592 (89%) n: 316	708 (94%) n: 281	1197 (95%) n: 437	1364 (95%) n: 499	1269 (95%) n: 664	1124 (86%) n: 651	1389 (92%) n: 704	1395 (93%) n: 683	1388 (90%) n: 665
In area	436 (65%) n: 162	634 (85%) n: 238	891 (71%) n: 332	648 (45%) n: 195	533 (40%) n: 240	550 (42%) n: 271	353 (23%) n: 190	278 (19%) n: 155	241 (16%) n: 129
Core fleet selection	227 (34%) n: 99	634 (85%) n: 238	848 (67%) n: 302	544 (38%) n: 138	451 (34%) n: 176	469 (36%) n: 227	295 (20%) n: 128	274 (18%) n: 141	205 (13%) n: 89

Filter	1999	2000	2001	2002	2003	2004	2005	2006	2007
Ungroomed data	1541 (100%) n: 1040	1269 (100%) n: 968	1352 (100%) n: 849	1329 (100%) n: 639	1602 (100%) n: 881	1430 (100%) n: 644	1942 (100%) n: 849	2045 (100%) n: 1139	2035 (100%) n: 1008
Fishing duration is not NA	1541 (100%) n: 1040	1269 (100%) n: 968	1352 (100%) n: 849	1329 (100%) n: 639	1602 (100%) n: 881	1430 (100%) n: 644	1942 (100%) n: 849	2045 (100%) n: 1139	2035 (100%) n: 1008
Positive fishing duration	1538 (100%) n: 1038	1269 (100%) n: 966	1341 (99%) n: 846	1326 (100%) n: 634	1602 (100%) n: 875	1430 (100%) n: 644	1942 (100%) n: 848	2045 (100%) n: 1139	2031 (100%) n: 1000
Duration under 12h	1535 (100%) n: 1030	1266 (100%) n: 959	1341 (99%) n: 846	1322 (99%) n: 631	1602 (100%) n: 875	1430 (100%) n: 644	1942 (100%) n: 848	2044 (100%) n: 1138	2031 (100%) n: 999
Headline under 60m	1492 (97%) n: 1011	1265 (100%) n: 953	1338 (99%) n: 845	1322 (99%) n: 631	1602 (100%) n: 875	1420 (99%) n: 637	1942 (100%) n: 848	2044 (100%) n: 1138	2031 (100%) n: 999
In a cluster	1437 (93%) n: 969	1232 (97%) n: 929	1310 (97%) n: 830	1313 (99%) n: 624	1588 (99%) n: 867	1415 (99%) n: 631	1939 (100%) n: 844	2035 (99%) n: 1127	2025 (100%) n: 991
150+ events per cluster	1182 (77%) n: 799	1179 (93%) n: 902	1256 (93%) n: 802	1269 (95%) n: 614	1498 (94%) n: 833	1394 (97%) n: 616	1872 (96%) n: 814	1976 (97%) n: 1067	2013 (99%) n: 969
In area	279 (18%) n: 172	244 (19%) n: 168	189 (14%) n: 108	369 (28%) n: 157	520 (32%) n: 212	254 (18%) n: 104	357 (18%) n: 136	535 (26%) n: 259	500 (25%) n: 199
Core fleet selection	277 (18%) n: 171	235 (19%) n: 155	189 (14%) n: 108	368 (28%) n: 156	460 (29%) n: 170	220 (15%) n: 92	242 (12%) n: 87	520 (25%) n: 237	375 (18%) n: 149

Filter	2008	2009	2010	2011	2012	2013	2014	2015	2016
Ungroomed data	1926 (100%) n: 796	1867 (100%) n: 838	2252 (100%) n: 1072	2185 (100%) n: 883	2253 (100%) n: 873	2187 (100%) n: 480	2008 (100%) n: 653	1976 (100%) n: 617	2136 (100%) n: 590
Fishing duration is not NA	1926 (100%) n: 796	1867 (100%) n: 838	2252 (100%) n: 1072	2185 (100%) n: 883	2253 (100%) n: 873	2187 (100%) n: 480	2008 (100%) n: 653	1976 (100%) n: 617	2136 (100%) n: 590
Positive fishing duration	1905 (99%) n: 792	1855 (99%) n: 829	2252 (100%) n: 1070	2182 (100%) n: 880	2250 (100%) n: 870	2187 (100%) n: 479	2008 (100%) n: 652	1976 (100%) n: 617	2136 (100%) n: 590
Duration under 12h	1903 (99%) n: 791	1855 (99%) n: 829	2252 (100%) n: 1070	2182 (100%) n: 879	2250 (100%) n: 870	2187 (100%) n: 479	2008 (100%) n: 652	1961 (99%) n: 616	2136 (100%) n: 590
Headline under 60m	1903 (99%) n: 791	1854 (99%) n: 828	2245 (100%) n: 1067	2182 (100%) n: 878	2250 (100%) n: 870	2187 (100%) n: 479	2008 (100%) n: 652	1961 (99%) n: 616	2126 (100%) n: 588
In a cluster	1877 (97%) n: 779	1853 (99%) n: 827	2240 (99%) n: 1059	2133 (98%) n: 869	2247 (100%) n: 862	2184 (100%) n: 476	1980 (99%) n: 643	1953 (99%) n: 613	2126 (100%) n: 587
150+ events per cluster	1853 (96%) n: 763	1845 (99%) n: 822	2170 (96%) n: 1017	2127 (97%) n: 855	2246 (100%) n: 858	2181 (100%) n: 469	1975 (98%) n: 636	1910 (97%) n: 602	2126 (100%) n: 586
In area	363 (19%) n: 151	410 (22%) n: 182	522 (23%) n: 274	709 (32%) n: 275	612 (27%) n: 180	623 (28%) n: 110	540 (27%) n: 115	532 (27%) n: 105	606 (28%) n: 114
Core fleet selection	324 (17%) n: 123	399 (21%) n: 164	488 (22%) n: 261	684 (31%) n: 251	605 (27%) n: 179	619 (28%) n: 108	538 (27%) n: 111	496 (25%) n: 82	566 (26%) n: 103

Filter	2017	2018	2019	2020	2021	2022	2023
Ungroomed data	1894 (100%) n: 645	2005 (100%) n: 595	2141 (100%) n: 757	2075 (100%) n: 704	1853 (100%) n: 611	1882 (100%) n: 512	1569 (100%) n: 624
Fishing duration is not NA	1894 (100%) n: 645	2005 (100%) n: 595	2141 (100%) n: 757	2075 (100%) n: 704	1853 (100%) n: 610	1882 (100%) n: 512	1569 (100%) n: 624
Positive fishing duration	1894 (100%) n: 645	2005 (100%) n: 595	2141 (100%) n: 754	2075 (100%) n: 702	1853 (100%) n: 608	1882 (100%) n: 512	1569 (100%) n: 623
Duration under 12h	1894 (100%) n: 644	2005 (100%) n: 595	2137 (100%) n: 752	2074 (100%) n: 701	1853 (100%) n: 608	1882 (100%) n: 512	1569 (100%) n: 623
Headline under 60m	1894 (100%) n: 644	2005 (100%) n: 595	2125 (99%) n: 749	2048 (99%) n: 698	1853 (100%) n: 608	1882 (100%) n: 512	1569 (100%) n: 623
In a cluster	1874 (99%) n: 634	1991 (99%) n: 587	2122 (99%) n: 746	2048 (99%) n: 695	1841 (99%) n: 604	1882 (100%) n: 512	1569 (100%) n: 621
150+ events per cluster	1836 (97%) n: 624	1953 (97%) n: 568	2093 (98%) n: 729	2013 (97%) n: 637	1835 (99%) n: 600	1882 (100%) n: 507	1569 (100%) n: 615
In area	466 (25%) n: 85	585 (29%) n: 157	748 (35%) n: 270	844 (41%) n: 245	840 (45%) n: 258	1210 (64%) n: 295	946 (60%) n: 374
Core fleet selection	421 (22%) n: 57	564 (28%) n: 146	718 (34%) n: 248	563 (27%) n: 174	771 (42%) n: 231	848 (45%) n: 238	784 (50%) n: 353

Table D.33: Summary of the BYX event (East Coast - North) 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 alfonsino.

Fishing year	Vessels	Trips	Records	Hours	Catch (t)	Records caught
1990	3	10	99	73.75	226.93	83.84
1991	3	17	238	112.93	634.50	95.38
1992	4	30	302	257.30	848.00	80.46
1993	2	30	138	127.28	544.20	89.13
1994	4	27	176	120.27	450.90	93.75
1995	5	46	227	116.32	468.62	88.11
1996	5	25	128	61.93	294.60	95.31
1997	6	28	141	96.28	273.63	79.43
1998	4	18	89	73.73	205.38	88.76
1999	4	35	171	100.90	276.98	85.38
2000	6	35	155	80.07	234.81	87.10
2001	6	25	108	48.42	188.99	87.96
2002	7	33	156	69.42	368.24	91.03
2003	6	25	170	79.83	460.24	95.88
2004	6	22	92	52.93	220.14	92.39
2005	5	21	87	46.73	242.08	97.70
2006	5	34	237	116.77	520.42	88.61
2007	3	30	149	103.85	375.32	91.28
2008	4	23	123	65.83	323.88	95.93
2009	4	21	164	97.82	398.61	92.68
2010	3	34	261	78.00	487.72	84.67
2011	4	33	251	84.85	684.17	92.83
2012	4	22	179	135.63	605.11	93.85
2013	4	22	108	35.10	618.70	97.22
2014	3	29	111	63.22	538.48	96.40
2015	3	20	82	41.60	496.49	95.12
2016	3	16	103	43.93	565.59	99.03
2017	4	17	57	13.37	421.45	98.25
2018	4	16	146	68.32	564.21	100.00
2019	4	24	248	114.25	718.04	99.60
2020	3	26	174	118.57	563.33	97.13
2021	4	25	231	172.92	771.08	98.70
2022	4	27	238	171.18	848.02	99.58
2023	3	32	353	354.65	784.34	99.15

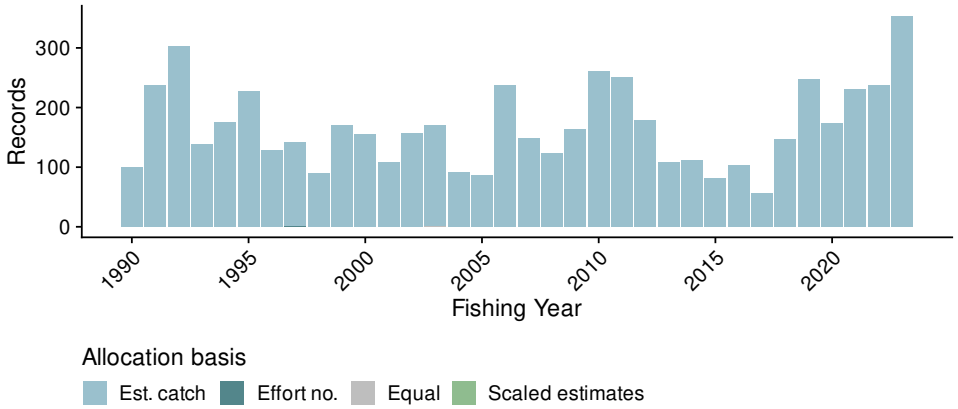

Figure D.98: Allocation basis for attributing landings to records in the BYX event (East Coast - North) catch-per-unit-effort dataset. Allocation basis is in terms of estimated catch, effort number, and/or equal.

Table D.34: Summary of stepwise selection for occurrence of positive catch in the BYX event (East Coast - North) series. 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	32	2 775	10.3	10.3	*
+ vessel_key	9	2 625	15.9	5.6	*
+ ns(log(fishing_duration), 3)	3	2 540	18.9	3.0	*
+ ns(log(effort_depth), 3)	3	2 496	20.6	1.7	*
+ cluster	4	2 443	22.6	2.0	*
+ ns(log(effort_height), 3)	3	2 421	23.5	0.9	

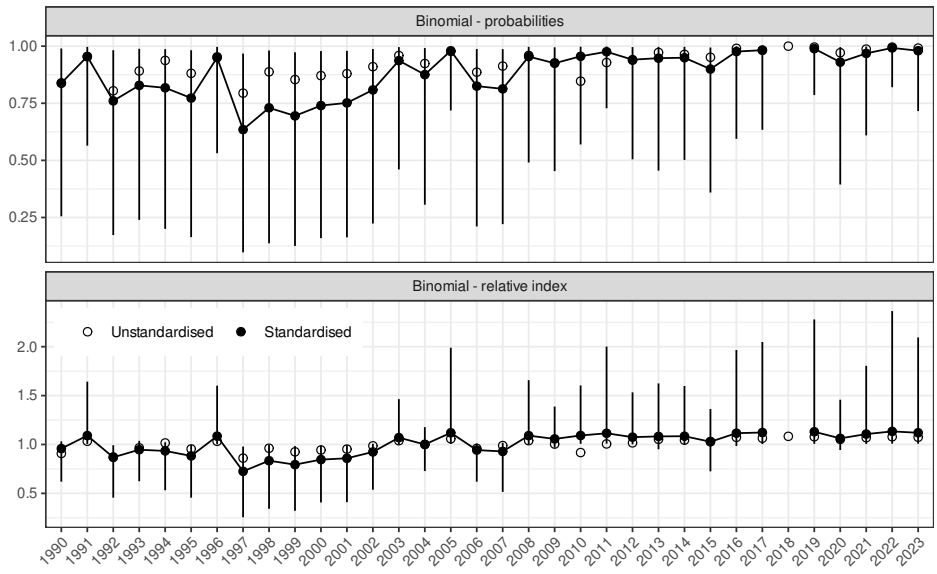

Figure D.99: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for occurrence of catch in the BYX event (East Coast - North) dataset, plotted as both probability of occurrence and as a relative index standardised to the geometric mean.

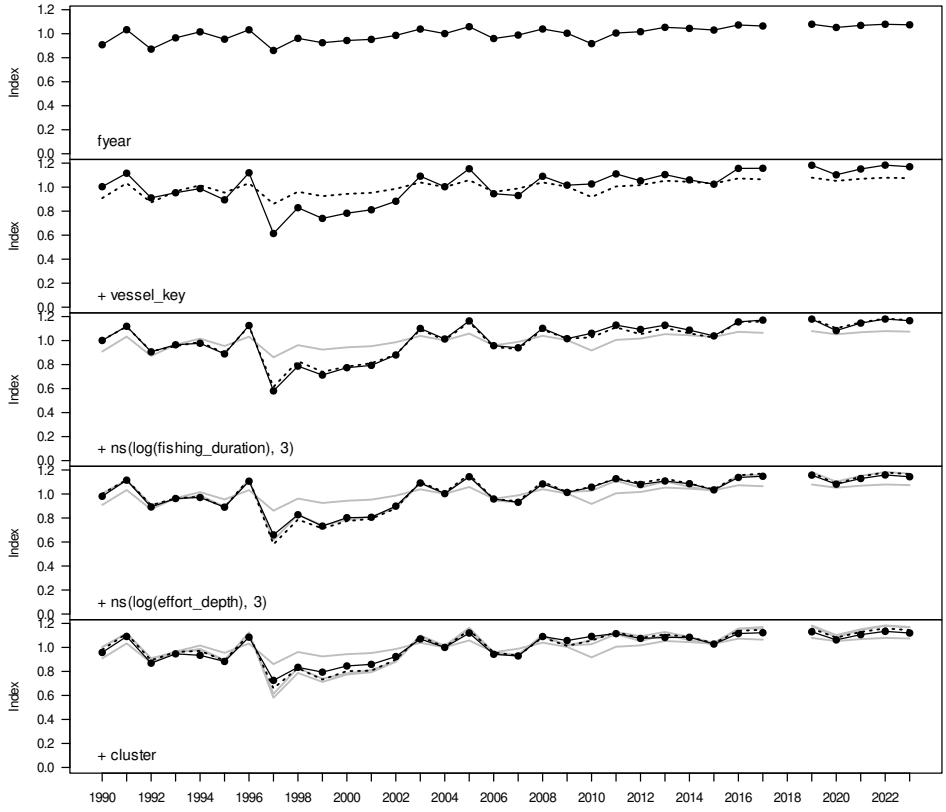

Figure D.100: Step plot for occurrence of catch in the BYX event (East Coast - North) dataset.

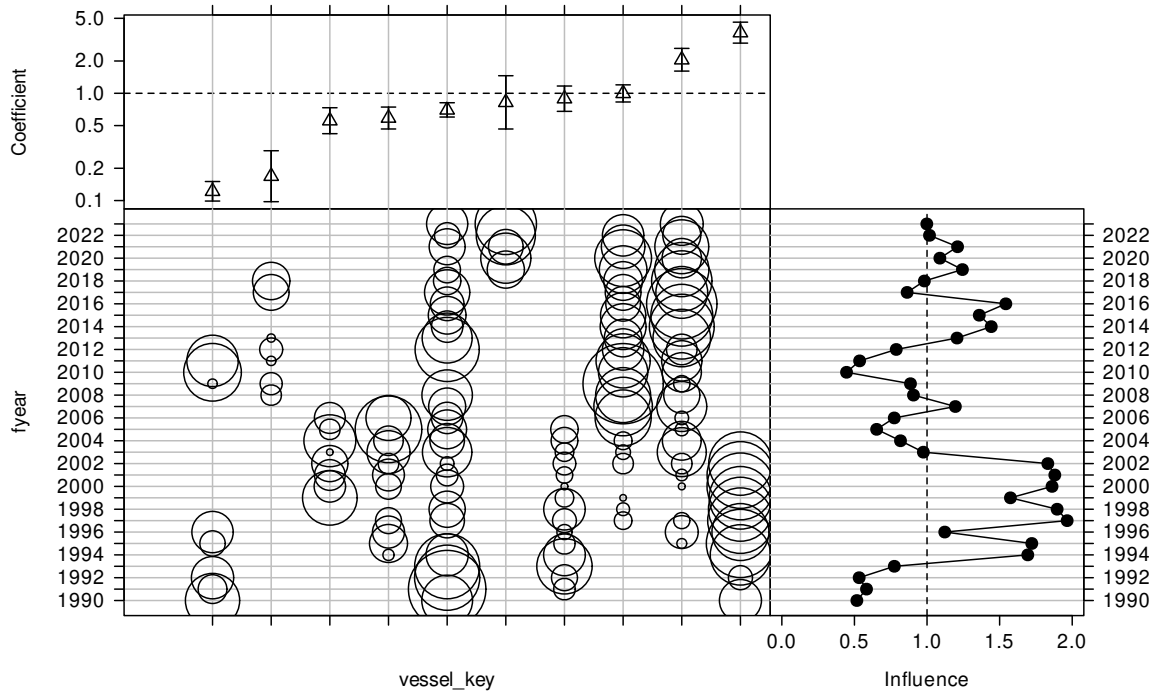

Figure D.101: CDI plot for vessel key for the occurrence of positive catch in the BYX event (East Coast - North) catch-per-unit-effort dataset.

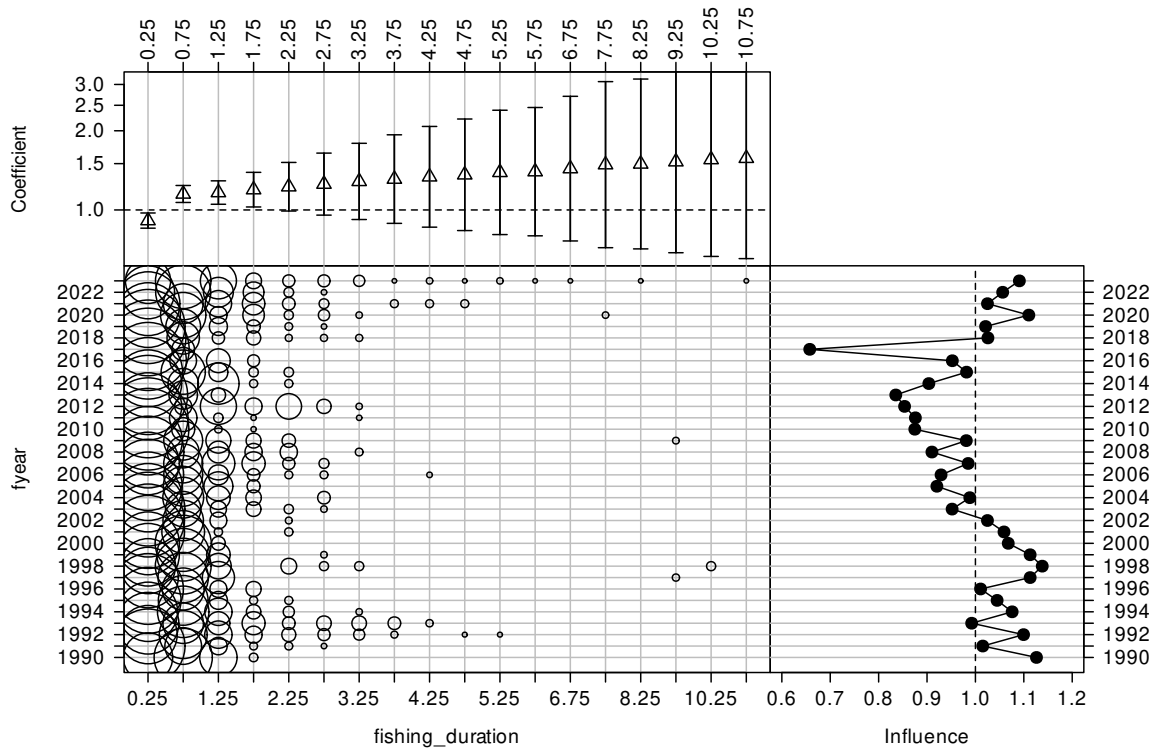

Figure D.102: CDI plot for fishing duration (h) for the occurrence of positive catch in the BYX event (East Coast - North) catch-per-unit-effort dataset.

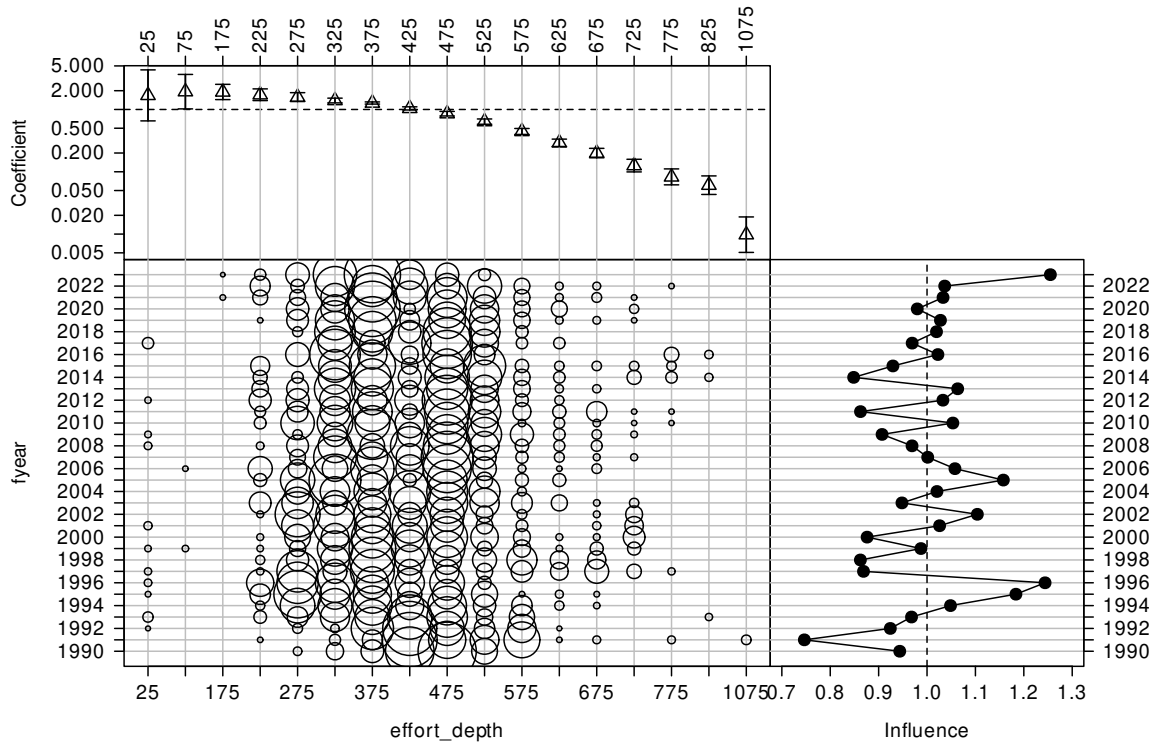

Figure D.103: CDI plot for effort depth (m) for the occurrence of positive catch in the BYX event (East Coast - North) catch-per-unit-effort dataset.

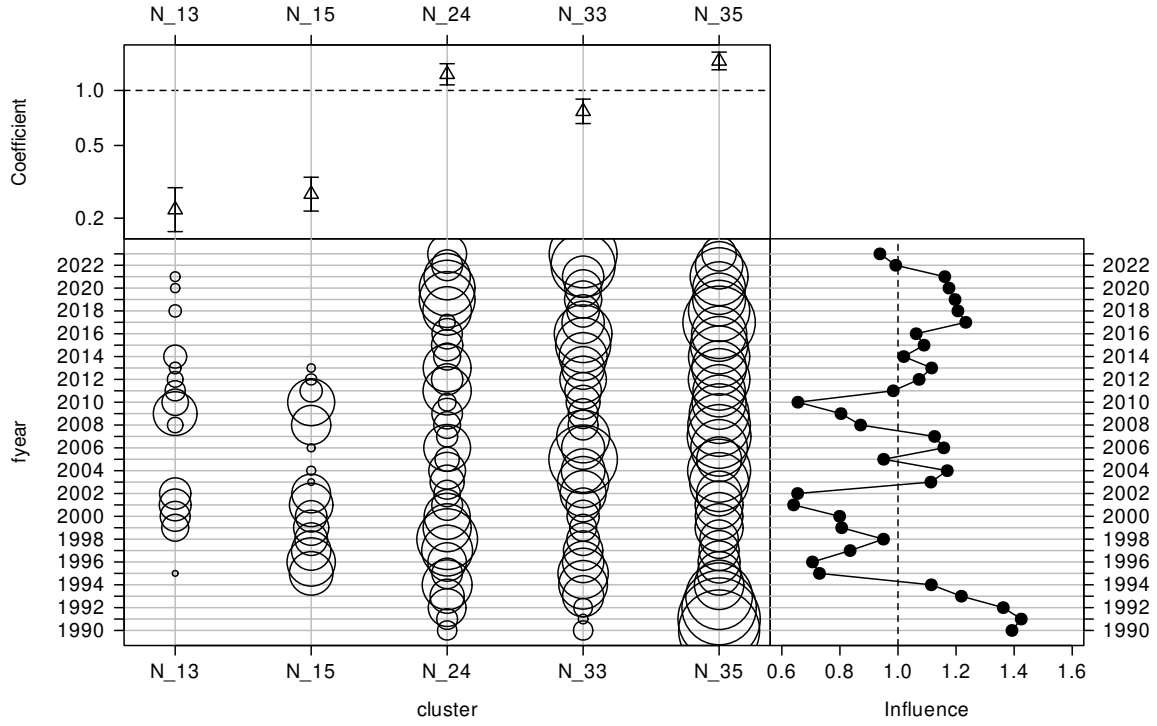

Figure D.104: CDI plot for cluster for the occurrence of positive catch in the BYX event (East Coast - North) catch-per-unit-effort dataset.

Table D.35: Summary of stepwise selection for the Weibull model for positive catches in the BYX event (East Coast - North) series. 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	35	94 673	6.5	6.5	*
+ vessel_key	9	94 322	12.5	6.0	*
+ cluster	4	94 081	16.5	4.1	*
+ primary_method	1	93 918	19.2	2.7	*
+ month	11	93 850	20.7	1.5	*
+ ns(log(effort_height), 3)	3	93 840	20.9	0.3	
+ ns(log(fishing_duration), 3)	3	93 833	21.1	0.2	
+ ns(log(effort_depth), 3)	3	93 833	21.2	0.1	

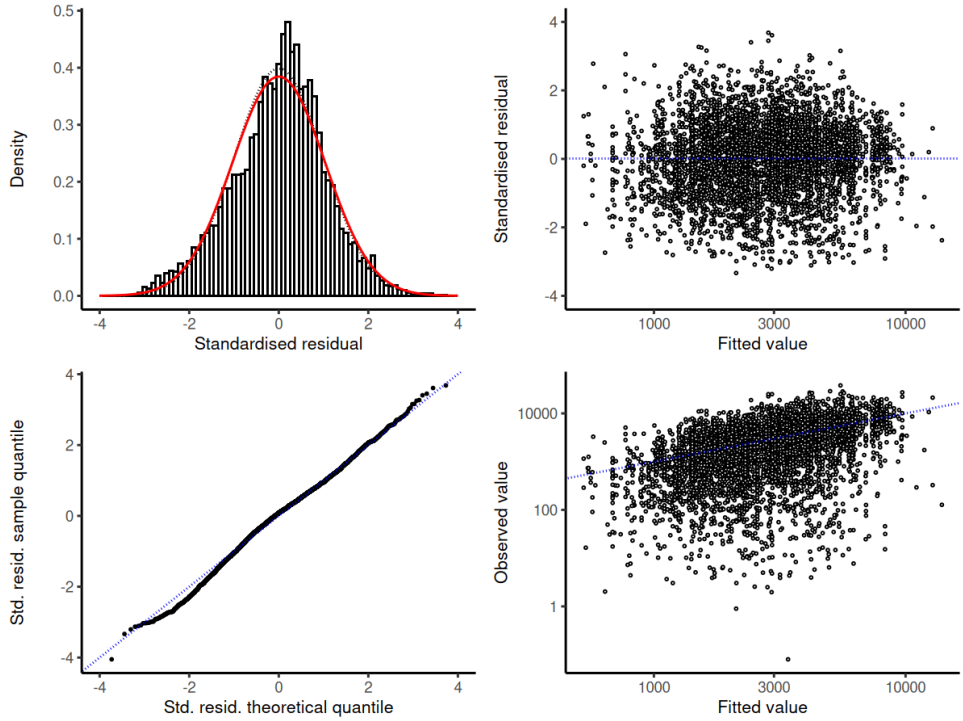

Figure D.105: Diagnostic plots for the selected Weibull model for positive catches in the BYX event (East Coast - North) dataset.

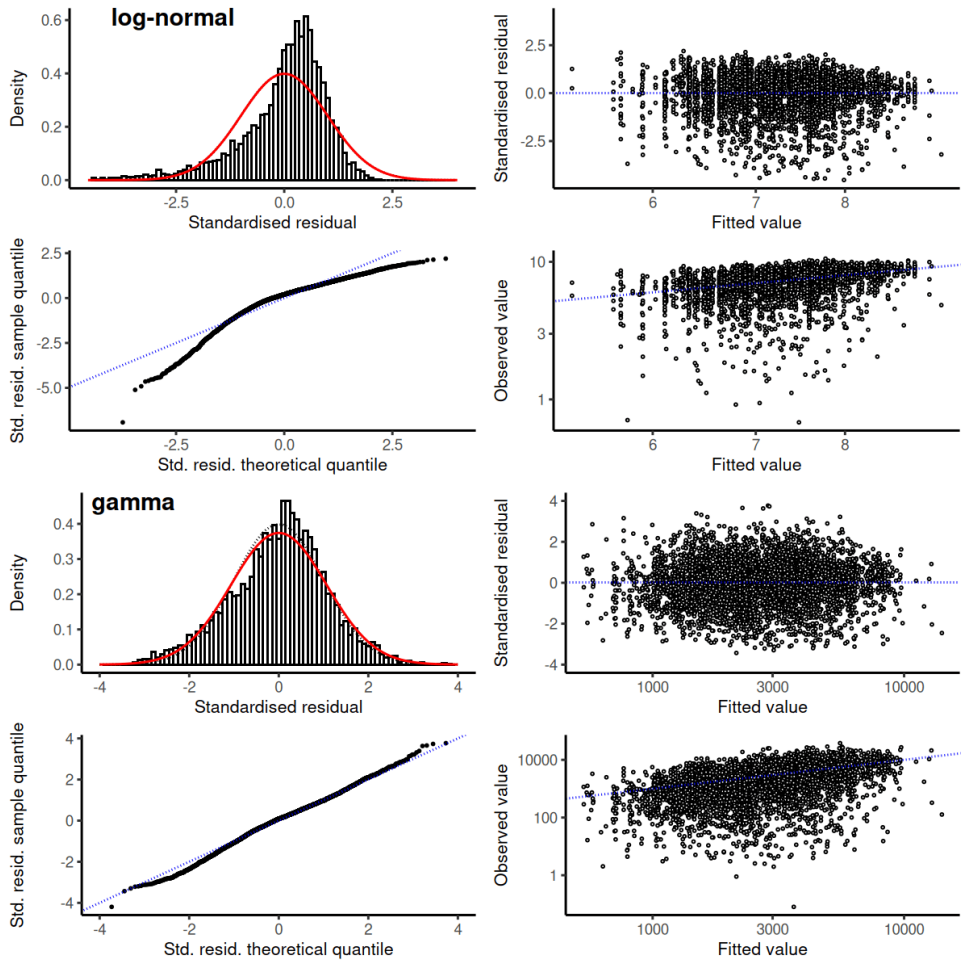

Figure D.106: Diagnostic plots for the alternative log-normal and gamma models considered for positive catches in the BYX event (East Coast - North) dataset.

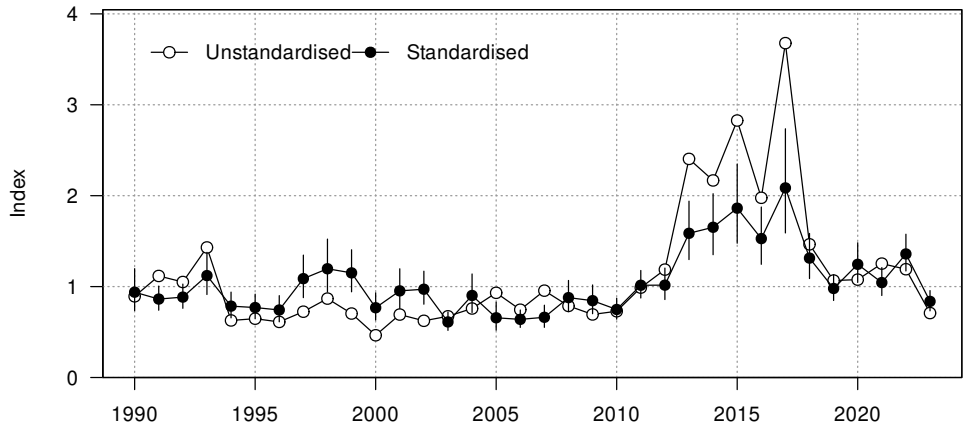

Figure D.107: Unstandardised (geometric mean; open circles) and standardised indices (black circles) for positive catch using the Weibull model for the BYX event (East Coast - North) dataset.

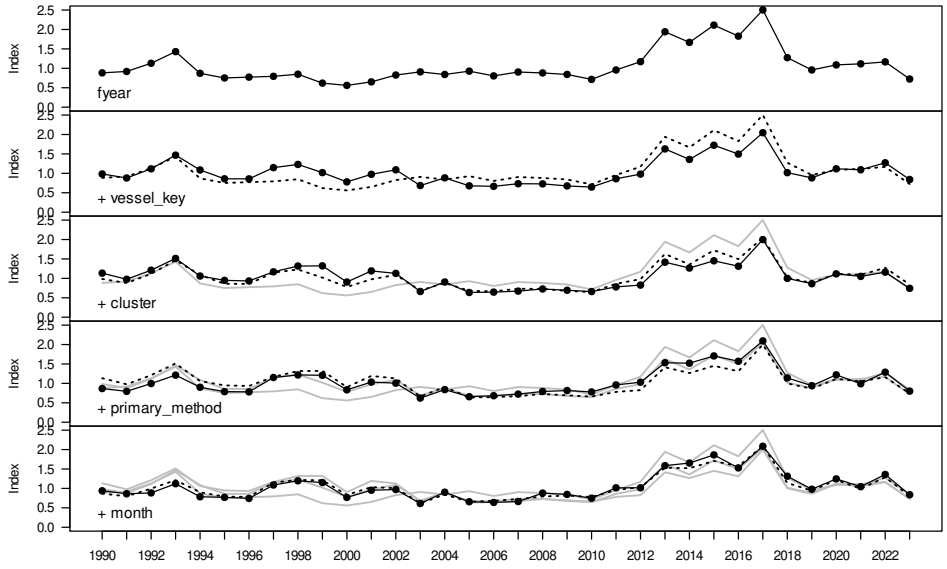

Figure D.108: Changes to the BYX event (East Coast - North) positive catch index as terms are successively entered into the Weibull model.

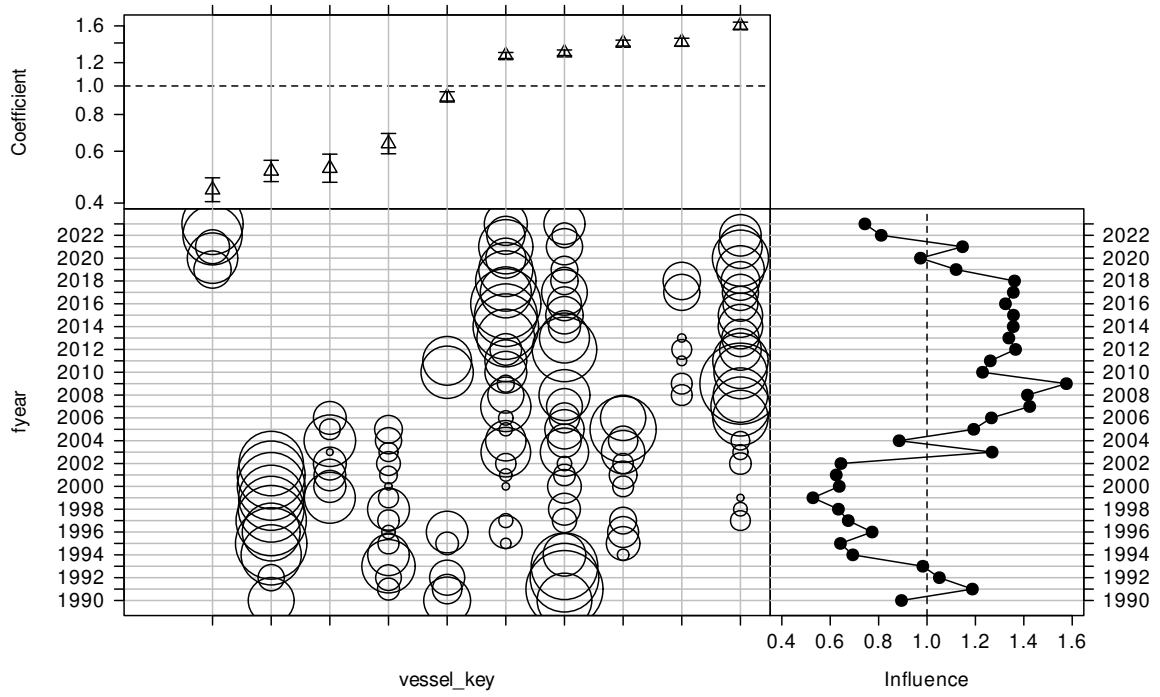

Figure D.109: CDI plot for vessel key for the Weibull model of positive catches in the BYX event (East Coast - North) catch-per-unit-effort dataset.

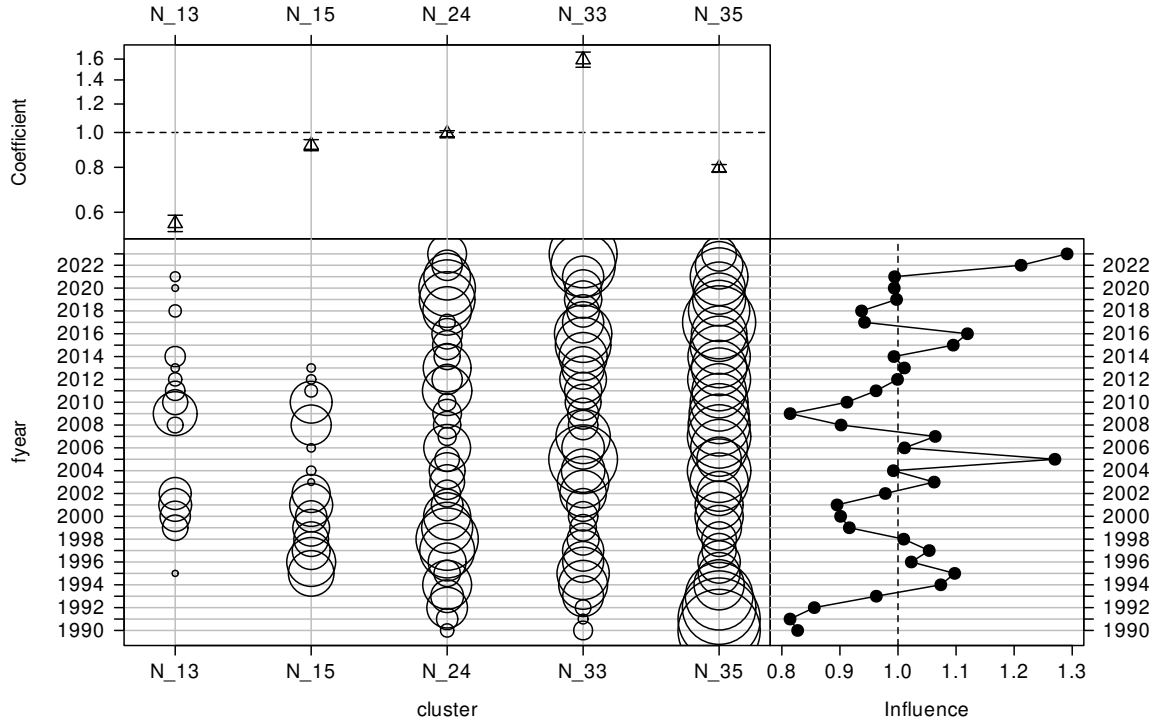

Figure D.110: CDI plot for cluster for the Weibull model of positive catches in the BYX event (East Coast - North) catch-per-unit-effort dataset.

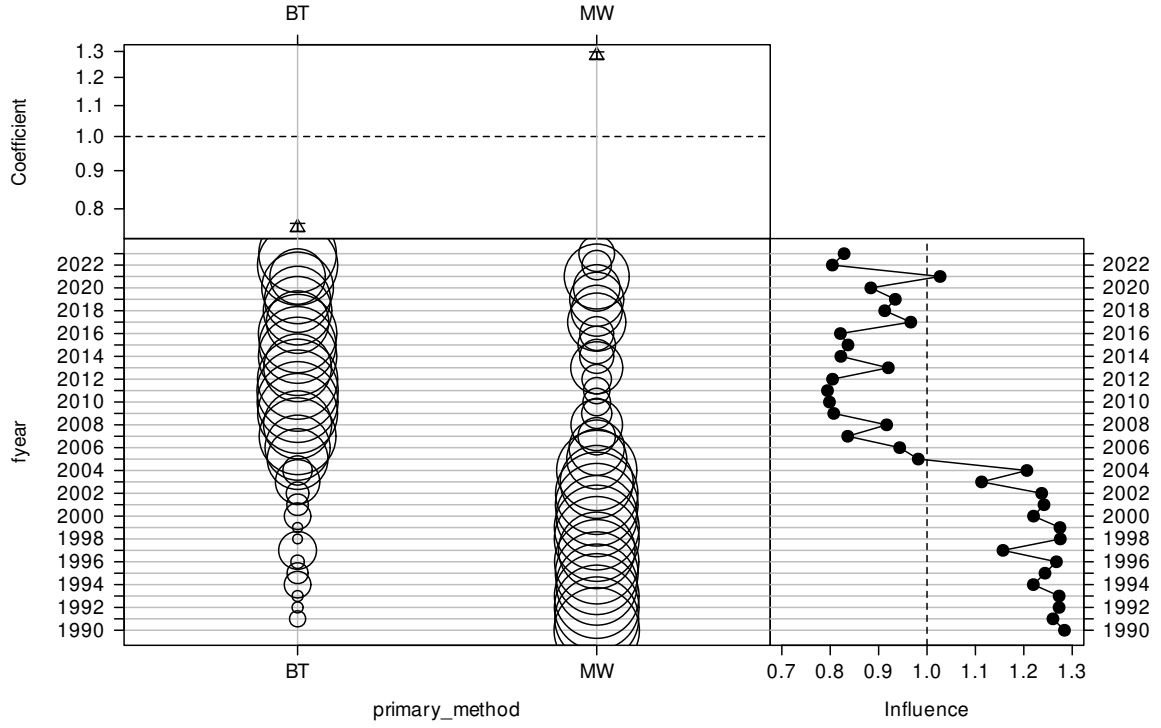

Figure D.111: CDI plot for primary method for the Weibull model of positive catches in the BYX event (East Coast - North) catch-per-unit-effort dataset.

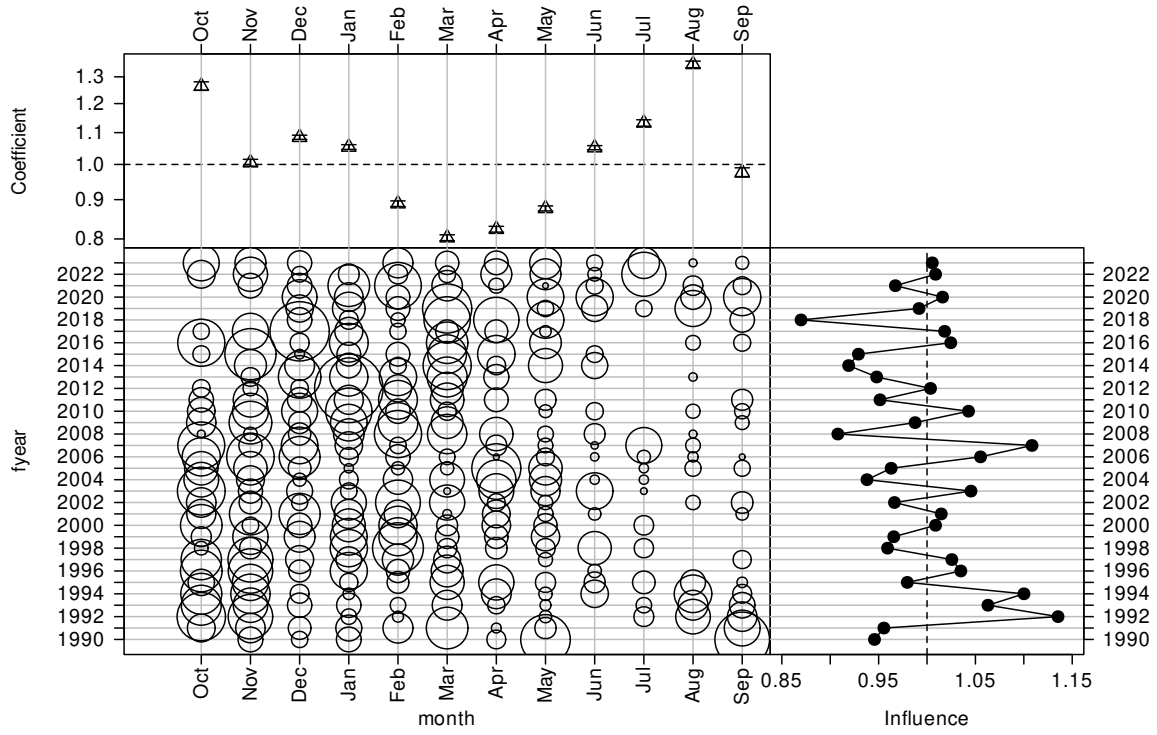

Figure D.112: CDI plot for month for the Weibull model of positive catches in the BYX event (East Coast - North) catch-per-unit-effort dataset.

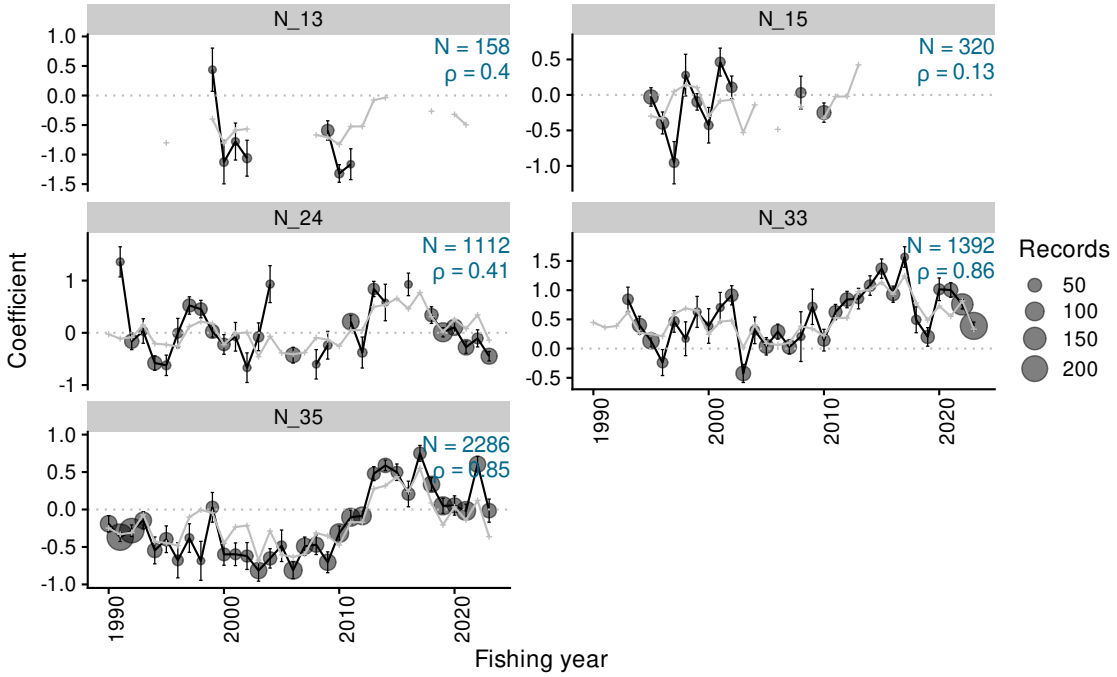

Figure D.113: Residual implied coefficients for area-year in the Weibull positive catch model for the BYX event (East Coast - North) dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 10 data points in an area-year stratum. The light grey line and points indicate the overall year indices; these are only plotted where there are data in a stratum.

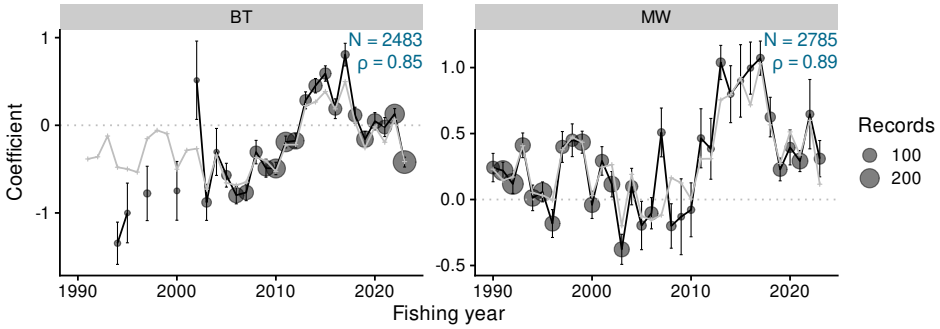

Figure D.114: Residual implied coefficients for primary method-year in the Weibull positive catch model for the BYX event (East Coast - North) dataset (black points, mean +/- one standard error). The dark grey circles indicate the number of data points. Implied coefficients are only plotted when there are at least 10 data points in a method-year stratum. The light grey line and points indicate the overall year indices; these are only plotted where there are data in a stratum.

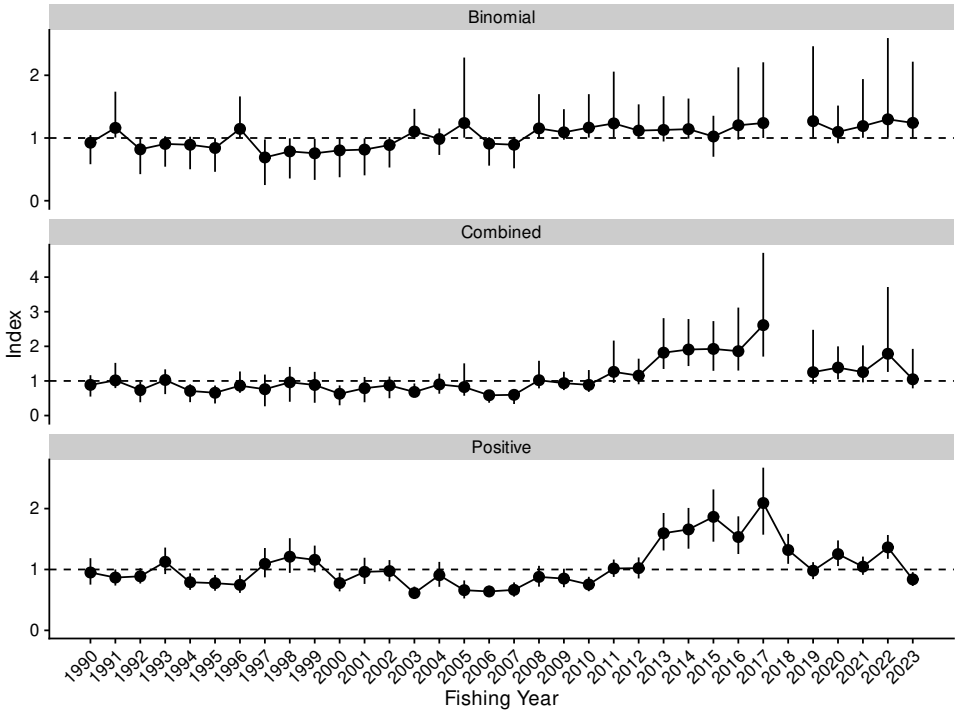

Figure D.115: Standardised indices and 95% confidence intervals for the BYX event (East Coast - North) dataset.

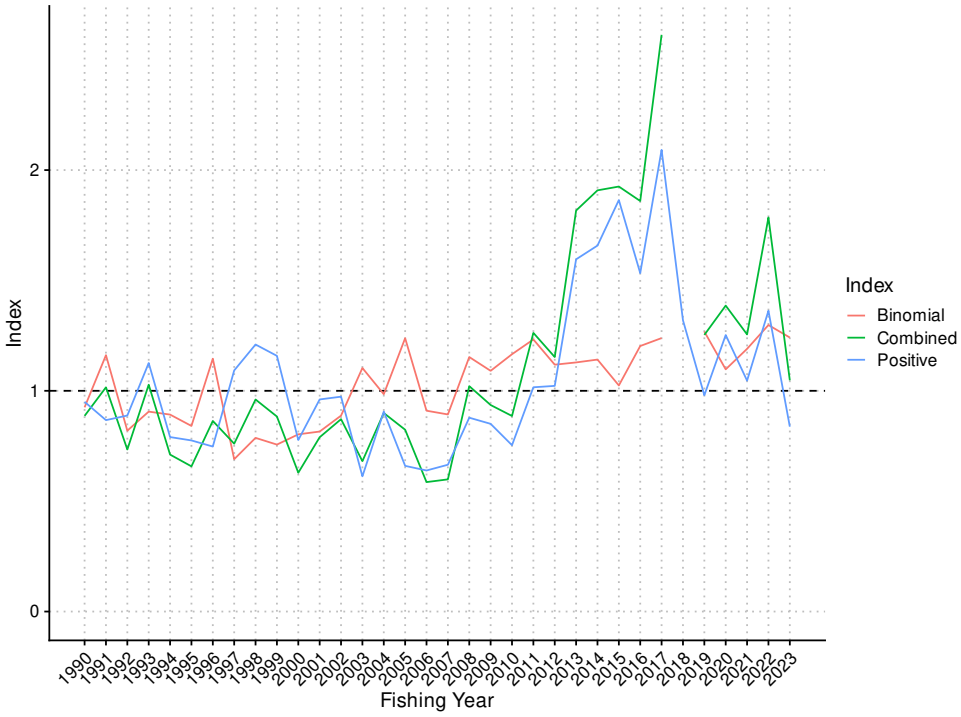

Figure D.116: Standardised indices for the BYX event (East Coast - North) dataset.

Table D.36: Annual indices and standard errors, with upper and lower bounds (LCI: 2.5%, UCI: 97.5%) for each model in BYX event (East Coast - North).

	Binomial				Combined				Positive			
Fishing year	index	SE	LCI	UCI	index	SE	LCI	UCI	index	SE	LCI	UCI
1990	0.925	0.119	0.582	1.047	0.886	0.158	0.548	1.166	0.950	0.111	0.751	1.185
1991	1.161	0.187	1.007	1.739	1.016	0.186	0.793	1.522	0.867	0.067	0.736	1.000
1992	0.819	0.145	0.424	0.992	0.734	0.150	0.384	0.973	0.888	0.064	0.769	1.021
1993	0.906	0.124	0.543	1.027	1.028	0.183	0.620	1.335	1.126	0.111	0.925	1.360
1994	0.892	0.132	0.502	1.020	0.711	0.132	0.387	0.903	0.790	0.069	0.665	0.937
1995	0.841	0.137	0.461	0.996	0.658	0.132	0.349	0.868	0.775	0.066	0.651	0.910
1996	1.146	0.168	1.002	1.663	0.863	0.157	0.659	1.273	0.748	0.074	0.616	0.907
1997	0.690	0.185	0.250	0.976	0.761	0.234	0.268	1.184	1.092	0.123	0.871	1.352
1998	0.787	0.163	0.355	0.995	0.961	0.257	0.398	1.405	1.210	0.145	0.944	1.514
1999	0.756	0.167	0.332	0.987	0.883	0.228	0.369	1.263	1.158	0.111	0.956	1.392
2000	0.803	0.157	0.374	0.991	0.629	0.146	0.297	0.871	0.777	0.078	0.640	0.945
2001	0.815	0.150	0.405	0.994	0.790	0.186	0.385	1.115	0.961	0.110	0.763	1.193
2002	0.888	0.124	0.530	1.015	0.872	0.160	0.500	1.126	0.973	0.089	0.806	1.154
2003	1.103	0.123	0.983	1.464	0.681	0.099	0.539	0.927	0.613	0.052	0.514	0.719
2004	0.985	0.108	0.730	1.152	0.899	0.148	0.631	1.210	0.906	0.104	0.715	1.125
2005	1.238	0.326	1.006	2.283	0.824	0.239	0.573	1.508	0.660	0.075	0.524	0.820
2006	0.910	0.116	0.559	1.012	0.586	0.088	0.370	0.714	0.639	0.048	0.547	0.734
2007	0.893	0.128	0.517	1.018	0.599	0.110	0.334	0.766	0.665	0.060	0.553	0.788
2008	1.153	0.177	1.004	1.699	1.021	0.203	0.785	1.582	0.878	0.087	0.718	1.060
2009	1.091	0.124	0.973	1.459	0.936	0.135	0.735	1.265	0.850	0.077	0.709	1.012
2010	1.166	0.177	1.007	1.699	0.886	0.161	0.684	1.315	0.754	0.060	0.643	0.879
2011	1.233	0.268	1.009	2.058	1.262	0.312	0.944	2.166	1.016	0.073	0.878	1.163
2012	1.118	0.136	1.002	1.536	1.153	0.189	0.903	1.643	1.022	0.088	0.852	1.198
2013	1.129	0.184	0.945	1.666	1.817	0.374	1.346	2.814	1.596	0.157	1.312	1.927
2014	1.142	0.163	0.990	1.629	1.908	0.346	1.430	2.788	1.658	0.171	1.341	2.011
2015	1.024	0.167	0.701	1.355	1.925	0.366	1.293	2.729	1.864	0.219	1.457	2.315
2016	1.203	0.294	0.975	2.127	1.860	0.464	1.300	3.120	1.533	0.158	1.254	1.873
2017	1.239	0.308	1.001	2.207	2.613	0.765	1.703	4.701	2.092	0.281	1.572	2.672
2018	-	-	-	-	-	-	-	-	1.320	0.125	1.093	1.585
2019	1.268	0.371	1.008	2.463	1.253	0.398	0.918	2.477	0.980	0.071	0.842	1.120
2020	1.097	0.153	0.916	1.517	1.386	0.243	1.047	1.999	1.253	0.107	1.056	1.477
2021	1.190	0.239	1.003	1.939	1.255	0.272	0.960	2.028	1.046	0.076	0.912	1.212
2022	1.298	0.404	1.010	2.594	1.785	0.626	1.260	3.714	1.363	0.100	1.175	1.566
2023	1.241	0.308	1.009	2.217	1.048	0.291	0.786	1.926	0.838	0.058	0.729	0.956

APPENDIX E: REPRESENTATIVENESS OF OBSERVER SAMPLING

E.0.1 The bottom trawl fishery

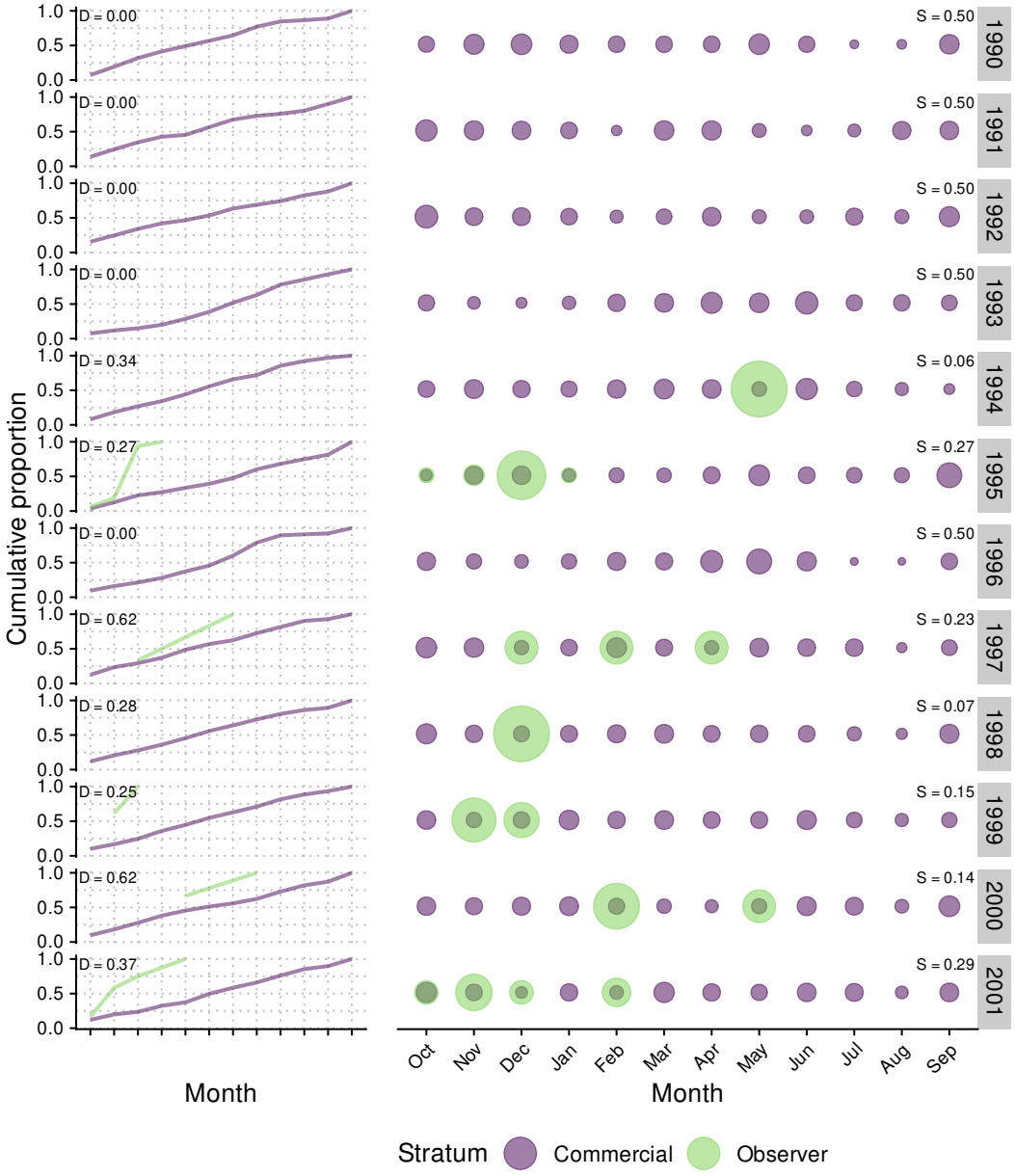

Figure E.1: Representativeness of observer sampling coverage of bottom trawl fishing events that caught alfonsino in 1990 to 2001 by fishing year and month. Observer data are for observed events with length sampling. Circle area is proportional to the proportion of events in a month, with proportions summing to one within each fishing year. D: Kolmogorov-Smirnov maximum absolute difference; S: Manhattan block distance.

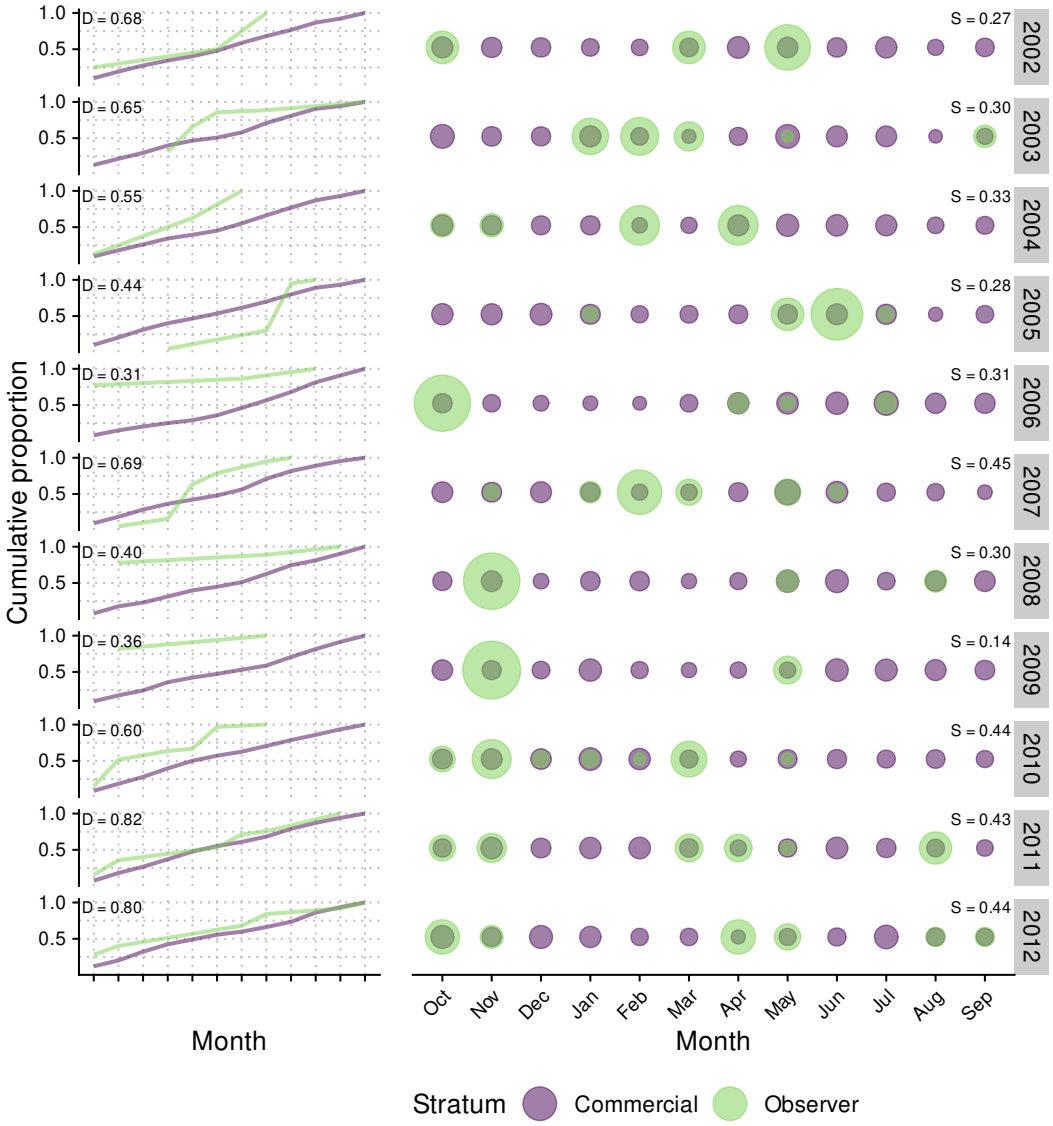

Figure E.2: Representativeness of observer sampling coverage of bottom trawl fishing events that caught alfonsino in 2002 to 2012 by fishing year and month. Observer data are for observed events with length sampling. Circle area is proportional to the proportion of events in a month, with proportions summing to one within each fishing year. D: Kolmogorov-Smirnov maximum absolute difference; S: Manhattan block distance.

E.0.2 The midwater trawl fishery

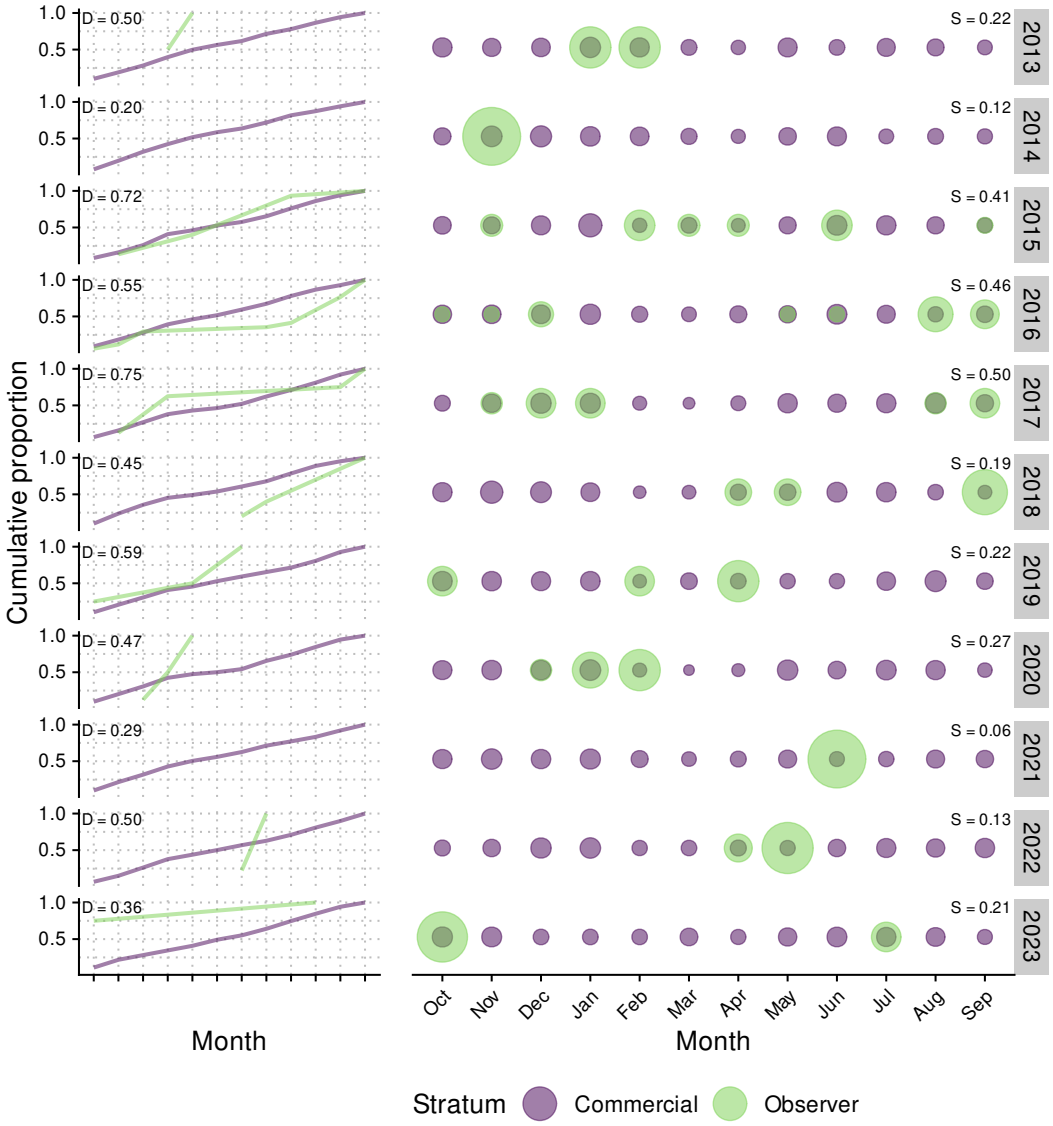

Figure E.3: Representativeness of observer sampling coverage of bottom trawl fishing events that caught alfonsino in 2013 to 2023 by fishing year and month. Observer data are for observed events with length sampling. Circle area is proportional to the proportion of events in a month, with proportions summing to one within each fishing year. D: Kolmogorov-Smirnov maximum absolute difference; S: Manhattan block distance.

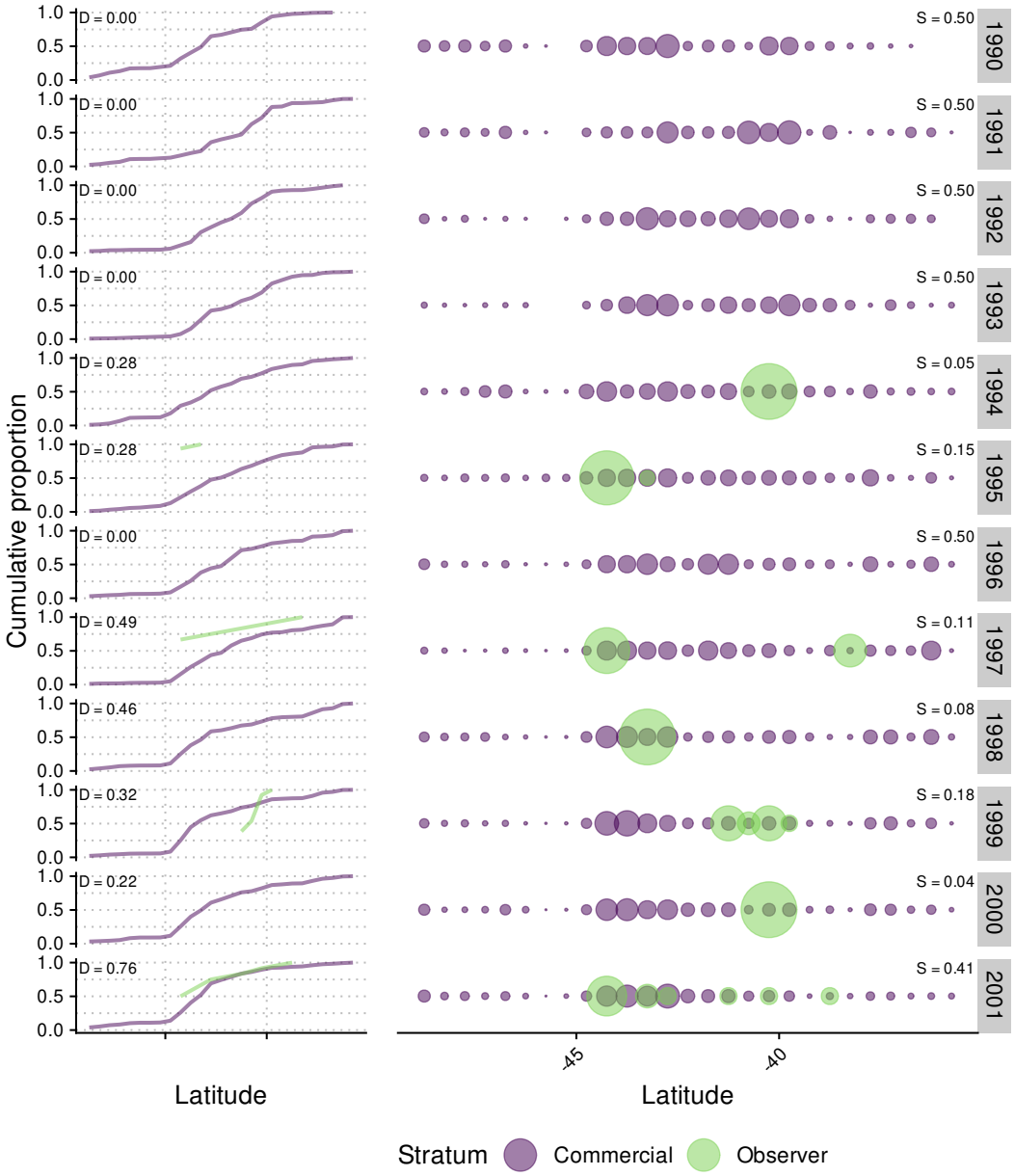

Figure E.4: Representativeness of observer sampling coverage of bottom trawl fishing events that caught alfonsino in 1990 to 2001 by fishing year and latitude. Observer data are for observed events with length sampling. Circle area is proportional to the proportion of events in a latitude bin, with proportions summing to one within each fishing year.

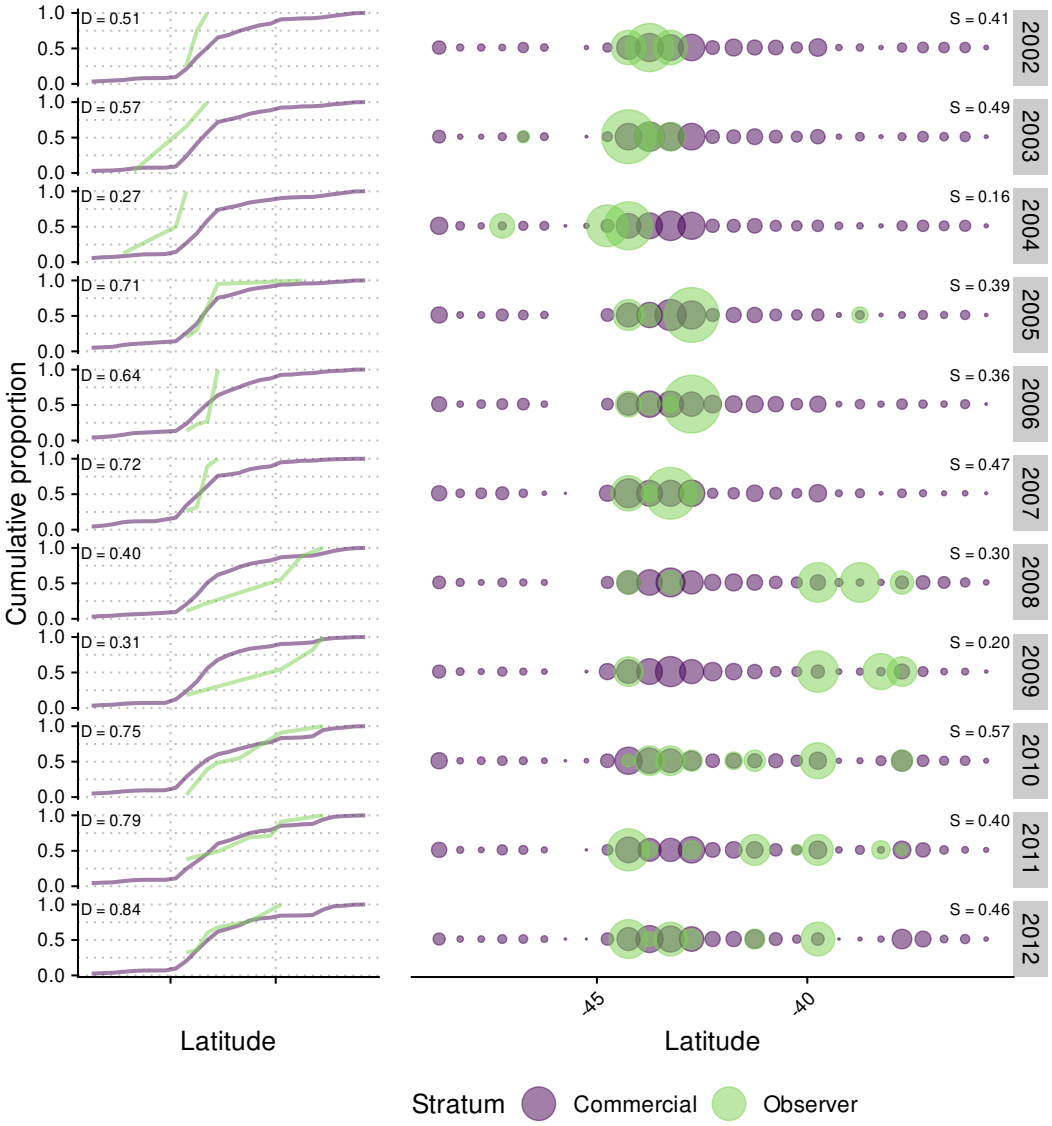

Figure E.5: Representativeness of observer sampling coverage of bottom trawl fishing events that caught alfonsino in 2002 to 2012 by fishing year and latitude. Observer data are for observed events with length sampling. Circle area is proportional to the proportion of events in a latitude bin, with proportions summing to one within each fishing year.

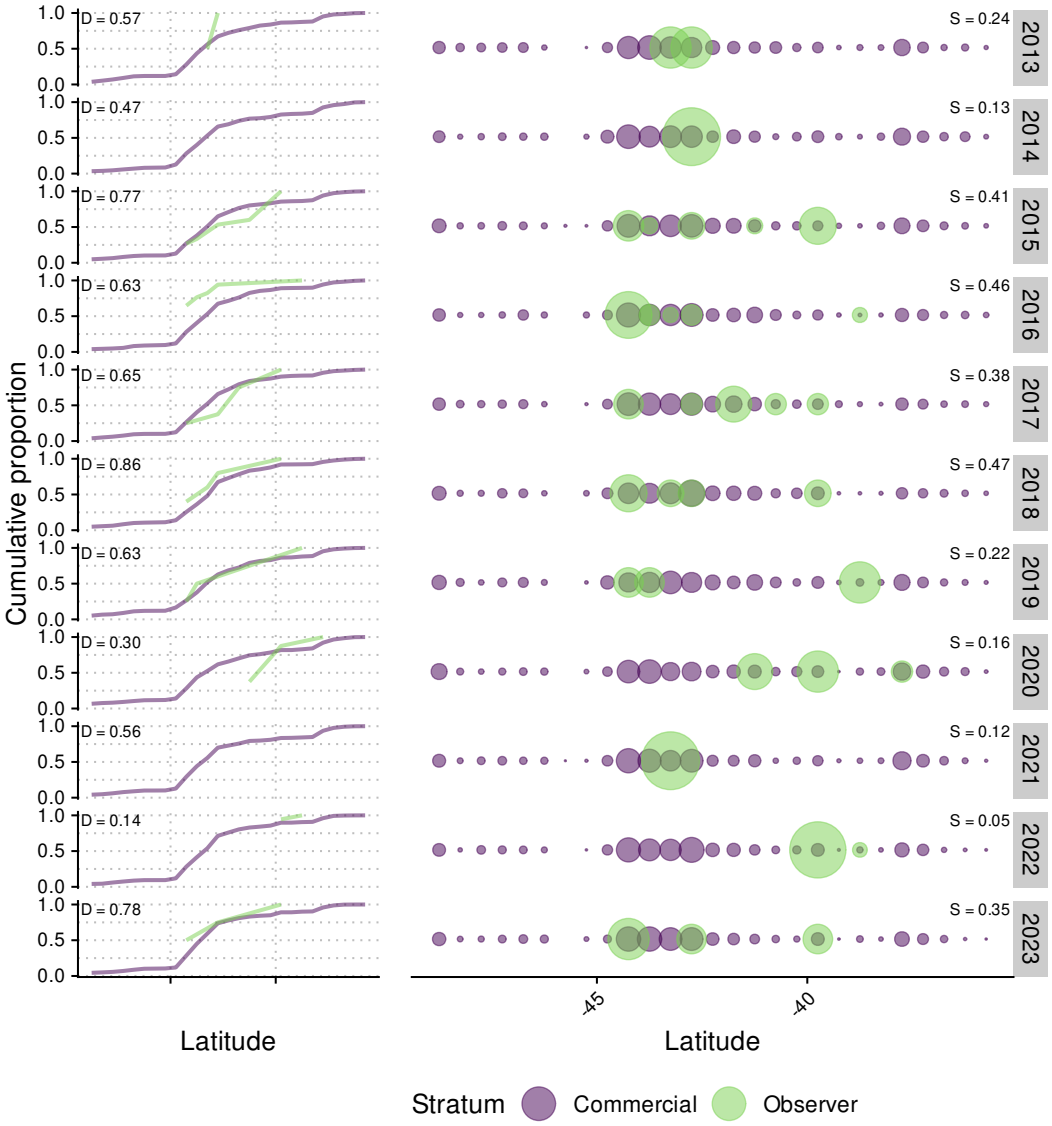

Figure E.6: Representativeness of observer sampling coverage of bottom trawl fishing events that caught alfonsino in 2013 to 2023 by fishing year and latitude. Observer data are for observed events with length sampling. Circle area is proportional to the proportion of events in a latitude bin, with proportions summing to one within each fishing year.

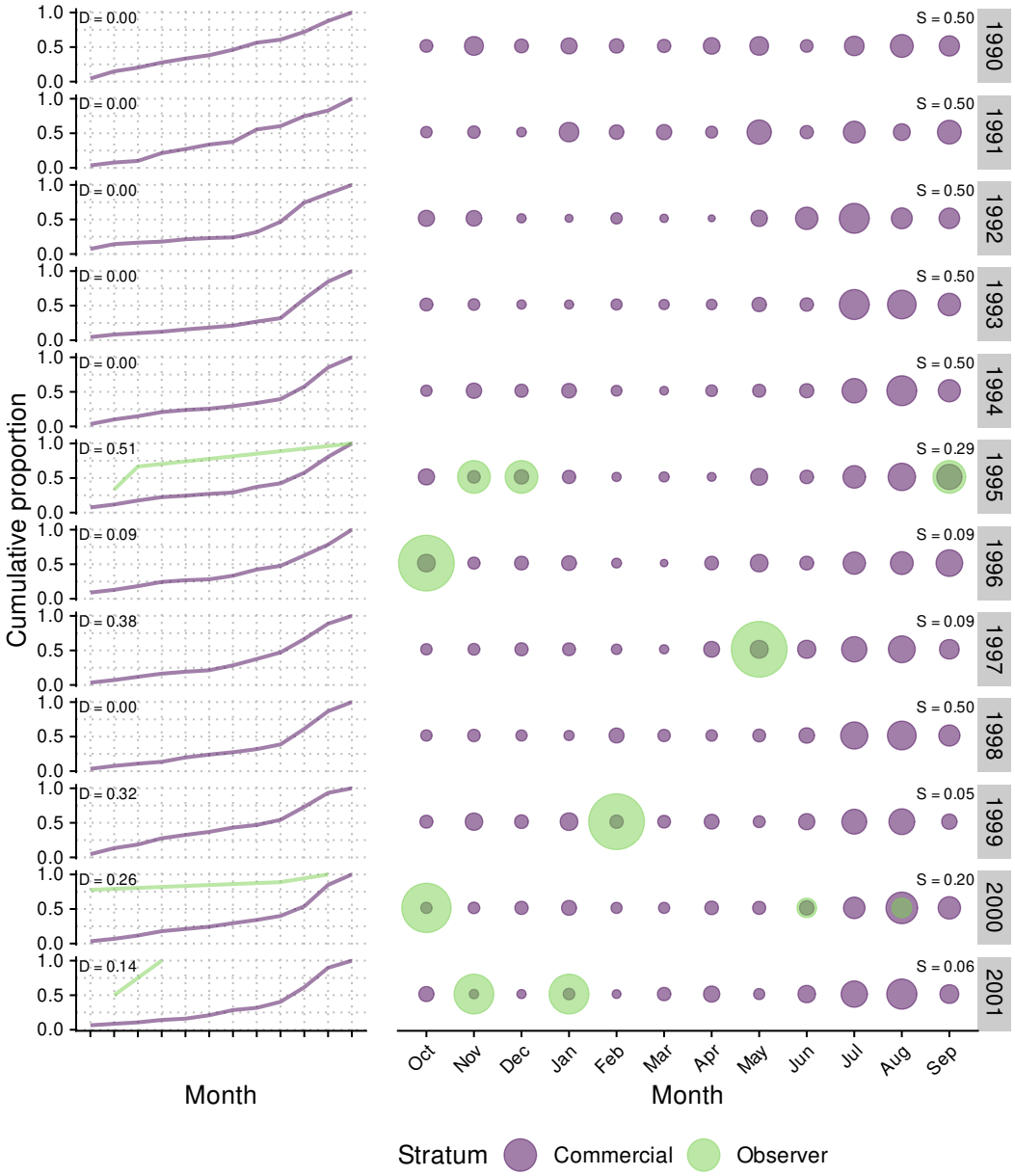

Figure E.7: Representativeness of observer sampling coverage of midwater trawl fishing events that caught alfonsino in 1990 to 2001 by fishing year and month. Observer data are for observed events with length sampling. Circle area is proportional to the proportion of events in a month, with proportions summing to one within each fishing year. D: Kolmogorov-Smirnov maximum absolute difference; S: Manhattan block distance.

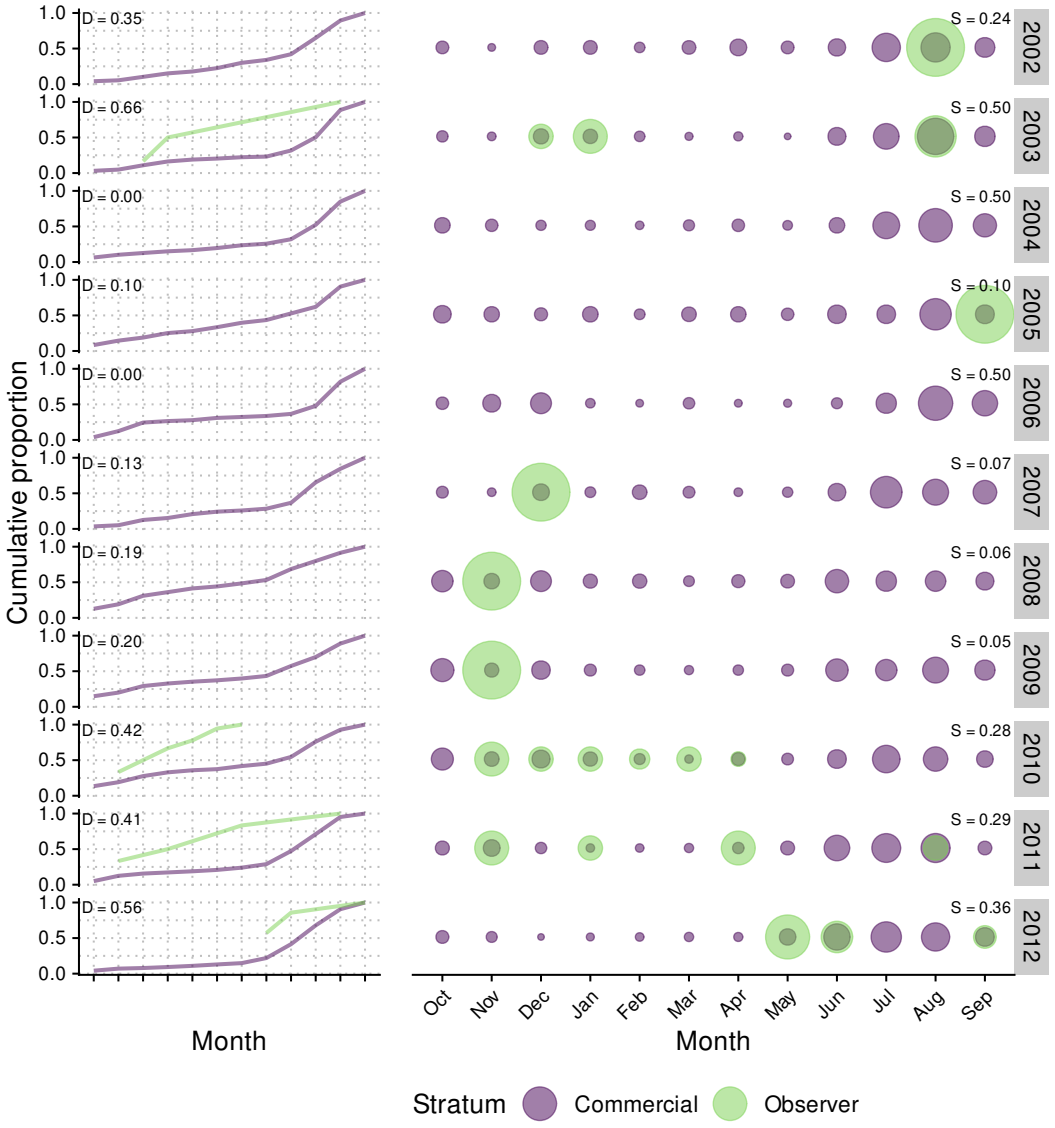

Figure E.8: Representativeness of observer sampling coverage of midwater trawl fishing events that caught alfonsino in 2002 to 2012 by fishing year and month. Observer data are for observed events with length sampling. Circle area is proportional to the proportion of events in a month, with proportions summing to one within each fishing year. D: Kolmogorov-Smirnov maximum absolute difference; S: Manhattan block distance.

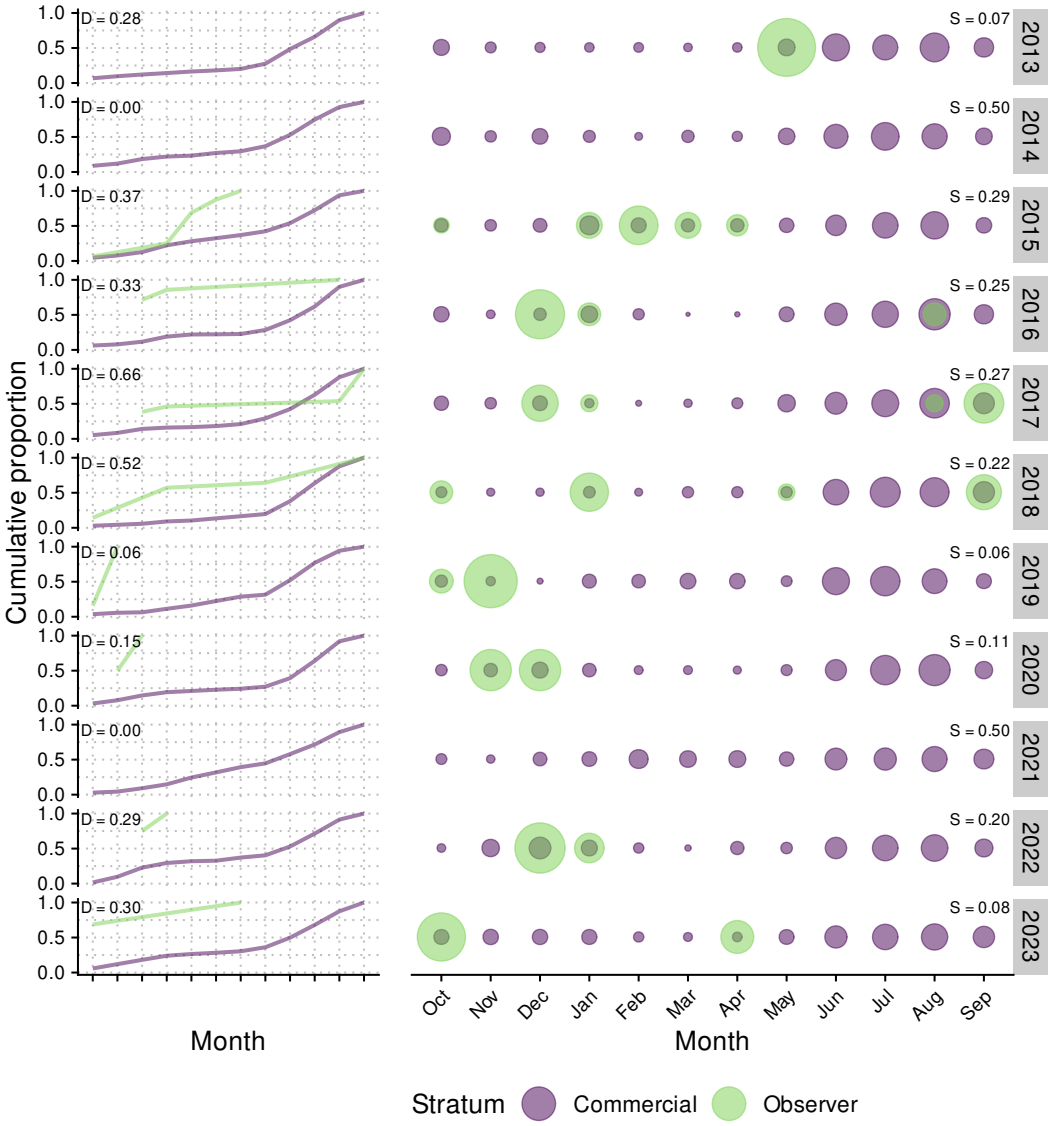

Figure E.9: Representativeness of observer sampling coverage of midwater trawl fishing events that caught alfonsino in 2013 to 2023 by fishing year and month. Observer data are for observed events with length sampling. Circle area is proportional to the proportion of events in a month, with proportions summing to one within each fishing year. D: Kolmogorov-Smirnov maximum absolute difference; S: Manhattan block distance.

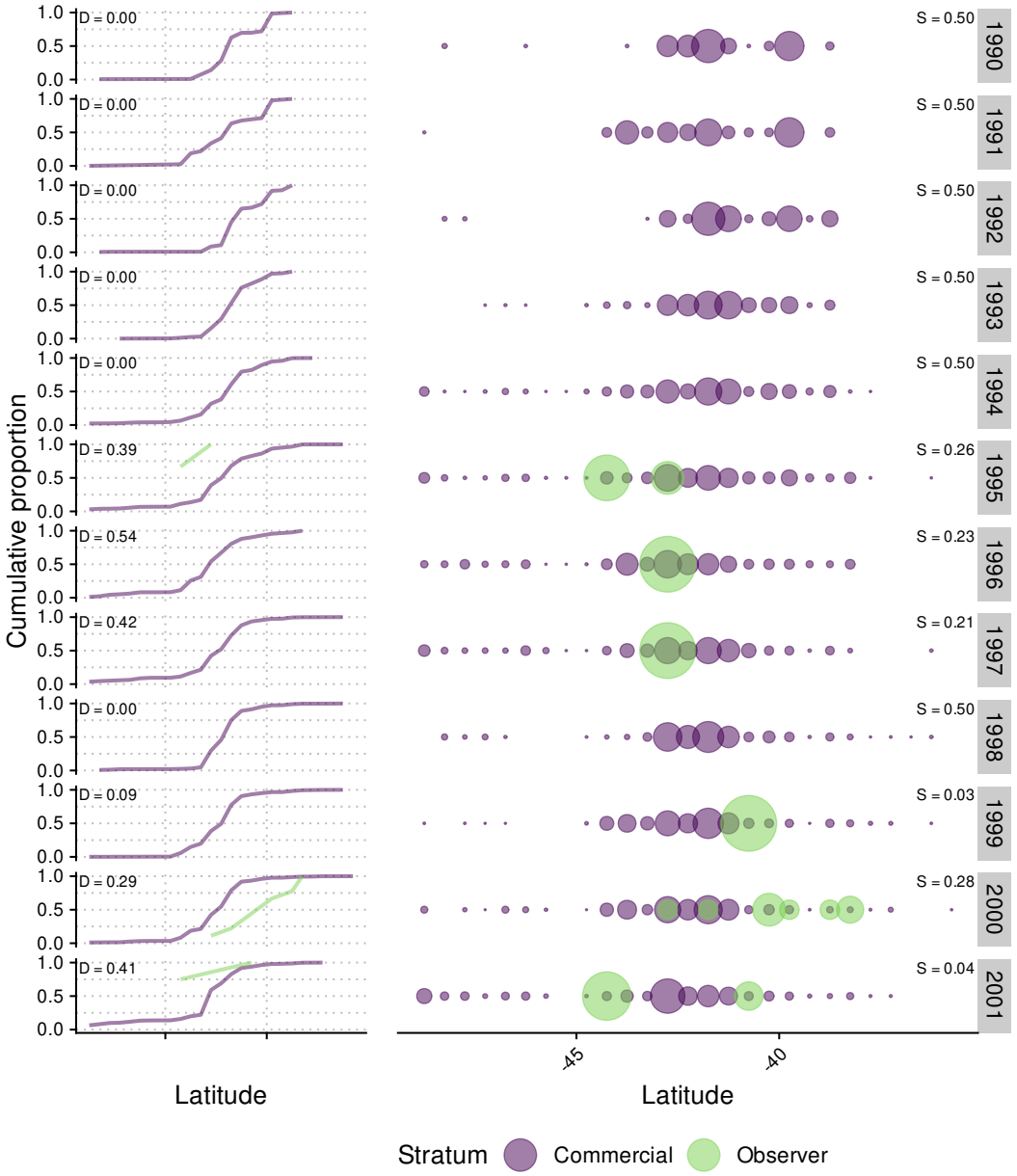

Figure E.10: Representativeness of observer sampling coverage of midwater trawl fishing events that caught alfonsino in 1990 to 2001 by fishing year and latitude. Observer data are for observed events with length sampling. Circle area is proportional to the proportion of events in a latitude bin, with proportions summing to one within each fishing year.

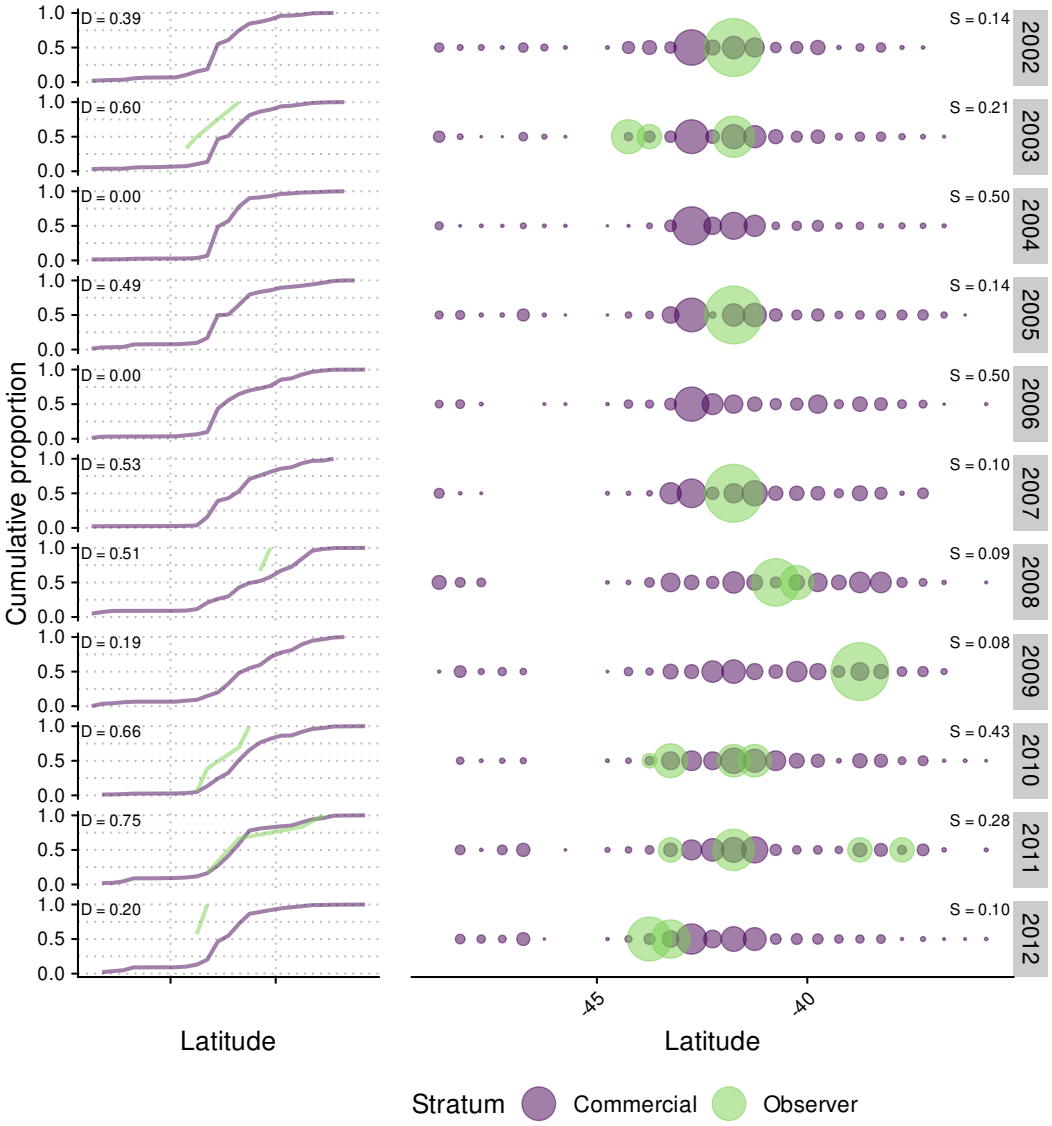

Figure E.11: Representativeness of observer sampling coverage of midwater trawl fishing events that caught alfonsino in 2002 to 2012 by fishing year and latitude. Observer data are for observed events with length sampling. Circle area is proportional to the proportion of events in a latitude bin, with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

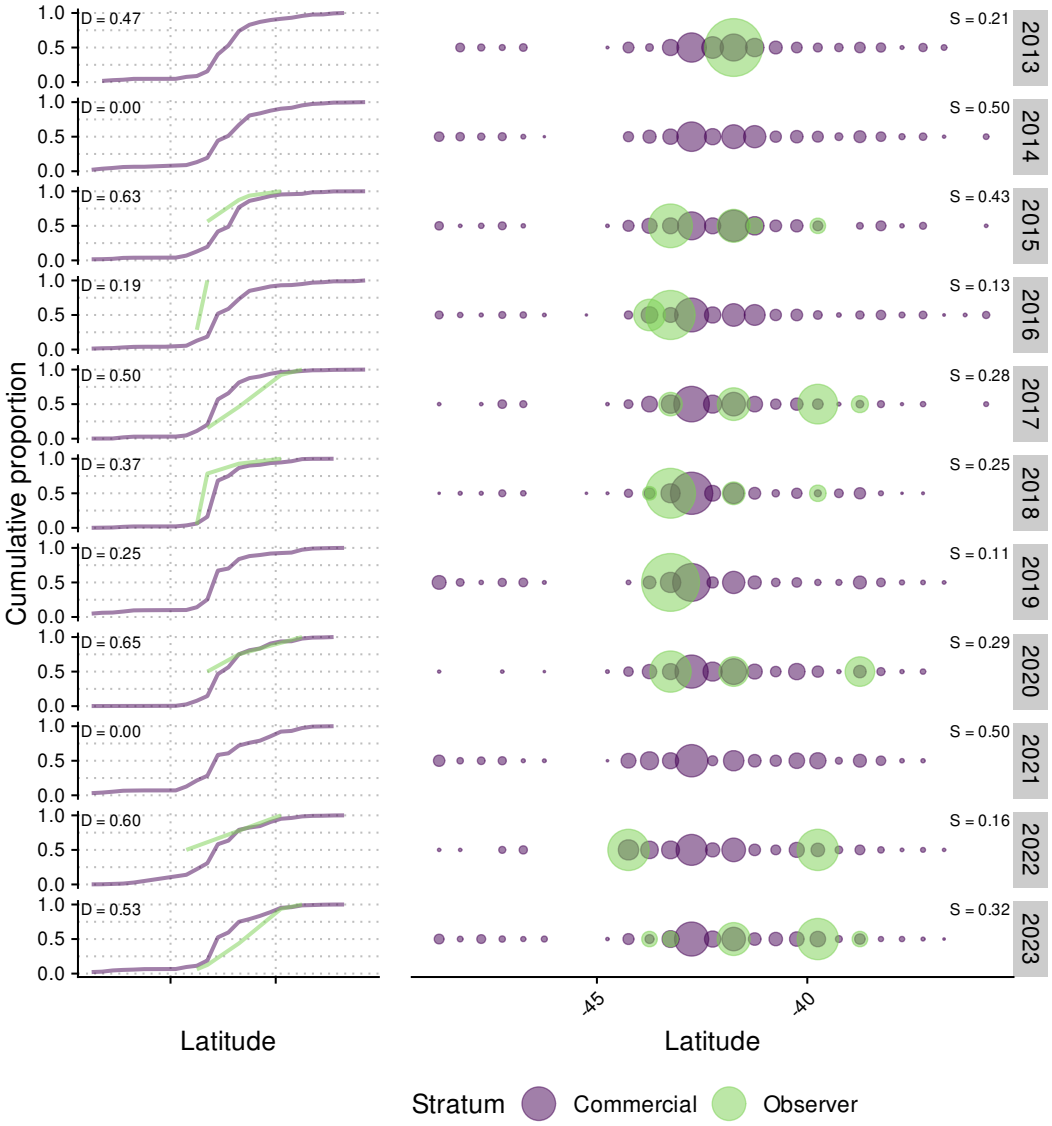

Figure E.12: Representativeness of observer sampling coverage of midwater trawl fishing events that caught alfonsino in 2013 to 2023 by fishing year and latitude. Observer data are for observed events with length sampling. Circle area is proportional to the proportion of events in a latitude bin, with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

APPENDIX F: GLOSSARY

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

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

Table F.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 - Seining	Electronic Reporting System - Seining
LCE	Lining Catch Effort Return (LCER)
NCE	Netting Catch, Effort and Landing Return (NCELR)
TCE	Trawl Catch Effort Return (TCER)
TCP	Trawl Catch, Effort and Processing Return (TCEPR)
TUN	Tuna Longlinging Catch Effort Return (TLCER)
LTC	Lining Trip Catch Effort Return (LTCER)
HCE	High Seas Catch, Effort and Landing Return (HS CELR)
HTC	High Seas Trawl Catch Effort Return (HS TCER)
HTU	High Seas Tuna Longlinging Catch Effort Return (HS TLCER)
HLC	High Seas Lining Catch Effort Return (HS LCER)

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

Code	Description
BLL	Bottom longline
BT	Bottom trawl
MW	Midwater trawl
PRB	Precision bottom trawl
PRM	Precision midwater trawl
SN	Set net

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

Code	Common name	Scientific name
BAR	Barracouta	*Thyrsites atun*
BNS	Bluenose	*Hyperoglyphe antarctica*
BYX	Alfonsino and long-finned beryx	*Beryx splendens, Beryx decadactylus*
CDL	Cardinal fish	*Epigonus telescopus*
HAK	Hake	*Merluccius australis*
HOK	Hoki	*Macruronus novaezelandiae*
LIN	Ling	*Genypterus blacodes*
ORH	Orange roughy	*Hoplostethus atlanticus*
SKI	Gemfish	*Rexea* spp.
SSO	Smooth oreo	*Pseudocyttus maculatus*
SWA	Silver warehou	*Seriolella punctata*

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

Code	Description
CEE	Central (East) (FMA 2)
SEC	South-East (Coast) (FMA 3)
SOE	South-East (Chatham Rise) (FMA 4)
SOU	Southland (FMA 5)